Annex I of Technical Volume 5
EVOLUTION OF REFERENCE LEVELS FOR REMEDIATION AND DEVELOPMENT OF A FRAMEWORK FOR POST-ACCIDENT RECOVERY

I–1. DEFINITION OF REFERENCE LEVELS FOR REMEDIATION

This annex describes the establishment of the framework for recovery following the Fukushima Daiichi accident. The selection of reference levels for recovery is closely related to the criteria used by Japanese authorities to define the populations to be evacuated as a result of the accident. These are described in more detail in Technical Volume 3.

I–1.1. Reference levels for evacuation

On the day of the accident, 11 March 2011, the Japanese Government issued an order requiring the evacuation of people within a 3 km radius of the Fukushima Daiichi Nuclear Power Plant (NPP) and the sheltering of people within 10 km of the NPP. The following day, the mandatory evacuation radius (restricted area) was extended to 20 km and the sheltering radius was raised to 30 km [I–1, I–2].

Following these immediate, geographically-based, evacuation and sheltering orders, the Japanese authorities established criteria for evacuation based on the recommendations of the International Commission on Radiological Protection (ICRP). In its 2007 recommendations, the ICRP recommended that a reference level in the range of 20 mSv/y to 100 mSv/y to members of the public should be adopted for the overall strategy in emergency situations [I–3].

On 7 April 2011, the Nuclear Safety Commission (NSC) announced that the radiation level of 20 mSv/y was appropriate for the criterion of the deliberate evacuation area in consideration of 'dose reduction as low as reasonably achievable'. After representations from the NSC, on 22 April 2011, the Prime Minister of Japan, as Director-General of the Nuclear Response Headquarters (NERHQ), established 'deliberate evacuation areas' beyond the 20 km zone where the cumulative additional effective dose might exceed 20 mSv within a year. Residents of these areas were evacuated between April and June 2011 [I–1, I–2].

On 16 June 2011, the government declared 'specific spots recommended for evacuation' for localized areas where the estimated additional effective dose might exceed 20 mSv in the first year after the accident [I–1].

The restricted area, deliberate evacuation area, and regions including specific spots for evacuation are illustrated in Fig 5.5–1.

I–2. REFERENCE LEVELS FOR REMEDIATION

I–2.1. Initial actions

The initial actions to establish criteria for remediation based on the ambient dose rate were in connection with the start of the educational year at schools and universities. In Japan, the start of the educational year falls in April. Hence, at the time of the accident in March, most schools were closed up to the end of the school year and spring break had started at the end of March. Fukushima Prefecture deliberated on whether or not the new term for schools and nursery centres should commence in April, as scheduled. Following the accident, a decision was made at the NERHQ that Ministry of Education, Culture, Sports, Science and Technology (MEXT) would take charge of establishing the benchmark for the reopening schools [I–1, I–4].

MEXT believed that it was important to ensure consistency with the criteria for the establishment of the deliberate evacuation area, and noted that the ICRP [I–2] recommended a reference level of between 1 and 20 mSv/y for an existing exposure situation where there are radioactive residues in the environment (e.g. after an emergency situation).

Hence, MEXT, in coordination with the NSC, chose 20 mSv/y as the criterion for allowing educational institutions to open.

MEXT estimated that the contribution of the internal radiation dose to the whole body radiation dose was, on average, 2.2% of the total exposure (with a range of 0–5.6%). Because this contribution was small, MEXT decided not to take it into account for the definition of a relevant benchmark. Assuming a student stays indoors for 16 hours and outdoors (in the schoolyard) for eight hours a day, and that the dose reduction due to the shielding effect of being indoors is 40%, an ambient dose equivalent rate[1] of 3.8 μSv/h was chosen to correspond to 20 mSv/y of exposure Therefore, MEXT decided to allow educational institutions to open if the measured ambient dose rate was 3.8 μSv/h or lower. Furthermore, MEXT considered that "it is appropriate to decrease the dose rate that students are exposed to as much as possible while adopting the criterion of 1–20 mSv/y as the reference level after an emergency situation has stabilized as a tentative guideline", and "even if an ambient dose rate exceeding 3.8 μSv/h is measured, the level that students are exposed to can be limited to 20 mSv/y by taking countermeasures to ensure activities are mainly done indoors.

The important issue in the public's perception of this process was that the same level was being suggested for both evacuation and for recovery. Even more relevant in the public perception was that this level was the driver for reopening the schools, and the parallel was drawn with the same value (20 mSv/y), defined as the occupational exposure limit for workers in the nuclear industry.

