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Final Report

The Follow-up IAEA International Mission on Remediation of Large Contaminated Areas Off-Site the Fukushima Daiichi Nuclear Power Plant

Tokyo and Fukushima Prefecture, Japan

14 – 21 October 2013

Contents

EXECUTIVE SUMMARY

In October 2011, the IAEA conducted an International Mission to Japan to support the remediation of large contaminated areas off-site TEPCO's Fukushima Daiichi Nuclear Power Plant (NPP). In response to the request made by the Government of Japan, in October 2013, the IAEA organized a follow-up International Mission on remediation of large contaminated areas off-site TEPCO's Fukushima Daiichi NPP (hereinafter referred to as the "Follow-up Mission" or the "Mission") with the main purpose of evaluating the progress of the on-going remediation works achieved since the previous mission in October 2011.

The Follow-up Mission Team involved 13 international experts. Additionally, 3 experts of the Working Group 5 (Subgroup 5.2, Remediation) in charge of preparing the IAEA Report on TEPCO Fukushima Daiichi Accident accompanied the Mission as observers to obtain first-hand information for the report.

The Follow-up Mission had the following three objectives:

1. To provide assistance to Japan in assessing the progress made with the remediation of the Special Decontamination Area (not included in the previous mission of 2011) and the Intensive Contamination Survey Areas;
2. To review remediation strategies, plans and works, in view of the advice provided by the previous mission on remediation of large contaminated off-site areas; and
3. To share its findings with the international community as lessons learned.

The Mission was conducted through the assessment of information provided to the Team and by means of professional and open discussions with the relevant institutions in Japan, including national, prefectural and local institutions. The Japanese authorities provided comprehensive information on their remediation programme. The Mission Team visited the affected areas, including several sites where activities on remediation were conducted. The Team also visited some temporary storage sites for radioactive waste and soil generated in the remediation activities, as well as a survey area for the Interim Storage Facility for radioactive soil and waste, and a demonstration facility for incineration of sewage sludge.

Overview

The *Act on Special Measures Concerning the Handling of Radioactive Pollution (“the Act on Special Measures”)* was enacted in August 2011 and took full effect from January 2012 as the main legal instrument to deal with all remediation activities in the affected areas, as well as the management of materials removed as a result of remediation activities. The Basic Principles based on the Act were published in November 2011, thus creating an institutional framework to implement remediation activities.

According to the Act on Special Measures, the affected areas have been rearranged into two categories:

- Special Decontamination Area. The area consists of the “restricted areas” located within a 20 km radius from TEPCO’s Fukushima Daiichi NPP, and “deliberate evacuation areas” where the annual effective dose for individuals was anticipated to exceed 20 mSv. The national government organises decontamination in these areas.
- Intensive Contamination Survey Area. This area includes the so-called Decontamination Implementation Areas, where an additional annual cumulative dose between 1 mSv and 20 mSv was estimated for individuals. Municipalities implement decontamination activities in these areas. In all these areas the average air dose rate exceeded 0.23 μSv/hour.

In a pragmatic approach for the remediation programme, the Special Decontamination Area is further divided into the three following categories as shown in figure 2:

- Area 1 (Green). Estimated annual dose level is below 20 mSv (and above 1 mSv)
- Area 2 (Yellow). Estimated annual dose level is between 20 mSv and 50 mSv; and
- Area 3 (Red). Estimated annual dose level is over 50 mSv, and the annual effective dose is expected to be more than 20 mSv after five years.

This Mission focused on remediation in the Special Decontamination Area, as it was not considered under the scope of the previous mission, and on following up on progress regarding the advice provided by the previous mission to enhance remediation planning and implementation in all the affected areas.

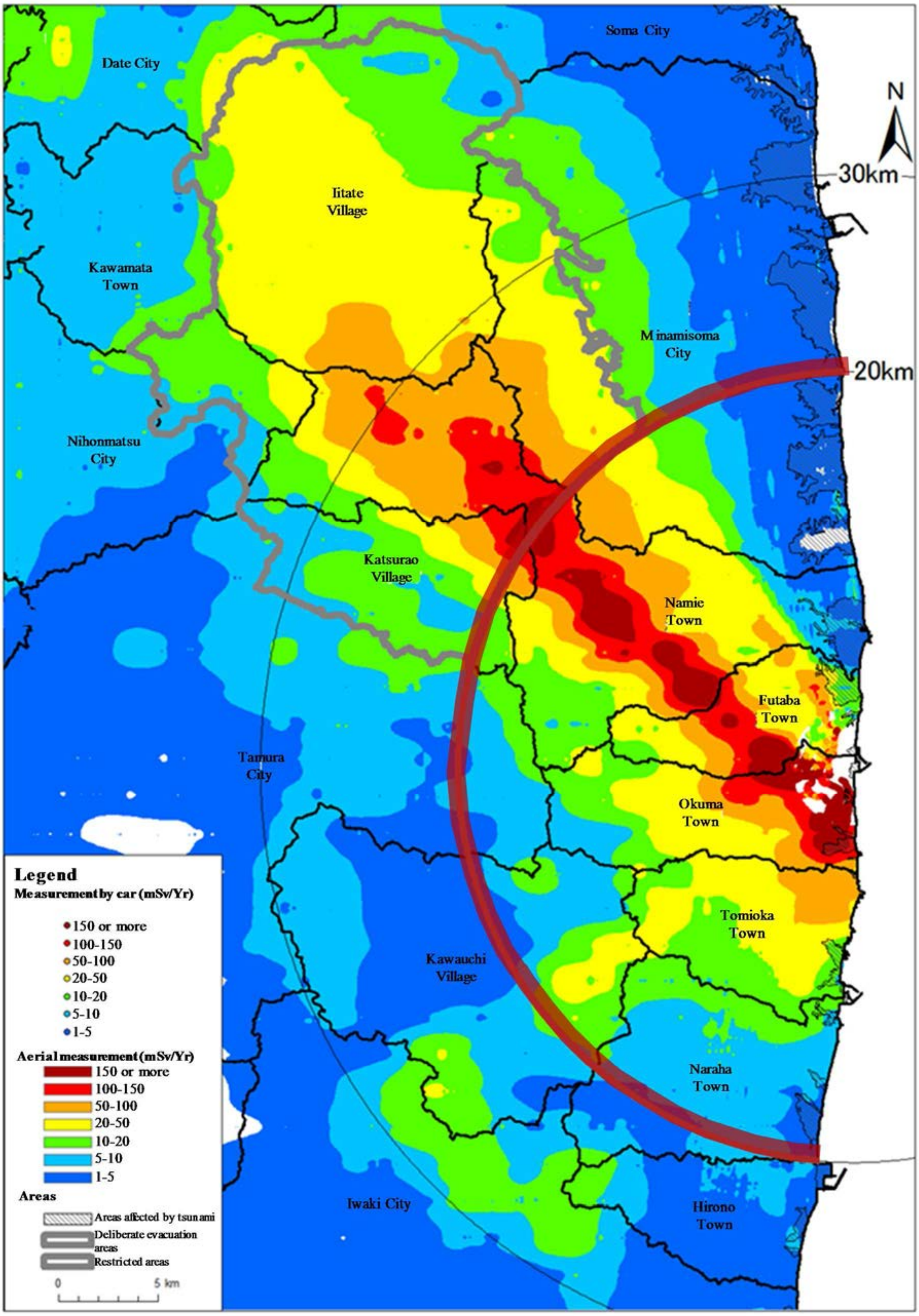

Figure 1: Restricted areas and areas to which evacuation orders have been issued around TEPCO's Fukushima Daiichi NPP (5 November, 2011).

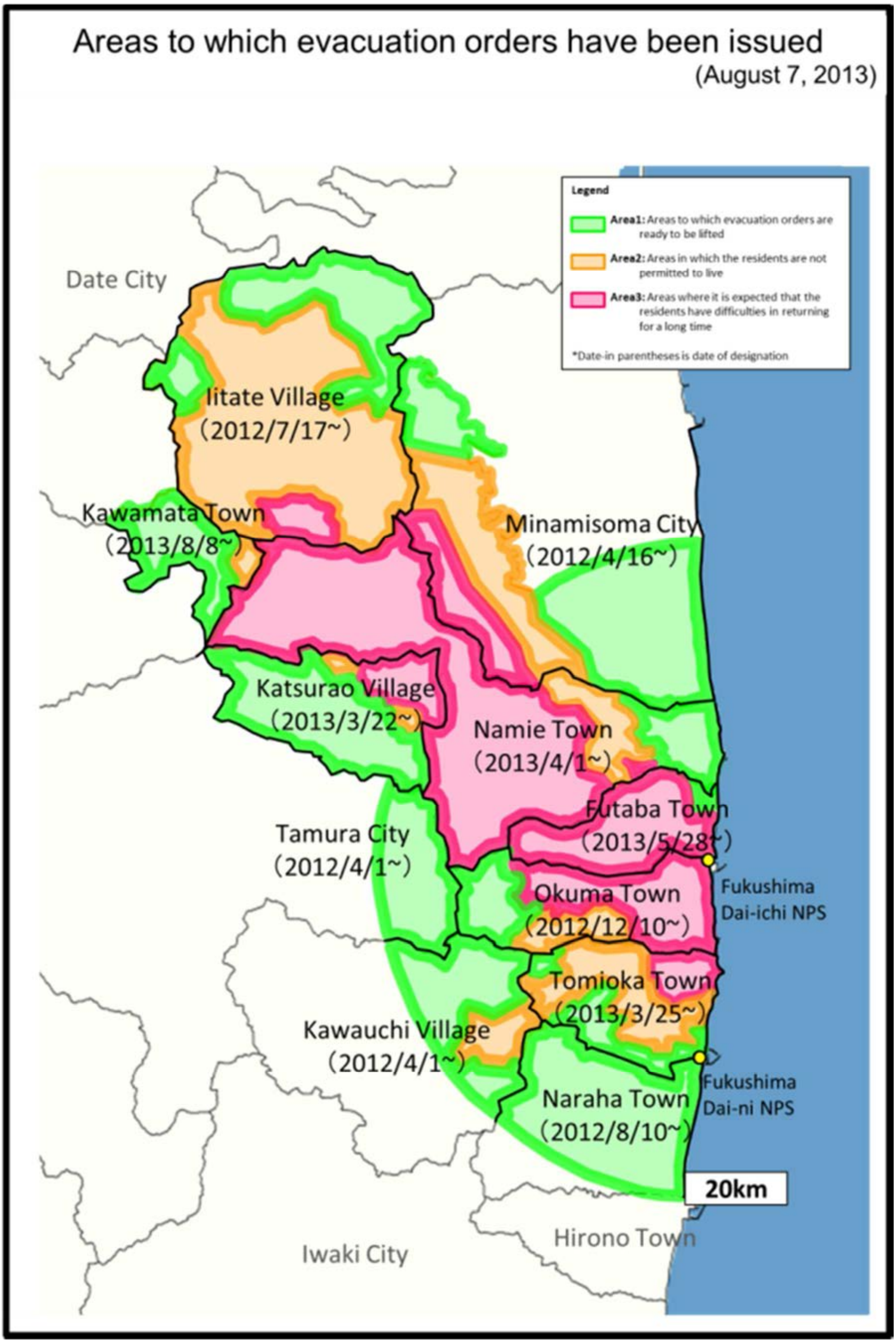

Figure 2: Current arrangement of the areas to which evacuation orders had previously been issued (7 August, 2013).

