ADVISORY OPINION

Assessment of the Impacts of the Discharge of ALPS-Treated Water into the Sea and Related Challenges

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SCIENCE COUNCIL OF JAPAN
Committee on Comprehensive Synthetic Engineering
Subcommittee on Nuclear Safety

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	Masaki Ichinose	(Associate Member)	Professor Emeritus, The University of Tokyo / Professor, Musashino University
	Michiko Ohkura	(Associate Member)	Specially Appointed Professor, Faculty of International Economics and Management, International Pacific

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Akiko Matsuo	(Associate Member)	Professor, Faculty of Science and Technology, Keio University
Masahiko Munechika	(Associate Member)	Professor, Faculty of Science and Engineering, Waseda University

Working Group on Study of the Environmental Impacts of Nuclear Accidents (26th Term)

Chair	Naoto Sekimura	(Associate Member)	Professor Emeritus, The University of Tokyo
Vice-Chair	Yuichi Moriguchi	(Member, Section III)	Professor Emeritus, The University of Tokyo / Emeritus Researcher, National Institute for Environmental Studies
Sec.	Yoshitaka Ito		Professor, Institute for Cosmic Ray Research, The University of Tokyo
Sec.	Keiko Tagami		Group Leader, Environmental Transfer Research Group, Department of Radiation Measurement and Dose Assessment, National Institute of Radiological Sciences, National Institutes for Quantum Science and Technology (QST)
Sec.	Daisuke Tsumune		Division Head and Professor, Center for Research in Radiation, Isotopes, and Earth System Sciences, University of Tsukuba
	Mitsuo Uematsu	(Associate Member)	Director-General, Center for Environmental Science in Saitama / Professor Emeritus, The University of Tokyo
	Koji Otsuka	(Associate Member)	Visiting Senior Research Scientist, RIKEN Nishina Center for Accelerator-Based Science / Professor Emeritus, Department of Physics, Graduate School of Science, The University of Tokyo
	Kyoko Ono	(Associate Member)	Deputy Director, Circular Technology Implementation Research Center, Research Strategy Headquarters, National Institute of Advanced Industrial Science and Technology (AIST)
	Takashi Nakano	(Associate Member)	Director and Professor, Research Center for Nuclear Physics, The University of Osaka
	Akiyo Yatagai	(Associate Member)	Professor, Graduate School of Science and Technology, Hirosaki University
	Takashi Aoi		Professor, Center for Nuclear Study, Graduate School of Science, The University of Tokyo / Specially Appointed Professor, The University of Osaka
	Yasuhito Igarashi		Specially Appointed Professor, Institute for Integrated Radiation and Nuclear Science, Kyoto University
	Yuichi Onda		Director and Professor, Center for Research in Radiation, Isotopes, and Earth System Sciences, University of Tsukuba
	Sakae Kinase		Principal Researcher, Monitoring Technology Development Group, Nuclear Emergency Assistance and Training Center, Nuclear Safety Research and Disaster-Preparedness Institute, Japan Atomic

	Energy Agency (JAEA)
Atsushi Shinohara	President, Osaka Aoyama University / Invited Professor, Institute for Radiation Sciences, The University of Osaka
Yoshio Takahashi	Professor, Graduate School of Science, The University of Tokyo / Director, Isotope Science Center
Kenji Nanba	Professor, Faculty of Symbiotic Systems Science, Fukushima University
Shinya Mizokami	Specialist S, Fukushima Daiichi Decontamination and Decommissioning Engineering Company, Tokyo Electric Power Company Holdings, Inc.
Haruka Minowa	Associate Professor, Radioisotope Research Center, The Jikei University School of Medicine
Hiroshi Yasuda	Professor, Research Institute for Radiation Biology and Medicine, Hiroshima University
Hiromi Yamazawa	Professor Emeritus, Nagoya University

EXECUTIVE SUMMARY

1. Background

In the aftermath of the accident at the Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Station (hereinafter referred to as '1F'), contaminated water generated by cooling fuel debris and related activities has been treated using the Advanced Liquid Processing System (ALPS) and other equipment and subsequently stored in tanks on the station site. The large number of tanks, however, became an obstacle to the smooth progress of decommissioning. As the stored water contains radioactive tritium (H-3), which cannot be removed chemically, several disposal options for tritium-containing water were compared in order to reduce the number of tanks, and it was ultimately decided that water treated by ALPS to meet regulatory standards for environmental discharge for radionuclides other than tritium (hereinafter 'ALPS-treated water') would be diluted to below the applicable tritium concentration standard and discharged into the sea. Over the more than two and a half years since August 2023, ALPS-treated water has been discharged as planned on 18 occasions (as of the end of March 2026), totaling approximately 141,000 m^3, and the amount in storage has decreased by approximately 7% from the level before discharge began.

