FY2015
Results of the Radioactive Material Monitoring in the Water Environment

June 2017

Ministry of the Environment

Contents

Outline

The following show the outline of the results of the FY2015 Monitoring of Radioactive Materials based on the Water Pollution Control Act.

Monitoring locations are as shown in Figure 1 and Figure 2.

1. National Radioactive Material Monitoring in the Water Environment in the Whole of Japan (FY2015)

○ Monitoring that was commenced in FY2014 at 110 locations for both public water areas and groundwater in 47 prefectures for the purpose of clarifying the distribution of radioactive materials in those areas nationwide (hereinafter referred to as the "Nationwide Monitoring").

○ The total β radioactivity and detected γ-ray emitting radionuclides were within the past measurement trends[1]. Lower detection limits differ by nuclide and sampling location, but overall were around 0.001 to 0.1 Bq/L in water, and around 1 to 100 Bq/kg in sediments. [2]

○ There were locations where the value of K-40 and total β were elevated in public water areas and some groundwater, but this was considered to have been influenced by seawater or soil / rocks.

○ As for other naturally occurring radionuclides, Ac-228, Bi-212, Bi-214, Pb-210, Pb-212, and Pb-214 were detected in higher concenrations than in past results. However, they were all considered to be in the thorium series or in the uranium series that are generally contained in natural soils and rocks

○ At some monitoring locations for public water areas, the artificial radionuclides Cs-134, Cs-137 and I-131 were detected exceeding their detection limits, but their values were within the past measurement trends.

○ It is appropriate to continue this monitoring the following fiscal year onward in order to clarify the distribution of radioactive materials in the water environment.

2. Radioactive Material Monitoring in the Water Environment in and around Fukushima Prefecture (FY2015)

○ In response to the accident at the Tokyo Electric Power Company’s Fukushima Daiichi NPS (hereinafter referred to as the "Fukushima NPS Accident"), monitoring has been conducted continuously since August 2011 at around 600 locations for public water areas and around 400 locations for groundwater in and around Fukushima prefecture for the purpose of clarifying the distribution of the accident-drived radioactive materials in the water environment (hereinafter referred to as the "Post-Earthquake Monitoring")

○ A summary of the radioactive cesium measurement results after the commencement of the FY2015 monitoring are as follows.

[1] "Within the past measurement trends" means that the results of the latest monitoring survey are evaluated from a technical perspective as not displaying extreme deviation from the results of past similar monitoring surveys.

[2] See Table 3.1-1, Table 3.1-2, and Table 3.1-3 of the Part 1report for the details of lower detection limits.

<Public water areas>

1) Water (detection limit: 1 Bq/L for both Cs-134 and Cs-137)

・At most locations radioactive cesium was not detectable, although several locations showed a positive result for these radionuclides.

2) Sediments (detection limit: 10 Bq/kg for both Cs-134 and Cs-137)

[Rivers]

・On the whole, the levels of both Cs-134 and Cs-137 were 300 Bq/kg or less at most locations, though relatively high levels were detected at some limited locations, such as those within the 20 km range. Changes in activity concentrations were observed as a decreasing trend at most locations.

[Lakes]

・On the whole, the levels of both Cs-134 and Cs-137 were 3,000 Bq/kg or less at most locations, though relatively high levels were detected at some limited locations, such as those within the 20 km range. Changes in activity concentrations were observed generally as a decreasing or unchanged trend at most locations except for several locations showing fluctuations.

[Coastal areas]

・On the whole, the levels of both Cs-134 and Cs-137 were 300 Bq/kg or less at most locations. Changes in activity concentrations were observed generally as a decreasing trend at most locations except for several locations showing fluctuations.

< Groundwater >

・Radioactive materials were not detectable in groundwater at all surveyed locations in FY2015 (detection limit: 1 Bq/L for both Cs-134 and Cs-137).

○ The results concerning radionuclides other than radioactive cesium were as follows:

• Sr-89: Was not detectable at any surveyed locations for groundwater.

• Sr-90: Was detected in sediment collected at several locations for public water areas, but basically remained at relatively low levels; Not detectable at any surveyed locations for groundwater

○ As measured activity concentrations are considered to fluctuate at some locations due to slight changes in sampling locations and properties, it is appropriate to continue this monitoring in the following fiscal years on an ongoing basis.

3. Other Radioactive Material Monitoring Conducted Nationwide (FY2015)

○The results of the Monitoring of Environmental Radioactivity Levels (hereinafter referred to as the “Monitoring of Levels), which has been conducted by the Nuclear Regulation Authority for the purpose of clarifying the existence or nonexistence of the influence of nuclear facilities, etc. nationwide, were all within the past measurement trends.

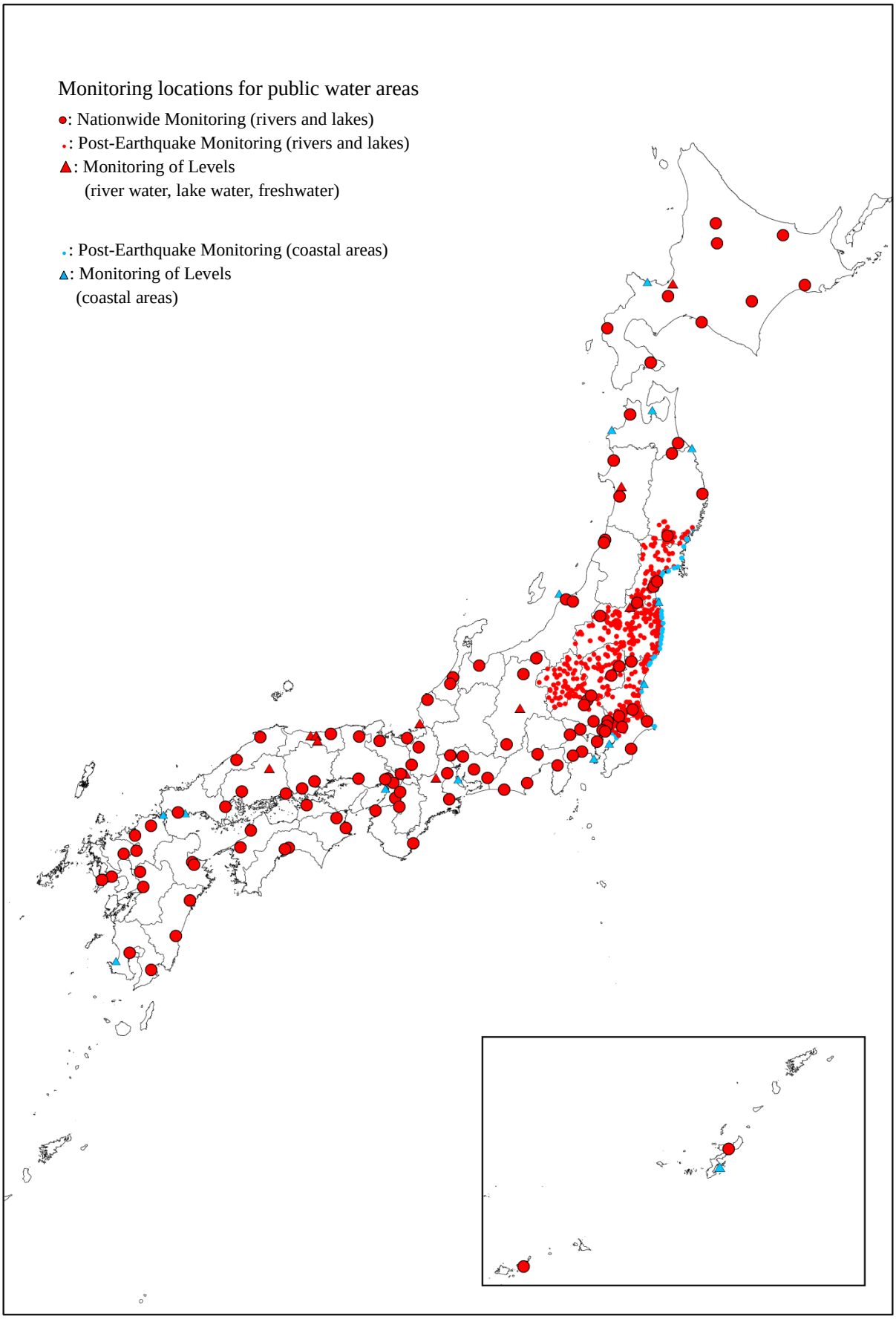


Figure 1 Locations for monitoring of radioactive materials (public water areas)

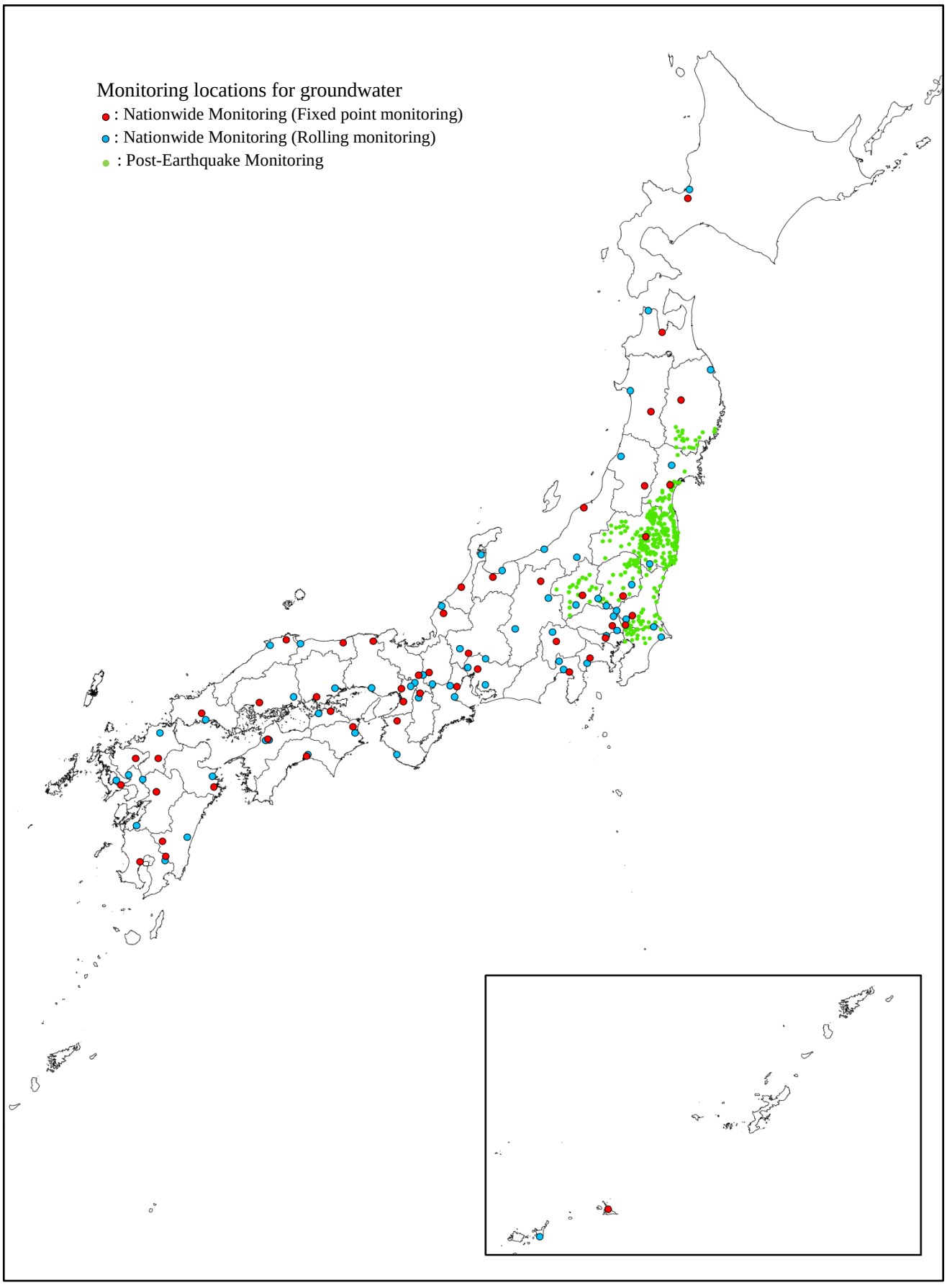


Figure 2 Locations for monitoring of radioactive materials (groundwater)

Part 1: National Radioactive Material Monitoring in the Water Environment in the Whole of Japan (FY2015)

1 Objective and Details

1.1 Objective

In response to the Fukushima NPS Accident, during which radioactive materials were discharged and causing environmental pollution, the Water Pollution Control Act was amended. It was decided that the Minister of the Environment should monitor pollution caused by radioactive materials in public water areas and groundwater and release the results from the perspective of preserving the health and living environment of the people.

Base on the above, this monitoring aims to clarify the distribution of radioactive materials in public water areas and groundwater nationwide.

1.2 Details

(1) Monitoring locations

- Public water areas: 110 locations (rivers: 107 locations; lakes: 3 locations)
- Groundwater: 110 locations

Monitoring locations were selected based on the following policy with a view to ensuring balanced nationwide monitoring (specific locations are as shown in Tables 1.2-2 and 1.2-3 and Figures 1.2-1 and 1.2-2).

(i) Public water areas

- The number of locations per prefecture was decided depending on the area and population, while securing at least one location in each prefecture.
- Locations within each prefecture were selected based on the following policy:
  a) Select representative rivers (including lakes) within each prefecture in the same numbers as those of the aforementioned locations in consideration of the area and population in their basins.
  b) Regarding rivers selected as explained in a), select locations from among those for the monitoring of hazardous materials, etc. conducted under the Water Pollution Control Act, which are selected in consideration of water utilization points. For an individual river, prioritize locations in the lower sections (including lakes located downstream).
  c) As this monitoring does not aim to clarify the influence of a specific sources, exclude locations close to those subject to the Environmental Monitoring around Nuclear Facilities, etc. (Radiation Monitoring Grants) in principle .

(ii) Groundwater

- Two locations were chosen for each prefecture and one more location was added for each prefecture where the amount of groundwater utilized had been large over the past several years.
- Locations within each prefecture were selected mainly from those for monitoring of environmental standard items for groundwater, based on the following conditions:
  a) Select regional representative wells (such as wells built for monitoring or major wells with especially high frequency of use) in consideration of the utilization amount of groundwater from respective

groundwater basins and water veins (hereinafter referred to as "groundwater basins, etc.").

b) Prioritize wells owned or managed by local governments, etc. in consideration of the convenience of coordination in case any additional survey is required.

c) Select one location for continuous fixed point monitoring from among the locations selected in the manner above, while taking into account the utilization amount and representativeness in a broader area of the relevant groundwater basin, etc. Other locations are for rolling monitoring (for 5 years in principle).

d) As this monitoring does not aim to clarify the influence of a specific sources, exclude locations close to those subject to the Environmental Monitoring around Nuclear Facilities, etc. (Radiation Monitoring Grants), in principle.

(2) Targets

・Public water areas: Water and sediments (for lakes, survey water both at the surface layer and bottom layers)
(Additionally, radioactive concentrations in soil and ambient dose rates are to be measured in the surrounding environment (river beds, etc.) near the sampling locations as reference.)

・Groundwater: Water
(Additionally, ambient dose rates are to be measured near the sampling locations as reference.)

(3) Frequencies and periods

・Public water areas: Once a year
However, monitoring was conducted four times a year at two locations (one location in eastern and western Japan, respectively) in order to check any annual variation.

・Groundwater: Fixed point monitoring was conducted once a year, and rolling monitoring was conducted once every five years in principle.

Periods for FY2015 monitoring are as shown in Table 1.2-4.

(4) Conducted analyses

The following analyses were conducted for collected samples.

・Measurement of total β radioactivity concentrations.

・γ-ray spectrometry measurement using a germanium semiconductor detector (all detectable radionuclides, including major naturally occurring radionuclides and artificial radionuclides, were surveyed in principle)

(5) Comparison with the past measurement trends

Obtained values were compared with the past measurement trends, and if any deviation was suspected, the validity of the measured values was rechecked (possibilities of transcription errors or insufficient adjustments of equipment, etc.).

This monitoring has just commenced. Therefore, the results of similar environmental monitoring conducted

so far are to be used for comparison for the time being. Specifically, the results of the Monitoring of Environmental Radioactivity Levels and Monitoring of the Surrounding Environment conducted by the Nuclear Regulation Authority, as well as the results of the Radioactive Material Monitoring in the Water Environment in and around Fukushima Prefecture conducted by the Ministry of the Environment were utilized. When making comparisons, due consideration was given to the possibility that the values of Cs-137 and other accident-derived radionuclides would have increased after the Fukushima NPS Accident.

Essentially, nationwide data for the past two decades were used. Also, with regard to the influence of the Fukushima NPS Accident., considering the influence immediately after it and based on actual measurement, "one year after the accident" was assumed to be a steady state, and therefore, the period from March 11, 2011 to March 10, 2012 was excluded.

(6) Measures to be taken when a value deviating from the past measurement trends was detected

The following measures are to be taken when a value deviating from the past measurement trends was detected (see Figure 1.2-3).

(6)-1 Release of preliminary values

Any value that is suspected to deviate from the past measurement trends should be immediately evaluated professionally by the chair and the deputy chair, and if it is judged highly urgent (when it has been confirmed that the value is highly likely to deviate from the past measurement trends, and additional detailed analyses are considered to be necessary), a preliminary report should be released as promptly as possible.

In such a case, the following related data should be compiled as basic data for professional evaluation. Members of the Evaluation Committee other than the chair and the deputy chair should be informed of the relevant information together with the professional evaluation by the chair and the deputy chair (see Table 1.2-1 for the chair and other committee members).

(i) Results of the measurement concerning water, sediments and ambient dose rates (results of the measurement of total β radioactivity concentrations and γ-ray spectrometry measurement)

(ii) Sampling dates, sampling locations (maps, water depth, river width, etc.), sampling methods, and sampling circumstances (photos)

(iii) Weather data for about one week near the measuring date (the amount of precipitation, in particular)

(iv) Ambient dose rates measured for the last one month or so in neighboring points

(v) Changes in past detected values of the relevant radionuclide

(6)-2 Detailed analyses and release of the results

For data for which the preliminary report was released as explained in (6)-1 above, the following detailed analyses are to be conducted and the results should be released.