I–2.2. Revision of the initial benchmark

Based largely on the concerns of the Japanese public that the 3.8 μSv/h remediation action level was too high because the benchmark for ensuring the safety of children had been set based on the same dose level as for areas requiring evacuation, MEXT undertook a re-evaluation.[2] In May 2011, this resulted in the 3.8 μSv/h benchmark being replaced by one of 1 μSv/h and adoption of 1 mSv/y as the long term objective for decontamination.

In parallel, in some cities of Fukushima Prefecture where the population had not been evacuated (e.g. Date City) decontamination activities were implemented for school and kindergarten yard with the help of institutes and experts who are familiar with radiation. In some cases, these activities are conducted with the cooperation of volunteers including parents. These spontaneous actions were aimed at optimizing the protection of children below the level of 20 mSv/y [I–4].

At the same time, the dose estimates had been refined based on assumptions that were more realistic and closer to the actual habits of children and young students. On 27 May 2011, MEXT issued the revised notification to Fukushima Prefecture, entitled Near-term Measures for Reducing the Dose Affecting Children and Students, etc. Received at Schools and Other Facilities in Fukushima Prefecture. Furthermore, MEXT decided to distribute dosimeters to all schools and nursery centres in Fukushima Prefecture, as well as offering financial support for schools at which the ambient dose rate

[1] Referred to as ambient dose rate (μSv/h) in many Japanese documents and this term is also used in this annex.

[2] After MEXT notified Fukushima Prefecture of the benchmark for judging the use of school buildings and grounds, the Japan Federation of Bar Association and the Japan Medical Association issued statements urging that the restrictions on the use of school grounds be dealt with carefully. In addition, MEXT Minister Yoshiaki Takaki received a request, dated 23 May 2011, from 70 parents and guardians in Fukushima Prefecture asking the Government to retract the 20 mSv/y benchmark for the use of school grounds [I–4].

of the school grounds and other areas measured more than 1 μSv/h, in order to help cover the costs of decontamination. The 1 μSv/h benchmark was determined:

— By use of a 1 mSv/y reference level.
— Considering a more realistic protection factor for indoor external doses (10% instead of 40%).
— Taking into account the actual schedule of students, at school as well as at home, instead of considering, by default, that 8 h/d were spent outside.

MEXT also suggested that, although it was not a requirement to restrict outdoor activities even if the ambient dose rate exceeded the guide, it was preferable that measures such as decontamination were taken promptly and that it was important to identify and decontaminate areas where high radiation doses were detected. It is from this move from a 20 mSv/y level to a 1 mSv/y level for school safety, coupled with the suggestion to decontaminate areas where the dose rate was exceeded, that the long term goal arose for the remediation of all localities where dose rates exceeded 1 mSv/y [I–4].

In the absence of a comprehensive programme for accident recovery based on sound radiation protection principles during this initial period (March–August 2011), a series of ad hoc solutions were implemented based on responses to specific issues.

I–2.3. Criteria for the management of contaminated material and radioactive waste

The Ministry of the Environment (MOE) presented the Disposal Guideline for Disaster Waste in Fukushima Prefecture in June 2011 [I–1, I–5, I–6]. In this guideline, MOE indicated several criteria such as:

— The incinerated ash of the disaster waste may be disposed in a landfill when the concentration of radioactive caesium is 8000 Bq/kg or less.
— When the concentration is between 8000 Bq/kg and 100 000 Bq/kg, the ash should be stored temporarily until the safety of disposal is confirmed.
— The ash should be stored within a facility that is capable of shielding radiation when the concentration exceeds 100 000 Bq/kg.

Because radioactive material of high concentration was detected in the incinerated ash, even in prefectures other than Fukushima, on 28 June 2011 the MOE presented the Guidelines for Measurement and Handling of Incinerated Ash in General Waste Incineration Facilities [I–7], based on the disposal policy for the disaster waste in Fukushima Prefecture This became the standard for the handling of the incinerated ash in 16 prefectures in Tohoku, Kanto and other districts.

On 31 August 2011, the MOE established a policy [I–7] that permitted the disposal of incinerated ash with a concentration of radioactive caesium in the range of 8000 Bq/kg to 100 000 Bq/kg in landfills. It had previously been considered preferable for such material to be stored temporarily until the safety of its disposal was confirmed. This change in policy was on the condition that public water and groundwater would be protected from contamination by radioactive caesium, and that the landfill sites would be placed under long term control, including restrictions on the use of the site.