Since the early stages after the accident, this Subcommittee has maintained a Working Group and continued to examine radiological environmental impacts. When the policy of discharging ALPS-treated water into the sea was adopted, the review structure was strengthened by, among other measures, adding marine specialists to the Working Group. The results of these reviews were reported at the National Symposia on Atomic Energy held in January 2025 and January 2026. The scientific assessment of safety based on current knowledge was consistent with assessments by international organizations. At the same time, it is the role of Japanese academia to examine issues relating to risk, safety, and reassurance from a broader perspective, drawing also on deliberations conducted by the Science Council of Japan before the ALPS-treated water issue arose, and to present its advisory opinion.

2. Current Situation and Issues

Before the discharge of ALPS-treated water into the sea began, its radiological environmental impacts and safety were assessed, including through third-party reviews by international organizations, and scientifically appropriate measures were implemented, such as enhancing environmental monitoring of radionuclides in surrounding waters. Nevertheless, persistent distrust stemming from marine contamination in the early period after the accident gave rise to concerns about reputational damage to marine products. Social and economic impacts did in fact occur, including tighter import restrictions imposed by neighboring countries.

Since the discharge began more than two and a half years ago, environmental monitoring data, including data obtained with the participation of overseas organizations, have accumulated, and it is increasingly being confirmed that impacts on surrounding waters have been extremely small, as

predicted in the prior radiological impact assessment. At the same time, scientific papers that exaggerate the environmental impacts of the marine discharge have been published in international academic journals, creating a troubling risk of confusion in scientific assessment.

Domestic opinion polls conducted after the discharge began have shown that views accepting marine discharge outnumber opposing views, and there have been moves to resume exports of marine products to neighboring countries, indicating that social reactions are gradually subsiding. However, many problems have been identified in the consensus-building process that led to the discharge decision. The discharge of ALPS-treated water has begun, with water that is already releasable and has comparatively low tritium concentrations. Yet, large quantities of tank-stored water require secondary treatment before discharge, and discharges are expected to continue for the next 30 years. Continuous improvement in safety and the rebuilding of relationships of trust among the parties concerned are critically important, not only for the discharge of ALPS-treated water but also for management of the entire decommissioning process, including contaminated-water control, fuel-debris retrieval, and radioactive waste treatment.

In light of these recent circumstances, it is necessary to compile a renewed objective assessment from an academic perspective based on the latest knowledge, while also organizing issues that do not fit easily within the framework of safety established by scientific assessment. These issues include relationships with stakeholders throughout the process leading to the discharge decision and communication of information within and outside Japan. It is also necessary to indicate directions for improvement.

3. Content of the Advisory Opinion

[General Statement] Based on the prior radiological impact assessment and the measured results of more than two years of post-discharge environmental monitoring, there is, at least at present, no issue with scientific safety as evaluated using dose-assessment methods consistent with international guidelines. By contrast, the consensus-building process with the parties concerned during the decision-making process for marine discharge cannot be regarded as successful. The overall decommissioning program is expected to extend over an even longer period in the future, owing to factors such as the need to discharge water requiring secondary treatment because of its higher radionuclide concentrations (see Chapter 2, Section (2), of the main text) only after those concentrations have been reduced to below the applicable regulatory standards, and delays in beginning full-scale fuel-debris retrieval. It is therefore necessary to move toward consensus-building that can earn trust, combining careful explanation with scientific evidence derived from integrated analysis of monitoring and simulation. A humble approach is required, recognizing that safety in the use of nuclear energy may involve risks that have not yet been identified.

Opinion 1: Quantitative Assessment of Discharged Radionuclides and Their Impacts

Tritium, a major radionuclide contained in ALPS-treated water, disperses rapidly in the ocean. The assessment that, as an annual average, it is diluted to the natural background concentration at distances of approximately 5 km offshore and approximately 30 km along the coast from the discharge outlet is reasonable. Tritium behaves like water and undergoes almost no bioaccumulation; the risk of accumulation in marine products is therefore extremely low. For long-lived radionuclides other than tritium, measurements confirm that ALPS treatment reduces the concentrations of all radionuclides to a level at which the sum of their ratios to the regulatory concentration limits (see footnote 9 in the main text) is less than one, after which the water is diluted several hundredfold before discharge. The assessed annual external and internal radiation doses to humans from discharging ALPS-treated water, for a 10 km × 10 km area offshore from 1F, were on the order of 10^{-5} mSv, five orders of magnitude below the exposure from natural radiation in Japan. The IAEA has also assessed the radiological impact as 'negligible.' These findings are supported by academic studies and environmental monitoring results in Japan and abroad. No increase in seawater tritium concentrations has been observed except at monitoring points near the discharge outlet, and there have been no reports of tritium becoming concentrated in marine products to detectable levels. Nevertheless, continuous long-term assessment is required in view of the effects of tritium that has continued to flow from the vicinity of 1F since the accident, the spatial and temporal limitations of the monitoring system, and the extent of accumulation of radionuclides other than tritium in marine products, the elucidation of their circulation mechanisms, and the associated uncertainties.