Main Findings

This report presents the main results and conclusions of the Mission.

The Team considers that the remediation of large contaminated areas represents a huge effort and recognizes that Japan is allocating enormous resources to developing strategies and plans and implementing remediation activities, with the aim of enhancing the living conditions of the people affected by the nuclear accident, including enabling evacuated people to return. The Team also considers that, as result of these efforts, Japan has achieved good progress in the remediation activities and, in general, has well considered the advice provided by the previous mission in 2011. The Team was pleased to see good progress in the coordination of remediation activities with reconstruction and revitalisation efforts.

The report also provides conclusions from the assessment of specific topics in the remediation programme, including the twelve points where the previous mission provided advice for improvement. It highlights important progress in all areas to date and offers advice on several points where the Team feels it is still possible to further improve current practices, taking into account both international standards and the experience of remediation programmes in other countries, which will further help to increase public confidence. While Japan continues its current remediation efforts, it is encouraged to take into consideration the Mission's advice for further optimisation of remediation activities.

HIGHLIGHTS OF IMPORTANT PROGRESS

Highlight 1: The Team acknowledges the institutional arrangements implemented by Japan to address the remediation needs of the areas affected by TEPCO’s Fukushima Daiichi NPP accident. The Team appreciates that Japan makes enormous efforts to implement the remediation programme in order to reduce exposures to people in the affected areas, to enable, stimulate and support the return of people evacuated after the accident, and to support the affected municipalities in overcoming economic and social disruptions. The review Team recognizes the involvement of a wide range of ministries and agencies, as well as institutions of the municipalities, to support remediation by providing financial resources, technical guidance and institutional assistance.

Highlight 2: Overall, the Team has seen many examples of good practice in stakeholder involvement, with demonstrable evidence that successful communication and engagement processes are being adopted at the national, prefectural and municipal level. It is clear that in some instances, key local community figures have been motivated to lead on engagement issues, gaining the trust of their communities. The national government is encouraging local authorities to conduct extensive consultations with local communities, and is respecting their outcome.

Highlight 3: The Team acknowledges that a large amount of crucial information (especially in relation to dose rates) has been produced since the accident that will help to drive decision-making processes. It is clearly important to foster confidence both in the accuracy of the information itself and in how it is interpreted, especially in terms of safety perceptions. This is particularly effective where trusted intermediaries are used, such as doctors and other independent experts.

Highlight 4: The Team believes that the Decontamination Information Plaza in Fukushima City and its associated outreach activities are a valuable asset in the overall stakeholder engagement process.

Highlight 5: The Team acknowledges that the Nuclear Regulation Authority (NRA) has set up a team to conduct a study on 'Safety and Security Measures towards Evacuees Returning Home'. It is beneficial to continue the measurement of individual external exposure doses for Fukushima Prefecture residents, to confirm the expected decreasing trend and justify the remediation decision as noted in Point 4. In addition to decontamination, other measures such as adjustment of life-styles and daily routines can also lead to reduction of individual exposures and to provide optimized protection.

Highlight 6: The Team welcomes the critical evaluation of the efficiency of the removal of contaminated material compared with the reduction in dose rate offered by different methods of decontamination, recognizing that this is an important tool in the application of decontamination methods. In addition, the Team notes a welcome change from guiding remediation efforts based on surface contamination reduction, to a reduction in air dose rates. This is leading some municipalities to conclude that an additional 1 mSv per year is more applicable to long-term dose reduction goals.

Highlight 7: The Mission Team welcomes the new approach for the comprehensive monitoring and management of data coordinated by the Nuclear Regulation Authority (NRA) for the purpose of assessing the status of environmental contamination.

Highlight 8: Good progress has been made in the remediation of affected farmland in the Intensive Contamination Survey Area. Furthermore, the intensive monitoring of foodstuffs has shown that much of the land can produce food below the reference level for permissible radioactivity, and that remediation measures such as the application of potassium fertilizer are effective. This result suggests that top soil removal is not necessarily the optimal solution to ensure food safety in the Intensive Contamination Survey Area.

Highlight 9: Comprehensive implementation of food safety measures has protected consumers and improved consumer confidence in farm produce, reflected in an increase in the economic value of the crops.

Highlight 10: Remediation of forests has been implemented in a limited manner by the removal of material under the trees in a 20-meter buffer strip adjacent to residences, farmland and public spaces, in response to public concern. The Mission Team acknowledges that the authorities in Japan have implemented a practical option for remediation of the forest areas.

Highlight 11: A comprehensive aquatic monitoring programme is ongoing. It includes environmental concentrations in water, sediment and suspended sediment, as well as extensive food monitoring of freshwater fish (wild and cultivated), with concentrations generally decreasing since 2011.

Highlight 12: The Mission Team found significant progress in the development and implementation of temporary storage facilities by municipalities and the national government for contaminated materials generated by on-going remediation activities. In addition, the Mission Team notes the progress made towards the establishment of interim storage facilities by the national government with the cooperation of municipalities and local communities.

Highlight 13: The Mission Team acknowledges that incineration is being used as an effective technology for volume reduction of contaminated material, with the adoption of measures to meet emission standards for limiting public exposure.

ADVICE

Point 1: To further improve the effectiveness of the institutional arrangements and public confidence in these arrangements, the relevant institutions in Japan are encouraged to assess the benefits that could be derived from a more active participation of the Nuclear Regulation Authority (NRA) in the review of remediation activities, with special consideration to the definition of relevant radiological remediation criteria and the review of the related safety assessments, particularly those required for the long term. The Mission Team also encourages the establishment of a mechanism and platform for learning and sharing the lessons from the development and implementation of temporary storage facilities between municipalities, and also between municipalities and the national government.

Point 2: Japanese institutions are encouraged to increase efforts to communicate that in remediation situations, any level of individual radiation dose in the range of 1 to 20 mSv per year is acceptable and in line with the international standards and with the recommendations from the relevant international organisations, e.g. ICRP, IAEA, UNSCEAR and WHO. The appropriate application of the optimisation principle in a remediation strategy, and its practical implementation, requires a balance of all factors that influence the situation, with the aim of obtaining the maximum benefit for the health and safety of the people affected. These facts have to be considered in communication with the public, in order to achieve a more realistic perception of radiation and related risks among the population.

The Government should strengthen its efforts to explain to the public that an additional individual dose of 1 mSv per year is a long-term goal, and that it cannot be achieved in a short time, e.g. solely by decontamination work. A step-by-step approach should be taken towards achieving this long-term goal. The benefits of this strategy, which would allow resources to be reallocated to the recovery of essential infrastructure to enhance living conditions, should be carefully communicated to the public.

The IAEA – and very likely also the international scientific community – is ready to support Japan in this challenging task.

Point 3: The Team believes that communicating the entire remediation and reconstruction programmes and how the various components interact (for example, trade-offs between reducing exposure and increasing waste volumes) could reduce some uncertainties and provide greater confidence in the decisions being made. Promoting a holistic view would also facilitate opportunities to plan key stakeholder engagement activities in advance, allowing the process to be proactive rather than reactive. It may be beneficial to formalise a process for sharing such initiatives between the municipalities, in order to determine whether these could be applied elsewhere. Such an approach might result in greater public confidence and contribute to enabling more people to return to their homes outside restricted areas.

Point 4: There needs to be a continued movement towards the use of the individual doses, as measured with personal dosimeters, to support remediation decisions. As the Nuclear Regulation Authority (NRA) is planning to coordinate a study that focuses on individual dose, it is recommended that the dose study include a background population and also tie individual dose measurements to decontamination efforts at the homes of the monitored individuals.

Point 5: The Team notes that by taking into consideration the natural processes leading to reduced availability of radiocaesium to crops, there is potential to further optimize the application of remediation measures and still produce safe foods. This will have the added benefit of conserving the nutrients in the soil and reducing the amount of removed soil that needs to be disposed of.

Point 6: The Team recommends continuing the optimization of the remediation of forest areas around residential areas, farmland and public spaces by concentrating efforts in areas that bring greatest benefit in reducing doses to the public and avoid damage to the ecological functioning of the forest where possible. The occupational hazards for remediation workers should be balanced against the benefit of the procedure in terms of dose rate and the concerns of residents. The impacts on erosion and radionuclide behaviour should be evaluated using models for radiocaesium in forests. Current research efforts by Japanese research centres are recommended to be included in this evaluation.

Point 7: The Team recommends continuing the monitoring of freshwater and marine environments, and suggests that these data be interpreted within the context of processes known to affect the concentrations of radiocaesium in water, sediment and biota. Monitoring data and further research may form the basis for consideration of site-specific remediation of affected areas.

Point 8: The Mission Team encourages the responsible organization(s) to carry out appropriate demonstrations of the safety of the facilities and activities for the management of contaminated materials, in particular for long-term activities, and to allow for their independent evaluation.

1. INTRODUCTION

The accident at TEPCO's Fukushima Daiichi NPP led to radioactive contamination of large areas. Soon after the accident the Government of Japan formulated a programme for the recovery of these areas.

