Start of introducing ICP-MS method for analyzing water samples for Strontium

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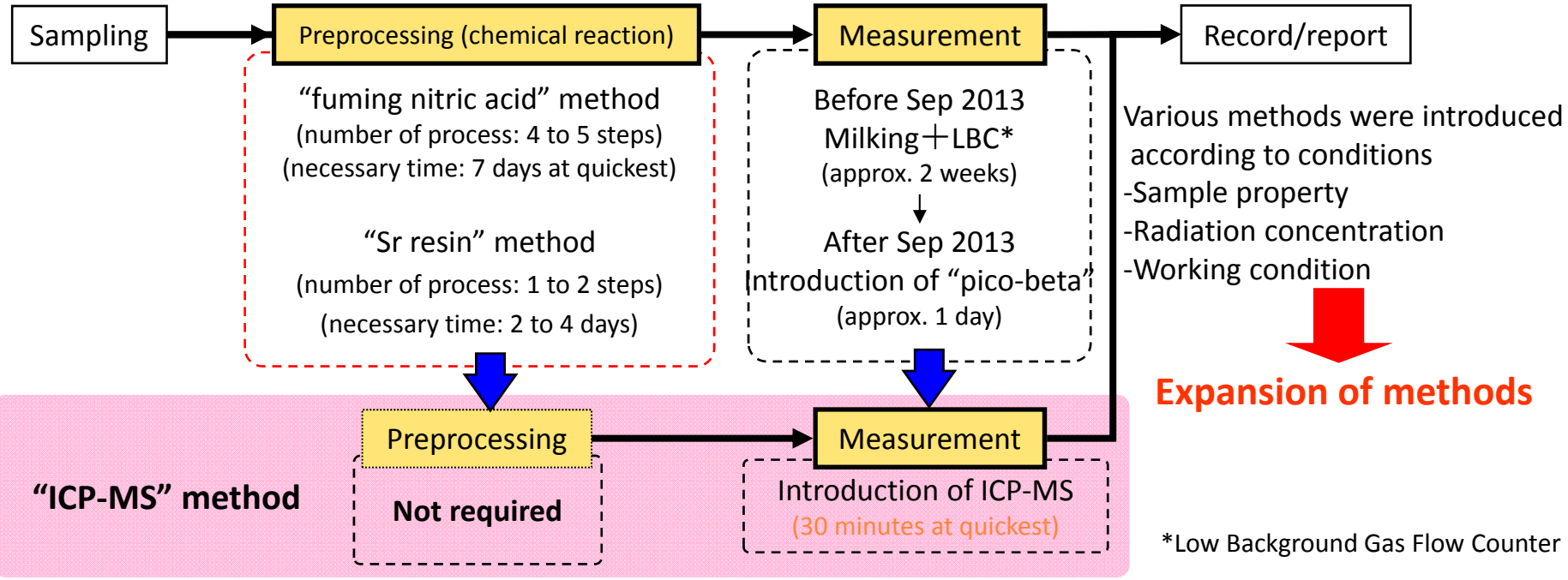
Tokyo Electric Power Company

東京電力 TEPCO

1. Current Strontium analysis and introduction of various methods

- Strontium analysis requires high skilled technology and time for analyzing due to its necessity of a highly challenging preprocessing
- Since introducing “Beta nuclide analysis (pico-beta) method” in September 2013, the time necessary for analysis has been largely shrunk.
- In August 2014, to simplify preprocessing (extracting Strontium by chemical processing) and shrinking time for analyzing, “Sr resin” method was introduced instead of “fuming nitric acid” method.
- Analysis of Strontium will be further sped up thanks to an innovative technique developed mainly by the Fukushima University known as “Inductively Coupled Plasma-Mass Spectrometry (ICP-MS)” method to analyze Strontium90 (a method that does not require preprocessing and takes only 30 minutes at quickest to analyze one liquid sample), which is due to be introduced at the site on December 1 after confirming data via verification tests.



