Summary of major responses to the RFI (classified into items and categories) [Topic 6 : Understanding the groundwater flow]

Particularly required technologies for contaminated water issues		Responses to the RFI			Trend of technical information in the responses	Expert Review Panel's comments
Item	Sub item	Category	No.	Keywords		
(1) Methods of data collection	Individual technology	Geophysical surveys and remote sensing	208	Aerial survey	There is a proposal in regard to methodology for hydrological and hydrochemical investigation from the Japanese Society of Civil Engineers. Regarding data acquisition method, aerial and satellite remote sensing technologies and various geophysical methods are proposed other than those for borehole investigation. There are proposals of borehole investigation method in order to capture hydraulic properties such as water table, permeability coefficient, and to measure groundwater flow direction and rate. Other than those above, groundwater investigations using tracers such as chlorofluorocarbons, radioisotopes of boron, tritium, carbon 14, helium-3 were proposed. Remote-controlled Cone Penetration Test system which uses special probes to measure groundwater level and radioactivity quickly, is also proposed.	Understanding the groundwater flow is important as a basis for the topics 4 (Management of Contaminated Water inside the Buildings) and 5(Management Measures to Block Groundwater from Flowing into the Sea). The proposal to implement tracer investigation that considers constituents in contaminated water such as B or Sr as indicators is worth noting. As the analytic accuracy for 90Sr in the soil is sufficiently high, they seem to be appropriate as tracers. Because 3H behaves exactly as groundwater, and the analysis of it is easy with high detection sensitivity, it can be applied as an indicator for groundwater analysis. But it is required that natural and accident-originated 3H are considered. The proposal related to 3He (as a gas phase daughter and "indicator" for tritium) was innovative and interesting, and it is also used for groundwater age measurement in combination with 3H. But analysis of 3He requires relatively expensive mass spectrometry analysis. Therefore, if 3He is being used primarily as a direct measure of tritium in water, then alternative gas phase techniques are preferred. The geophysical monitoring and tomography proposals are interesting but may have limited applicability at Fukushima because of the significant amount of underground infrastructure. In regard to the idea of the "micro-chemical laboratory" to be deployed at the well side, it is important to understand the need of real-time monitoring by expensive equipment.
			344	Aerial survey, geophysical subsurface profiling, borehole geophysical logging		
			323, 413, 481	Electrical survey		
		Survey using boreholes	182	Hydrological and geochemical surveys		
			272, 678	Water level measurement		
			282, 387	Observation of water level, chemistry and boring core		
			571	Permeability tests, flow meter logging		
			572	Flow-direction / flow-velocity logging		
			654	Boring core observation, permeability tests		
		Survey using tracers	182, 429, 661, 372	Boron isotopes, radioisotopes (3H, 14C), CFCs, helium isotope (3He)		
		Others	451	Geophysical survey and monitoring using control drilling		
			709, 767	Control drilling under contamination		
			289	Groundwater flow measurement using optical fiber sensor		
			492	Know-how at Los Alamos		
			710	Non-man operation of corn penetration test		
	Integrated survey / Data collection		108	Hydrological survey, water level analysis	The Japanese Society of Civil Engineers proposed a comprehensive method for hydrological and hydrochemical investigation including groundwater flow direction and rate measurement. There are many proposals for the method of comprehensive evaluation which is based on investigation consisting of multiple techniques/methods as ways to understand the condition of groundwater including the collection and arrangement of existing data.	
			349	Geological, hydrological data		
			388	Upward groundwater flow via fractures, analysis of hydrogeological structure		
			655	Surveys of recharge, wide and site areas		
			677	Groundwater path, flow-direction / flow-velocity, hydro geochemical survey		
			742	Experience in Selafield		
			745	Water level, temperature, pH, EC, tracer		
			755	Geospatial database		
	Monitoring	Monitoring using boreholes	175, 245, 272, 349, 499	Water level, pore pressure	For the methodologies to understand the groundwater condition, before, during and after the countermeasures for the contaminated water issues, there are some proposals for monitoring programs. Continuous measurements of water table, pore pressure and radioactivity by monitoring in borehole are proposed. Other proposed monitoring methods are for surficial water run-off, infiltration, discharge from the sea floor, sea-floor radioactivity, and so on.	
			606	Water level, radiation level		
			407	Water level, chemistry, velocity, nuclide concentration		
			169, 181	Gamma logging		
			718	Monitoring of 90Sr and 137Cs		
			745	Experience in assessment of ground leak detection and monitoring technologies		
			767	Telemetry systems for real-time monitoring of water level and temperature		
		Others	272	Surface flow, infiltration amount, soil condition, outflow to ocean, etc.		