As a major part of this recovery programme in the areas off-site the Fukushima Daiichi NPP, Japan is implementing remediation efforts. The final aim of the recovery strategy, and therefore of the remediation programme, is to improve the living conditions of the people affected by the accident.

In October 2011, the IAEA conducted an International Mission to Japan to support the remediation of large contaminated areas off-site TEPCO's Fukushima Daiichi NPP. The Mission was concluded by highlighting some areas where important progress was made and by formulating pieces of advice on several points where the Mission Team felt that practices could be improved.

In response to the request made by the Government of Japan, in October 2013, the IAEA organized this follow-up International Mission on Remediation of Large Contaminated Areas Off-site the Fukushima Daiichi NPP with the main purpose of evaluating the progress achieved with the on-going remediation works since the previous mission in October 2011. The Follow-up Mission Team involved 13 international experts. Additionally, 3 experts of the Working Group 5 (Subgroup 5.2, Remediation) in charge to prepare the IAEA Report on TEPCO's Fukushima Daiichi Accident accompanied the Mission, as observers to obtain first-hand information for the mentioned report.

The Follow-up Mission had the following three objectives:

1. To provide assistance to Japan in assessing the progress made with the remediation of the Special Decontamination Area (not included in the previous mission of 2011) and the Intensive Contamination Survey Areas;

2. To review remediation strategies, plans and works, in view of the advice provided by the previous mission on remediation of large contaminated off-site areas; and

3. To share its findings with the international community as lessons learned.

The authorities of Japan provided comprehensive information on their remediation programme. The Mission was conducted through the assessment of the information provided to the Team, and by means of professional and open discussions with the relevant institutions in Japan, including national, prefectural and local institutions. The Mission Team also visited the affected areas, including several sites where activities on remediation were conducted. The Team also visited some temporary storage sites for radioactive waste and soil, as well as a survey area for the future Interim Storage Facility for radioactive soil and waste generated in the remediation activities, and a demonstration facility for incineration of sewage sludge.

This Mission was in line with the IAEA Action Plan on the Nuclear Safety that was approved by the Board of Governors on 19 September 2011 and endorsed by the Member States of the IAEA. In particular, the Mission is in connection with actions to strengthen the emergency response to nuclear accidents and the protection of people and the environment from ionizing radiation.

2. INSTITUTIONAL ARRANGEMENTS AND GENERAL CONCEPTS

2.1. Main Findings

The remediation work in the areas affected by the accident at the Fukushima Daiichi NPP is organized according to the Act on Special Measures.

This act defines responsibilities for the national and local governments, the nuclear power producers and the citizens in the affected areas. It also defines the activities that have to be carried out in the different areas with regard to (i) monitoring and measurements to be taken, (ii) the treatment, storage and disposal of waste generated during remediation activities, and (iii) the measures to be taken for remediation, including decontamination.

2.2. Progress Made

To control the exposure of the public after the accident, the Government of Japan has implemented the Act on Special Measures, which divides the affected area into two categories:

- The "Special Decontamination Area" consists of the "restricted areas" located within a 20 km radius from TEPCO's Fukushima Daiichi NPP, and "Deliberate Evacuation Areas" where the annual effective dose for individuals was anticipated to exceed 20 mSv. The national government promotes decontamination in these areas.
- The "Intensive Contamination Survey Area" includes the so-called Decontamination Implementation Areas, where an additional annual effective dose between 1 mSv and 20 mSv was estimated for individuals. Municipalities implement decontamination activities in these areas. In all these areas the average air dose rate exceeded 0.23 µSv/hour.

In addition, regulation for activity concentrations in food were defined in 2011, which were further reduced in April 2012. From the beginning, intensive monitoring programmes to measure activity concentrations in foods were implemented to strictly control exposures from the intake of food.

Based on the Basic Principles on the Act of Special Measures, a system has been established to give priority to remediation activities in areas for which decontamination is most urgently required with respect to protection of human health and to implement such measures taking into account the existing levels of radiation. The Ministry of the Environment, as one of the implementing authorities, is coordinating and implementing remediation works giving due consideration to this policy on prioritisation.

However, the announcement made by the authorities shortly after the accident that "additional radiation dose levels should be reduced to annual doses below 1 mSv in the long run" is often misinterpreted and misunderstood among people, both inside and outside the Fukushima Prefecture. People generally expect that current additional radiation doses should be reduced below 1 mSv per year immediately, as they believe that they are only safe when additional dose they receive is below this value.

In existing exposure situations, any level of individual radiation dose in the range of 1 to 20 mSv per year is acceptable and in line with the international standards and with the recommendations from the relevant international organisations, e.g. ICRP, IAEA, UNSCEAR and WHO. The intention of recommending this range by international institutions is to identify an optimized strategy that cautiously and appropriately balances the different factors that influence the net benefit of the remediation measures to ensure dose reduction.

To facilitate the reconstruction process following the triple disaster of earthquake, tsunami and nuclear accident, the Reconstruction Agency was established in February 2012. In this framework, various ministries and authorities cooperate to optimize the remediation work:

- the Ministry of the Environment is responsible for off-site remediation and waste management;
- the Ministry of Agriculture, Forestry and Fishery is involved in countermeasures related to forest and agricultural areas;
- the Ministry of Health, Labour and Welfare is responsible for radiation protection of remediation workers;
- the Cabinet Office for the designation and rearrangement of evacuated areas, and
- the Nuclear Regulation Authority supports all activities by the coordination of monitoring and the provision of scientific and technical advice.

In the years from 2011 to 2013, 1,317 billion Yen were allocated for remediation and the management of waste that is being generated during the remediation work, etc.

Additionally, the Ministry of the Environment opened the Fukushima Office for Environmental Restoration in Fukushima City in January 2012 and five branch offices in

Fukushima Prefecture in April 2012 to conduct national remediation work and strengthen coordination with the local governments.

2.3. Highlight

Highlight 1: The Team acknowledges the institutional arrangements implemented by Japan to address the remediation needs of the areas affected by TEPCO's Fukushima Daiichi NPP accident. The Team appreciates that Japan makes enormous efforts to implement the remediation programme in order to reduce exposures to people in the affected areas, to enable, stimulate and support the return of people evacuated after the accident, and to support the affected municipalities in overcoming economic and social disruptions. The review Team recognizes the involvement of a wide range of ministries and agencies, as well as institutions of the municipalities, to support remediation by providing financial resources, technical guidance and institutional assistance.

2.4. Advice

Point 1:

To further improve the effectiveness of the institutional arrangements and public confidence in these arrangements, the relevant institutions in Japan are encouraged to assess the benefits that could be derived from a more active participation of the Nuclear Regulation Authority (NRA) in the review of remediation activities, with special consideration to the definition of relevant radiological remediation criteria and the review of the related safety assessments, particularly those required for the long term. The Mission Team also encourages the establishment of a mechanism and platform for learning and sharing the lessons from the development and implementation of temporary storage facilities between municipalities, and also between municipalities and the national government.

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Japanese institutions are encouraged to increase efforts to communicate that in remediation situations, any level of individual radiation dose in the range of 1 to 20 mSv per year is acceptable and in line with the international standards and with the recommendations from the relevant international organisations, e.g. ICRP, IAEA, UNSCEAR and WHO. The appropriate application of the optimisation principle in a remediation strategy, and its practical implementation, requires a balance of all factors that influence the situation, with the aim of obtaining the maximum benefit for the health and safety of the people affected. These facts have to be considered in communication with the public, in order to achieve a more realistic perception of radiation and related risks among the population.

The Government should strengthen its efforts to explain to the public that an additional individual dose of 1 mSv per year is a long-term goal, and that it cannot be achieved in a short time, e.g. solely by decontamination work. A step-by-step approach should be taken towards achieving this long-term goal. The benefits of this strategy, which would allow resources to be reallocated to the recovery of essential infrastructure to enhance living conditions, should be carefully communicated to the public.

The IAEA – and very likely also the international scientific community – is ready to support Japan in this challenging task.

3. STAKEHOLDER INVOLVEMENT

3.1. Main Findings

The Team has seen and heard about a wide range of interrelated challenges for the national government, prefectural and municipal authorities. Although these challenges are primarily technical, many if not all of them also have an important socio-political element. Therefore, overall progress will be greatly facilitated through gaining consensus among residents.

From the citizen's perspective there is a clear desire to see decontamination work being carried out, and for the relevant authorities to demonstrate its success in line with the predetermined objectives. One of the overriding concerns is the health implications of contaminated areas for children, both today and in the future. A further concern relates to the siting of both the temporary storage sites and interim storage facilities.

The formulation of the "Act on Special Measures Concerning the Handling of Radioactive Pollution" provided much needed clarity on the roles and responsibilities of the various authorities. It established the way that they would interact and their overall aspirations in terms of impact reduction. This provided a sound platform upon which the necessary stakeholder engagement activities were designed.

The success of remediation works is primarily demonstrated through the resultant reduction in overall dose rates. This is crucial for residents, so that when decontamination goals are achieved they will have renewed confidence to return to the previously contaminated regions, consume local products and rebuild their lives. Developing trust is the key to gaining such confidence, and it is imperative to engage closely with citizens through a formalised stakeholder engagement programme that is all-inclusive, transparent and continuous.

One example of such engagement is the Decontamination Information Plaza in Fukushima City, which provides an opportunity for people to learn in an interactive way, not only about the remediation projects being undertaken, but also about the principles of radiation protection, background radioactivity and how radioactive materials are used in daily life. Crucially, this helps to put the contamination and associated dose levels in the Fukushima Prefecture into context. Information is provided through websites and pamphlets, and a telephone hotline is available to provide answers to technical and health-related questions. Individuals have the opportunity to talk to medical and technical experts about the remediation works, and active outreach is conducted outside Fukushima City through mobile exhibits. The current generic design for the proposed Interim Storage Facilities also incorporates a Public Information Centre.

The Government initiative of engaging with the public and gaining their feedback through a consultation process on the "Basic Principles" of the decontamination programme was a crucial instrument in ensuring that an appropriate two way dialogue was put into practice. This approach should help the public to feel that their concerns, views and aspirations are being considered within the overall decision making process.

The provision of individual dose meters and the associated support process, whereby individuals' dose levels are explained to them by medical experts, offers a further example of how engagement is working at the prefecture and municipality levels. Within both the prefectures and municipalities there is clear evidence that respected community figures have been proactive in leading engagement activities to help the community to better understand the success of remediation activities and safety in relation to the temporary storage sites.