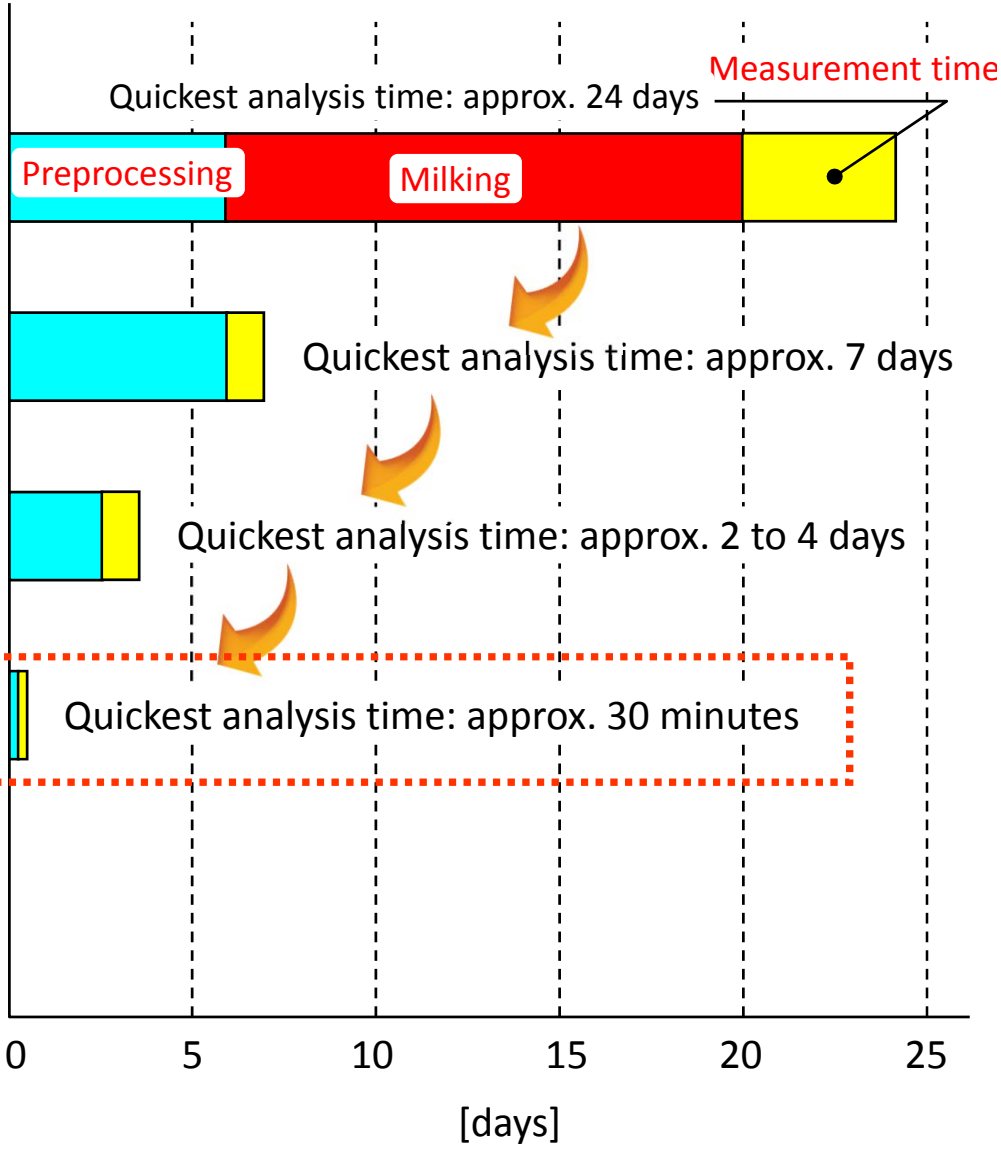
2. Shrinking time for analyzing Strontium

1. “fuming nitric acid” method and “LBC”
   (Fukushima Daini, KK, other sites)

2. “fuming nitric acid” method and “pico-beta”
   (some sites, technical organizations)

3. “Sr resin” method and “pico-beta”
   (technical organizations)

4. “ICP-MS” method



※ ASTM:D19.04 RADIOACTIVITY IN WATER
ASTM:C26.05 NUCLEAR FUEL CYCLE, METHODS OF TEST
DOE METHODS COMPENDIUM RP501(a), Rev.1

3. Overview of ICP-MS Strontium Analysis（1/2）

- ICP-MS is a new method to analyze Strontium90, already in practical use which was developed with the cooperation of Fukushima University, PerkinElmer Japan Co., Ltd., the Japan Atomic Energy Agency and the Japan Agency for Marine-Earth Science and Technology and is the first time in the world to realize measurement of Strontium90 in water with low concentration as 1 Bq/L.