			372	3He in soil gas and groundwater		
			377, 594	Contaminated water, measurement of radiation		
			661	Geo-electrical imaging and monitoring		
			743	Experience of real-time monitoring		
			744	Natural attenuation monitoring of nuclides in soil		
			330, 409	Monitoring in the ocean area		

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Item	Sub item	Category	No.	Keywords		
(2) Rapid nuclide analysis method	Analysis of 90Sr	Mass spectrometry (ICP-MS, TIMS)	117	Analysis time : 15 minutes for 1 water sample (> 3 Bq/L), 3 hours for 8 soil samples (> 5 Bq/L)	Regarding 90Sr analysis, in addition to the widely-used conventional method with liquid scintillation, analytic methods using ICP-MS or Cerenkov counting are proposed. There are many proposals in which analytical duration is very much shortened compared to 24 days for the conventional ones.	The proposed methods to reduce analytical time and costs were generally reasonable. For example, the use of ICP-MS for strontium has many benefits -- primarily reducing the complexity of sample preparation. In regard to the Cerenkov technique, some specificity should be requested in relation to handling of matrix effects and the expected variability in environmental samples (e.g., different levels of salt). The DOE Savannah River National Laboratory has developed and deployed rapid radio-analytical methods that use multistage micro-columns for the pre-separation. These methods successfully generated high quality (NIST traceable) data in 3-4 hours for 90Sr in water, soil, and so on - the other laboratories using standard approaches had difficulties in completing within 8 hour turnaround time. Regarding the 90Sr analysis, it is better to keep two or three more methods other than ICP-MAS and Cherenkov methods for future implementation. Regarding the methods that employ ICP-MS and Cherenkov counter, as ICP-MS instrument is commonly used and easy to operate, it will be easier to secure analysis personnel than the conventional method which is fairly complicated and requires proficiency.
			177	ICP-MS for low saline sample, beta analysis for high saline sample		
			182	Integration into lithology		
		Scintillator (liquid, gas and plastic)	193	Specifying 90Y using energy window		
			209	Development of detector using gas scintillator		
			624	Analysis time : < 20 minutes (> 30 Bq/L)		
			659	Analysis time : 12 hours (> 0.05 Bq/L)		
			717	Know-how using liquid scintillator		
		Cherenkov counter	290, 300	Analysis time : 100 - 1000 seconds (about 10 Bq/L)		
			540	Analysis time : 2 - 3 minutes (about 2 - 10 Bq/L), 1 hour (about 1 Bq/L)		
			723	Detect 90Y in aqueous streams		
			767	Analysis time : 20 hours (> 0.3 Bq/L)		
		Others	282	Analysis time : 0.3-0.5 days (0.3 Bq/L)		
			357	Analysis time : about 1 day (practical use in 2015)		
			625	Analysis time : 24 hours (> 0.1 Bq/L)		
			749	Alpha, beta and gamma spectroscopy		
			309, 311	Separation procedure to isolate Sr		
	Analysis of 3H	Scintillator (liquid, gas)	209	Development of detector using gas scintillator	There are many proposals for analyzing 3H by an innovative method with the commonly-used conventional liquid scintillator. They are mainly about introducing the pre-treatment procedure of ion exchange in order to analyze in a shorter time than its traditional duration of 27 hours.	
			290, 300	Analysis time : 5 minutes (> 10000 Bq/L), 3 hours (> 2 Bq/L)		
			473	Membrane separation 3H monitor		
			474	analysis time reduction using ion exchange method and simultaneous analysis		
			492	Analysis time : < 24 hours, mobile laboratory		
			610	analysis time reduction using ion exchange and spillover methods		
			615	Analysis time : 50 minutes (> 10 Bq/L), in development		
			659	Analysis time : 4.5 hours (> 15 Bq/L), mobile laboratory		
			717	Analysis time : 5 hours (> 60 Bq/L), know-how of analysis		
		Beta counter	352	Analysis time : < 1 minute, demonstrated using prototype		
			624	Analysis time : 40 minutes		
			767	Analysis time : 65 minutes, 3H Micro Distillation		
		Others	282	Analysis time : 0.15-0.25 days (> 370 Bq/L)		
(3) Rapid and/or unmanned borehole drilling method	Unmanned drilling	Remote drilling	244, 448	Air hammer, hydraulic hammer	There are some proposals on drilling methods with air-hammer, or vibratory sonic methods, which don't use mud water but use remote-controlled machine equipped with self-running cart. They aren't of the rotary-type drilling method that conventionally uses mud water. For the method of avoiding contamination of core sample by contaminants from shallower layers, only the relatively conventional methods of double-tube drilling have been proposed.	The proposal to modify a cone penetrometer (CPT) for Fukushima conditions is worth consideration. CPT is a standard technology that has been used for many decades - the proposal advocated modifying for remote control. An alternative to a fully automated system would be development of a system that uses automation to reduce the number of people needed and speed operations.