The Team was provided with examples of where technical approaches to remediation, the siting of temporary storage sites and the associated engagement activities had been successful. It is important that mechanisms are in place to ensure that this positive learning experience can be shared between the municipalities. It is also important that different approaches relating to either decontamination activities or engagement mechanisms are adequately explained in neighbouring municipalities.

It is crucial that opportunities are sought to ensure citizens understand that the remediation process often involves a balance between reducing exposure risks and increasing waste volumes. The communication of risk concept is therefore important, as is communication of the entire remediation life-cycle, so that a proactive rather than reactive approach to engagement can be adopted. Consideration of the complete lifecycle of the remediation works allows stakeholders to better understand the implications of each decision being made, so that such decisions are not assessed in isolation. Progress with siting of the interim storage facilities, for example, might provide greater trust and confidence that the waste accumulated at the temporary storage sites will have a place to be taken to and will not remain where it is currently stored.

It is recognised by all parties that there are still many challenges ahead especially in relation to people's confidence that they can safely return to their homes, as well as acceptance of the temporary waste storage sites being constructed in proximity to those already living there. Continued stakeholder engagement will, therefore, be a crucial part of the overall decontamination programme so that the public gains more confidence in the benefits of the decontamination activities and storage of resulting waste in the temporary waste storage sites.

3.2. Progress Made

During the previous expert mission in 2011, it was recommended that the national government considered utilising universities and other academic institutions to assist in the further development of stakeholder involvement strategies and the methods by which such strategies could be implemented. The rationale behind this suggestion was to bring together as much stakeholder expertise from within Japan as possible especially those who might have both national (culturally specific) and potentially international knowledge and experience. The Team was provided with many positive examples where both communication and two-way engagement is being practiced by the national government and local authorities.

The Team has seen that the importance of stakeholder engagement has been recognised at both the national and local levels, and that a wide range of interrelated approaches are being adopted. It is important not only to maintain but also to build upon this important facet of the work as engagement should be a continuous process. Planning engagement activities in advance as part of a more holistic approach will give opportunities to be seen as providing proactive rather than reactive engagement.

3.3. Highlights

Highlight 2: Overall, the Team has seen many examples of good practice in stakeholder involvement, with demonstrable evidence that successful communication and engagement processes are being adopted at the national, prefectural and municipal level. It is clear that in some instances, key local community figures have been motivated to lead on engagement issues, gaining the trust of their communities. The national government is encouraging local authorities to conduct extensive consultations with local communities, and is respecting their outcome.

Highlight 3: The Team acknowledges that a large amount of crucial information (especially in relation to dose rates) has been produced since the accident that will help to drive decision-making processes. It is clearly important to foster confidence both in the accuracy of the information itself and in how it is interpreted, especially in terms of safety perceptions. This is particularly effective where trusted intermediaries are used, such as doctors and other independent experts

Highlight 4: The Team believes that the Decontamination Information Plaza in Fukushima City and its associated outreach activities are a valuable asset in the overall stakeholder engagement process.

3.4. Advice

Point 3:

The Team believes that communicating the entire remediation and reconstruction programmes, and how the various components interact (for example, trade-offs between reducing exposure and increasing waste volumes), could reduce some uncertainties and provide greater confidence in the decisions being made. Promoting a holistic view would also facilitate opportunities to plan key stakeholder engagement activities in advance, allowing the process to be proactive rather than reactive. It may be beneficial to formalise a process for sharing such initiatives between the municipalities, in order to determine whether these could be applied elsewhere. Such an approach might result in greater public confidence and contribute to enabling more people to return to their homes outside restricted areas.

4. RADIATION PROTECTION

4.1. Main Findings

4.1.1. Radiation Protection of the Public

4.1.1.1.Dose criteria

The Mission Team acknowledges that the generic dose criterion for existing exposure situation declared by the Government of Japan is in the range of 1 to 20 mSv per year for the radiation exposure of public. Based on this criterion, the Japanese authorities have established secondary criteria of dose rate in the air and radiocaesium concentrations in different media.

4.1.1.2.Secondary criteria

Gamma doses in air

The dose rate assessments for established areas are based upon the following formula (example for 1 mSv per year):

{[0.23 (measured air dose rate) - 0.04 (natural radiation dose rate) μSv/h] x [8h+16h x 0.4 (shielding factor due to staying indoors)]} x 365 days/1000 = 1 mSv per year.

This estimation assumed 8 hours of outdoor and 16 hours of indoor activities.

The Mission Team has recognized that the values obtained from the calculation above, resulting from external exposure to radiation cannot be considered as radiation doses specific to an individual. Individual doses will be strongly dependent on the behaviour of an individual. These dose rates can only be taken as an indicator for a whole area, in which an individual person lives or is going to live. According to measurements of individual external doses using personal dosimeters, significant overestimation of individual doses may occur if such generically estimated air dose rates are taken as representative of doses to a specific individual. However, the Mission Team considers that such overestimation has the merit of providing public assurance of radiation safety.

Activity levels in food

The Mission Team has acknowledged that the limits for food were determined for the sum of activity concentrations of ^{134}Cs and ^{137}Cs taking into account an annual dose criterion of 1 mSv per year. The limit of 10 Bq/kg for drinking water was directly taken from the

"Guideline for drinking-water quality" of the WHO and would lead to an estimated annual dose value of 0.1 mSv, assuming a representative water consumption rate .

New limits for the sum of ^{134}Cs and ^{137}Cs (established by Ministry of Health, Labour and Welfare) came into force since 1 April 2012 of 10 Bq/kg for drinking water, 50 Bq/kg for milk, 50 Bq/kg for infant foods, and 100 Bq/kg for other food items.

The Mission Team acknowledges that radionuclide activity concentration limits in food were derived based on dose coefficients and equations identical to those used in the derivation of the current Codex Alimentarius guideline levels. Actual measured radionuclide concentrations in the vast majority of food (except for some forest products such as game animals and mushrooms) are significantly below the indicated limits and are constantly decreasing.

External exposure

The Mission Team was informed about the measurements of the individual external radiation doses collected from the municipalities in the Fukushima Prefecture, which were reported by the 6th Committee Meeting on Fukushima Health Management Survey, Fukushima Prefectural Government in April 2012. The summary includes the data for about 70,400 participants in 22 municipalities. Measurements were taken when short-lived iodine isotopes had already decayed away. Based on the available information, the average annual individual effective doses for all municipalities (around 0.1 to 0.2 mSv) are 3 to 7 times lower than those estimated using the equation above.

The Team acknowledges that the requirements of the IAEA International Basic Safety Standards (BSS), related to existing exposure situation reference dose range, are taken into account. Considering the decrease observed in the values of air dose rates since 2011 to the present, the individual doses due to the external exposure to radiation will decrease correspondingly in future years. It is recommended to continue the monitoring of air dose rate to quantify this trend. It is beneficial to give opportunities to measure individual external exposure doses for Fukushima Prefecture residents, especially children, to provide reassurance in response to the population's concerns about health risks.

Internal exposure

The Team has been informed about the large-scale program of food control and had the opportunity to visit a measurement facility for rice in Date City. The measurement facility visit confirmed the practical feasibility of large scale surveys of packaged rice (millions of measurements). The Mission Team was told that only a negligible percentage of packages had radiocaesium activity concentration above 100 Bq/kg. The good practice of food monitoring for radionuclide activity concentrations is acknowledged by the Team.

The Mission Team was informed that a whole body counting survey, involving 149,578 residents of Fukushima Prefecture, was carried out in the period between June 2011 and August 2013. The committed effective doses of internal exposure due to radiocaesium intake were below 1 mSv for 149,566 people. In ten and two cases this value was estimated to be in the order of 2 mSv and 3 mSv, respectively.

The Mission Team considers that the resulting doses from internal exposure to radiation in Fukushima residents are very low. Consequently, future extensive internal exposure surveys of the general population of Fukushima Prefecture is not recommended. Only the residents returning to their homes should be involved in the programme of whole body counting survey.

4.1.2. Radiation Protection of Remediation Workers

The Mission Team has appreciated that the Government of Japan has established the "Guideline on Prevention of Radiation Hazards for Workers Engaged in Decontamination Works" in December 2011. This guideline requires that contractors, that will be performing decontamination works, make efforts to minimize exposure of their employees to ionizing radiation to the fullest extent possible. The newly amended scheme of radiation protection for workers also regulates activities for waste disposal works of materials contaminated by radioactive isotopes released during the accident. The new scope includes protection from external exposure, prevention from contamination and training of workers. In the implementation of decontamination works, a contractor should also perform contamination level and air dose rate measurements before and after performing decontamination to evaluate the effectiveness of their activities.

The Mission Team has observed that soil and forest decontamination workers and waste management workers are provided with personal monitors. In the case of temporary storage facilities, workers are provided with radiation detectors to regularly measure exposure levels. The visited incineration facility, which is part of waste management process, makes use of many kinds of personal protective equipment needed for radiation protection. The air pressure inside the incinerator building is kept lower than the outside air pressure to prevent potentially contaminated air going outside the facility. Air contamination levels are measured in-situ regularly. The facility also performs both internal and external worker's contamination monitoring regularly. Stand-alone air dose monitors are placed in some strategic points such as in the entry and exit of building's offices area. The reading can be easily checked by passing people.

The Mission team acknowledges that records of all kinds of radiation protection measurements e.g. radiation doses received by the worker, are kept within the decontamination companies or radioactive waste facility accordingly.

The Mission Team has seen many good radiation protection practices being implemented in the incineration facility. The above mentioned Guideline can also be considered as being in line with the IAEA standards for planned exposure situations for radiation workers. In the decontamination of forest areas, however, conventional hazards could be of more relevance than the radiation hazards. Slippery areas during rainy season and land contours of the forests have the potential to increase the conventional risks of accidents for the workers. Nevertheless, the Mission Team has acknowledged that good radiation protection practices and assessment of radiation doses received both by the public and by radiation workers is a very good measure to increase public confidence in the decontamination program.