- The “ICP-MS” method enables qualitative and quantitative analysis, by earning peak of Strontium90 alone combining “column separation” and “metal oxidation reaction separation” as reprocessing methods to remove materials such as Zirconium90 and Yttrium90, mass of which are the same as Strontium90.

- The method was not only broadly published in a science magazine “Analytical Methods”, but also published in domestic academic conferences and Isotope news.

3. Overview of ICP-MS Strontium Analysis（2/2）

＜Function of each device (graph matches with circled number)＞

① In “column separation,” it uses Strontium resin adsorption to separate the elements which might become a risk such as Zirconium90, Yttrium90, and Germanium 74.

② After breaking the water particle to a smaller size by using “Ultrasonic nablizers.” Next step is to isolate the strontium90, Zirconium90, and Yttrium90 from the others by using ICP-MS “reaction-cell” which is a technical device that uses the differences in oxidation for each element.

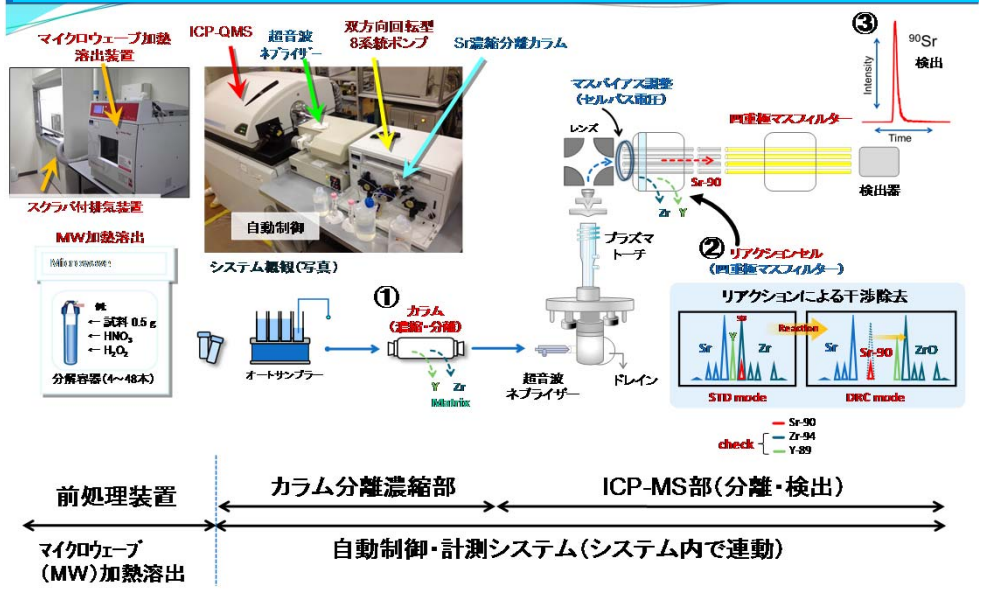
$^{90}Zr + {}^{16}O \rightarrow {}^{106}ZrO$ （mass number 106）

$^{90}Y + {}^{16}O \rightarrow {}^{106}YO$ （mass number 106）

^{90}Sr almost does not react with Oxygen （mass number 90）

③ By using ① and ②’separate operation,the peak to close of mass number 90 will only become a Strontium 90, therefore it enables to evaluate