- Concrete analyses to identify radionuclides (including measurement of individual radionuclides through a radiochemical analysis)
- Additional measurement in the surrounding areas of the relevant surveyed location

(7) Disclosure of measurement results

The measurement results data are made publicly available on the following Ministry of the Environment website:

http://www.env.go.jp/en/water/rmms/surveys.html

Table 1.2-1 List of members of the Evaluation Committee on Radioactive Material Monitoring in the Water Environment

IIMOTO Takeshi (Deputy chair)	Senior Associate professor, Division for Environment, Health and Safety, the University of Tokyo
ISHII Nobuyoshi	Principal Researcher, Environmental Transfer Parameter Research Team, The Fukushima Project Headquarters, National Institute of Radiological Sciences, National Institutes for Quantum and Radiological Science and Technology
TOKUNAGA Tomochika	Professor, Department of Environment Systems, Graduate School of Frontier Sciences, the University of Tokyo
HAYASHI Seiji	Research Group Manager & Head of Environmental Assessment Section, Fukushima Branch, National Institute for Environmental Studies
FUKUSHIMA Takehiko (Chair)	Professor, Doctoral Program in Integrative Environment and Biomass Sciences, Graduate School, University of Tsukuba

Table 1.2-2 List of locations for the FY2015 Nationwide Monitoring (public water areas) (No. 1)

No.	Prefecture	Property	Sampling location		
			Water area	Location	Municipality
1	Hokkaido Prefecture	River	Ishikari River	Water purification plant intake at Ishikari River in Asahikawa City	Asahikawa City
2		River	Ishikari River	Intake at the Shirakawa water purification plant in Sapporo City	Sapporo City
3		River	Teshio River	Nakashibetsu Bridge (Intake at the Higashiyama water purification plant in Shibetsu City)	Shibetsu City
4		River	Tokoro River	Tadashi Bridge	Kitami City
5		River	Kushiro River	Intake at the Aikoku water purification plant in Kushiro City	Kushiro City
6		River	Tokachi River	Nantai Bridge	Obihiro City
7		River	Sarugawa River	Sarugawa Bridge (Tomigawa)	Hidaka Town
8		River	Matsukura River	Mitsumori Bridge (Before the confluence with Torasawa River)	Hakodate City
9		River	Shiribeshi-toshibetsu River	Intake at the Kitahiyama simple water plant in Kitahiyama Town	Setana Town
10	Aomori Prefecture	River	Iwaki River	Tsugaru-ohashi Bridge	Nakadomari Town
11		River	Mabechi River	Shiriuchi Bridge	Hachinohe City
12	Iwate Prefecture	River	Mabechi River	Fugane Bridge	Ninohe City
13		River	Heigawa River	Miyako Bridge	Miyako City
14		River	Kitakami River	Chitose Bridge	Ichinoseki City
15	Miyagi Prefecture	River	Abukuma River	Iwanuma (Abukuma Bridge)	Iwanuma City
16		River	Natori River	Yuriage-ohashi Bridge	Natori City
17	Akita Prefecture	River	Yoneshiro River	Noshiro Bridge	Noshiro City
18		River	Omono River	Kurose Bridge	Akita City
19	Yamagata Prefecture	River	Mogami River	Ryou Bridge	Sakata City
20		River	Akagawa River	Shinkawa Bridge	Sakata City
21	Fukushima Prefecture	River	Agano River	Shingo Dam	Kitakata City
22		River	Abukuma River	Taisho Bridge (Fushiguro)	Date City
23		River	Kujigawa River	Takachihara Bridge	Yamatsuri Town
24	Ibaraki Prefecture	Lake	Lake Kasumigaura	Center of the lake	Miho Village
25		River	Kokai River	Fumimaki Bridge	Toride City
26	Tochigi Prefecture	River	Nakagawa River	Shinnaka Bridge	Nakagawa Town
27		River	Kinugawa River	Kinugawa Bridge (Hoshakuji Temple)	Utsunomiya City
28	Gunma Prefecture	River	Tonegawa River	Toneozeki Weir	Chiyoda Town/Gyoda City (Saitama Prefecture)
29		River	Watarase River	Watarase-ohashi Bridge	Tatebayashi City
30	Saitama Prefecture	River	Arakawa River	Kuge Bridge	Kumagaya City
31		River	Arakawa River	Akigase Intake Weir	Saitama City/ Shiki City
32		River	Edogawa River	Nagareyama Bridge	Nagareyama City (Chiba Prefecture) / Misato City
33	Chiba Prefecture	River	Tonegawa River	Kakozeki Weir	Tonosho Town
34		River	Ichinomiya River	Nakano Bridge	Ichinomiya Town
35		Lake	Lake Inbanuma	Lower area of water purification plant intake	Sakura City
36	Tokyo Metoropolis	River	Edogawa River	Shinkatsushika Bridge	Katsushika City
37		River	Tamagawa River	Haijima raw water supply point	Akishima City
38		River	Sumida River	Ryogoku Bridge	Chuo City / Sumida City
39		River	Arakawa River	Kasai Bridge	Koto City / Edogawa City
40	Kanagawa Prefecture	River	Tsurumi River	Rinko Tsurumigawa Bridge	Yokohama City
41		River	Sagami River	Banyu Bridge	Hiratsuka City
42		River	Sakawa River	Sakawa Bridge	Odawara City
43	Niigata Prefecture	River	Shinano River	Heisei-ohashi Bridge	Niigata City
44		River	Agano River	Oun Bridge	Niigata City
45	Toyama Prefecture	River	Jinzu River	Hagiura Bridge	Toyama City
46	Ishikawa Prefecture	River	Saigawa River	Okuwa Bridge	Kanazawa City
47		River	Tedori River	Hakusangoguchi Dike	Hakusan City
48	Fukui Prefecture	River	Kuzuryu River	Fuseda Bridge	Fukui City
49		River	Kitagawa River	Takatsuka Bridge	Obama City
50	Yamanashi Prefecture	River	Sagami River	Katsuragawa Bridge	Uenohara City
51		River	Fujikawa River	Nanbu Bridge	Nanbu Town
52	Nagano Prefecture	River	Shinano River	Ozeki Bridge	Iiyama City
53		River	Saigawa River	Koichi Bridge	Nagano City
54		River	Tenryu River	Tsutsuji Bridge	Iida City

Table 1.2-2 List of locations for the FY2015 Nationwide Monitoring (public water areas) (No. 2)

No.	Prefecture	Property	Sampling location		
			Water area	Location	Municipality
55	Gifu Prefecture	River	Kisogawa River	Tokai-ohashi Bridge（Naruto）	Kaizu City
56		River	Nagara River	Tokai-ohashi Bridge	Kaizu City
57	Shizuoka Prefecture	River	Kanogawa River	Kurose Bridge	Numazu City
58		River	Ooi River	Fujimi Bridge	Yaizu City / Yoshida Town
59		River	Tenryu River	Kaketsuka Bridge	Iwata City / Hamamatsu City
60	Aichi Prefecture	River	Shonai River	Mizuwake Bridge	Nagoya City
61		River	Yahagi River	Iwazutenjin Bridge	Okazaki City / Toyota City
62		River	Toyogawa River	Eshima Bridge	Toyokawa City
63	Mie Prefecture	River	Suzuka River	Ogura Bridge	Yokkaichi City
64		River	Miyakawa River	Watarai Bridge	Ise City
65	Shiga Prefecture	River	Adogawa River	Joan Bridge	Takashima City
66		Lake	Lake Biwako	Karasakioki-Chuo	—
67	Kyoto Prefecture	River	Yuragawa River	Yuragawa Bridge	Maizuru City
68		River	Katsura River	Before the confluence of three tributaries of Katsura River	Oyamazaki Town
69	Osaka Prefecture	River	Inagawa River	Gunko Bridge	Itami City (Hyogo prefecture)
70		River	Yodogawa River	Sugaharashirokita-ohashi Bridge	Osaka City
71		River	Ishikawa River	Takahashi	Tondabayashi City
72	Hyogo Prefecture	River	Kakogawa River	Kakogawa Bridge	Kakogawa City
73		River	Mukogawa River	Hyakkenbi	Takarazuka City
74		River	Maruyama River	Kaminogo Bridge	Toyooka City
75	Nara Prefecture	River	Yamato River	Fujii	Oji Town
76		River	Kinokawa River	Okura Bridge	Gojo City
77	Wakayama Prefecture	River	Kinokawa River	Shinrokkaizeki Weir	Wakayama City
78		River	Kumano River	Kumano-ohashi Bridge	Shingu City
79	Tottori Prefecture	River	Sendai River	Gyotoku	Tottori City
80	Shimane Prefecture	River	Hiikawa River	Kandatsu Bridge	Izumo City
81		River	Gonokawa River	Sakurae-ohashi Bridge	Gotsu City
82	Okayama Prefecture	River	Asahikawa River	Otoite Weir	Okayama City
83		River	Takahashi River	Kasumi Bridg	Kurashiki City
84	Hiroshima Prefecture	River	Ota River	Water purification plant intake in Hesaka	Hiroshima City
85		River	Ashida River	Kominomi Bridge	Fukuyama City
86	Yamaguchi Prefecture	River	Nishiki River	Water purification plant intake for the city	Iwakuni City
87		River	Koto River	Suenobu Bridge	Ube City
88	Tokushima Prefecture	River	Yoshino River	Takase Bridge	Ishii Town
89		River	Nakagawa River	Nakagawa Bridge	Anan City
90	Kagawa Prefecture	River	Dokigawa River	Marugame Bridge	Marugame City
91	Ehime Prefecture	River	Shigenobu River	Deai Bridge	Matsuyama City
92		River	Hijikawa River	Hijikawa Bridge	Ozu City
93	Kochi Prefecture	River	Kagami River	Kachuzeki Weir	Kochi City
94		River	Niyodo River	Hatazeki Weir (1) Center of flow	Ino Town
95	Fukuoka Prefecture	River	Onga River	Hinode Bridge	Nogata City
96		River	Nakagawa River	Shiobara Bridge	Fukuoka City
97		River	Chikugo River	Senoshita	Kurume City
98	Saga Prefecture	River	Kasegawa River	Kase Bridge	Saga City
99	Nagasaki Prefecture	River	Honmyo River	In front of Tenma Park	Isahaya City
100		River	Uragami River	Ohashizeki Weir	Nagasaki City
101	Kumamoto Prefecture	River	Kikuchi River	Shiroishi	Nagomi Town
102		River	Midori River	Uesugizeki Weir	Kumamoto City
103	Oita Prefecture	River	Oita River	Funaichi-ohashi Bridge	Oita City
104		River	Oono River	Shirataki Bridge	Oita City
105	Miyazaki Prefecture	River	Gokase River	Miwa	Nobeoka City
106		River	Oyodo River	Shinaioi Bridge	Miyazaki City
107	Kagoshima Prefecture	River	Kotsuki River	Iwasaki Bridge	Kagoshima City
108		River	Kimotsuki River	Matase Bridge	Kanoya City
109	Okinawa Prefecture	River	Genka River	Water intake	Nago City
110		River	Miyara River	Omoto water intake	Ishigaki City

Table 1.2-3 List of locations for the FY2015 Nationwide Monitoring (groundwater) (No. 1)

No.	Prefecture	Property	Municipality	District	Monitoring method
1	Hokkaido Prefecture	Groundwater	Sapporo City	Kitasanjonishi,Chuo Ward	Fixed point monitoring
2		Groundwater	Ishikari City	Kitaoyafuru	Rolling monitoring
3	Aomori Prefecture	Groundwater	Aomori City	Shinmachi	Fixed point monitoring
4		Groundwater	Sotogahama Town	Minmayamasukawa	Rolling monitoring
5	Iwate Prefecture	Groundwater	Morioka City	Motomiya	Fixed point monitoring
6		Groundwater	Kuji City	Osanaicho	Rolling monitoring
7	Miyagi Prefecture	Groundwater	Sendai City	Honcho,Aoba Ward	Fixed point monitoring
8		Groundwater	Osaki City	Furukawaosaki	Rolling monitoring
9	Akita Prefecture	Groundwater	Daisen City	Niiyaji	Fixed point monitoring
10		Groundwater	Katagami City	Showaokubo	Rolling monitoring
11	Yamagata Prefecture	Groundwater	Yamagata City	Hatagomachi	Fixed point monitoring
12		Groundwater	Tsuruoka City	Takarada	Rolling monitoring
13	Fukushima Prefecture	Groundwater	Koriyama City	Asahi	Fixed point monitoring
14		Groundwater	Hanawa Town	Itaniwa	Rolling monitoring
15	Ibaraki Prefecture	Groundwater	Tsukuba City	Kenkyugakuen	Fixed point monitoring
16		Groundwater	Koga City	Komahane	Rolling monitoring
17		Groundwater	Joso City	Sakatemachi	Rolling monitoring
18	Tochigi Prefecture	Groundwater	Shimotsuke City	Machida	Fixed point monitoring
19		Groundwater	Ashikaga City	Omataminamicho	Rolling monitoring
20		Groundwater	Haga Town	Yatsuki	Rolling monitoring
21	Gunma Prefecture	Groundwater	Maebashi City	Shikishimacho	Fixed point monitoring
22		Groundwater	Tatebayashi City	Shiromachi	Rolling monitoring
23		Groundwater	Tomioka City	Tajino	Rolling monitoring
24	Saitama Prefecture	Groundwater	Saitama City	Mikura,Minuma Ward	Fixed point monitoring
25		Groundwater	Kawaguchi City	Higashihongo	Rolling monitoring
26		Groundwater	Kuki City	Yoshiba	Rolling monitoring
27	Chiba Prefecture	Groundwater	Kashiwa City	Funato	Fixed point monitoring
28		Groundwater	Katori City	Sawarai	Rolling monitoring
29		Groundwater	Asahi City	Ro	Rolling monitoring
30	Tokyo Metoropolis	Groundwater	Koganei City	Kajinocho	Fixed point monitoring
31		Groundwater	Nishitokyo City	Yatocho	Rolling monitoring
32	Kanagawa Prefecture	Groundwater	Hadano City	Imaizumi	Fixed point monitoring
33		Groundwater	Odawara City	Renshoji	Rolling monitoring
34	Niigata Prefecture	Groundwater	Niigata City	Nagata,Chuo Ward	Fixed point monitoring
35		Groundwater	Minamiuonuma City	Miya	Rolling monitoring
36		Groundwater	Joetsu City	Minatocho	Rolling monitoring
37	Toyama Prefecture	Groundwater	Toyama City	Funahashikitamachi	Fixed point monitoring
38		Groundwater	Uozu City	Shinjuku	Rolling monitoring
39	Ishikawa Prefecture	Groundwater	Hakusan City	Kuramitsu	Fixed point monitoring
40		Groundwater	Nanao City	Hamataka,Tsumugimachi	Rolling monitoring
41	Fukui Prefecture	Groundwater	Fukui City	Ote	Fixed point monitoring
42		Groundwater	Sakai City	Sakaichotako	Rolling monitoring
43	Yamanashi Prefecture	Groundwater	Showa Town	Saijyoshinden	Fixed point monitoring
44		Groundwater	Hokuto City	Akenochoasao	Rolling monitoring
45	Nagano Prefecture	Groundwater	Nagano City	Tsurugamidoricho	Fixed point monitoring
46		Groundwater	Tomi City	Kurakake	Rolling monitoring
47		Groundwater	Kiso Town	Fukushima	Rolling monitoring
48	Gifu Prefecture	Groundwater	Gifu City	Kanoshimizucho	Fixed point monitoring
49		Groundwater	Tajimi City	Maebatacho	Rolling monitoring
50		Groundwater	Ibigawa Town	Kamino	Rolling monitoring
51	Shizuoka Prefecture	Groundwater	Numazu City	Hara	Fixed point monitoring
52		Groundwater	Fuji City	Kunikubo	Rolling monitoring
53		Groundwater	Fujinomiya City	Kamiide	Rolling monitoring
54	Aichi Prefectur	Groundwater	Nagoya City	Kawaharatori,Showa Ward	Fixed point monitoring
55		Groundwater	Okazaki City	Nakajimachonakaueno	Rolling monitoring
56		Groundwater	Tsushima City	Nakaishikichokitayama	Rolling monitoring

Table 1.2-3 List of locations for the FY2015 Nationwide Monitoring (groundwater) (No. 2)

No.	Prefecture	Property	Municipality	District	Monitoring method
57	Mie Prefecture	Groundwater	Suzuka City	Inoucho	Fixed point monitoring
58		Groundwater	Kameyama City	Taikojicho	Rolling monitoring
59		Groundwater	Tsu City	Shiroyama	Rolling monitoring
60	Shiga Prefecture	Groundwater	Moriyama City	Miyakecho	Fixed point monitoring
61		Groundwater	Otsu City	Goryocho	Rolling monitoring
62		Groundwater	Koka City	Shigarakichonagano	Rolling monitoring
63	Kyoto Prefecture	Groundwater	Kyoto City	Kamihonnojimaecho,Nakagyo Ward	Fixed point monitoring
64		Groundwater	Yawata City	Yawatashinade	Rolling monitoring
65	Osaka Prefecture	Groundwater	Sakai City	Daisennakamachi,Sakai Ward	Fixed point monitoring
66		Groundwater	Takatsuki City	Banda	Rolling monitoring
67	Hyogo Prefecture	Groundwater	Itami City	Kuchisakai	Fixed point monitoring
68		Groundwater	Toyooka City	Saiwaicho	Fixed point monitoring
69		Groundwater	Kakogawa City	Kakogawachojikemachi	Rolling monitoring
70	Nara Prefecture	Groundwater	Nara City	Sakyo	Fixed point monitoring
71		Groundwater	Yamatokoriyama City	Honjocho	Rolling monitoring
72	Wakayama Prefecture	Groundwater	Kinokawa City	Takano	Fixed point monitoring
73		Groundwater	Shirahama Town	Taira	Rolling monitoring
74	Tottori Prefecture	Groundwater	Tottori City	Saiwaicho	Fixed point monitoring
75		Groundwater	Yonago City	Kuzumo	Rolling monitoring
76	Shimane Prefecture	Groundwater	Matsue City	Nishikawatsucho	Fixed point monitoring
77		Groundwater	Izumo City	Himebara	Rolling monitoring
78	Okayama Prefecture	Groundwater	Kurashiki City	Fukui	Fixed point monitoring
79		Groundwater	Bizen City	Sakane	Rolling monitoring
80	Hiroshima Prefecture	Groundwater	Hiroshima City	Kamisenocho, Aki Ward	Fixed point monitoring
81		Groundwater	Fukuyama City	Ashidachofukuda	Rolling monitoring
82	Yamaguchi Prefecture	Groundwater	Yamaguchi City	Ouchimihori	Fixed point monitoring
83		Groundwater	Hofu City	Kokuga	Rolling monitoring
84	Tokushima Prefecture	Groundwater	Tokushima City	Fudohoncho	Fixed point monitoring
85		Groundwater	Komatsushima City	Tauracho	Rolling monitoring
86	Kagawa Prefecture	Groundwater	Takamatsu City	Bancho	Fixed point monitoring
87		Groundwater	Marugame City	Dokichohigashi	Rolling monitoring
88	Ehime Prefecture	Groundwater	Matsuyama City	Hiraimachi	Fixed point monitoring
89		Groundwater	Toon City	Tanokubo	Rolling monitoring
90		Groundwater	Tobe Town	Takooda	Rolling monitoring
91	Kochi Prefecture	Groundwater	Kochi City	Kerako	Fixed point monitoring
92		Groundwater	Nankoku City	Hataeda	Rolling monitoring
93	Fukuoka Prefecture	Groundwater	Kurume City	Tanushimarumachiakinari	Fixed point monitoring
94		Groundwater	Nogata City	Ueki	Rolling monitoring
95	Saga Prefecture	Groundwater	Saga City	Yamatochoniiji	Fixed point monitoring
96		Groundwater	Tara Town	Tara	Rolling monitoring
97	Nagasaki Prefecure	Groundwater	Isahaya City	Eidamachi	Fixed point monitoring
98		Groundwater	Omura City	Morizonomachi	Rolling monitoring
99	Kumamoto Prefecture	Groundwater	Kumamoto City	Suizenji,Chuo Ward	Fixed point monitoring
100		Groundwater	Arao City	Masunaga	Rolling monitoring
101		Groundwater	Minamata City	Kojo	Rolling monitoring
102	Oita Prefecure	Groundwater	Saiki City	Kamioka	Fixed point monitoring
103		Groundwater	Usuki City	Suehiro	Rolling monitoring
104	Miyazaki Prefecture	Groundwater	Miyakonojo City	Minamiyokoichicho	Fixed point monitoring
105		Groundwater	Kobayashi City	Minaminishikata	Fixed point monitoring
106		Groundwater	Saito City	Okadomi	Rolling monitoring
107	Kagoshima Prefecture	Groundwater	Kagoshima City	Tamazatocho	Fixed point monitoring
108		Groundwater	Soo City	Sueyoshichominaminogo	Rolling monitoring
109	Okinawa Prefecture	Groundwater	Miyakojima City	Hirarahigashinakasonezoe	Fixed point monitoring
110		Groundwater	Ishigaki City	Ohama	Rolling monitoring