On 30 April 2011, a high concentration of radioactive caesium was detected in sewage sludge in Fukushima Prefecture. After this was reported, inspections for radioactive material in sewage sludge were conducted in other prefectures and similarly high concentrations were detected.

On 12 May 2011, NERHQ presented the document Concept of Provisional Handling of Sewage By-products in Fukushima Prefecture [I–1] to indicate that dehydrated sludge with a radiocaesium concentration exceeding 100 000 Bq/kg should be stored appropriately in the prefecture after volume reduction.

On 16 June 2011, following requests from other prefectures to determine criteria for dehydrated sludge, the NERHQ presented the Provisional View on By-products of Sewage Treatment and the like in which a High Concentration of Radioactive Materials is Detected [I–1], which stated that:

— Sludge in which a concentration of radioactive caesium over 100 000 Bq/kg has been detected should, where possible, be stored in a facility within the prefecture from which the sludge originated and that is capable of shielding radiation.
— Sludge with radioactive caesium of 8000 Bq/kg or less may be disposed of in a landfill on certain conditions, such as that the landfill site is not be used for residential purposes.
— Sludge with radioactive caesium in the concentration range of 8000 Bq/kg to 100 000 Bq/kg may be disposed of in a landfill under certain conditions.

Again, ad hoc reactions to specific issues (notably, derivation of reference levels specific to a particular waste problem) in this initial period resulted in reference levels that were extended to other forms of decontamination waste (for instance, removed top soil).

I–3. DEVELOPMENT OF A COMPREHENSIVE FRAMEWORK FOR POST-ACCIDENT RECOVERY

Following the initial work, the recovery activities moved towards a more 'global' framework, with the MOE taking much greater responsibility for decontamination activities and waste management.

I–3.1. Act on Special Measures Concerning the Handling of Radioactive Pollution

The Act on Special Measures Concerning the Handling of Environment Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District — Off the Pacific Ocean Earthquake that Occurred on March 11, 2011, (hereafter referred to as Act on Special Measures Concerning the Handling of Radioactive Pollution) [I–8], was enacted in August 2011, to provide a comprehensive framework for off-site recovery operations following the Fukushima Daiichi accident. The MOE became the responsible authority for decontamination. The basic principles and related orders for handling radioactive pollution were established and the Act came into force on 1 January 2012. Thus, a comprehensive framework for off-site decontamination was established, under which decontamination works have been steadily implemented under the responsibility of the national government.

The basic principles under the Act provide a decontamination policy, with the priority placed on areas where decontamination is required from the viewpoint of human health, i.e. public facilities, commercial facilities, residences, farmlands, roads, forests (those areas within 20 m from living environment). Among them, the living environment for children is given a high priority [I–9, I–10].

With regard to decontamination, the NERHQ issued a Basic Concept for Pushing Ahead with Decontamination Works [I–11] and a Basic Policy for Emergency Response on Decontamination Work in August 2011 [I–12], which compile the immediate targets and working principles for decontamination. Under this basic policy, as a specific target for decontamination work, the government aimed to reduce the estimated additional annual effective dose to less than 20 mSv/y by carrying out decontamination work in areas where the additional expected doses are greater than 20 mSv/y. But even in areas where the additional expected doses are lower than 20 mSv/y, the government and municipalities were expected to work to optimize the protection of populations to 1 mSv/y in the long term, through remediation including decontamination, and by giving a high priority to thorough decontamination work in children's living spaces [I–13].

It was recognized that, at that time, some municipalities had proactively completed some decontamination that was effective in terms of dose reduction. To support these initiatives and help

municipalities that were not yet involved in this work, a Fukushima Decontamination Promotion Team was established.

This Act also deals with the management of contaminated wastes. The Act provides a description of the categories for the waste that are generated during off-site remediation of areas affected by the nuclear accident and that has been produced by the tsunami that hit the coastal area of Tohoku. The Act also defines Designated Waste as waste containing radionuclides with activity concentrations above specified levels and under the responsibility of the national government.

The execution of the recovery programme is described in detail in Sections 5.2–5.5 of Technical Volume 5 which cover, respectively, remediation, on-site stabilization and preparation for decommissioning, waste management, and the revitalization of the infrastructure and community.