Device Appearance and the Process at Each Section

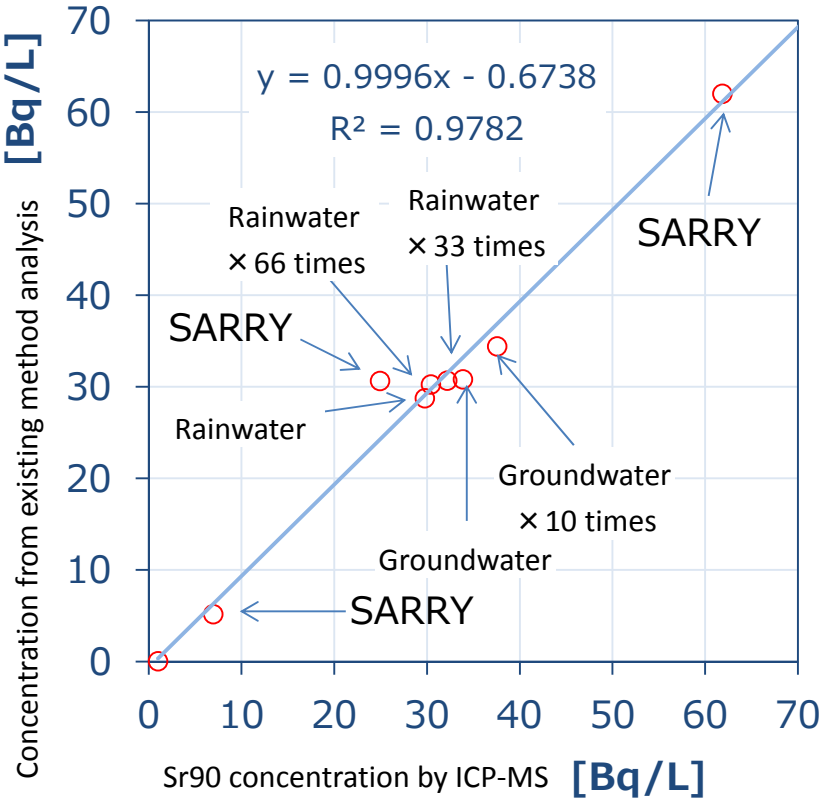


4. ICP-MS Strontium analysis verification test results (JAEA laboratory)

- At JAEA laboratory, verification test was conducted using [SARRY exit water], [simulant samples of rainwater inside the dikes], [simulant samples of groundwater bypass water] samples in which radioactive Strontium was added, and was confirmed that the results did not differ significantly from the measurement results of the existing methods. (Lower right figure “Correlativity of Sr90 data”

- Detection limit of 1.7Bq/L was earned at the verification test at JAEA laboratory. The new ICP-MS which was planned to be introduced to the site was expected to meet the level of 0.5Bq/L, 3.3 times much sensitivity improvement.

  However, the actual level was 0.3Bq/L at Fukushima Daiichi laboratory, much better than expected.