4.2. Highlight

Highlight 5: The Team acknowledges that the Nuclear Regulation Authority (NRA) has set up a team to conduct a study on 'Safety and Security Measures towards Evacuees Returning Home'. It is beneficial to continue the measurement of individual external exposure doses for Fukushima Prefecture residents, to confirm the expected decreasing trend and justify the remediation decision as noted in Point 4. In addition to decontamination, other measures such as adjustment of life-styles and daily routines can also lead to reduction of individual exposures and to provide optimized protection.

5. REMEDIATION STRATEGY IMPLEMENTATION

5.1. General Concepts and Remediation of Populated Areas

5.1.1. Main Findings

The remediation approach in the populated areas affected by the Fukushima Daiichi nuclear accident is based on the designation of the area into one of two categories, namely Special Decontamination Area and Intensive Contamination Survey Area. In the first area the national government develops a remediation implementation plan for each municipality and selects contractors that perform remediation work. Before the work is carried out, contractors may implement pilot tests and decide upon the most effective procedures. In the second, municipalities implement decontamination. To assist the municipalities in developing a remediation approach, the MOE developed Decontamination Guidelines as shown below**:**

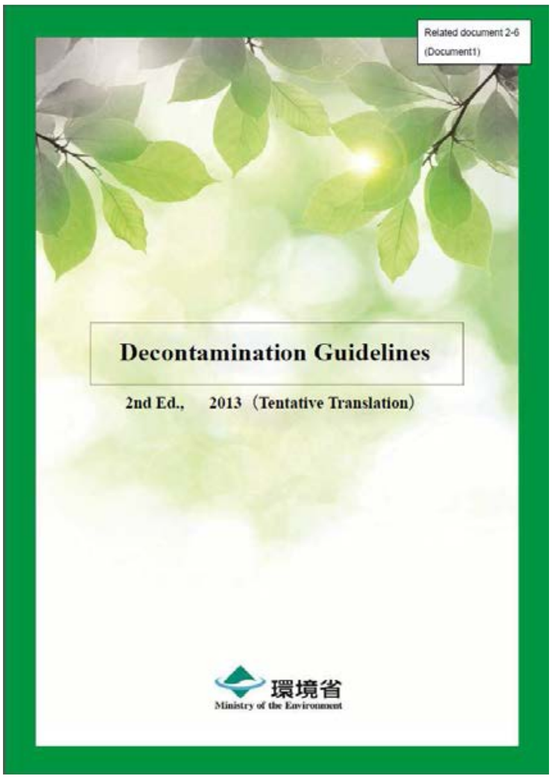

Figure 3: Front page of the Decontamination Guidelines produced by the Ministry of the Environment.

The Decontamination Guidelines present the municipalities different techniques of decontamination. This is an important achievement. These guidelines are intended to explain decontamination processes in a concrete and straightforward manner. The guidelines are divided into four parts: *i*) the Guidelines for Methods for Investigating and Measuring the Status of Environmental Pollution in Intensive Contamination Survey Areas; *ii*) the

Guidelines Pertaining to Decontamination and Other Measures; *iii*) the Guidelines Pertaining to the Collection and Transfer of Removed Soil, and *iv*) Guidelines Pertaining to the Storage of Removed Soil. The first edition of these guidelines, which was formulated in December 2011, has been revised and now incorporates lessons learned and new technologies acquired since the first edition to promote more effective decontamination. In addition to the Decontamination Guidelines, the MOE has established a website (in Japanese) titled Decontamination Technology Options Exploitation (DETOX) to provide municipalities and potential contractors with information on decontamination and waste management/minimization technologies. Finally, from November 2011 to March 2013, sixty-two technologies were completed and demonstrated through an evaluation process. Currently eleven additional technologies are under evaluation.

It has been demonstrated by the Nuclear Regulation Authority (NRA) that the risk of internal dose from radioactive contamination in populated areas is very low. The most commonly used methods of decontamination are those that reduce external exposures and are most suitable for application on a large scale. Therefore, ongoing remediation efforts largely focus on the reduction of external radiation dose through the removal of radioactive contamination from the living environment. This is achieved by removing the soil and fallen leaves, washing or wiping of the contaminated surface of different objects, etc. Additional remediation efforts also involve a modification in the exposure pathway by covering the contaminated soil with non-contaminated soil and ploughing gardens and agricultural fields. Table 1 presents some of the techniques used for decontamination and the situations in which they are used.

Table 1: Decontamination techniques used to remove radioactive material from different objects.

Decontaminated item	Decontamination technique used
Eaves and roof gutters	Wiping and high-pressure washing after removing deposited material
Storm water catch basins	High-pressure washing after removing deposited material
Street gutters	High-pressure washing after removing deposited material
Roofs	Wiping, washing, high-pressure washing
Outer walls	Wiping, washing, high-pressure washing
Gardens and other grounds	Mowing grass, collection of clippings, pruning, surface soil removal, replacing turf, ploughing
Parking lots and other paved surfaces	Washing, high-pressure washing, surface removal (shot blasting, grit blasting, etc.)
School athletic grounds etc. (dirt)	Surface dirt removal
Roads (asphalt paved surfaces)	Washing, high-pressure washing, shaving off

The implementation of some of the methods described in table is shown in Figure 4.


Wiping off rooftop and walls


Wiping off a gutter


High pressure water cleaning of a drain pipe


High pressure water cleaning of paved road


Mowing and removal of sludge


Removal of crushed stones and topsoil, and cover with clean soil

Figure 4: Demonstration of some decontamination methods utilized in the remediation works.

If any alternative technologies to those outlined in the Decontamination Guidelines are proposed for application, individual consultation between a municipality and the MOE is held to study their appropriateness. A final decision is made by the MOE through the management process.

The national government has carried out model projects and preliminary decontamination projects to evaluate the effectiveness of decontamination technologies. The decontamination effectiveness is generally expressed as the decrease rate in the surface contamination density due to each decontamination technique. The completion of these projects constitutes an important achievement as data related to the decontamination rates are being accumulated to help guide future decontamination efforts.

Examples of decontamination effectiveness for some of the methods provided in the previous table are shown below. However, these decontamination methods may become less effective (with respect to per cent reduction in dose rates) as time passes and natural decay and weathering occur.

- 60 to 80% after surface wiping
- 40 to 80% after high-pressure washing
- Up to 60% after mowing
- 40 to 80% when topsoil is stripped
- 70 to 100% when soil is replaced (for cases of higher levels of contamination)

The reduction rate for high-pressure washing varied greatly regardless of the levels of surface contamination. However, high pressure washing techniques generate a large volume of water that needs to be treated. Therefore, nearly all wet roof decontamination has been replaced with wiping methods and other wet decontamination methods. The MOE provides guidance on appropriate implementation of wet and non-wet decontamination methods and considers the needs to manage secondary waste.

The contamination reduction rates of different decontamination techniques, as listed above, have normally been evaluated for individual methods. However, the reduction in dose is normally measured collectively after application of several technologies. In field remediation efforts, it may be the case that only a few of the decontamination methods used will achieve substantial reductions in the measure dose rate (after decontamination). Therefore, it would be useful to identify which specific decontamination methods are most effective in reducing the overall dose to individuals for different types of remediated areas. When additional planning factors are included, such as cost, schedule, and safety, it may be possible to exclude some decontamination methods that do not greatly contribute to the reduction of the dose rate. This procedure could speed up the remediation process and reduce costs and associated waste volumes.

A further important aspect discussed with the Japanese counterparts is the influence of the background[1] in the determination of the contamination reduction rates after the application of a specific technique. If the background level is high compared with the extent of contamination, the decrease of the dose rate appears to be small even if surface decontamination is carried out and is very efficient. The reason for the observation is that whilst the radiation dose from the treated contamination surface at the exact location decreases when decontamination is performed, the contamination remains in the surrounding area, so there is no decrease in the background (surrounding) radiation dose. Therefore, the measured radiation dose does not decrease much, even though the radioactive material in a specific surface has been removed. In such situations where the degree of contamination at a specific surface is relatively low, the background effects will dominate, and thus the effect of decontamination on the overall radiation dose at that specific location will not be evident.

The Cabinet Office provided the Mission Team with the predictions of air dose rates for up to 21 years after the accident - which allow for physical decay, weathering and migration of radiocaesium down the soil profile. The predictions constitute a valuable tool for focusing the decontamination effort. The predictions show a decline in external dose rates from around 10 mSv per year to below 5 mSv per year in most of the Intensive Contamination Survey Area. Currently, considerable resources are being applied in remediation efforts in the Intensive Contamination Survey Area where people receive relatively low doses. The Mission Team believes that delaying decontamination a few years may be considered as a viable strategy as it may make decontamination unnecessary in some of these areas in the near future.

It has recently been demonstrated that the air dose rate, registered by means of flyover methods or ground level measurements (in μSv/hour), is a conservative estimate of the

[1] Background involves radioactive material present in the natural world, radioactive material released by nuclear testing etc.), and radioactive material derived from the accident which is present at a location a short distance away from the measuring point.

annual dose. In six sample populations from different municipalities, the actual mean integrated dose from personal dosimeters was 2.6 to 7 times lower than the mean estimated dose calculated using air dose rates. Long-term dose monitoring integrates the variations in dose rates with location and time and provides useful data for indicating whether decontamination goals have been achieved. Therefore, the individual dose, measured by means of personal dosimeters, potentially provides a good tool in generating useful information for remediation, acceleration of efforts and better use of resources including labour which is currently a constraint. It would provide better information to guide where the highest individual doses will be received by residents. Collecting individual dose using dosimeters in an appropriate manner requires logistical and labour efforts from the community health sector in municipalities. Nevertheless, the benefits in being able to optimize where and when to perform remediation efforts using the most relevant dose rate data may be of great benefit in reducing labour requirements for remediation.

5.1.2. Progress Made

In the previous IAEA mission (October 2011), it was acknowledge that some school sites were remediated. On that occasion the Mission Team was informed that 400 school playgrounds had already been appropriately remediated. It has also been appreciated by the Team that the use of demonstration sites to test and assess various remediation methods was a very helpful way to support the decision-making process.

In this Mission, it was reported that decontamination plans have been established in 10 municipalities out of 11 target municipalities in the Special Decontamination Area and that decontamination work is going on or is in preparation in 9 municipalities and has already been completed in 1 city (Tamura) according to its plan[2].