I–4. DEFINITION OF CONTAMINATED AREAS AND REVISION OF EVACUATION ZONES

I–4.1. Definition of areas subject for decontamination

As indicated above, the Act on Special Measures Concerning the Handling of Radioactive Pollution is the main legal instrument dealing with all remediation activities in the affected areas, as well as the management of materials removed as a result of those activities [I–9, I–10]. The Act specified two categories of land (Fig. 5.2–3):

— **Special Decontamination Areas (SDA):** This consists of the former 'restricted areas' located within a radius of 20 km of the Fukushima Daiichi plant, and the former "deliberate evacuation areas" where the projected additional annual cumulative dose for individuals would reach 20 mSv.
— **Intensive Contamination Survey Area (ICSA):** This includes the 'decontamination implementation areas', where an additional annual cumulative effective dose between 1 and 20 mSv was estimated for individuals.

In the SDA**,** decontamination is implemented by the national government. It includes 11 municipalities in Fukushima Prefecture. The SDA covers locations where the cumulative additional annual effective dose is estimated to be greater than 20 mSv and, in principle, all the residents have been evacuated from these areas. Full scale decontamination will be carried by MOE, with the aim of reducing effective dose in residential and farmland area to less than 20 mSv/y.

The Reconstruction Agency was established on 10 February 2012 as the leading government body responsible for the reconstruction process.[3] It was also responsible for promoting and coordinating the policies and measures of the government as well as supporting reconstruction projects to be implemented by the local municipalities. This agency plays a major role in the decisions to allow repopulation of the evacuation area. Such decisions will be based on ensuring that the infrastructure of the municipalities is re-established, and that the radiation dose rate conditions in the municipalities are at the levels agreed between the stakeholders and the national and local government bodies [I–9].

In the ICSA, decontamination is implemented by each municipality, with financial and technical support from the national government. The ICSA initially comprised 102 municipalities in eight prefectures, in which dose rates implying additional annual effective doses in excess of 1 mSv were anticipated. The communities in the ICSA are carrying out their daily activities while decontamination work is under way. Other supporting activities in Fukushima Prefecture include provision of training to individuals performing decontamination services (decontamination workers, field supervisors and contract managers), the Decontamination Information Plaza which acts as an

[3] Under the Act on Establishment of Reconstruction Agency (2012).

information hub for the area, and a dosimetric campaign using dosimeters for external exposure and whole body counting to establish the committed effective doses to the population.

The long-term goal of radiation protection for an additional annual effective dose of 1 mSv/y or less for the SDA and ICSA, is stated to be consistent with ICRP guidance [I–14]. It is likely that it will take several years to meet this long term goal in some regions.

I–4.2. Cold shutdown state

On 16 December 2011, the NERHQ concluded that the reactors of the Fukushima Daiichi NPP had become stable, and the accident at the NPP had come to an end. More specifically, the NERHQ reached the judgment that the overall safety of the NPP had been secured by the achievement of such targets as the 'cold shutdown state' of the reactor, securing of the more stable cooling of the spent nuclear fuel pool, reduction in the overall quantity of accumulated water, and control of dispersion of radioactive material [I–1].

I–4.3. Revision of evacuation zones

On 26 December 2011, the NERHQ, in the 'Basic Concept and Issues to be Challenged for Rearranging the Restricted Areas and Areas to which Evacuation Orders Have Been Issued Where Step Has Been Completed' [I–13], indicated that the situation had evolved, since April 2011 in the areas defined for the evacuation of the population, and that these areas would be revised accordingly. This document determined a new classification for the areas under evacuation. The designation of areas is still based on the 20 mSv/y reference level, with the government becoming proactively involved in decontamination (particularly for the living conditions of children), infrastructure reconstruction and damage compensation. On this basis, the government developed the following designations [I–15]:

— **Area 1.** Areas to which evacuation orders are ready to be lifted: These are areas where external projected doses are certain to decline to 20 mSv/y or below. Efforts had to be made to restore infrastructures, implement decontamination and restore economic activities in order to allow residents to return as soon as possible.
— **Area 2**. Areas in which residents are not permitted to live: Areas where external projected annual effective doses may still exceed 20 mSv and residents are requested to remain in the area where they have been evacuated to reduce their exposure. Decontamination will nevertheless be implemented in order to allow residents to return in the future.
— **Area 3.** Areas where it is expected that residents will face difficulties in returning for a long time. Areas where the level of contamination by radioactive material is and will remain extremely high. As the effect of decontamination work in this area will be limited because of the high contamination levels, efforts will also be made to find the best possible living environment for evacuees.