Opinion 2: Methodological and Information-Disclosure Issues Supporting the Assessment

The ocean-dispersion model used for radiation dose assessment has previously been validated against observational data from the early period after the 1F accident, but validation using monitoring data obtained since the start of ALPS-treated water discharge is important. Simulated tritium concentrations generally agree with monitoring data, although more quantitative validation is needed. At present, even the most frequent high-precision monitoring is limited to approximately once a week, and does not adequately capture the mean of highly variable concentrations. The relatively high detection limits, which yield many non-detects, also make it difficult to calculate mean values. Moreover, the arrangement of monitoring stations does not adequately reflect the characteristics of the seawater flow field around the discharge outlet and in surrounding waters. To make monitoring more efficient, multiple institutions should cooperate in reviewing the system, giving the highest priority to increasing observation frequency while also lowering detection limits, optimizing the arrangement of stations, and reviewing the number of stations. Publication and evaluation of monitoring results should also move away from a siloed, institution-by-institution approach toward a system that enables cross-institutional comparison and comprehensive evaluation, while simultaneously ensuring the independence and transparency of the measurements and assessments conducted by the respective institutions. Before each discharge, the operator makes information such as radionuclide concentrations in the ALPS-treated water publicly available, but access to that information could be

improved, for example through links from government portal sites. Given longstanding concern about reputational damage, trusted communication that focuses on what recipients of the information wish to know is called for. One option would be for a trusted institution to assume overall responsibility for information provision, potentially including the establishment of an evaluation and monitoring body as mentioned in Opinion 4.

Opinion 3: Issues Beyond Safety – Rebuilding Relationships of Trust

The radiation dose assessment indicates that radiological effects on humans are negligible. However, merely presenting a scientific, quantitative safety assessment based on methods established by international organizations is insufficient from the perspective of 'science in society,' particularly 'dialogue with society.' Future preparedness and its scientific foundations should be examined broadly, taking into account the following lessons from the 1F accident: The accident eroded trust in science and technology. Confused communication during the early post-accident period left lingering distrust of scientists and specialist institutions in the nuclear field. Preparedness for compound disasters involving a nuclear emergency was inadequate. Fostering a sense of reassurance requires not only an internationally substantiated safety assessment but also messages from organizations trusted by diverse recipients of information. Beyond one-way explanations, consensus must be built and relationships of trust developed through two-way communication and dialogue among stakeholders.

Opinion 4: Governance of Long-Term Decommissioning

In carrying out the disposal of ALPS-treated water over the approximately 30-year period envisaged, the roles of major parties, including TEPCO, the Nuclear Regulation Authority, the Ministry of Economy, Trade and Industry, the Ministry of the Environment, the Fisheries Agency, Fukushima Prefecture, and the IAEA, should be clarified and coordination among them strengthened. In addition, in light of the information disclosure issues highlighted in Opinion 2 – and referencing the 2012 Atomic Energy Commission statement regarding medium- to long-term measures for decommissioning and its reference to ensuring transparency (see Chapter 6, Section (3), of the main text) – it is also worth considering the establishment of an "independent and open" evaluation and monitoring body for the disposal of ALPS-treated water, as part of the government's responsibilities. Disposal of ALPS-treated water should proceed with an overarching view of its relationship to the long-term roadmap for decommissioning as a whole, including fuel-debris retrieval, which is now clearly delayed relative to the initial schedule, interim decommissioning goals, and the desired final state. The ALPS-treated-water issue should serve as an opportunity to improve governance of the entire decommissioning process through prompt disclosure of information, including inconvenient information, and greater transparency in important decision-making processes, thereby contributing to the development of a robust, multilayered framework for broader nuclear safety. This is expected not only of those engaged in science and technology, but also of policymakers and decision-makers.

Developing human resources capable of contributing to decommissioning practice and governance, and ultimately to nuclear safety, is also an important responsibility of the academic community.