In relation to the Intensive Contamination Survey Area, 100 municipalities had to implement monitoring surveys and formulate a decontamination implementation plan which stipulates area, method and contractors to implement decontamination work. As of the end of March 2013, plans have been formulated in 94 municipalities. As the decontamination involves large areas (including public facilities, residential houses, roads, farmland and forest) municipalities had to clarify the targets and priorities, with consideration to the protection of

[2] Decontamination work in a municipality is implemented only after the development of the decontamination plan and securing the consent of land owners and of temporary storage sites.

public health. Decontamination work is now being implemented based on the decontamination plans developed by each municipality. These efforts clearly represent significant progress compared with the situation in 2011. Nevertheless, decontamination may take up to 5 years in many municipalities (mainly in Fukushima Prefecture), and 2 to 3 years in municipalities in other prefectures.

In the Report of the 2011 mission, attention was called to the potential risk of misunderstandings that could arise if the efforts were directed only or mainly to activities per unit area [surface contamination levels (Bq/m^2) or activity concentrations (Bq/m^3)] rather than dose levels. It was suggested that investment of time and effort in removing contamination beyond certain levels (the so-called optimized levels) from everywhere, such as all forest areas and areas where the additional exposure is relatively low, would not automatically lead to a reduction of doses for the public. It was also emphasized that the risk of generating unnecessarily huge amounts of residual material should be taken into consideration. The Team encouraged authorities to maintain their focus on remediation activities that bring the best results in reducing the doses to the public. From the discussions presented above it becomes clear that this recommendation has been taken into consideration by the Japanese authorities.

5.1.3. Highlight

Highlight 6: The Team welcomes the critical evaluation of the efficiency of the removal of contaminated material compared with the reduction in dose rate offered by different methods of decontamination, recognizing that this is an important tool in the application of decontamination methods. In addition, the Team notes a welcome change from guiding remediation efforts based on surface contamination reduction, to a reduction in air dose rates. This is leading some Municipalities to conclude that an additional 1 mSv per year is more applicable to long-term dose reduction goals.

Highlight 7: The Mission Team welcomes the new approach for the comprehensive monitoring and management of data coordinated by the Nuclear Regulation Authority (NRA) for the purpose of assessing the status of environmental contamination.

5.1.4. Advice

Point 4:

There needs to be a continued movement towards the use of the individual doses, as measured with personal dosimeters, to support remediation decisions. As the Nuclear Regulation Authority (NRA) is planning to propose a study that focuses on individual dose, it is recommended that the dose study include a background population and also tie individual dose measurements to decontamination efforts at the homes of the monitored individuals.

5.2.Food and Agricultural Areas

5.2.1. Main Findings

5.2.1.1.Reduction of total annual dose to the public

The intensive food monitoring and prompt implementation of food restrictions after the Fukushima Daiichi NPP accident greatly reduced the internal dose and has contributed to the targeted reduction of the total annual dose to the public. Since then, internal dose has been minimized by continuing food restrictions, the extent and ready accessibility of food monitoring, removal of land from production (e.g. currently (Oct 2013) 5,300 hectares of rice paddy fields have been kept out of production) and the decline in availability and transfer of radiocaesium from soils to crops.

Food restrictions have been essential in ensuring low internal dose during the first two years after the accident. However, further remediation of farmland is necessary to ensure future reduced annual radiation doses to the public, while resuming agricultural production and restoring rural livelihoods.

5.2.1.2.Remedial options implemented

About 18,200 hectares of farmland have been remediated in the Intensive Contamination Survey Area (Figure 5). It is expected that remediation of over 26,500 hectares will be carried out by the end of 2014. The number of farmers who will restart agricultural activities in the Special Decontamination Area depends on the progress of remediation and the subsequent lifting of evacuation orders in each municipality.

The ongoing remediation largely involves decontamination and treatment of land by ploughing or enhanced fertilization. Remediation measures for each area are selected on a case-by-case basis depending on the current radiocaesium activity concentration; in the topsoil, as well as the farmers' preference. Current remediation measures include application of potassium fertilizer, cleaning or pruning of fruit trees, deep ploughing and topsoil removal. The average cost for remediation of farmland is about 1,500 yen/m^2 in the Special Decontamination Area.

Figure 5: Paddy rice fields are being remediated, producing safe rice

The current recommended threshold for topsoil removal remained the same as in 2011, namely a radiocaesium activity concentration in the soil equal or higher than 5,000 Bq/kg. The amount of potassium fertilizer applied depends on soil type and fertility level and is modified in response to measured radiocaesium activity concentrations in the harvested crops.

Intensive monitoring of foodstuffs has shown that much of the remediated land can produce food below the reference level for permissible radioactivity, and that remediation measures are effective. When topsoil does not have to be removed, it has the advantage that nutrients can be conserved and less soil has to be disposed.

The radiocaesium activity concentration in soils will be lower than originally measured soon after the accident, due to natural processes. Such natural processes include natural decay of radiocaesium, in particular ^{134}Cs with a short half-life of 2 years. With regard to activity concentration in food products, application of potassium fertilizer and increasing fixation of radiocaesium by the soil will further reduce the uptake of radiocaesium by crops. This is confirmed by monitoring data in Fukushima Prefecture showing that only 71 out of 10 million rice bags exceeded the reference level in 2012.

5.2.1.3.Food safety measures

Immediately after the accident at the TEPCO's Fukushima Daiichi NPP on 11 March 2011, the Government of Japan set provisional regulation values by adopting the "Indices relating to limits on food and drink ingestion" which had been determined to prepare for nuclear emergencies, on the basis of an intervention level of 5 mSv per year. On 1 April 2012, the Government of Japan established current limits on a basis of 1 mSv per year, consistent with the Codex Alimentarius guideline levels. The limits of total radioactivity attributable to ^{134}Cs and ^{137}Cs are 100 Bq/kg for general foods, 50 Bq/kg for milk and infant foods, or 10 Bq/kg for drinking water. The further reduction of the regulation measure resulted in increasing confidence in food products from the affected areas. Prices for beef, peach and cucumber in 2012 were about 20 to 30 % lower than before the accident; but recently the prices of some products from Fukushima have increased, reflecting the return of consumers' confidence in food from the affected areas.

Comprehensive monitoring of food products has protected the food chain in Japan. However, despite the rapid decline of ^{134}Cs in food and soils over the next few years, long-term sustainable solutions will need to be identified due to the long physical half-life of ^{137}Cs of about 30 years. These solutions will require a good understanding of the behavior of radiocaesium in the contaminated areas in Japan, and the application of reliable models for predicting the transfer of radiocaesium in the environment.

5.2.2. Highlights

Highlight 8: Good progress has been made in the remediation of affected farmland in the Intensive Contamination Survey Area. Furthermore, the intensive monitoring of foodstuffs has shown that much of the land can produce food below the reference level for permissible radioactivity, and that remediation measures such as the application of potassium fertilizer are effective. This result suggests that top soil removal is not necessarily the optimal solution to ensure food safety in the Intensive Contamination Survey Area.

Highlight 9: Comprehensive implementation of food safety measures has protected consumers and improved consumer confidence in farm produce, reflected in an increase in the economic value of the crops.

5.2.3. Advice

Point 5:

The Team notes that by taking into consideration the natural processes leading to reduced availability of radiocaesium to crops, there is potential to further optimize the application of remediation measures and still produce safe foods. This will have the added benefit of conserving the nutrients in the soil and reducing the amount of removed soil that needs to be disposed of.

5.3. Forest Areas

5.3.1. Main Findings

Remediation of contaminated forested areas as shown in Figure 6 has started. Plant material and the upper organic litter layer of forest soil are being removed from the first twenty meters of forest adjacent to residential areas, farmland and public spaces (e.g. forest tracks). The average cost for remediation of forest is about 1300 yen/m^2 in the Special Decontamination Area.

The partial decontamination of forests has reduced the external dose rate by about 30-40% at the sites of decontamination, but some of the areas being cleaned up have low external dose rates, and therefore the actual reduction of doses to people is small. The costs of these activities are high, and the main benefit is in reducing public concern about the received annual dose. However, there are some disadvantages associated with this method of remediation, notably the detrimental impact potentially associated with greater soil erosion and possible redistribution and migration of radionuclides inside and outside the forests. Implementation also brings occupational risks for remediation workers, due to the challenges of working on steep slopes using cutting instruments in slippery and sometimes wet conditions.

The balance between the advantages and disadvantages of remediation of forests varies with dose rate, population density and topography. Therefore, the decontamination of forest land should be optimized by being flexibly implemented on a case-by-case basis.

Figure 6: Remediation of forests around residential areas, farmland and public spaces.

5.3.2. Highlight

Highlight 10: Remediation of forests has been implemented in a limited manner by the removal of material under the trees in a 20-meter buffer strip adjacent to residences, farmland and public spaces, in response to public concern. The Mission Team acknowledges that the authorities in Japan have implemented a practical option for remediation of the forest areas.

5.3.3. Advice

Point 6:

The Team recommends continuing the optimization of the remediation of forest areas around residential areas, farmland and public spaces by concentrating efforts in areas that bring greatest benefit in reducing doses to the public and avoid damage to the ecological functioning of the forest where possible. The occupational hazards for remediation workers should be balanced against the benefit of the procedure in terms of dose rate and the concerns of residents. The impacts on erosion and radionuclide behaviour should be evaluated using models for radiocaesium in forests. Current research efforts by Japanese research centres are recommended to be included in this evaluation.

5.4. Aquatic Areas

5.4.1. Main Findings

The area impacted by the Fukushima accident contains a number of streams and rivers draining steep, forested catchments. These streams and rivers are linked to an extensive network of weirs and irrigation channels that support rice cultivation in floodplains and lowlands. Monitoring of sediment, suspended sediment, water and biota in freshwater ecosystems for radiocaesium has continued in Fukushima Prefecture and other prefectures within the Intensive Contamination Survey Area. These data indicate declining radiocaesium activity concentrations in water of lakes and rivers, of less than 1 Bq/l, and more variable patterns for sediment and aquatic species.

Even though freshwater ecosystems make insignificant direct contributions to the annual dose to the general public (limited external exposure and internal doses to a limited number of consumers), catchment losses and sediment transport could lead to accumulation of radiocaesium in low lying areas such as paddy fields.

Given the complexities in manipulating aquatic ecosystems, remediation is unlikely to yield significant and lasting positive effects. Remediation efforts have been tested after the Chernobyl accident, but have not been successfully implemented for freshwater systems.