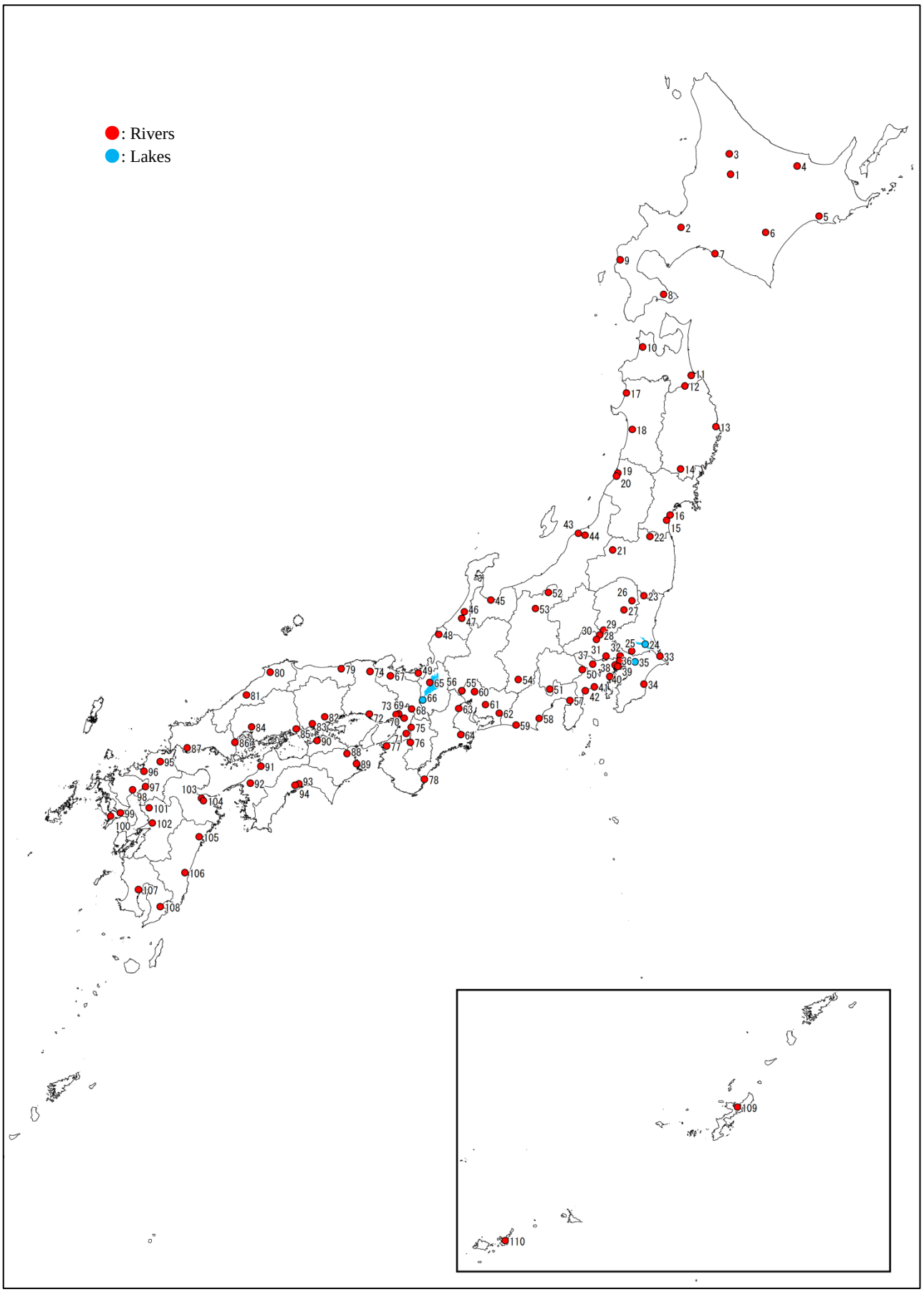


Figure 1.2-1 Map showing locations for the FY2015 Nationwide Monitoring (public water areas)

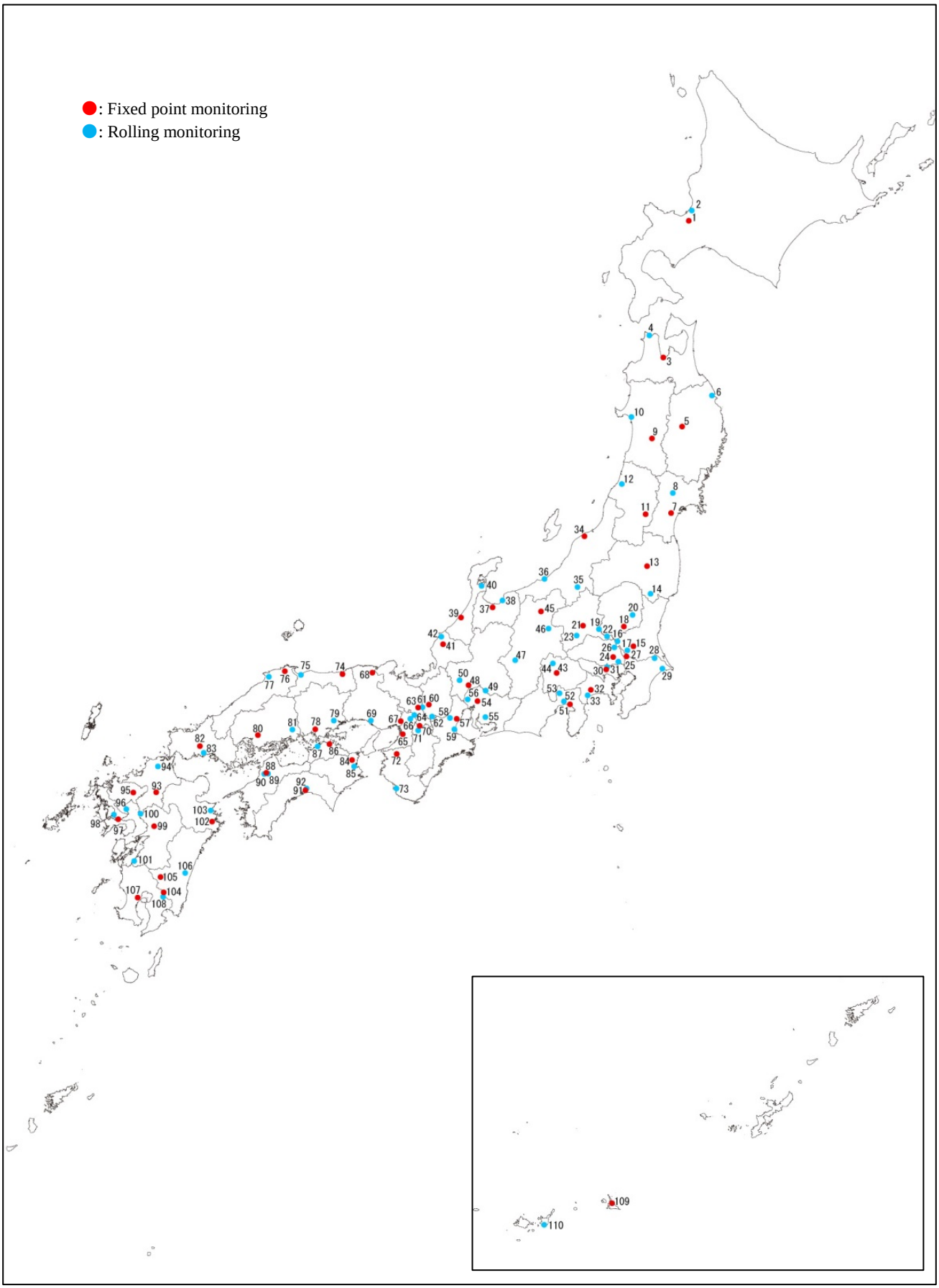


Figure 1.2-2 Map showing locations for the FY2015 Nationwide Monitoring (groundwater)

Table 1.2-4 Monitoring points and period by block (FY2015)

Blocks	Prefectures	Public water areas		Groundwater	
		Number of Locations(※1)	Period	Number of locations	Period
Hokkaido block	Hokkaido	9	Oct. 15 to Oct. 22	2	Oct.14to Oct.22
Tohoku block	Aomori, Iwate, Miyagi, Akita, Yamagata and Fukushima	14	Oct. 13 to Oct. 29	12	Oct.13to Oct.29
Kanto block	Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa, Niigata, Yamanashi and Shizuoka	26 (2)	Oct. 13 to Dec. 8	27	Oct.13to Nov.4
Chubu block	Toyama, Ishikawa, Fukui, Nagano, Gifu, Aichi and Mie	15	Oct. 15 to Nov. 30	18	Oct.14to Nov.9
Kinki block	Shiga, Kyoto, Osaka, Hyogo, Nara and Wakayama	14 (1)	Oct. 14 to Oct. 28	14	Oct.14to Oct.29
Chugoku-Shikoku block	Tottori, Shimane, Okayama, Hiroshima, Yamaguchi, Tokushima, Kagawa, Ehime and Kochi	16	Oct. 14 to Nov. 7	19	Oct.14to Nov.16
Kyushu and Okinawa block	Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagoshima and Okinawa	16	Oct. 13 to Nov. 7	18	Oct.13to Nov.5
Survey to check annual variation	Gunma and Okayama	2	Oct. 13 to Jan. 25	-	-

(*1) Numbers in parentheses are those of monitoring locations for lakes and other numbers are those of monitoring locations for rivers.

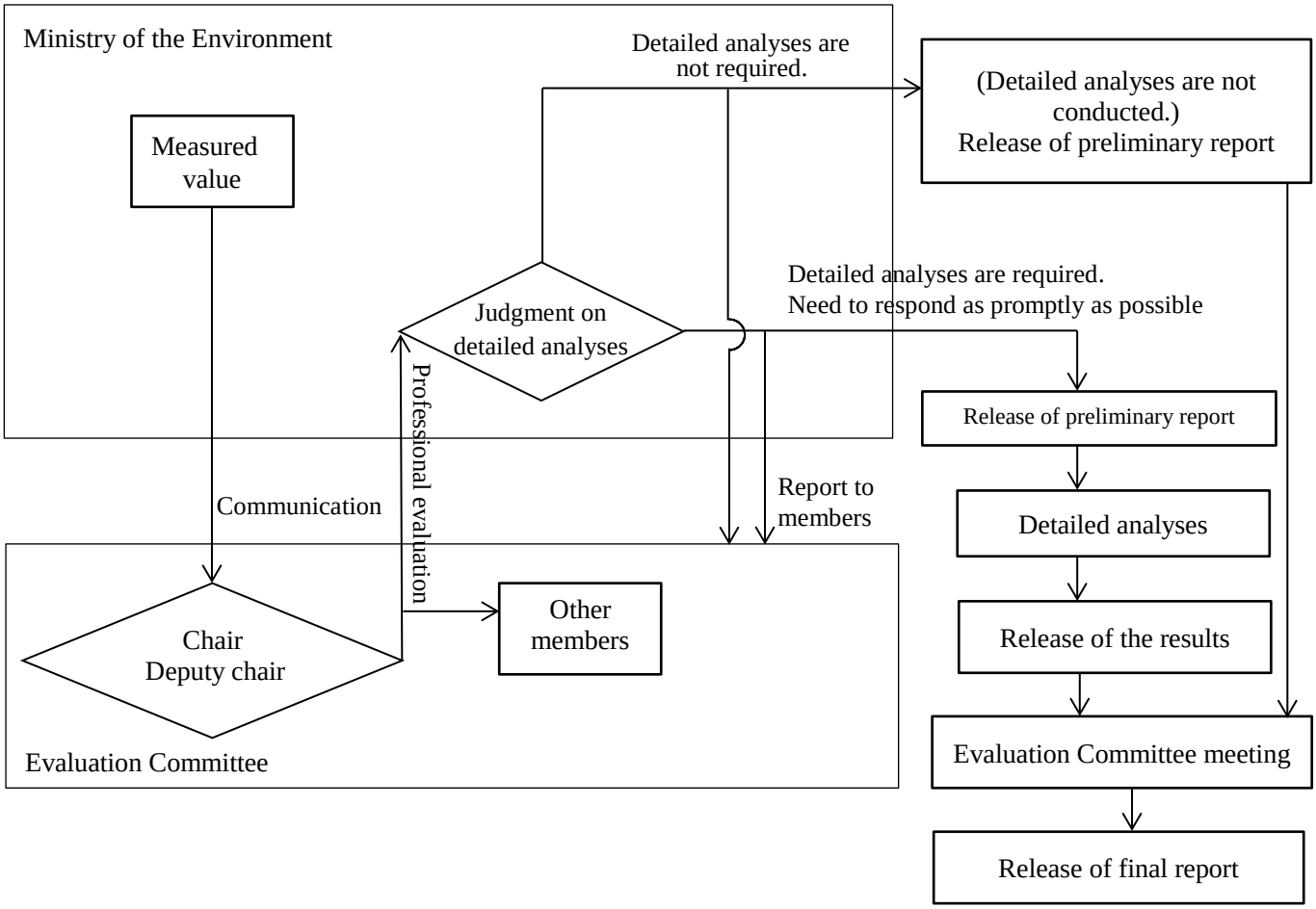


Figure 1.2-3 Procedures for professional evaluation of the results of the Nationwide Monitoring

2. Survey Methods and Analysis Methods

2.1 Survey methods

Samples were collected based on the following guidelines in principle, as outlined below.

- Water Quality Survey Method (September 30, 1971; Notice Kansuikan No. 30 issued by the Director General of the Water Quality Preservation Bureau, Ministry of the Environment)
- Sediment Survey Method (August 8, 2012; Notice Kansuitaisuihatsu No. 120725002 issued by the Director General of the Environmental Management Bureau, Ministry of the Environment)
- Groundwater Quality Survey Method (September 14, 1989; Notice Kansuikan No. 189 issued by the Director General of the Water Quality Preservation Bureau, Ministry of the Environment)
- Environmental Sample Collection Method (1983, Ministry of Education, Culture, Suports, Science and Technology's (hereinafter referred to as "MEXT")'s Radioactivity Measurement Method Series)
- Sample Pretreatment for Instrumental Analysis Using Germanium Semiconductor Detectors (1982, MEXT's Radioactivity Measurement Method Series)

(1) Public water areas

• Water:

Water samples of around 160 L (hydrochloric acid added) and around 2 L (nitric acid added) were collected at the predetermined locations. Out of the 160L (hydrochloric acid added), 80L was used for the γ-ray spectrometry analyses and the remaining 80L was preserved for possible detailed analysis. Out of the 2 L (nitric acid added), 1 L was used for the analyses of total β radioactivity concentrations. Additionally, the transparency (or Secchi disk depth) was measured upon collecting water samples, and if any influence of rainwater was suspected as a result of a comparison with past data or when there seems to be an influence of rainwater in light of the circumstances at locations without any past data where the transparency (or Secchi disk depth) was 50 cm or less, sampling at such locations was judged to be inappropriate.

・Sediments:

Bottom sediment samples of around 6 L were collected at the predetermined points at a depth of around 10 cm from the surface layer by using an Ekman-Birge grab sampler, and 3 L out of the 6 L was used for the γ-ray spectrometry analyses.

・Soil:

Soil samples (around 5 cm in diameter) were collected at a depth of around 5 cm at five points within a 3 to 5 meter square (four vertexes and the diagonal intersection point), or when it is difficult to find an appropriate square to determine such five sampling points, at five points with 3 to 5 meter intervals along a river, and were brought back separately. Samples thus collected at the five points were mixed in equal amounts respectively and were used for analysis.

・Ambient dose rates (soil sampling locations):

Ambient dose rates were measured by installing NaI (Tl) scintillation survey meters at a height of 1 m from the ground surface on both banks of a river (or in the case of a lake, installing a NaI (Tl) scintillation survey meter at one point on lake side) in a manner to face the sampling point of river water (or lake water).

(2) Groundwater

• Water:

Groundwater samples of around 160 L (hydrochloric acid added) and 2 L (nitric acid added) were collected at the predetermined wells, etc. 80 L of the 160 L (hydrochloric acid added) was used for the γ-ray spectrometry analyses and the remaining 80 L was preserved for possible detailed analysis. 1 L of the 2 L (nitric acid added) was used for the analyses of total β radioactivity concentrations.

When collecting water samples, water temperature, transparency, pH, and electrical conductivity are confirmed to remain constant by letting the water pass for several minutes, and changes in the transparency, etc. thereafter were recorded as notes.

・Ambient dose rates:

Ambient dose rates were measured by installing NaI (Tl) scintillation survey meters at a height of 1 m from the ground surface near the relevant wells, etc. in a manner to face the sampling point of groundwater (or the groundwater layer).

2.2 Analysis methods

The measurement of total β radioactivity concentrations and γ-ray spectrometry measurement using a germanium semiconductor detector were conducted by the following methods for public water areas (water, sediments and soil) and groundwater (water). The γ-ray spectrometry measurement covered analyses of all the detectable radionuclides (including artificial radionuclides and major naturally occurring radionuclides) in principle. Detected values were indicated with two significant digits in the unit of "Bq/L" in the case of water samples from public water areas and groundwater samples, and in the unit of "Bq/kg (dry)" in the case of sediment samples from public water areas.

Adopted analysis methods were basically in line with the MEXT's Radioactivity Measurement Method Series, and detection limits were set around 0.001 to 0.01 Bq/L for water samples and around 1 to 30 Bq/kg (dry) for sediment samples. (However these detection limits did not apply to radionuclides with short half-lives or those with extremely low γ-ray emission rates.)

・Measurement of total β radioactivity concentrations: Concentrate and dry up samples, and then conduct measurement using a low-background gas-flow proportional counter.

・γ-ray spectrometry measurement: After proper pretreatment, put samples in a U-8 container or a 2 L Marinelli beaker and conduct measurement using a germanium semiconductor detector; The following 62 types of γ-ray emitting radionuclides (18 naturally occurring radionuclides and 44 artificial radionuclides) were surveyed. The measurement results of γ-ray emitting radionuclides were corrected for attenuation, and reported the figures as radioactivity concentrations as of the time of completing sampling.

Table 2.2-1 Surveyed γ-ray emitting radionuclides

Naturally occurring radionuclides (18 radionuclides)		Artificial radionuclides (44 radionuclides)				
Ac-228	Ra-224	Ag-108m	Co-58	I-131	Np-239	Te-129m
Be-7	Ra-226	Ag-110m	Co-60	I-132	Ru-103	Te-132
Bi-212	Th-227	Am-241	Cr-51	La-140	Ru-106	Y-91
Bi-214	Th-228	As-74	Cs-134	Mn-54	Sb-124	Y-93
K-40	Th-231	Ba-140	Cs-136	Mn-56	Sb-125	Zn-63
Pa-234m	Th-234	Bi-207	Cs-137	Mo-99	Sb-127	Zn-65
Pb-210	Tl-206	Ce-141	Fe-59	Nb-95	Sr-91	Zr-95
Pb-212	Tl-208	Ce-143	Ga-74	Nb-97	Tc-99m	Zr-97
Pb-214	U-235	Ce-144	Ge-75	Nd-147	Te-129	

3. Results

The outline of detectable radioactive materials at each monitoring location is as follows.