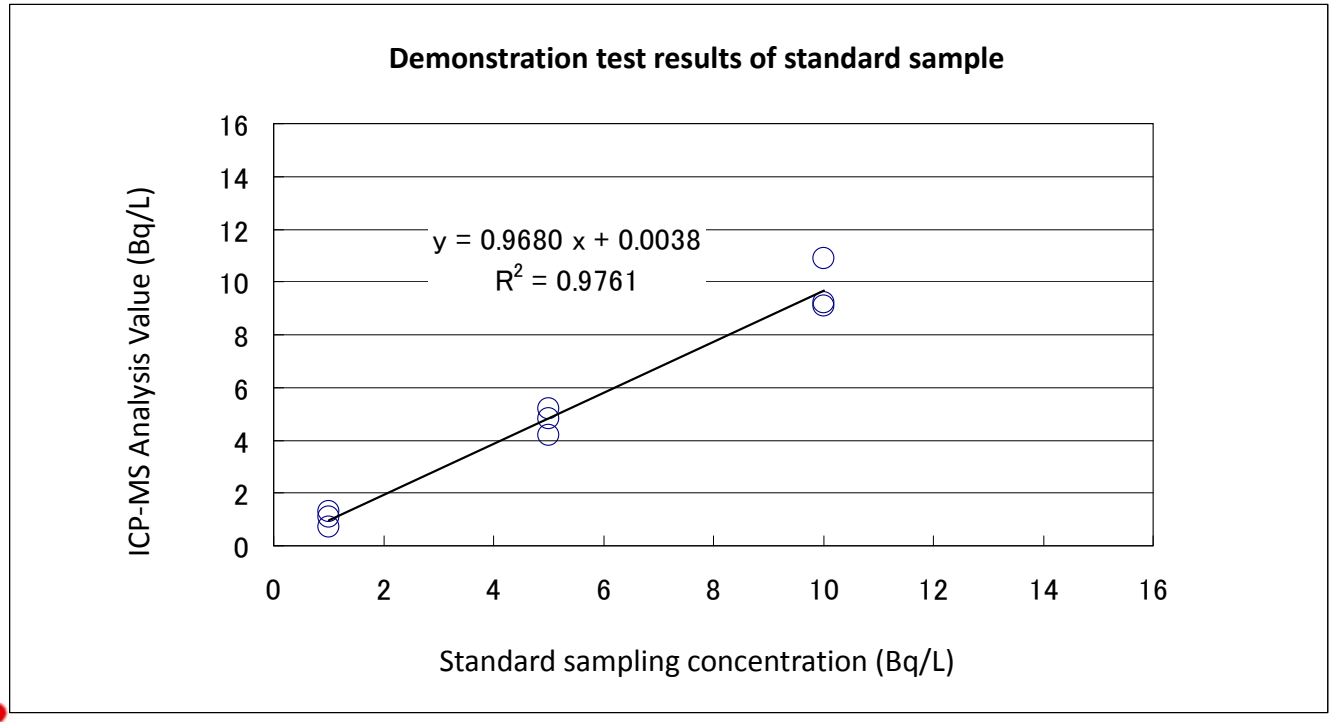
Correlativity of Sr90 data

5. Demonstration test results of strontium analysis using ICP-MS (Fukushima Daiichi Lab)

Analysis results of standard samples

Unit: Bq/L

Nuclide	Standard sampling concentration (Bq/L)	Analysis result using ICP-MS		
		1st	2nd	3rd
Sr-90	1	0.7	1.3	1.1
	5	4.2	4.8	5.2
	10	9.2	9.1	10.9



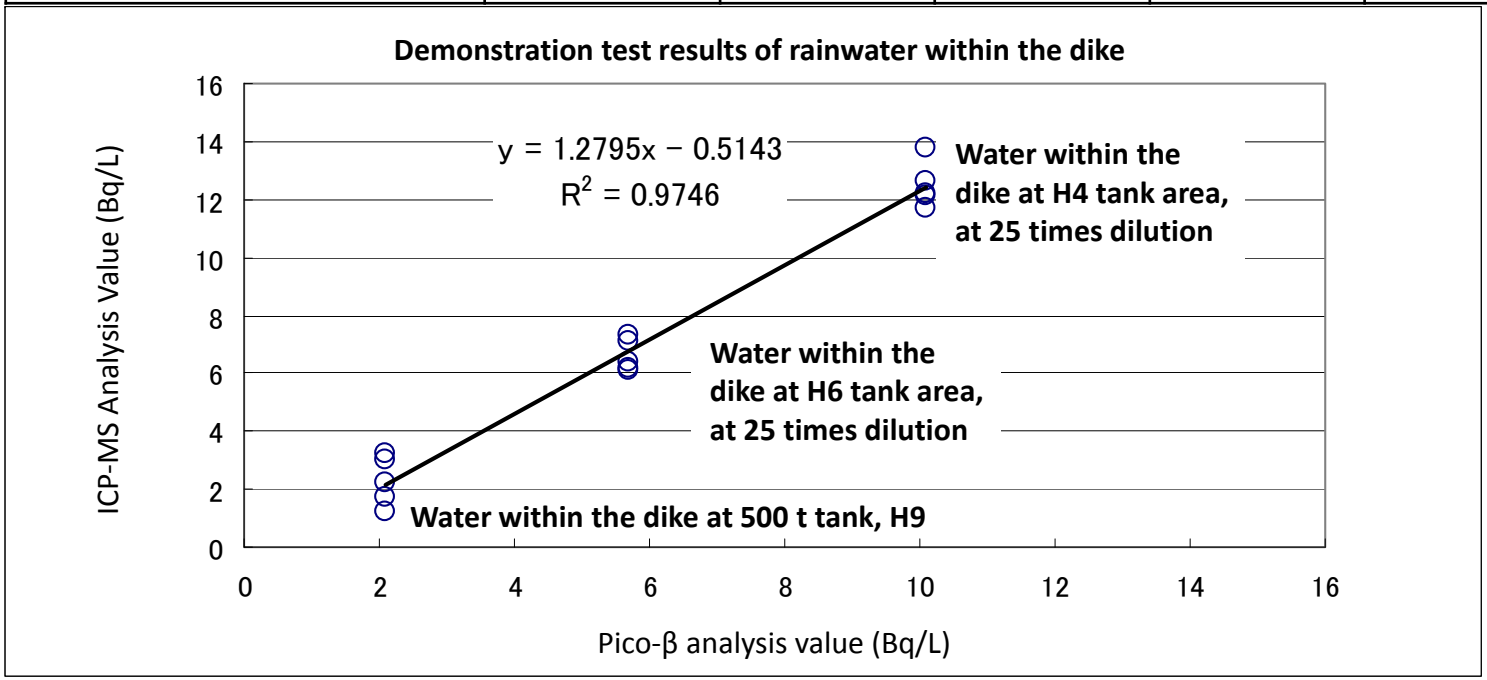
- There was a correlation between the data from standard sample analysis and was confirmed to be applied to low concentration as 1 to 10Bq/L
- By improving flow etc. , analyzing time was shortened to 23 minutes per sample including measurement and washing