			349	Vibratory sonic drilling, double cased well		
			582	Remote control, control by computer		
			710	Non-man operation of corn penetration test		
		Robotic drilling	345	Remotely controlled robotic technologies		
		Control drilling	451, 709, 767	Drilling from low radiation area		
	Rapid and efficient method		492	Hydraulic hammer		
	Method for preventing contamination in shallower parts		349, 582	Double cased well		

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Particularly required technologies for contaminated water issues		Responses to the RFI			Trend of technical information in the responses	Expert Review Panel's comments
Item	Sub item	Category	No.	Keywords		
(4) Groundwater flow and nuclide migration analysis	Modelling for groundwater flow and nuclide migration		181	Coupled with geophysical logging and real-time monitoring	There are many modeling proposals to conduct groundwater flow and radionuclide migration analyses using ordinary analysis codes. Some of them can analyze and visualize the surface water and groundwater at the same time.	Many good models are submitted for treating database, GIS, groundwater flow and radionuclide migration. Process of building the model is important such as setting the analysis area wider enough than the target area. The required groundwater flow model is not general but site-specific to represent the analysis area. Evaluation of effect and impact on management of contaminated water should be done based on such a model. The implementation of the model should be considered carefully. Common understanding is that the geological structure of the site is not simple, which needs to be taken into account before constructing the model. The steps to model construction should be collecting existing data, making database, and demonstrating using GIS. The models should have the ability to easily access related information, quickly assess different barrier scenarios, and graphically output to enhance communication with stakeholders and regulators. Many of the proposed models meet these requirements. It is critical to understand groundwater flow and chemical feature, and be able to predict how it can change through which measures. Hydrological monitoring to evaluate the prediction is needed. There is an opinion that the area should be completely closed for the management measures to block groundwater from flowing into the site, but as we have inspected the site and read the article about partial sinking of the ground, we think it requires prudence. It is desirable to stop water as we perform monitoring, confirming how things will develop as we go.
			199, 246, 302, 428, 481	Integrated analysis of surface flow and groundwater flow, visualization		
			231	Verification of groundwater flow		
			279	Inverse analysis using local model, evaluation by tracer test		
			302	Prediction of radionuclide transport, representation of freezing processes		
			310, 605	Groundwater flow, radionuclide transport		
			319	Analysis of contaminant flow		
			346	Modeling software package for contaminant transport		
			349	Model based on geological and hydrological data, know-how of drilling		
			406	Comparison and discussion of several evaluation results		
			425	Transport behavior of radionuclides, landward movement of the sea water		
			562	Analysis in wide, medium and site area		
			604	Geostatistical method		
			661	Modeling based on geological model, geo-electrical imaging, tracer test		
			734	Model for planning barrier implementation		
			737	Coupling of groundwater flow and heat flow		
	Total modeling including risk management and/or policy decision		199, 481	Integrated management system for groundwater flow	The Japanese Association of Groundwater Hydrology proposed to make a conceptual groundwater model, and the Japanese Society of Civil Engineers proposed to make an expert system for visualization of the state of contamination. There are many proposals for groundwater analysis covering risk control to decision making, specifically by gathering existing data, building database and concept model, and visualizing groundwater flow based on GIS in order to adjust observation plans and models to be communicated to stakeholders, which will then be utilized to improve mid and long-term plans.	
			232, 410, 735	Simulation for contaminant transport		
			259	Integrated management system for contaminated water issue		
			293	Groundwater flow, contaminated water flow in coastal zone		
			324	Simulation of impermeable wall and outflow to the ocean		
			325, 530, 739	Conceptual models for groundwater, development and site		
			351	Modeling of radionuclide migration		
			416	Advices for short-term and medium-term problems		
			424	Remote geophysical monitoring, remediation efficacy		
			576	Monitoring and analysis system for wide-area groundwater flow		
			634	Visualization of contaminant transport		
			680	Expert system for visualization of contamination		
			731	Model to support the ground freezing strategy		
			733	System modeling for radiological risks		
			740	Contaminant migration modeling, risk assessment		
			741	Estimation of contaminated soil and groundwater volumes		
	Consideration of the geochemical environment		426	Desorption of cesium and increasing its flux into the ocean	It is noted that salinization of groundwater possibly causes desorption of radionuclides that have once been adsorbed on a solid in an aquifer.	
Others	Leakage detection using 3He		372, 745	Concentration of 3H and 3He	There is a proposal to use 3He online measurement in order to detect 3H contaminated water spill underground.	

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