3.1 Detection of total β radioactivity and γ-ray emitting radionuclides

(1) Public water areas

1) Water

The results of the measurement of total β radioactivity and γ-ray emitting radionuclides in water samples from public water areas are as shown in Table 3.1-1 and Figure 3.1-1.

a) Total β radioactivity

The detection rate for total β radioactivity was 92.9% with detected values ranging from not detectable to 4.1 Bq/L. Although the values of samples exceeded the range of past measured values at several locations, all instances were attributable to high K-40 concentrations. Therefore, all of which were within the past measurement trends.

b) γ-ray emitting radionuclides

Eight types of γ-ray emitting radionuclides (five naturally occurring radionuclides and three artificial radionuclides) as shown in Table 3.1-1 and Figure 3.1-1 were detected, while other types of γ-ray emitting radionuclides were not detectable at any of the locations surveyed.

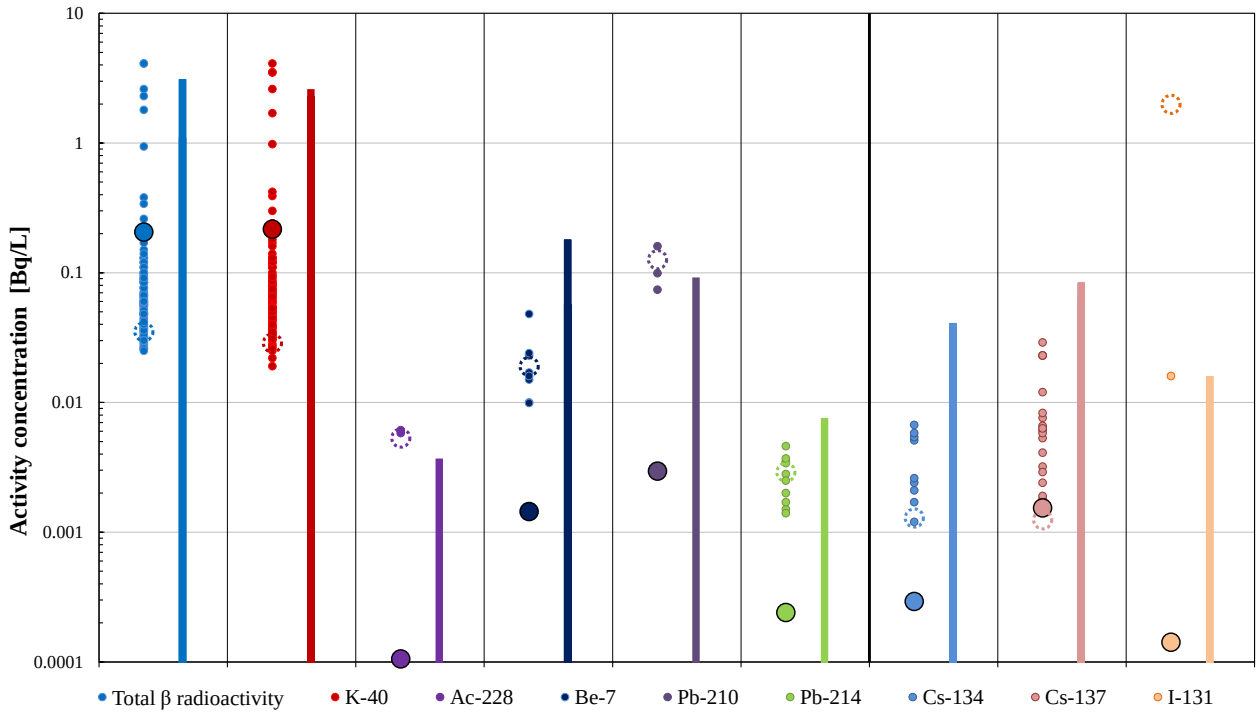
The detection rates of naturally occurring radionuclides were approximately 10% or less, except for K-40, for which the detection rate was approximately 92.0%. K-40 was detected at some locations with the highest concentrations being, at the maximum, higher than the range of past measurement records but such high concentrations were considered to have been caused by the influence of seawater (explained later). At some locations, the detected concentrations of Ac-228 and Pb-210 exceeded the range of past measured values; both are naturally occurring thorium series radionuclides and generally contained in natural soils and rocks. The measured values of other naturally occurring radionuclides all fell within the past measurement trends.

Regarding artificial radionuclides, the detection rates of Cs-134 was 8.0%, Cs-137 was 16.8% and I-131 was 0.9% but detected values of Cs-134 was 0.0067Bq/L or less, Cs-137 was 0.029Bq/L or less and I-131 was 0.016 Bq/L or less: all of which were within the past measurement trends.

Table 3.1-1 Detection of total β radioactivity and γ-ray emitting radionuclides in water samples from public water areas

Radionuclides			Number of samples	Number of detections	Detection rate[%]	Measured values [Bq/L]		Maximum records [Bq/L]	
						Range	Detection limits	FY2014 Nationwide monitoring	Monitoring of Levels (*1)
Total β radioactivity			113	105	92.9	ND – 4.1	0.024 – 0.29	1.1	3.1
γ-ray emitting radionuclides	Naturally occurring	K-40	113	104	92.0	ND – 4.1	0.015 – 0.084	2.6	2.3
		Ac-228	113	2	1.8	ND – 0.0061	0.0029 – 0.020	0.0037	ND
		Be-7	113	8	7.1	ND – 0.048	0.0071 – 0.057	0.057	0.18
		Pb-210	113	3	2.7	ND – 0.16	0.051 – 1.4	0.092	No data
		Pb-214	113	10	8.8	ND – 0.0046	0.0012 – 0.012	0.0076	No data
	Artificial	Cs-134	113	9	8.0	ND – 0.0067	0.00073 – 0.0046	0.022	0.041
		Cs-137	113	19	16.8	ND – 0.029	0.00070 – 0.0049	0.065	0.084
		I-131	113	1	0.9	ND – 0.016	0.0026 – 51	ND	0.016

(*1) Results of the Monitoring of Environmental Radioactivity Levels and the Monitoring of the Surrounding Environment conducted in Japan nationwide FY1996 to FY2015 (excluding data from March 11, 2011 to March 10, 2012)



<Legend> : Detected value
: Mean value (arithmetic mean calculated assuming ND = 0)
: Mean value of lower Detection Limits(Arithmetic mean)
: Range of past measured values (FY 2014 Nationwide Monitoring and Monitoring of Levels, etc., from FY 1996 to FY2015 (excluding data from March 11, 2011 to March 10, 2012))

(*) The vertical axes are logarithmically scaled because the order of magnitude of detected values varies between different radionuclides.

Figure 3.1-1 Detection of total β radioactivity and γ-ray emitting radionuclides in water samples from public water areas

2) Sediments

The results of the measurement of total β radioactivity and γ-ray emitting radionuclides in sediment samples from public water areas are as shown in Table 3.1-2 and Figure 3.1-2.

a) Total β radioactivity

Total β radioactivity was detected at all locations surveyed, with detected values ranging from 160 to 1,200 Bq/kg (dry): all of which were within the past measurement trends.

b) γ-ray emitting radionuclides

12 types of γ-ray emitting radionuclides (ten naturally occurring radionuclides and two artificial radionuclides) as shown in Table 3.1-2 and Figure 3.1-2 were detected, while no other types of γ-ray emitting radionuclides were detectable.

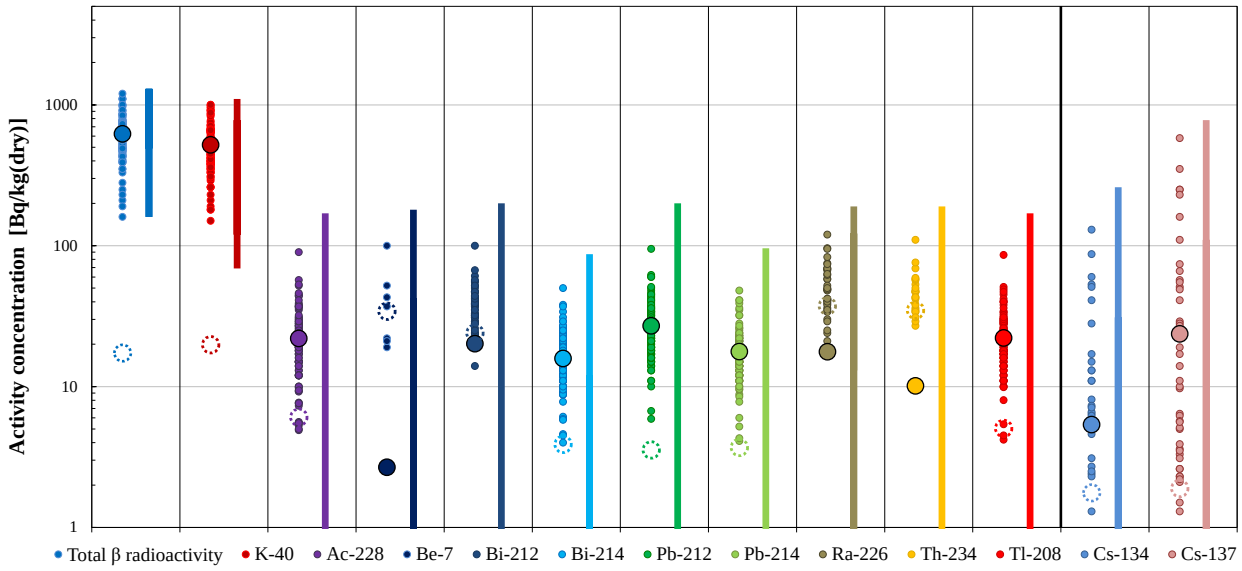
The detection rates of the 6 naturally occurring radionuclides other than Be-7, Bi-212, Ra-226, and Th-234 exceeded 95%. Regarding naturally occurring radionuclides, all of which were within the past measurement trends.

Regarding artificial radionuclides, the detection rates of Cs-134 and Cs-137 were 23.6% and 40.0%, but detected values were 130Bq/kg(dry) or less for Cs-134 and 580Bq/kg(dry) or less for Cs-137: all of which were within the past measurement trends.

Table 3.1-2 Detection of total β radioactivity and γ-ray emitting radionuclides in sediment samples from public water areas

Radionuclides			Number of samples	Number of detections	Detection rate[%]	Measured values [Bq/kg (dry)] Range	Measured values [Bq/kg (dry)] Detection limits	Maximum records [Bq/kg(dry)] FY2014 Nationwide monitoring	Maximum records [Bq/kg(dry)] Monitoring of Levels (*1)
Total β radioactivity			110	110	100.0	160 – 1,200	15 – 23	1,300	1,300
γ-ray emitting radionuclides	Naturally occurring	K-40	110	110	100.0	150 – 1,000	13 – 63	1,100	780
		Ac-228	110	108	98.2	ND – 90	3.4 – 10	170	ND
		Be-7	110	7	6.4	ND – 100	10 – 98	180	42
		Bi-212	110	61	55.5	ND – 100	1.8 – 55	200	No data
		Bi-214	110	109	99.1	ND – 50	2.1 – 13	87	12
		Pb-212	110	109	99.1	ND – 95	1.7 – 28	200	No data
		Pb-214	110	110	100.0	4.1 – 48	1.8 – 13	96	No data
		Ra-226	110	37	33.6	ND – 120	18 – 120	190	122
		Th-234	110	23	20.9	ND – 110	19 – 100	190	No data
		Tl-208	110	109	99.1	ND – 86	2.6 – 18	170	No data
	Artificial	Cs-134	110	26	23.6	ND – 130	0.75 – 6.1	260	31
		Cs-137	110	44	40.0	ND – 580	0.83 – 5.5	780	110

(*1) Results of the Monitoring of Environmental Radioactivity Levels and the Monitoring of the Surrounding Environment conducted in Japan nationwide FY1996 to FY2015 (excluding data from March 11, 2011 to March 10, 2012)



<Legend> : Detected value
: Mean value (arithmetic mean calculated assuming ND = 0)
: Mean value of lower Detection Limits(Arithmetic mean)
: Range of past measured values (FY 2014 Nationwide Monitoring and Monitoring of Levels, etc., from FY 1996 to FY2015 (excluding data from March 11, 2011 to March 10, 2012))

(*)Details of the detection of Cs-134 and Cs-137 are explained later.
(*) The vertical axes are logarithmically scaled because the order of magnitude of detected values varies between different radionuclides.

Figure 3.1-2 Detection of total β radioactivity and γ-ray emitting radionuclides in sediment samples from public water areas

(2) Groundwater

The results of the measurement of total β radioactivity and γ-ray emitting radionuclides in groundwater samples are as shown in Table 3.1-3 and Figure 3.1-3.

a) Total β radioactivity

The detection rate for total β radioactivity was approximately 86.4%, with detected values ranging from not detectable to 0.42 Bq/L: all of which were within the past measurement trends.

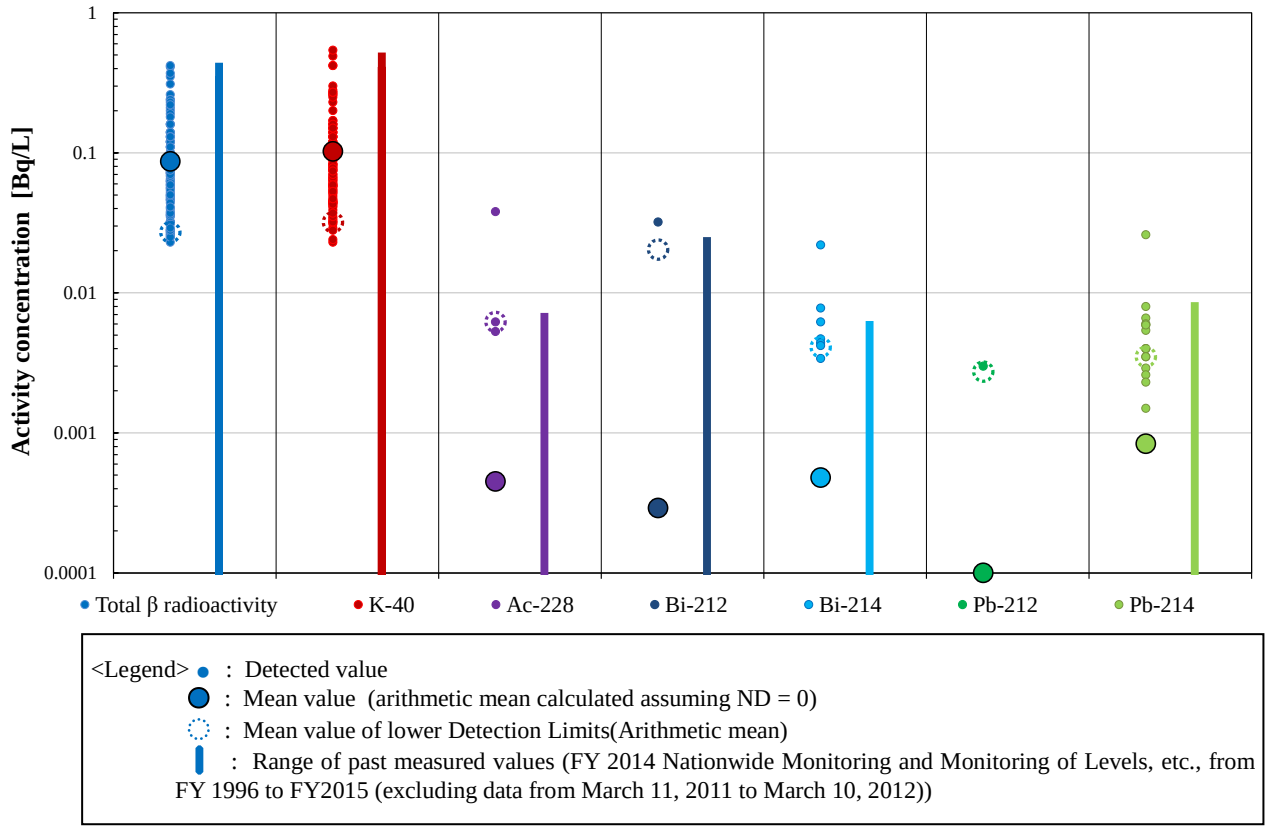
b) γ-ray emitting radionuclides

Six types of γ-ray emitting radionuclides (all naturally occurring radionuclides) as shown in Table 3.1-3 and Figure 3.1-3 were detected, while no other types of γ-ray emitting radionuclides were detectable. Out of these detected γ-ray emitting radionuclides, K-40 was detected at concentration levels slightly exceeding the range of past measurement records but this is a radionuclide generally contained in natural soils and rocks, etc. (explained later). The detected concentrations of Ac-228, Bi-212, Bi-214, Pb-212 and Pb-214 also exceeded the range of past measured values at some locations, but these were all naturally occurring thorium or uranium series radionuclides generally contained in natural soils and rocks. Considering that their past detected values are based on the survey results for very limited regions (Ac-228 detected in five prefectures [Miyagi, Yamagata, Shiga, Osaka and Nagasaki]; Bi-212 only in Niigata Prefecture; Bi-214 in six prefectures [Shizuoka, Toyama, Ishikawa, Aichi, Shiga and Hyogo]; no instances of detection for Pb-212; Pb-214 detected in nine prefectures [Miyagi, Niigata, Aichi, Shiga, Wakayama, Shimane, Hiroshima, Kagawa and Ehime]), it is inferred that the measured values of these radionuclides all fell within the past measurement trends.

Table 3.1-3 Detection of total β radioactivity and γ-ray emitting radionuclides in groundwater samples

Radionuclides			Number of samples	Number of detections	Detection rate [%]	Measured values [Bq/L]		Maximum records [Bq/L]	
						Range	Detection limits	FY2014 Nationwide monitoring	Monitoring of Levels (*1)
Total β radioactivity			110	95	86.4	ND – 0.42	0.024 – 0.062	0.44	0.35
γ-ray emitting radionuclides	Naturally occurring	K-40	110	99	90.0	ND – 0.54	0.016 – 0.080	0.52	0.41
		Ac-228	110	3	2.7	ND – 0.038	0.0037 – 0.014	0.0072	No data
		Bi-212	110	1	0.9	ND – 0.032	0.011 – 0.039	0.025	No data
		Bi-214	110	7	6.4	ND – 0.022	0.0023 – 0.0087	0.0063	No data
		Pb-212	110	1	0.9	ND – 0.0030	0.0015 – 0.0069	ND	No data
		Pb-214	110	16	14.5	ND – 0.026	0.0015 – 0.0081	0.0086	No data

(*1) Results of the Monitoring of Environmental Radioactivity Levels and the Monitoring of the Surrounding Environment conducted in Japan nationwide FY1996 to FY2015 (excluding data from March 11, 2011 to March 10, 2012)



(*) The vertical axes are logarithmically scaled because the order of magnitude of detected values varies between different radionuclides.

(*) Radionuclides shown with no past measured values were either undetectable or had never been measured.

Figure 3.1-3 Detection of total β radioactivity and γ-ray emitting radionuclides in groundwater samples

3.2 Consideration regarding detected radionuclides

(1) Detection of naturally occurring radionuclides

1) Correlation between activity concentrations of K-40 and seawater

As explained in 3.1 above, activity concentrations of K-40 were at levels exceeding the range of past measurement records (2.6 Bq/L at the maximum) in water samples collected at some locations in public water areas.

Locations where high concentration level of K-40 was detected were at tidal river, and showed high electrical conductivity (EC) (1,820 mS/m at the maximum). This suggests the influence of the intrusion of seawater. Therefore, a comparison was made using all available data to clarify the correlation between activity concentrations of K-40 and EC (see Figure 3.2-1).

As shown in Figure 3.2-1, a positive correlation was found between them..