Based on this policy, the NERHQ held consultations with Fukushima Prefecture and relevant municipalities as well as residents, and on 30 March 2012 it decided to revise the restricted areas and evacuation areas as shown in Fig 5.2–4 [I–15].

I–4.4. Evolution in the framework for decontamination

By the beginning of 2014, decontamination plans for 10 out of the 11 target municipalities in the SDA were established. Decontamination work has been in operation, or in preparation, in nine municipalities and was completed in one city (Tamura). Since local circumstances differ from one area to another, differences have been observed regarding the progress among municipalities. The MOE announced that decontamination work will be implemented in cooperation with reconstruction

measures in accordance with the situation of each municipality, and it will revise the current plans and schedules of work. Accordingly, decontamination in some cities (Nahara, Kawauchi and Okuma) was completed by the end of FY2013. For Minamisoma, Iitate, Kawamata, Katsurao, Namie and Tomioka, the decontamination plans were revised in December 2013 and new schedules were agreed in consultation with each municipality and community. For example, decontamination of residential areas will be prioritized so that evacuees can return to their homes. In the meantime, reconstruction of infrastructure (water supply, sewage, roads, etc.) will be started [I–10].

In the ICSA, 94 municipalities out of 100 designated municipalities have developed their decontamination plans.[4] These plans cover large targets (public facilities, residential houses, farmland and forests). The MOE produced a list of specific decontamination methods in the Ordinance for Enforcement of the Act, and published Decontamination Guidelines to provide concrete descriptions on each process of decontamination. Municipalities have also developed "original and innovative measures and know-hows, from the view point of the promotion of effective and efficient decontamination work and mutual understanding with local residents" [I–10].

In September 2013, the MOE announced new policies for two aspects of decontamination:

— A new follow-up of decontamination work based on continuous monitoring of ambient dose rates in places where decontamination has occurred.
— A new framework for decontamination of forested areas. The decontamination of forests has been limited to within 20 m from the residential area under decontamination (reflected in the Decontamination Guidelines issued in December 2013). But this framework could evolve in the future to take account of the results of new research.

In December 2013, a new policy was announced concerning Area 3 of the SDA [I–10, I–16]. Based on the recognition that residents need to start new lives because of the difficulty in returning to the most contaminated places within the SDA, additional compensation has been provided and discussions with the relevant parties are taking place to build a long term vision for the future territories and their residents.

I–4.5. Practical measures for evacuees to return to their homes

In November 2013, the Nuclear Regulation Authority of Japan published new radiation protection guidelines for evacuees who wish to return [I–17]. This document proposes to establish a global system for supporting evacuees. It also proposes that evacuees who wish to return use personal dosimeters in order to be able to manage doses efficiently and to properly focus decontamination activities based on the actual doses received by people in their daily lives, and not on projected doses.

In addition it is proposed to:

— Develop precise radiation maps of cities;
— Implement decontamination and reconstruction in a coherent way;
— Identify the sources of exposure based on actual individual doses and remove them;
— Use radiation shielding where decontamination is not sufficient in terms of dose reduction.

Teams of counsellors, selected by the local municipalities, will be deployed depending on the specific situation and needs of each municipality. The counsellors are intended to help people to manage individual doses, to ensure health consultations, and provide advice on dose reduction. Counsellors will also help evacuees who do not wish to return home by providing information on radiation protection and also help to rebuild their living conditions.

[4] By March 2015, remediation measures had been completed in 19 of these municipalities.

The counsellors will, themselves, be supported by a network of experts from radiation protection, radiation monitoring, and medical staff, and will be trained in order to provide advice that meets the practical needs of evacuees.

In December 2013, the fourth Supplement to the Interim Guidelines on Criteria for Determining Nuclear Damage Indemnification Coverage was published to cover the damage associated with prolonging the evacuation orders [I–18]. This Supplement covers the compensation for the mental suffering of people from the areas remaining off-limits for the foreseeable future, as well as the compensation for new housing for returning home or acquiring housing at new locations. People who had left an area where the evacuation order was lifted would continue to receive compensation for a period of one year (after the lifting of the evacuation order). People returning to live in the affected areas within a year after the lifting of the evacuation order would also be compensated for the fact that many services, such as public transport or shops will not be as available as they were before the nuclear accident [I–19] (see Section 5.5.4.4).

The process of returning people to evacuated areas began in April 2014 when, after discussions with evacuees and Tamura City Government, the evacuation order was lifted.

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