5. Demonstration test results of strontium analysis using ICP-MS (Fukushima Daiichi Lab)

Analysis results of samples (rainwater retained within the dike)

Unit Bq/L

Sample name	Analysis result using pico-β	Analysis result using ICP-MS				
		1st	2nd	3rd	4th	5th
Water within the dike at 500-ton tank, H9	2.1	3.0	3.2	2.2	1.2	1.7
Water within the dike at H6 tank area, at 25 times dilution	5.7	6.4	6.2	7.1	7.3	6.1
Water within the dike at H4 tank area, at 25 times dilution	10.1	13.8	11.7	12.6	12.1	12.2



■ It was verified with the analysis results of rainwater within the dike that quite equivalent values to the ones measured by the conventional methods (Pico-β) have been obtained.

6. Application samples to strontium analysis using ICP-MS and future issues

- Analysis targets by ICP-MS method will be freshwater of which limit values is more than 1 Bq/L and with few interfering ionic species (shown in blue shaded part in the table). Firstly, apply ICP-MS method to Sr measurement of the rainwater within the dike verified through the demonstration test, and expand the application range in a phased manner.
- The second ICP-MS machine will be purchased taking into account the usage conditions of the first one installed at the Environmental control bldg and its ongoing technical development (the improvement of its reading capability and the application of seawater).
- **Future issues:** For groundwater at 4m depth and seawater, etc which requires the removal of interfering ionic species such as chlorine, promote the technical development under the initiative of Fukushima University and device manufacturers putting it as a top priority, to which TEPCO will also proactively provide assistance and cooperation. It is also necessary to develop the technology to ensure the limit value at 0.01 Bq/L or around.

Sample		Measuring device	Measuring time (approx.)	Measuring frequency (No. of samples/month)	Limit value	Remarks
Retained water at the basement of turbine bldg.		LBC (Grossβ measurement)	2 hrs	2	1E+4～1E+6Bq/L	Alternative measurement with Grossβ
Rainwater within the dike		**GM pipe type survey meter (Sr measurement)**	**1 hr**	**50 (approx.)**	**1Bq/L**	Alternative measurement with simplified measurement methods
Observation wells for monitoring leakage from tanks, etc.		LBC (Grossβ measurement)	2 hrs	750 (approx.)	20～30Bq/L	Alternative measurement with Grossβ
Groundwater bypass	Daily discharge control	LBC (Grossβ measurement)	2 hrs	20 (approx.)	5Bq/L	Alternative measurement with Grossβ
	Periodically discharge control		8 hrs	3	1Bq/L	
	Detailed analysis	LBC (Grossβ measurement)	4 weeks	1	0.01Bq/L	Composite samples
Subdrain water				2		
Seawater				10		
Groundwater at bank protection 4m in depth		Pico-β (Sr measurement)	10 days	10 (approx.)	2Bq/L	

7. Implementation schedule

■August 8, 2014

：Install ICP-MS on site.

■Mid August through the mid November, 2014

：Conduct the cross-check between the demonstration test and the conventional methods

■December 1, 2014

：Plan to start the operation.