There is the potential to manage irrigation practices to avoid contamination of floodplain soils by sediment transported from contaminated catchments, but research efforts are needed to evaluate their effectiveness, feasibility and applicability. For instance, the irrigation of floodplain agriculture could be timed to exclude periods of high flow and turbidity to minimize the opportunity for recontamination of decontaminated soils with more contaminated sediment. As radiocaesium activity concentrations continue to decline, deposits of fine-grained contaminated sediment behind irrigation weirs could be removed, further reducing the potential for transport of contaminated sediment to agricultural lands.

5.4.2. Highlight

Highlight 11: A comprehensive aquatic monitoring programme is ongoing. It includes environmental concentrations in water, sediment and suspended sediment, as well as extensive food monitoring of freshwater fish (wild and cultivated), with concentrations generally decreasing since 2011.

5.4.3. Advice

Point 7:

The Team recommends continuing the monitoring of freshwater and marine environments, and suggests that these data be interpreted within the context of processes known to affect the concentrations of radiocaesium in water, sediment and biota. Monitoring data and further research may form the basis for consideration of site-specific remediation of affected areas.

6. WASTE MANAGEMENT

6.1. Main Findings

6.1.1. Waste Management Strategy, Categorization and Clearance

A major focus of on-going recovery efforts is related to the management of very large volume of contaminated material generated from remediation activities. For Fukushima Prefecture, the estimated volume is 28 million m^3. Managing such enormous volume requires extraordinary efforts in handling, treating, storing and eventual disposal of the material. The “Act on special measures” has provided all stakeholders (national government, local government and municipalities) with a good basis and framework for the organization and implementation of activities and measures for management of the contaminated material.

The MOE has defined criteria for categorization of contaminated material with regard to origin and activity concentrations. It has also specified the responsibilities of agencies at national and local levels for the management of the different categories of contaminated materials throughout their lifecycle. This definition of categories and allocation of responsibilities has provided a clear path forward in the management of contaminated material, as observed by the Mission Team during the review meetings and site visits. The flow diagram for treatment of specified waste and waste and soil from decontamination (Fukushima Prefecture) is shown in Figure 7.

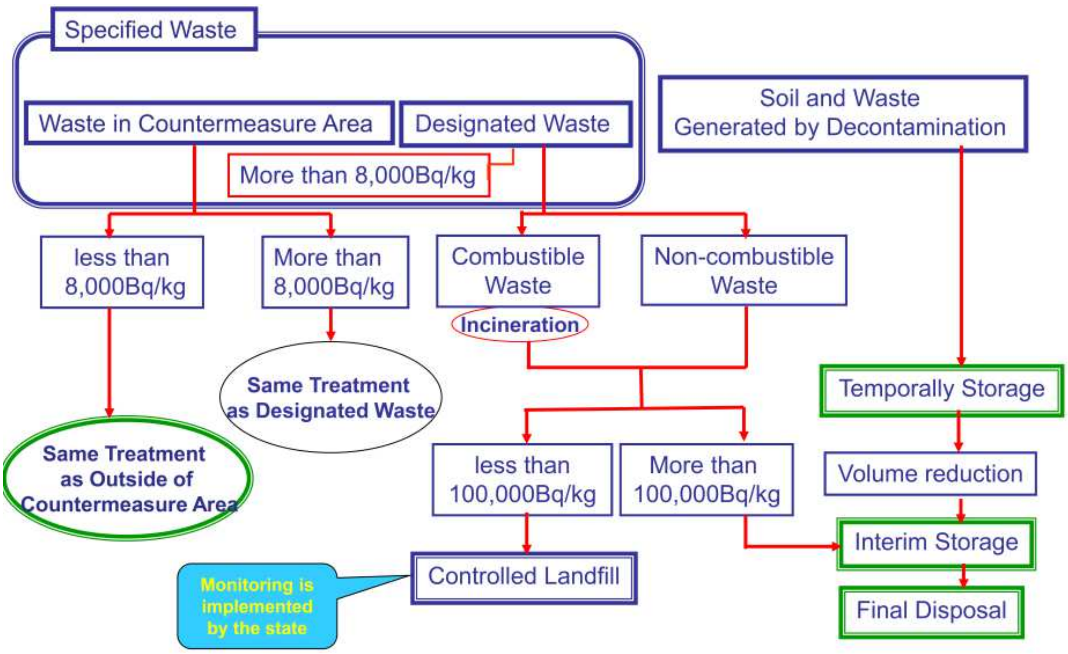

Figure 7: Flow diagram for treatment of specified waste and decontamination waste and soil (Fukushima Prefecture).

The 2011 mission pointed out that a substantial proportion of contaminated waste has only very low levels of contamination. Therefore, it was suggested that appropriate criteria be established that would allow part of that material to be declared as conditionally cleared material i.e. not to be treated as radioactive waste. In this regard, the Mission Team noted the progress made in terms of guidelines issued by the MOE for recycling of incombustible disaster waste e.g. use of concrete debris as base course material for construction of roads. According to these guidelines, concrete debris with activity up to 3,000 Bq/kg can be utilized in this way provided that a 30 cm thick shielding layer is placed on the top of the contaminated material (Figure 8).

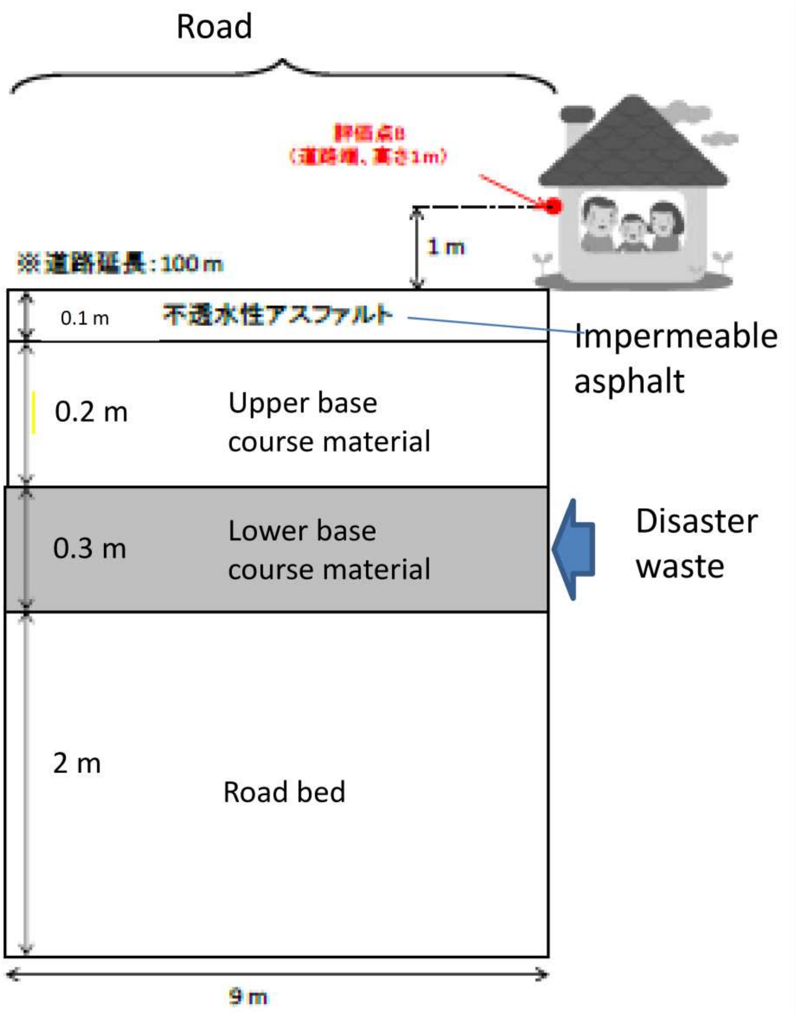

Figure 8. Use of conditionally cleared material for road construction.

The Mission Team encourages the extensive implementation of these guidelines and other possible ways of conditional clearance as this will contribute to reducing the burden of managing very large volumes of contaminated material as radioactive waste.

6.1.2. Storage of Contaminated Material

According to the Decontamination Plan formulated by the MOE, contaminated soil and waste generated from decontamination activities in Fukushima Prefecture are to be collected and stored at, or near, the sites undergoing decontamination in temporary storage facilities for approximately 3 years. Afterwards, the material will be placed in an Interim Storage Facility (ISF), and after interim storage up to 30 years, final disposal will be carried out outside Fukushima Prefecture (Figure 9).

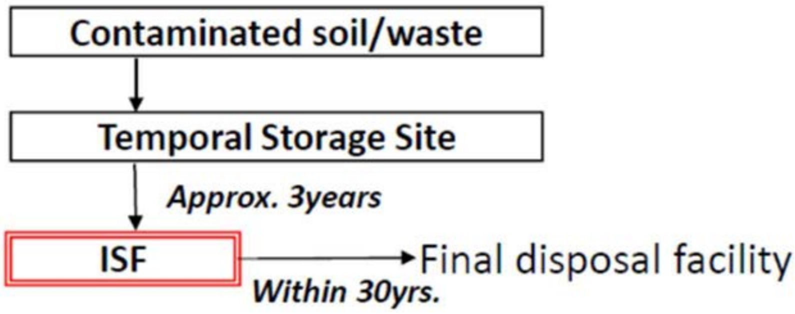

Figure 9: Schematic representation of the storage and disposal scheme of contaminated soil and waste.

In line with this plan, significant progress was noted in the development of temporary storage facilities by municipalities and by the national government to address the contaminated materials generated from the on-going remediation activities. The MOE has prepared guidelines for design and implementation of such facilities. A collection of good practices based on experience gained has also been compiled by the Fukushima Office of the MOE.

According to information provided, as of October 2013, temporary storage sites have been created in 460 locations in municipalities of Fukushima Prefecture. Contaminated materials generated during decontamination works are collected and stored in these facilities in different types of large flexible bags.

The Mission Team visited two temporary storage facilities, in Date city and Kawauchi village. The temporary storage facility visited in Date city is a good example of a design that includes necessary features to meet the requirements prescribed in the MOE guidelines for packaging, shielding, preventing rain water penetration, preventing outflow of contaminated water, drainage collection, gas venting, record keeping, etc. Some of the good practices followed in this storage facility are included in the MOE collection of good practices. These include, but are not restricted to, the use of:

(i) Metal plate tags on each package with detailed information on type of stored material, dose rate, weight, date of storage, etc.; and

(ii) Chipping apparatus for volume reduction of removed branches and leaves.