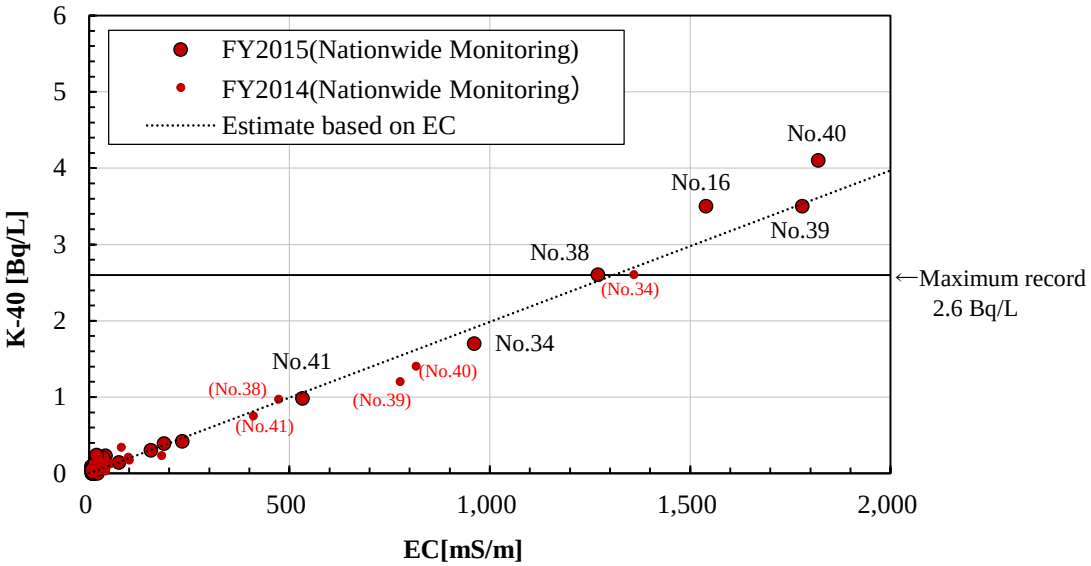


Figure 3.2-1 Correlation between the K-40 concentration and electrical conductivity(EC) in water samples from public water areas

In the meantime, according to the results of the Monitoring of Levels, conducted for the 20-year from FY1996 to FY2015 (monitoring of 548 samples collected from 18 prefectures), the average concentration (average) of K-40 was approximately 8.9 Bq/L and the maximum concentration was 14 Bq/L (see Table 3.2-1).

Table 3.2-1 Results of the Monitoring of Levels, etc., concerning K-40 inseawater (*1)

Number of surveys	Number of detections	Detection rate [%]	Average [Bq/L]	Maximum [Bq/L]
548	521	95.0	8.9	14

(*1) Results of the Monitoring of Environmental Radioactivity Levels and the Monitoring of the Surrounding Environment conducted in Japan nationwide from FY1996 to FY2015

EC in seawater is generally around 4,500 mS/m, and the estimated activity concentrations of K-40 with possible influence of seawater were obtained by using the following formula based on the measurement results of EC for

the relevant river water.

$$\text{(Activity concentration of K-40 in river water)} = \text{(Average activity concentration of K-40 in seawater)} \times \frac{\text{(Measured EC in the river water)}}{\text{(Ordinary values of EC in seawater)}}$$

The estimated activity concentrations of K-40 in the river water are indicated with a dashed line (‥‥) in Figure 3.2-1, and the estimate values were very close to the measured activity concentrations of K-40. Therefore, relatively high activity levels of K-40 measured in the latest monitoring are considered to have been caused by the intrusion of seawater and fall within the past measurement trends.

In the same manner, the correlation between the K-40 concentration and EC was also checked with regard to groundwater samples (see Figure 3.2-2, scales of the vertical and horizontal axes differ from those for Figure 3.2-1). However, no clear correlation was found for groundwater samples. The concentrations of K-40 in groundwater samples from Site No. 94 (Ueki, Nogata City, Fukuoka Pref.: 0.54 Bq/L) slightly exceeded the range of past measured values (maximum value: 0.52 Bq/L). This location is in the areas where the geological conditions are known to have relatively high potassium concentrations in soil(Figure 3.2-3). Accordingly, the K-40 concentration for groundwater samples in the latest monitoring is considered to fall within the past measurement trends.

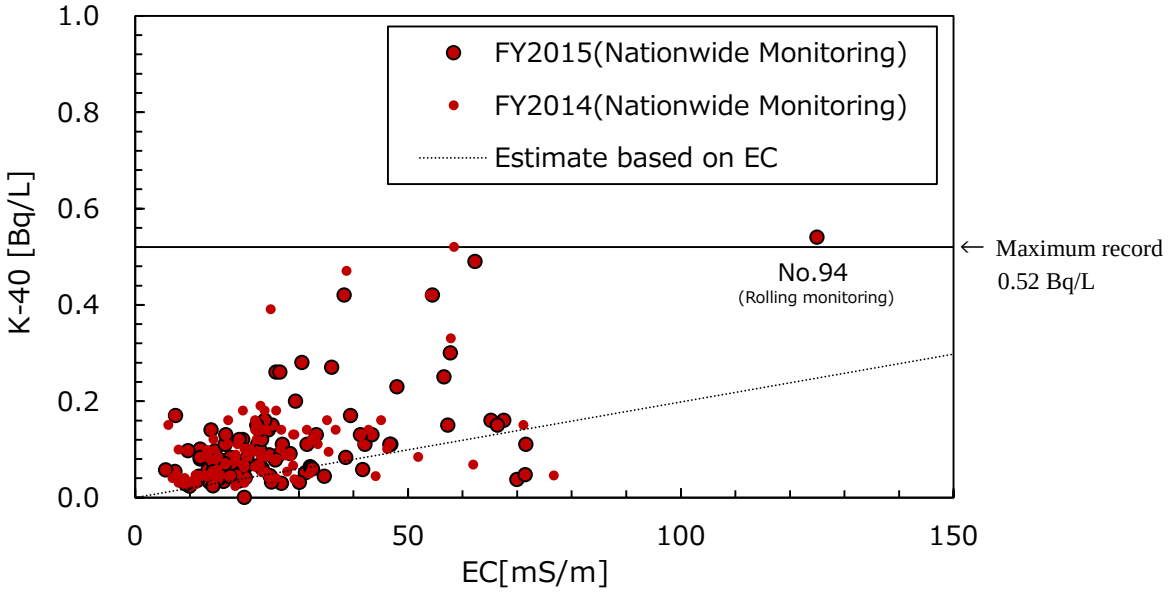
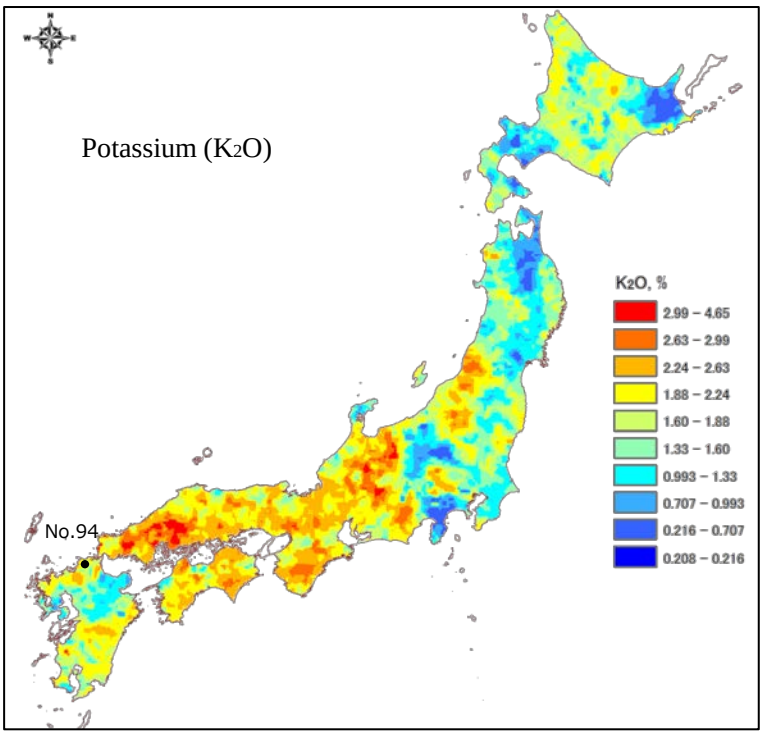


Figure 3.2-2 Correlation between the K-40 concentration and electrical conductivity(EC) in groundwater samples



Reference: Website of the Geological Survey of Japan, AIST
https://gbank.gsj.jp/geochemmap/setumei/radiation/setumei-radiation.htm

Figure 3.2-3 Distribution of potassium (K_2O) in soil in Japan

2) Uranium and thorium series radionuclides

As explained in 3.1 above, uranium and thorium series radionuclides were detected at relatively high concentration levels in sediment samples from public water areas. Such radionuclides were detected as shown in Table 3.2-2.

These naturally occurring radionuclides exist widely within the earth's crust and belong to the same decay series, which implies the existence of some correlations among detected values.

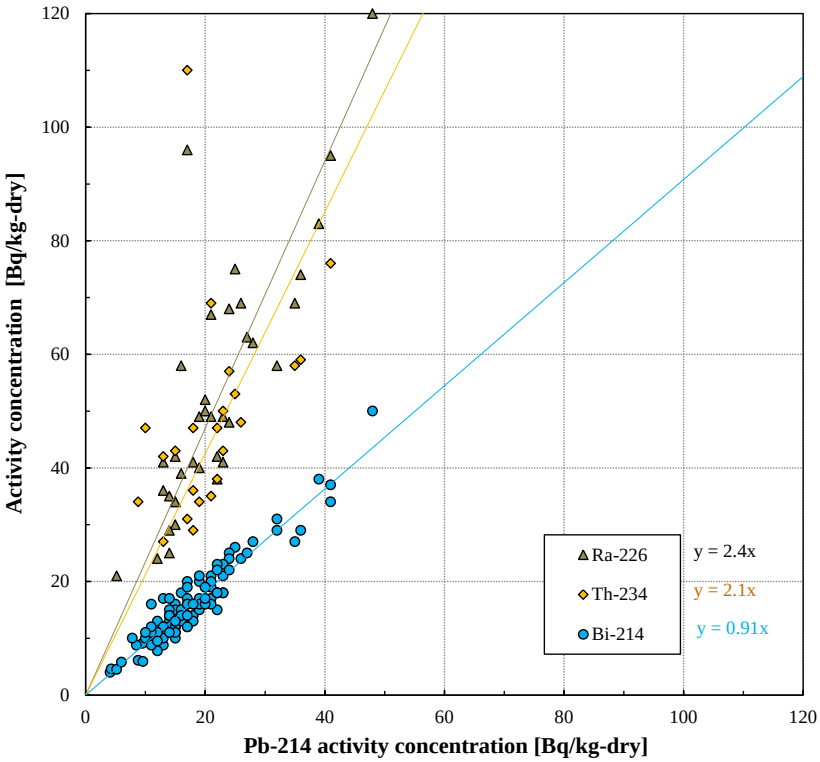
Table 3.2-2 Detection of uranium and thorium series naturally occurring radionuclides

Radionuclides			Number of samples	Number of detections	Detection rate [%]	Measured values [Bq/kg (dry)]	
						Range	Detection limits
γ-ray emitting radionuclides	Uranium Series	Th-234	110	23	20.9	ND - 110	19 - 100
		Ra-226	110	37	33.6	ND - 120	18 - 120
		Pb-214	110	110	100.0	4.1 - 48	1.8 - 13
		Bi-214	110	109	99.1	ND - 50	2.1 - 13
	Thorium series	Ac-228	110	108	98.2	ND - 90	3.4 - 10
		Pb-212	110	109	99.1	ND - 95	1.7 - 28
		Bi-212	110	61	55.5	ND - 100	1.8 - 55
		Tl-208	110	109	99.1	ND - 86	2.6 - 18

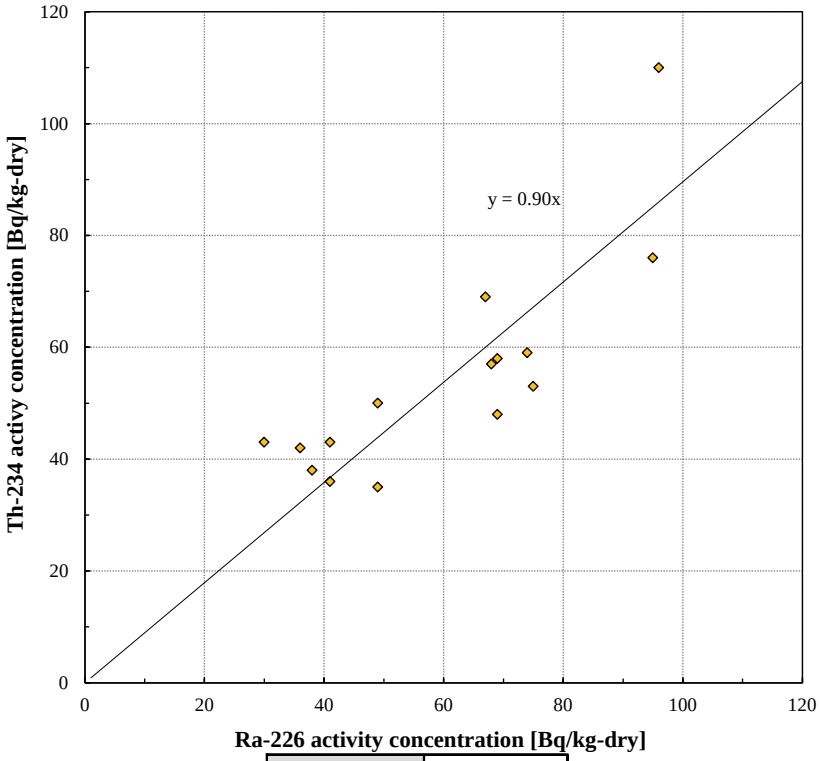
Figure 3.2-4 and Figure 3.2-5 show the correlation among uranium series radionuclides and among thorium series radionuclides, respectively, based on the radionuclides with the highest detection rate (with instances of non-detection excluded). Figure 3.2-4 (Upper) reveals that, while uranium series Pb-214 and Th-234 did not correlate well with each other, Ra-226 and Th-234 correlated well with each other (Figure 3.2-4 [Bottom]). Moreover, high correlations were also observed among the other uranium series or among thorium series radionuclides. From this information it can be inferred that the radionuclides of the two series reflected the geology of the locations at which they had been detected.

Note that it is generally accepted that "granite contains larger amounts of naturally occurring radionuclides than other kinds of rocks", and that "natural radiation doses correlate to some extent with uranium and thorium series radionuclides" (both according to the Geological Society of Japan[3]). For reference, Figure 3.2-6 shows the distribution map of granite in Japan, while Figure 3.2-7 shows the distribution map of natural radiation doses in Japan.

[3] http://www.geosociety.jp/hazard/content0058.html

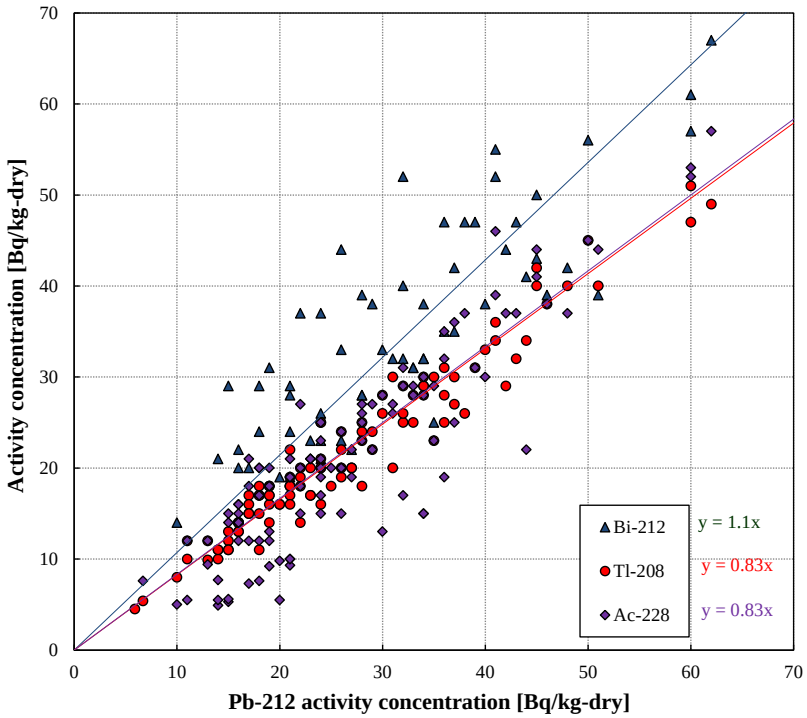


Correlation coefficient	Bi-214	Ra-226	Th-234
Pb-214	0.95	0.82	0.40



Correlation coefficient	Th-234
Ra-226	0.83

Figure 3.2-4 Correlations among uranium series radionuclides



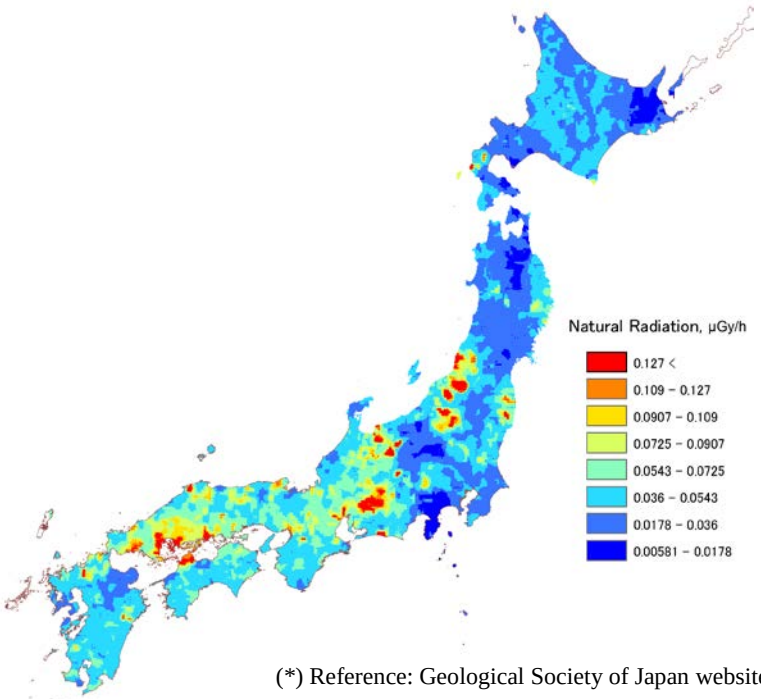
Correlation coefficient	Ac-228	Bi-212	Tl-208
Pb-212	0.92	0.89	0.98

Figure 3.2-5 Correlations among thorium series radionuclides

(*) Reference: Seamless Digital Geological Map of Japan (1:200,000) ® ; AIST website[4]

Figure 3.2-6 Distribution of granite in Japan

(parts highlighted in pink in the Figure are locations where granite exists)



(*) Reference: Geological Society of Japan website[5]

Figure 3.2-7 Natural radiation doses in Japan (Gy = Sv for γ-rays and β-rays)

[4] https://gbank.gsj.jp/seamless/

[5] http://www.geosociety.jp/hazard/content0058.html

(2) Detection of artificial radionuclides

1) Cs-134 and Cs-137 in sediments

Radioactive cesium was detected in sediment samples from public water areas in Hokkaido, Tohoku, Kanto, Chubu, Kinki, and Kyushu blocks (44 locations in total; both Cs-134 and Cs-137 were detected at 26 locations (all in Tohoku and Kanto Blocks); only Cs-137 detected at 18 locations).

To better understand the concentration levels of the detected radioactive cesium species, the following comparisons were made:

(i) Regarding locations also surveyed in the Post-Earthquake Monitoring, a direct comparison with the data for the relevant locations obtained through said monitoring

(ii) Regarding locations that do not fall under the category of (i) above but are in Tokyo Metropolis or other prefectures where the Post-Earthquake Monitoring is conducted, a comparison with data for other locations in said prefectures

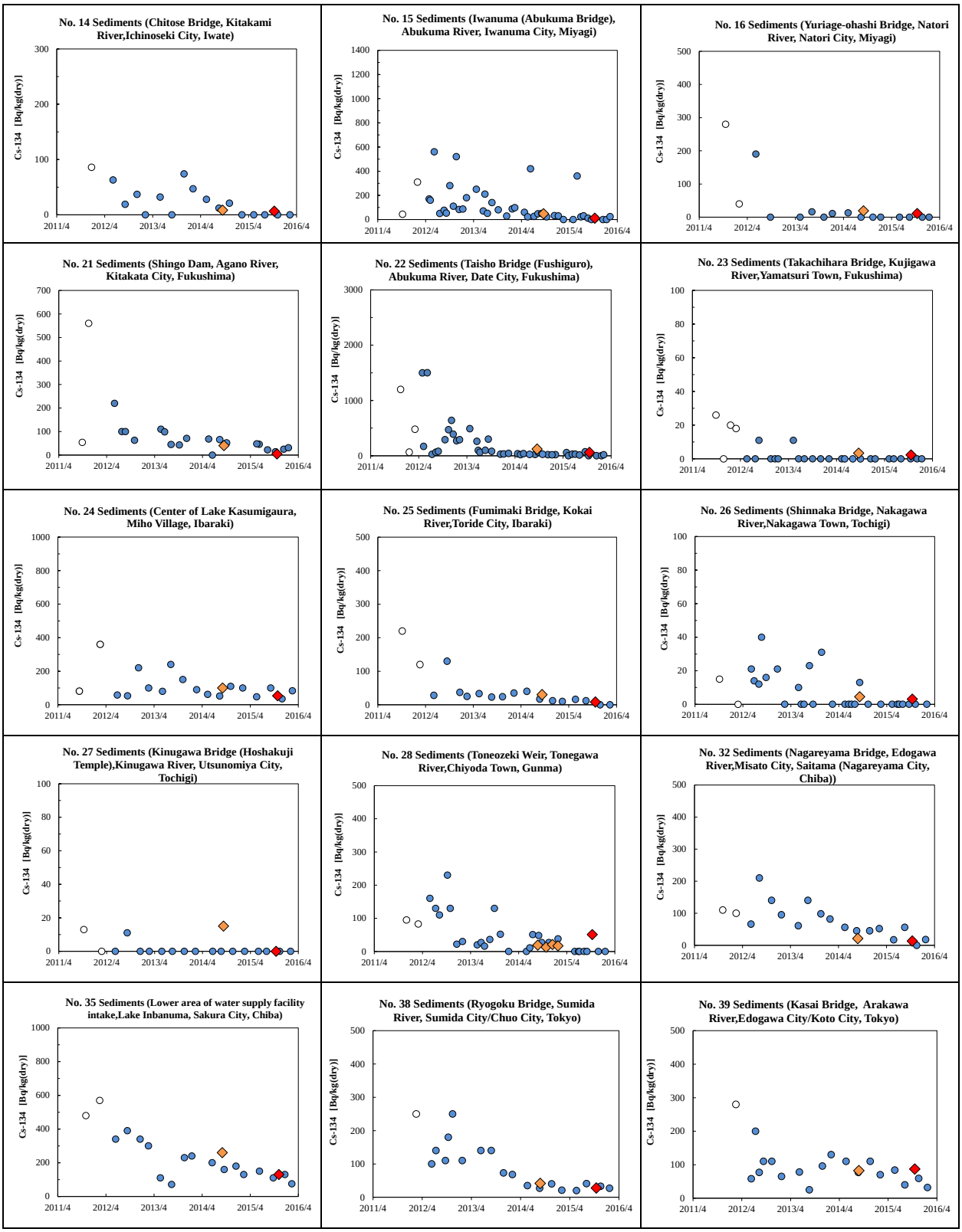
(iii) Regarding locations that do not fall under the categories of (i) and (ii) above, a comparison with the data for areas around the relevant locations obtained through the Post-Earthquake Monitoring

(iv) Regarding locations where measured values did not exceed the range of past measurement records, a comparison with data obtained through the Monitoring of Environmental Radioactivity Levels, etc.

(i) Comparison with the past Post-Earthquake Monitoring results for the same locations

Regarding locations also surveyed in the Post-Earthquake Monitoring, the measured values in the latestmonitoring were compared with the past measurement records for the same locations (see Figure 3.2-8).

A result of 350 Bq/kg for Cs-137 was detected in a sample from No. 39 but such deviations were considered to be within minor fluctuations in light of the past similar monitoring results, and the results of the latest monitoring were found to be within the past measurement trends.



<Legend>

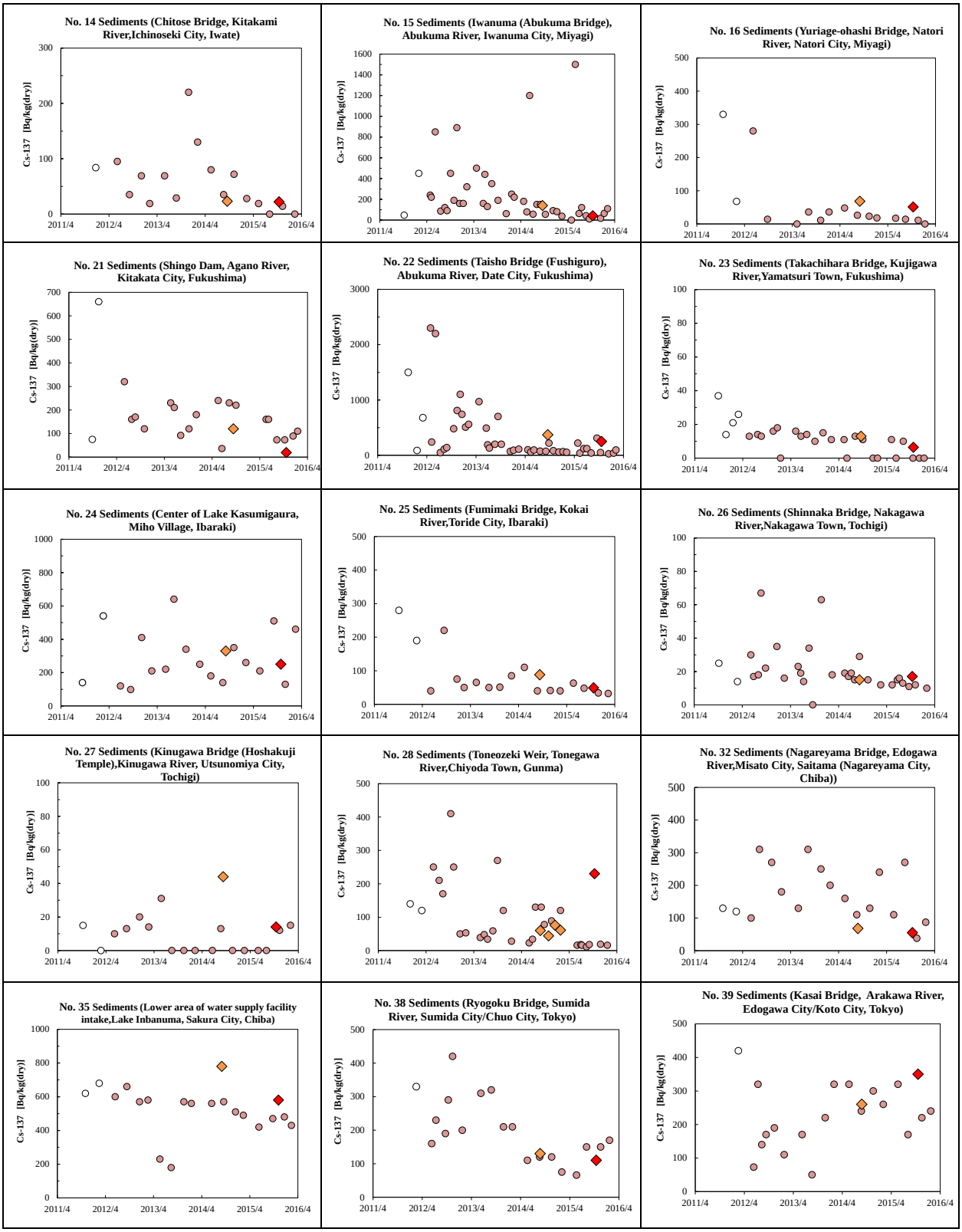
◆ : FY2015 Nationwide Monitoring results

◆: FY2014 Nationwide Monitoring results

● : Post-Earthquake Monitoring results

○ : Post-Earthquake Monitoring results (measurement results from March 11, 2011 to March 10, 2012 excluded from the past measured values used as reference data)

Figure 3.2-8 (1) (i) Comparison with the past Post-Earthquake Monitoring results for the same locations [Cs-134]



<Legend>

◆ : FY2015 Nationwide Monitoring results

◇ : FY2014 Nationwide Monitoring results

● : Post-Earthquake Monitoring results

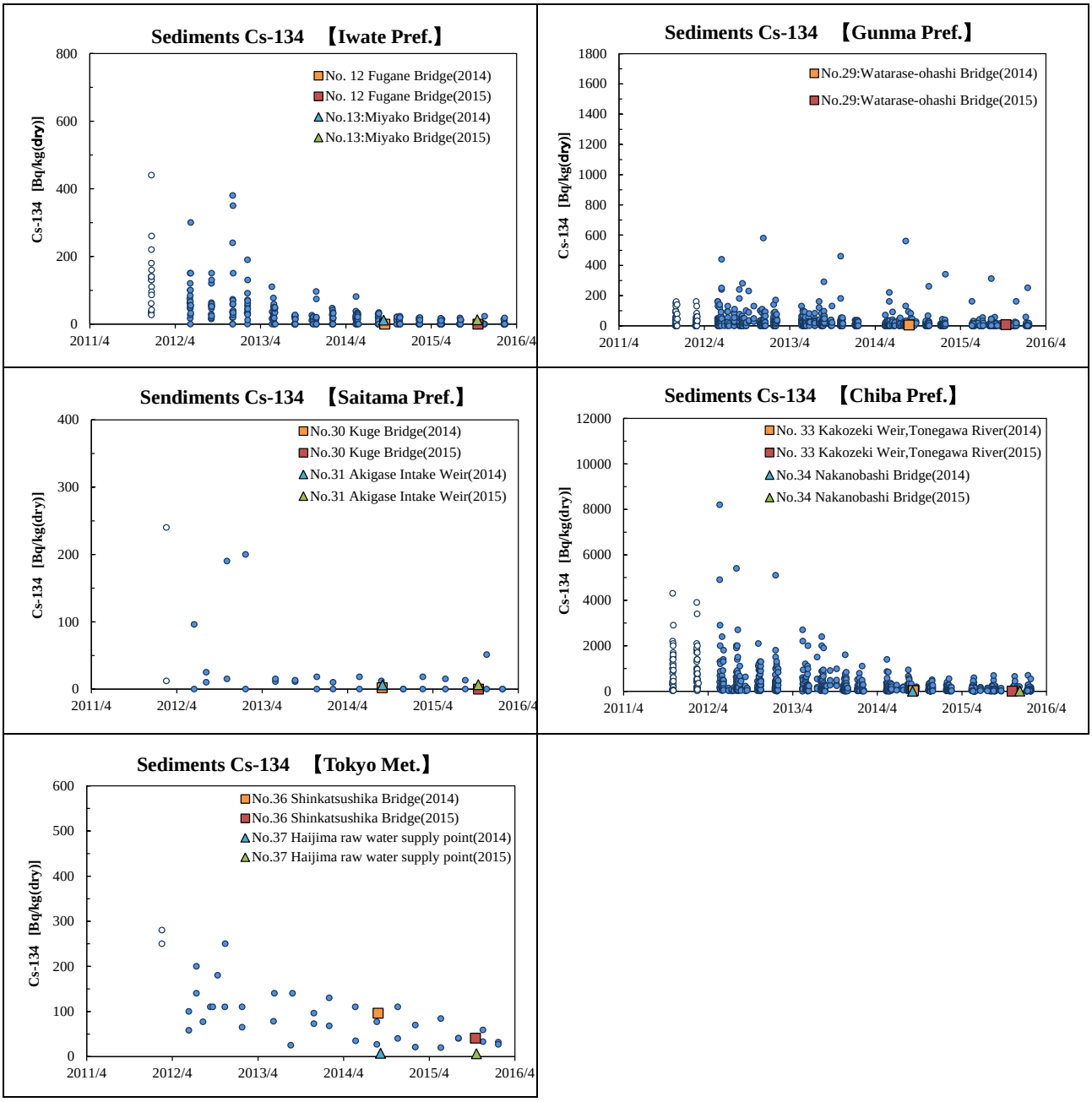
○ : Post-Earthquake Monitoring results (measurement results from March 11, 2011 to March 10, 2012 excluded from the past measured values used as reference data)

Figure 3.2-8 (2) (i) Comparison with the past Post-Earthquake Monitoring results for the same locations [Cs-137]

(ii) Comparison with the past Post-Earthquake Monitoring results in the same prefectures

Regarding locations that have not been surveyed in the Post-Earthquake Monitoring, the measured values in the latest monitoring were compared with the past Post-Earthquake Monitoring results for locations in the same prefectures (see Figure 3.2-9).

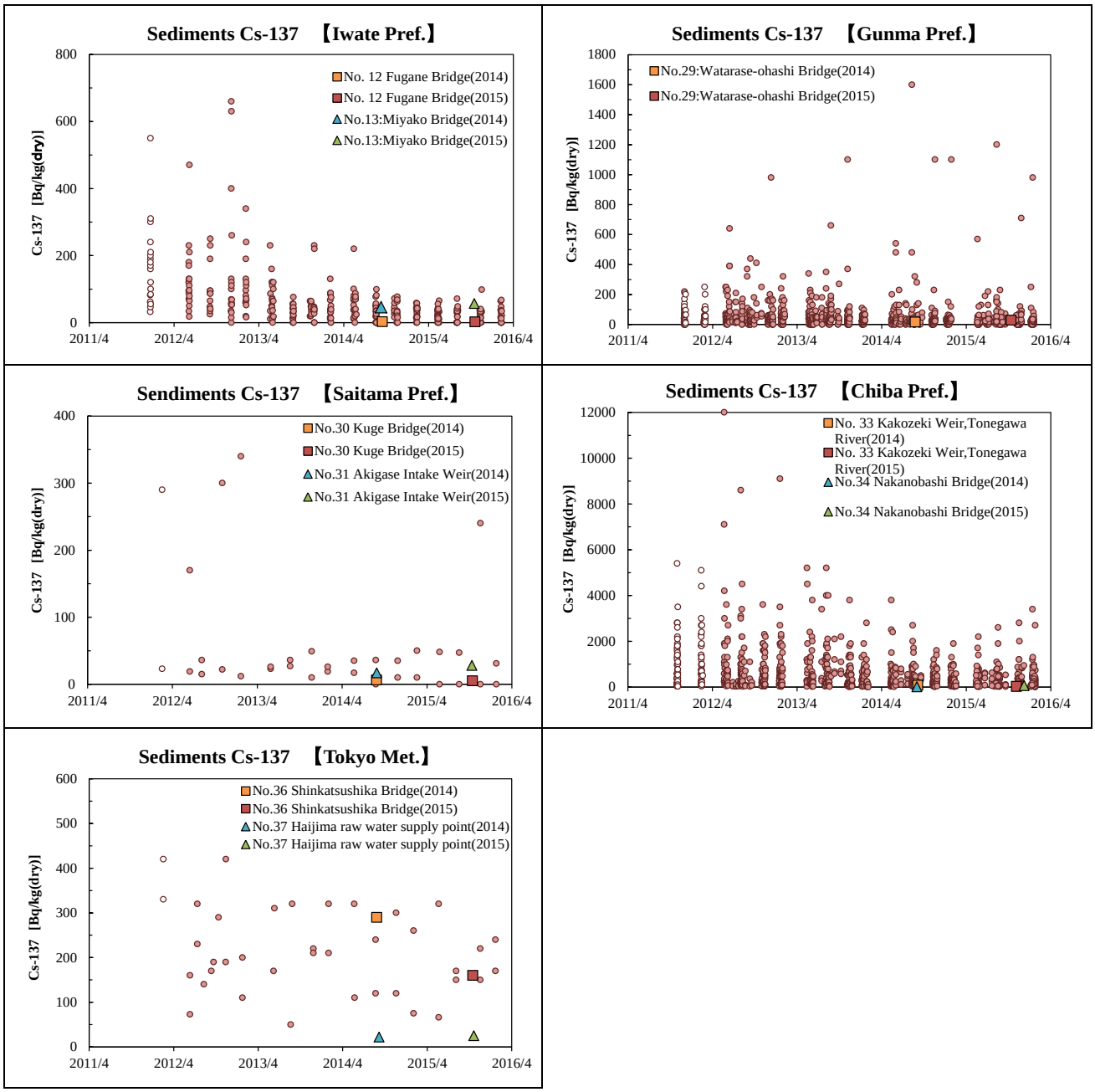
The measured values in the latest monitoring were found to be all within the past measurement trends.



● : Post-Earthquake Monitoring results

○ : Post-Earthquake Monitoring results (measurement results from March 11, 2011 to March 10, 2012 excluded from the past measured values used as reference data)

Figure 3.2-9 (1) (ii) Comparison with the past Post-Earthquake Monitoring results in the same prefectures [Cs-134]



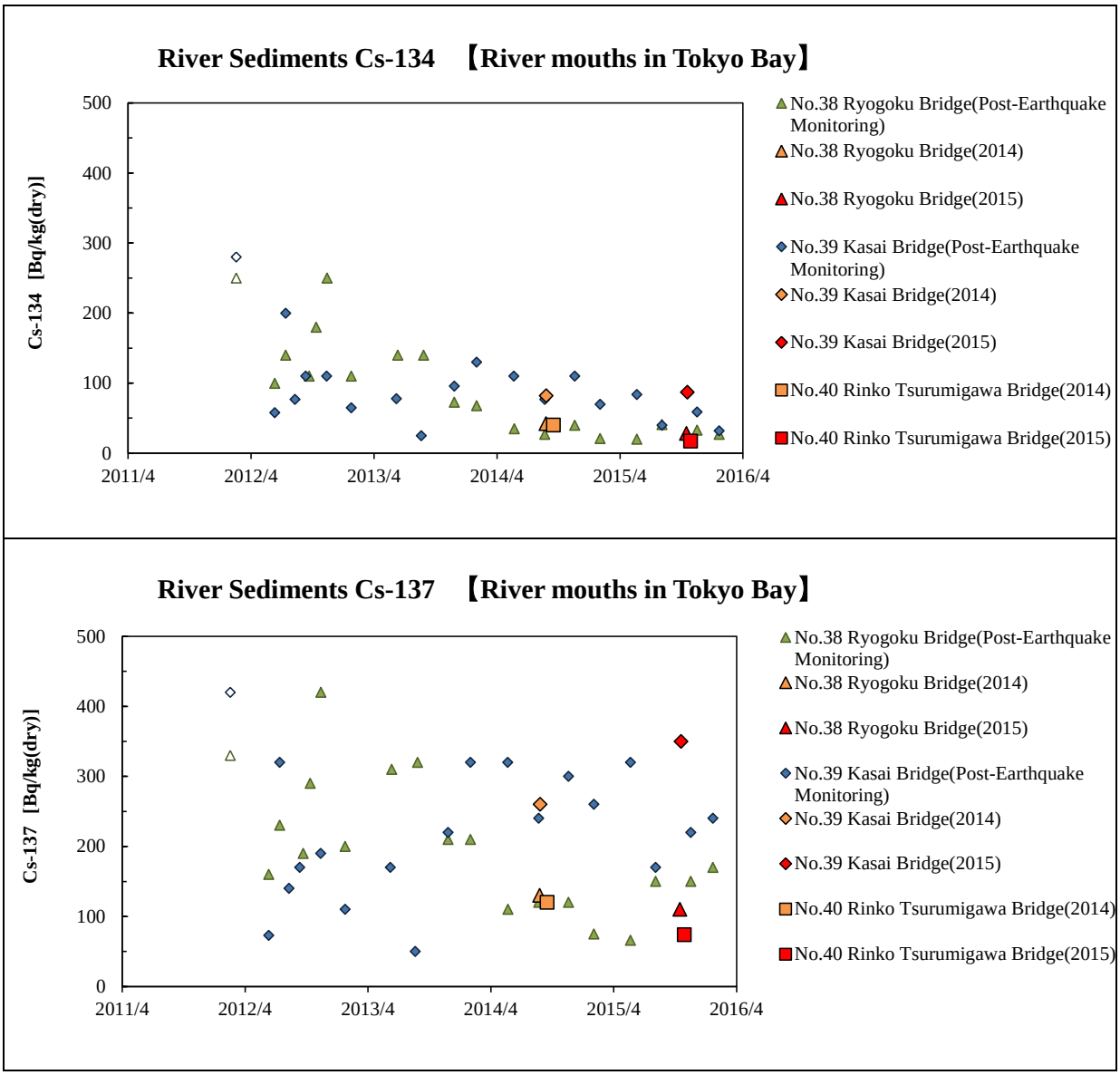
● : Post-Earthquake Monitoring results

○ : Post-Earthquake Monitoring results (measurement results from March 11, 2011 to March 10, 2012 excluded from the past measured values used as reference data)

Figure 3.2-9 (2) (ii) Comparison with the past Post-Earthquake Monitoring results in the same prefectures [Cs-137]

(iii) Comparison with the past Post-Earthquake Monitoring results for nearby locations

Regarding Location No. 40 (Rinko Tsurumigawa Bridge, Tsurumi River, Yokohama City, Kanagawa Prefecture), it was considered to be appropriate to make a comparison with the past data for nearby locations although the Post-Earthquake Monitoring had not been conducted in Kanagawa Prefecture. Therefore, a comparison was made with the past data for Location No. 38 (Ryogoku Bridge, Sumida River, Chuo City/Sumida City, Tokyo Metropolis) and Location No. 39 (Kasai Bridge, Arakawa River, Koto City/Edogawa City, Tokyo Metropolis), both of which are located at the mouths of the Sumida River and the Arakawa River to Tokyo Bay (see Figure 3.2-10). As a result, it was found that the measured values for Location No. 40 were within the past measurement trends.



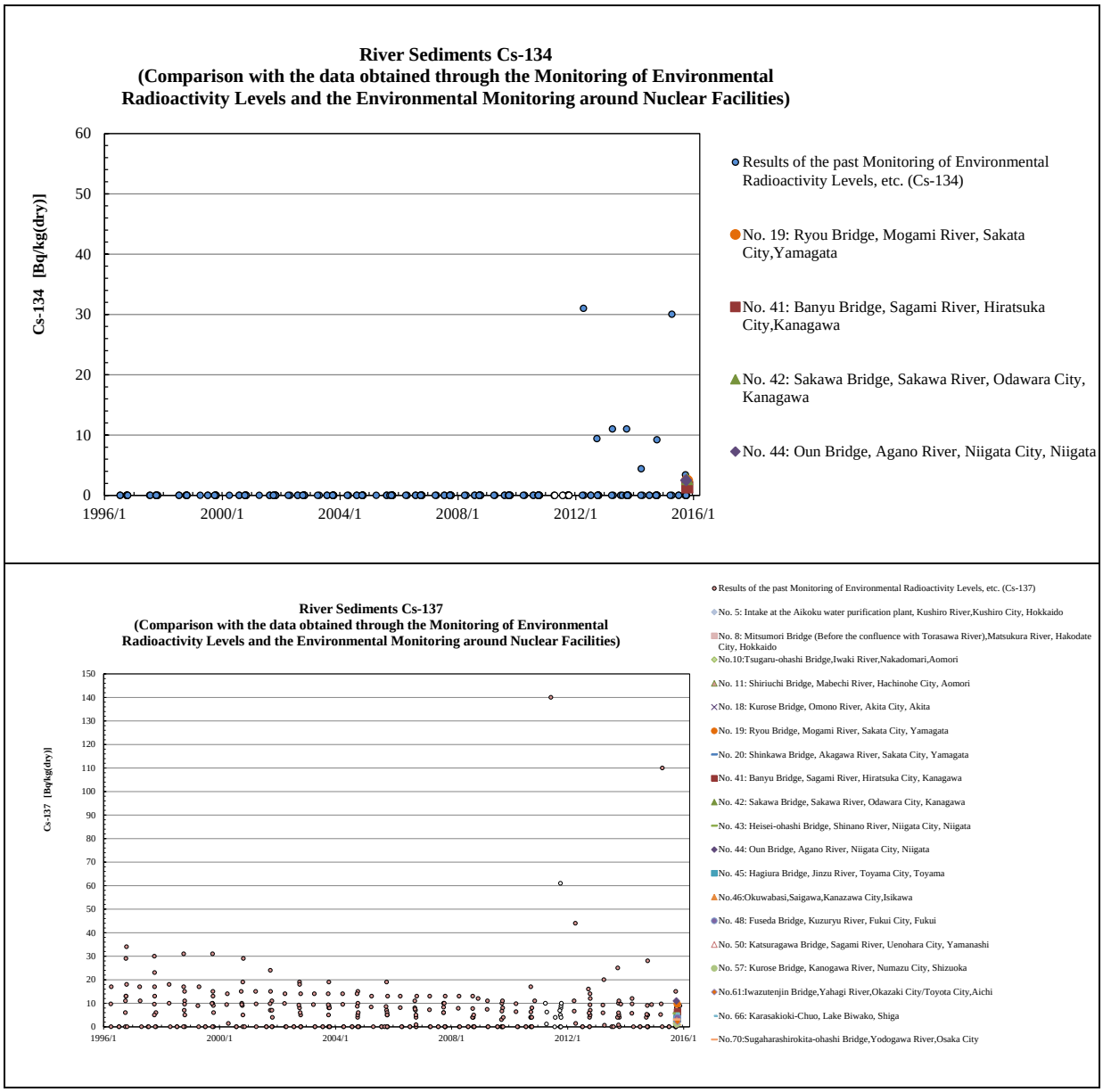
(*) White small diamond and triangle show the measurement results from March 11, 2011 to March 10, 2012, which were excluded from the past measured values used as reference.

Figure 3.2-10 (iii) Comparison with the past Post-Earthquake Monitoring results for nearby locations

(iv) Comparison with the data obtained through the Monitoring of Levels, etc.

Regarding locations where measured values did not exceed the range of past measurement records, the measured values in the latest monitoring were compared with the data obtained through the Monitoring of Levels, etc. to check the concentration levels (see Figure 3.2-11).

Cs-134 and Cs-137 were detected at Location No. 19 (Ryou Bridge, Mogami River, Sakata City, Yamagata Prefecture), Location No. 41 (Banyu Bridge, Sagami River, Hiratsuka City, Kanagawa Prefecture), Location No. 42 (Sakawa Bridge, Sakawa River, Odawara City, Kanagawa Prefecture), and Site No.44 (Oun Bridge, Agano River, Niigata City, Niigata Prefecture). At other locations , only Cs-137 was detected and the measured values all fell within the past measurement trends.



(*) Upper: Cs-134; Bottom: Cs-137

(*) White small circles show the measurement results from March 11, 2011 to March 10, 2012, which were excluded from the past measured values used as reference.

Figure 3.2-11 (iv) Comparison with the data obtained through the Monitoring of Levels, etc.

Regarding locations where both Cs-134 and Cs-137 were detected (all in the Tohoku and Kanto blocks), a good correlation was observed in the activity concentration ratios of Cs-137 and Cs-134. The calculated activity concentration ratio was (Cs-137/Cs-134) approximately 4.3. When assuming that detected Cs-134 and Cs-137 were those discharged due to the Fukushima NPS Accident, this ratio could be found to be close to the theoretical ratio (approx. 4.3) as of November 2015 after the discharge in March 2011 (see Figure 3.2-12). This suggests that Cs-134 and Cs-137 detected in sediment samples collected in the Tohoku and Kanto blocks were derived from the Fukushima NPS Accident.

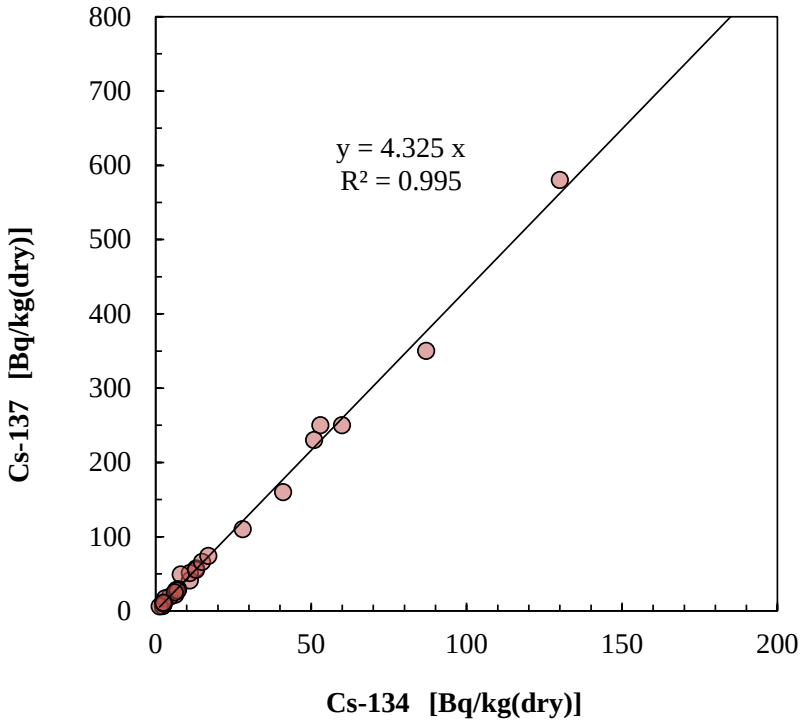


Figure 3.2-12 Concentration ratio (Cs-137/Cs-134) [sediments (public water areas)]

(Reference: Changes over the years in concentration ratios (Cs-137/Cs-134) in consideration of half-life periods)

Radionuclide	Half-life (year)	2011/3	2012/3	2013/3	2014/3	2015/3	2015/11
Cs-134	2.0648	1	0.71	0.51	0.36	0.26	0.21
Cs-137	30.1671	1	0.98	0.96	0.93	0.91	0.90
Cs137／Cs134		1	1.37	1.87	2.56	3.50	4.28

(*) The concentration ratio at the time of the latest monitoring (around November 2015) is estimated to be approximately 4.3 (highlighted in yellow in the table above).

Given these facts, Cs-134 and Cs-137 detected in sediment samples from public water areas were mostly derived from the Fukushima NPS Accident, except for some locations for which causal relations were unclear, but detected values were all within the past measurement trends.

2) Cs-134 and Cs-137 in water

Cs-134 or Cs-137 were detected at 19 out of the 110 locations where water samples from public water areas were collected (a total of 19 locations: both Cs-134 and Cs-137 were detected at 9 locations (all in the Tohoku and Kanto blocks] and only Cs-137 was detected at ten locations). However, the maximum values were 0.0067 Bq/L for Cs-134 and 0.029 Bq/L for Cs-137, both of which were 50% or less of their respective corresponding maximum values in the FY2014 National Radioactive Material Monitoring. Moreover, these values fell within the range of past measured values from the Monitoring of Environmental Radioactivity Levels (0.041 Bq/L max. for Cs-134 and 0.084 Bq/L max. for Cs-137).

Regarding the 9 locations (all in the Tohoku and Kanto blocks) where both Cs-134 and Cs-137 were detected, the concentration ratio (Cs-137/Cs-134) calculated in the same manner as in the case of sediment samples also showed a good correlation. The obtained concentration ratio was approx. 4.2. When assuming that detected Cs-134 and Cs-137 were those discharged due to the Fukushima NPS Accident, this ratio was found to be close to the theoretical ratio (approx. 4.3) as of November 2015 after the discharge in March 2011 (see Figure 3.2-13). This suggests that Cs-134 and Cs-137 detected in water samples collected in the Tohoku and Kanto blocks were derived from the Fukushima NPS Accident.

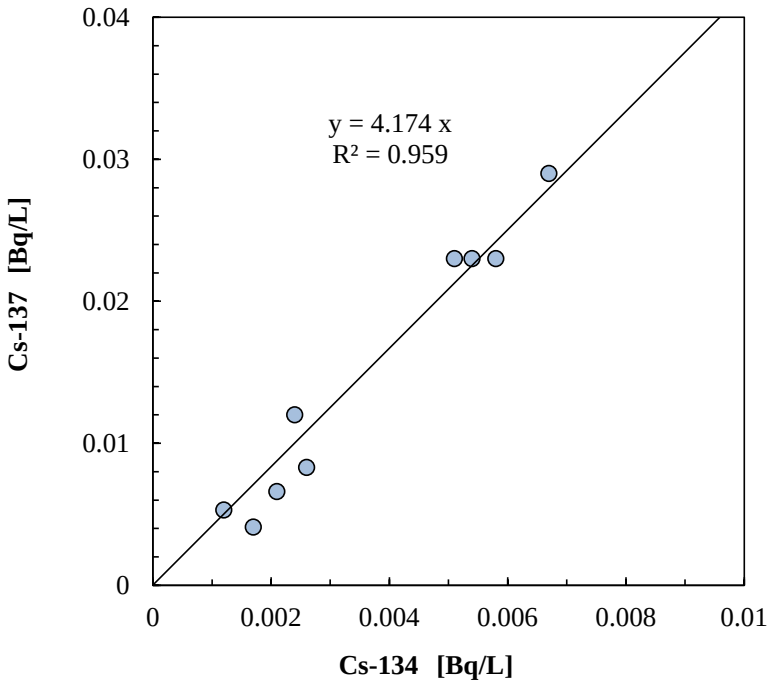


Figure 3.2-13 Concentration ratio (Cs-137/Cs-134) [Water (public water areas)]

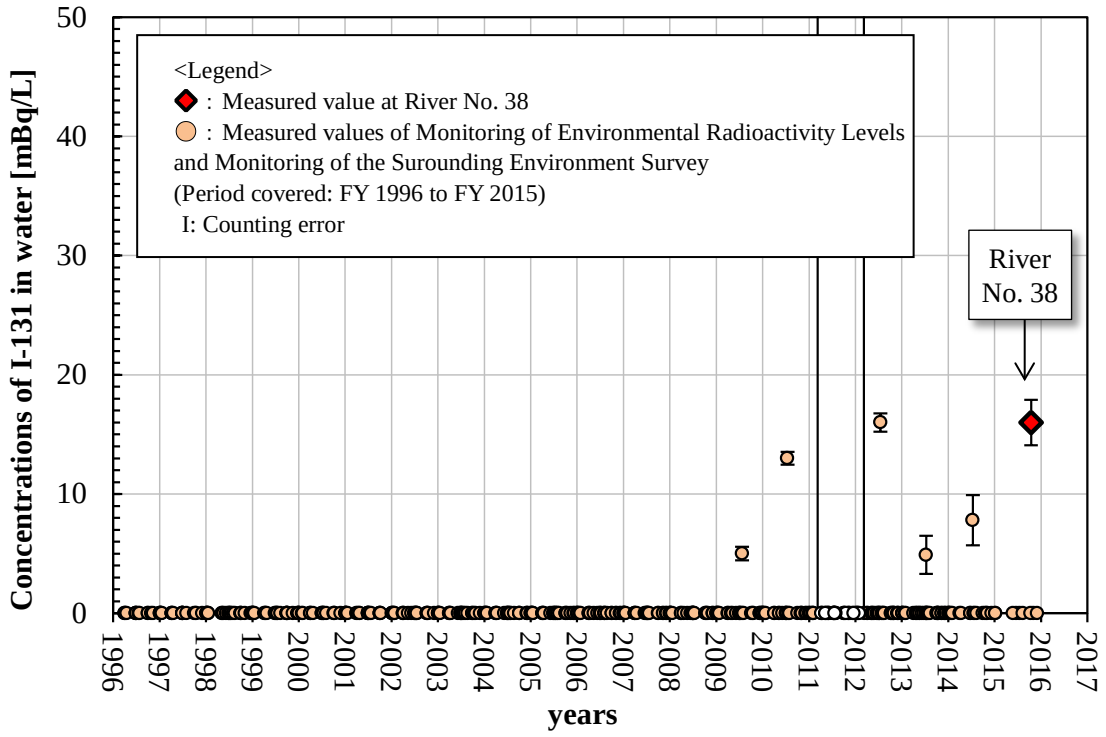
3) Cs-134 and Cs-137 in groundwater

Cs-134 and Cs-137 were not detectable in groundwater samples collected at any of the 110 locations (detection limit: approx. 0.001 to 0.002 Bq/L).

4) I-131 in water from public water areas

I-131 was detected in water samples from one location out of a total of 110 locations in public water areas. Its measured value was 0.016 Bq/L and fell within the past measurement trends, and was within the range of past measurement values (0.016 Bq/L max.) in the Monitoring of Environmental Radioactivity Levels.

Figure 3.2-14 shows the past detection trends for I-131 in water samples from public water areas.



Remarks: The measurement results from March 11, 2011, to March 10, 2012 were excluded.

Figure 3.2-14 River No. 38 and past trends in detection [public water areas (water) I-131]

I-131 has a short half-life of eight days. Now, after more than four years since the Fukushima NPS accident, it is considered very unlikely that any I-131 derived from the Fukushima NPS accident will be detected.

Meanwhile, I-131 is used as an oral medicine for the treatment of thyroid cancer and Basedow's disease. It is accepted that the radioactive material (I-131) administered to a patient is evacuated from the body as exhaled breath, urine, feces, sweat, saliva, and breast milk and that the fecal and urinary excrement is treated at sewage treatment works before discharge into rivers.[6] In disposal facilities for medical radioactive waste, there are outlet concentration limits established for radioactive isotopes contained in waste liquids. When I-131 is the only radioactive isotope species contained in wastewater, it is required that its outlet concentration limit should be a three-month mean of 4×10^{-2} Bq/cm^3 (40 Bq/L) or less.[7]

The WHO Guidelines for Drinking Water Quality recommend a guidance level of 10 Bq/L for I-131, assuming a life-long intake; the I-131 concentration detected from River Site No. 38 was a very low value, approximately

[6] *Manual for Proper Use of Internal Radiotherapy Using Radioactive Sodium Iodide (I-131) Capsules*, Revised 3rd Edition (Japan Radiological Society, Japanese Society of Nuclear Medicine, Japan Endocrine Society, Japan Thyroid Association, Japan Association of Endocrine Surgeons, Japanese Society of Thyroid Surgery, Japanese Society of Nuclear Medicine Technology), Jul. 10, 2013.

[7] MHW Ordinance No. 50, Nov. 5, 1948 Ordinance For Enforcement of the Medical Practitioners' Act, Last Revised by MHLW Ordinance No. 151, Sept. 30, 2015, Article 30-26, Para. 1, Appended Table 3 (Re: Article 30-26)

one 600th of the above value (0.016 Bq/L).

3.3 Survey to check annual variation

At two locations[8] (both in rivers), namely, Location No. 28 (Toneozeki Weir, Tonegawa River, Chiyoda Town, Gunma Prefecture) and Location No. 83 (Kasumi Bridge, Takahashi River, Kurashiki City, Okayama Prefecture), surveys were conducted four times during the period from October 13, 2015 to January 25, 2016.

The two locations had been surveyed four times, respectively, in FY2014 during the period from August 25, 2014 to January 26, 2015. An analysis was performed including the results for FY2014.

Radionuclides were detected as shown in Tables 3.3-1 and Table 3.3-2. Figures 3.3-1 and 3.3-2 show the changes in radionuclides detected in and after FY2014. Tables 3.3-1 and 3.3-2 also show the coefficients of variation[9] (= sample standard deviation /average) for variations in detected values.

The coefficients of variation in water samples ranged from 13 to 21% for total β radioactivity and K-40, and stood at 32% for Cs-137, respectively.[10]

The coefficients of variation in sediment samples ranged from 4.3 to 29% for total β radioactivity and naturally occurring radionuclides (Ac-228, Bi-212, Bi-214, Pb-212, Pb-214, Tl-208, and K-40), and from 48 to 59% for radioactive cesium.

[8] It was decided to select one location each in eastern and western Japan. All 110 locations were first divided into two for convenience (Locations No. 1 to No. 55 were classified as eastern Japan and Locations No. 56 to No. 110 were classified as western Japan) and the two locations of the median number in respective categories were selected.

[9] In this summary: coefficient of variation = sample standard deviation divided by the average ; hereinafter the same shall apply.

[10] Regarding fluctuations due to, among other things, the number of times of the survey conducted for radioactive materials in the environment, FY2012 survey instances show 12 to 16 % fluctuations in the amount of radioactive cesium contained in riverbed sediments (9 samples collected during the same period). At River Site No. 28 where radioactive cesium was detected, a drop in water transparency probably due to sludge disturbance caused by pleasure boats or winds in the vicinity was observed. Then, the water and bottom sampling points were slightly relocated with recognizable fluctuations in sediment grain-size distribution. Because the changes in sediment grain-size distribution might have affected the concentration of radioactive cesium, the changes in sediment grain-size distribution and Cs-137 concentration at River Site No. 28 are graphically summarized in Figure 3.3-3. This has revealed that sediment samples with high clay and silt contents tend to have higher Cs-137 concentrations. Accordingly, it was inferred that the fluctuations in the amount of radioactive cesium in samples from River Site No. 28 had occurred due to the changes in the grain-size distribution in the sediment samples.

Table 3.3-1 Detection trends for radioactive materials at the same location[River No. 28]

	Radionuclides	FY2014				FY2015				Coefficient of variation [%]
		Aug 25	Oct 27	Dec 15	Jan 26	Oct 13	Nov 24	Dec 25	Jan 22	
Water [Bq/L]	Total β radioactivity	0.068	0.12	0.12	0.11	0.090	0.099	0.071	0.10	21
	K-40	0.097	0.11	0.078	0.094	0.12	0.11	0.096	0.11	13
	Cs-134	0.0015	0.0020	<0.0010	0.0018	<0.0022	<0.0014	<0.0014	<0.0014	-
	Cs-137	0.0074	0.0072	0.0048	0.0049	0.0029	0.0035	0.0043	0.0052	32
Sediment [Bq/kg (dry)]	Total β radioactivity	410	350	350	380	720	460	490	430	27
	K-40	290	330	280	280	290	370	320	320	10
	Ac-228	15	9.8	12	15	23	18	22	20	28
	Bi-214	<12	11	13	13	14	15	16	12	13
	Pb-212	18	16	21	16	28	18	16	18	21
	Pb-214	11	11	16	11	14	15	17	13	18
	Tl-208	16	12	13	14	18	11	15	17	17
	Cs-134	19	13	21	17	51	25	26	21	48
	Cs-137	60	44	76	61	230	110	110	96	59

(*) The coefficients of variation are shown only for radionuclides detected seven times or more.

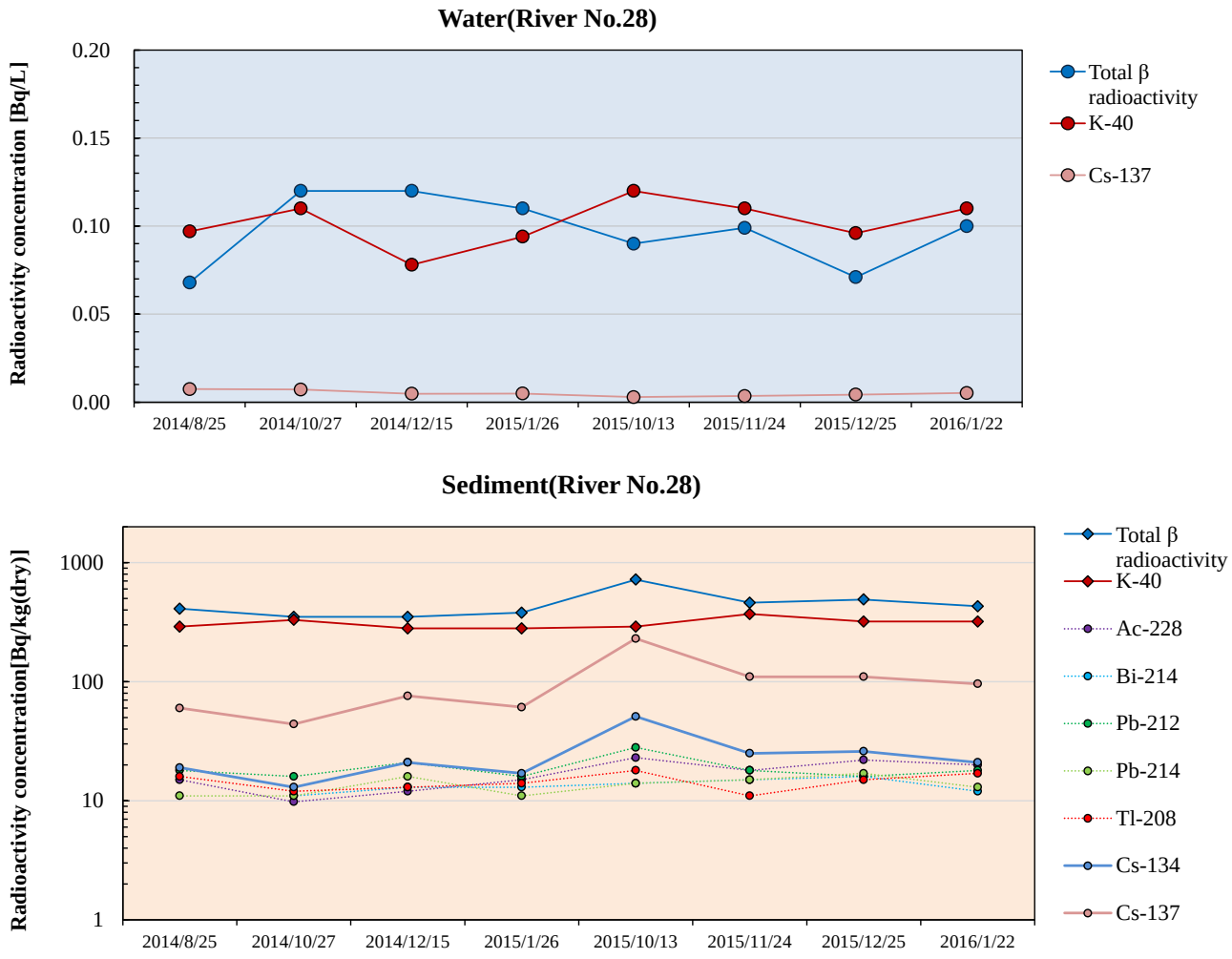


Figure 3.3-1 Changes in detection trends for radioactive materials at the same location[River No. 28]

Table 3.3-2 Detection trends for radioactive materials at the same location [River No. 83]

	Radionuclides	FY2014				FY2015				Coefficient of variation [%]
		Aug 30	Oct 28	Dec 15	Jan 26	Oct 16	Nov 30	Dec 22	Jan 25	
Water [Bq/L]	Total β radioactivity	0.046	0.064	0.037	0.038	0.048	0.047	0.041	0.035	21
	K-40	0.034	0.045	<0.028	0.034	0.045	0.042	0.038	0.031	15
	Be-7	<0.024	0.012	<0.0073	<0.0073	<0.024	<0.018	<0.013	<0.0085	-
	Pb-212	<0.0019	<0.0021	<0.0019	0.0013	<0.0019	<0.0015	<0.0015	<0.0014	-
Sediment [Bq/kg (dry)]	Total β radioactivity	1000	980	890	920	1000	1000	950	940	4.3
	K-40	870	830	910	770	920	920	840	840	6.1
	Ac-228	13	25	12	19	25	21	29	25	29
	Bi-212	42	34	23	28	28	<33	37	<34	22
	Bi-214	15	21	17	17	16	19	16	19	11
	Pb-212	28	28	24	27	28	26	26	27	5.2
	Pb-214	21	23	19	15	21	20	22	18	13
	Ra-226	50	<42	36	<39	<37	<46	<44	<41	-
	Th-234	<30	<41	30	42	<31	<47	<45	<47	-
	Tl-208	25	20	21	25	23	24	15	19	16

(*) The coefficients of variation are shown only for radionuclides detected five times or more.

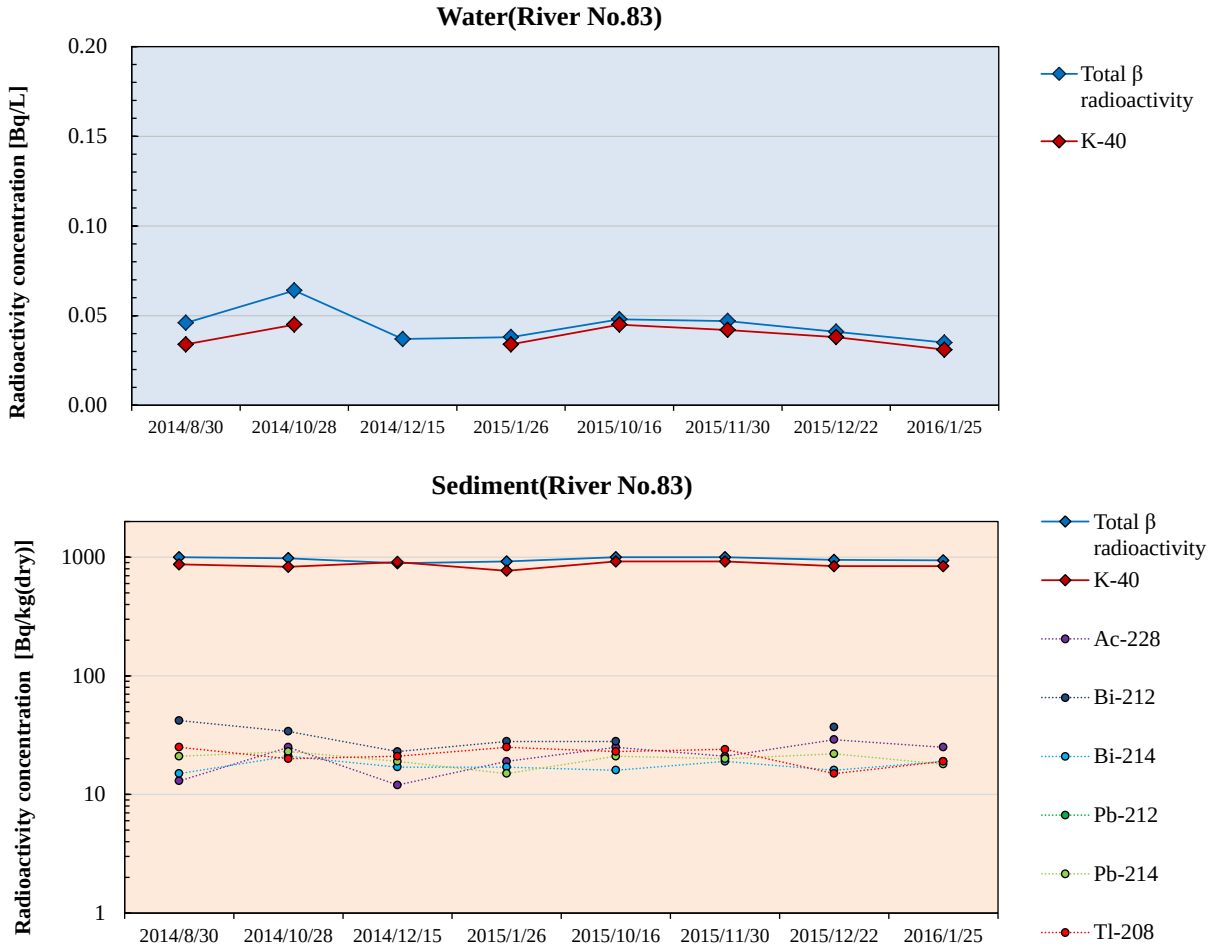


Figure 3.3-2 Changes in detection trends for radioactive materials at the same location[River No. 83]

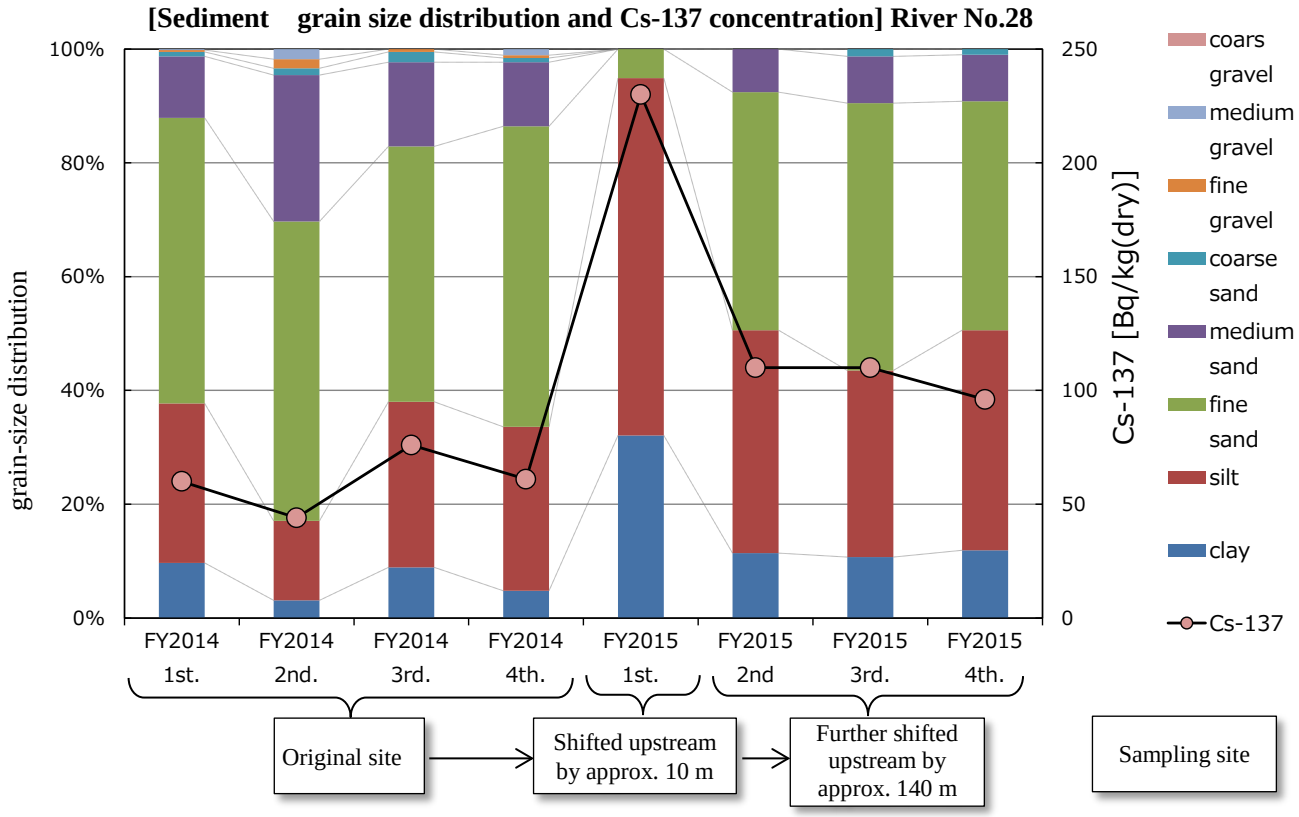


Figure 3.3-3 Changes in sediment grain-size distribution and Cs-137 concentration [River No. 28]

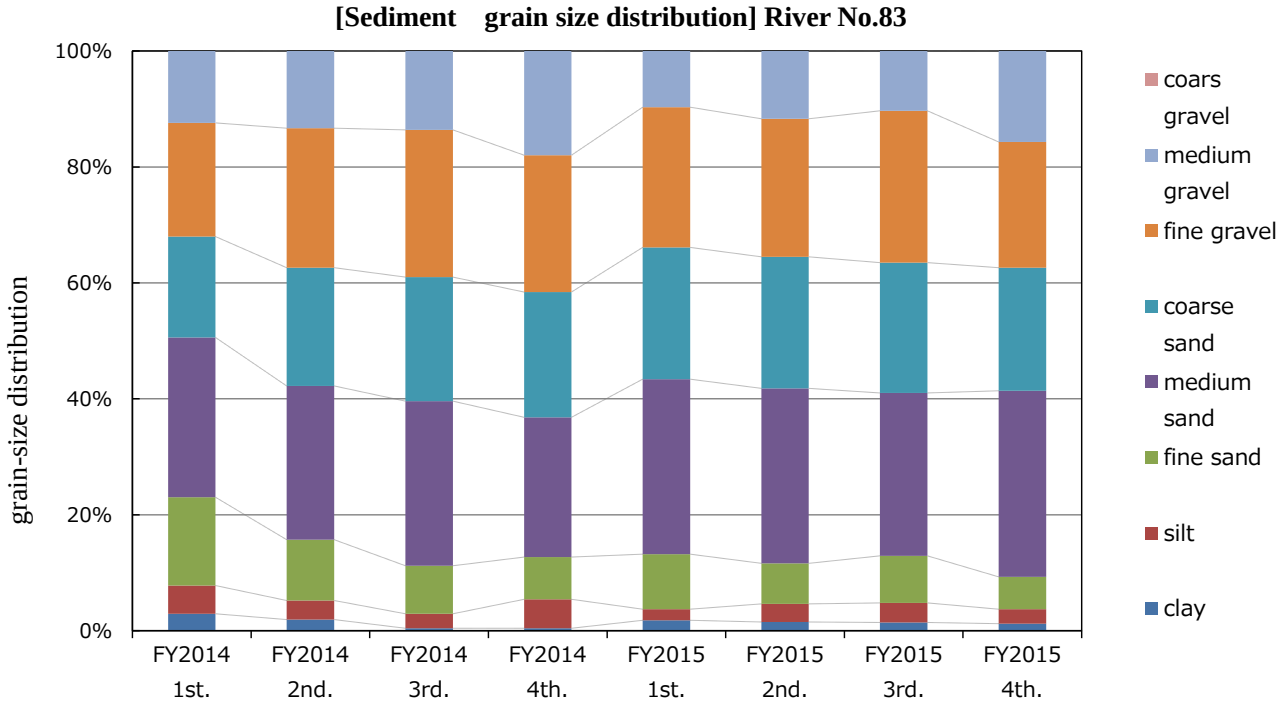


Figure 3.3-4 Changes in sediment grain-size distribution [River No. 83]