Figure 10 shows a schematic view and a photograph of the temporary storage facility in Date city.

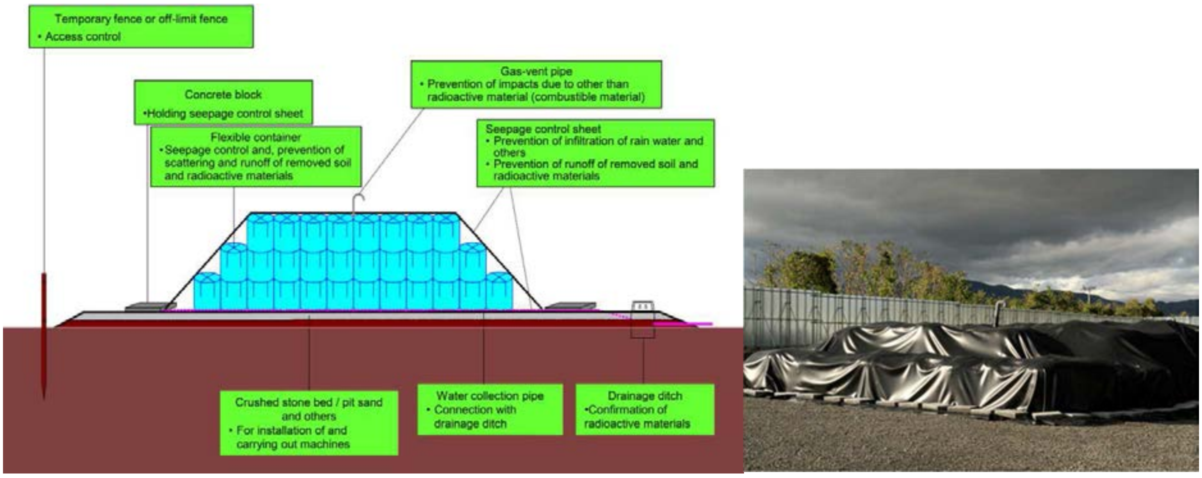

Figure 10: A temporary storage facility in Date city.

While noting the progress made in securing sites and establishing a large number of temporary storage facilities, it was also clear to the Mission Team that many more of such facilities are needed to continue with the planned decontamination activities.

The Mission Team was informed about the plans and on-going efforts to establish ISF. According to the conceptual design, in addition to storage, the ISF will have facilities for performing other functions, e.g. segregation, volume reduction, monitoring, R&D, public information, etc. (Figure 11).

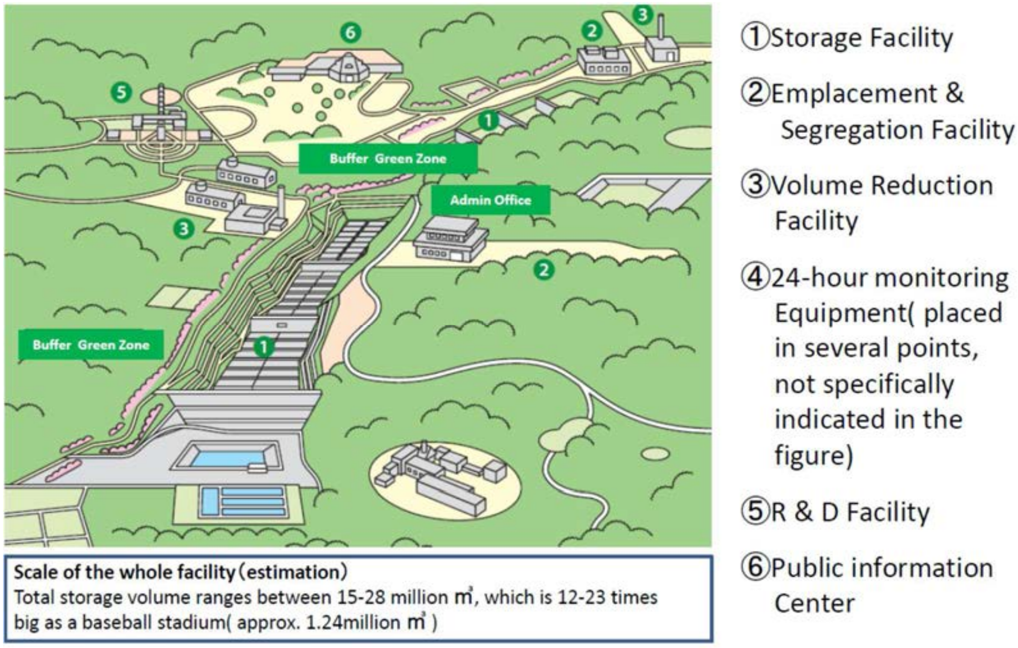

Figure 11: Illustration of Interim Storage Facility (ISF)

The MOE has identified potential sites in 3 towns in Futaba County for investigation of their suitability for locating ISF. The Mission Team visited one of these sites in Okuma town where survey work is being conducted with the agreement of local community. The current MOE target for commencement of ISF services is January 2015. The Mission Team encourages the Japanese authorities to persist in their efforts to fulfil this target. The establishment of ISF is a crucial step because it will:

i) Provide for consolidation and safe management of contaminated material in a centrally located facility; and

ii) Facilitate obtaining the agreement of landowners for leasing their land for temporary storage facilities as it will provide confidence that the timely implementation of the next step of the integrated strategy for the management of contaminated materials is secured.

6.1.3. Sharing of Practical Experience

An enormous amount of work has been carried out in Japan since the accident. Most of this work has been carried out under emergency conditions. Under these conditions very good results have been achieved. However the accident took place 2.5 years ago and the current remediation activities, including waste disposal are no longer being carried out under an emergency exposure situation. The official transition to an existing exposure situation occurred at the end of December 2011.

In the early stages after the accident the major efforts of the Japanese authorities were devoted to the stabilization of the overall situation with regard to the consequences of the accident. Many measures have been taken to ensure the immediate protection of the people and the environment. Urgent decontamination works have been carried out and Storage Facilities have been deployed to manage the contaminated materials generated by the early activities (within and outside the evacuation area). During the period of stabilization after the accident, the need for urgent action has naturally brought up difficulties in implementing a harmonized strategy for the development of temporary storages. As a consequence, the Mission Team could observe a disparity in the quality of the Temporary Storage Facilities. These differences might have an adverse impact, on the medium and long term evolution of the Temporary Storage Facilities. Issues and concerns on the evolution of Temporary Storage Facilities include stability of the structure made of stacked bags, changes with time in the condition of plant and other organic matter in the bags, leaching processes, and the durability/degradation and retrievability of bags. During the field visits the Mission Team observed that different types of bags are being used for temporary storage, with different qualities and durability.

Figure 12: Examples of flexible bags for storage of contaminated material.

These bags have different characteristics with respect to weather resistance, waterproof capability and durability. While some bags are expected to last up to three years, others have a durability of five years or more.

The Mission Team believes that it is not now justified to continue remediation and associated waste or contaminated material management activities "in an urgent" manner as occurred during the “stabilization phase”. In the current existing exposure situation, measures have to be taken considering the long term perspective. The time is now right to learn the lessons from the management of contaminated materials during the stabilization period, including the development of Temporary Storage Facilities, exchange of information and experience between the different actors of the remediation and decontamination and waste management activities, extract the good practices in the different municipalities and at the governmental level and identify the points to be improved or corrected. The Mission Team encourages the establishment of a mechanism that facilitates the sharing of experience gained with the implementation of temporary storage facilities. This would allow better communication between municipalities and also between municipalities and the national government.

6.1.4. Safety Demonstration for Facilities and Activities for the Management of Contaminated Materials

Demonstration of safety is an essential element in the development of waste management facilities. It is how the operator establishes confidence in the safety of the facility and provides tools/arguments to gain public confidence in the overall process. It is understood that during the initial phase after the accident, many temporary storage facilities had to be constructed in an urgent manner. However, as the situation is stabilizing greater care needs to be taken in the further development of waste management facilities. In this context, it is imperative that safety of these facilities is demonstrated.

As an example, the national government is in the process of selecting the site and developing the design of the ISF intended to operate for at least 30 years. The Mission Team considers that the time is appropriate for initiating the development of a safety case for that facility. At this stage, safety of the facility could be established at a generic level and include quantitative assessment of the potential radiological impacts of the facility, in normal and extreme conditions (e.g. earthquake, flooding, etc.).

6.1.5. Interdependencies

According to the IAEA Safety Standards, in particular to the safety requirements on the predisposal management of radioactive waste (GSR Part 5), “*interdependencies among all* *the steps in the predisposal management of radioactive waste, as well as the impact of the anticipated disposal option shall be appropriately taken into account*".

As far as activities under the MOE and the Fukushima Prefecture are concerned, the strategy for the management of contaminated materials includes temporary storage for a planned period of 3 years followed by 30 years of interim storage prior to disposal in dedicated facilities. The implementation of the strategy will consequently take place on a rather long period of time which has to be taken into account in the overall strategy implementation for the management of contaminated materials. The implications of the actions taken in the first steps of the strategy implementation on subsequent steps need to be analysed and evaluated. Ideally, all activities from the generation of contaminated material up to its disposal are to be seen as parts of an entire life-cycle and the management elements of each step have to be compatible with subsequent steps.

From the analysis of the documents provided to the Mission Team and also based on the discussions and visits that took place, it can be concluded that much work on the development of disposal facilities for contaminated materials remains to be done.

It is unclear how, in the actions and measures that have been taken so far, in particular during the stabilization period, compatibility with future management steps has been considered. As an example, the bags that are used to store the contaminated materials differ from one temporary storage facility to the other. Black jute bags, with a durability of 2 to 3 years, are used in some places whereas in other places contaminated material is conditioned in thick blue bags whose durability is of around 5 years. There is no evidence that the integrity of these bags is compatible with the estimated delivery time of the ISF. In other words, it is not clear if the retrieval and transportation of the bags for the ISF, and potentially for future disposal, have been adequately taken into account when choosing the bag type.

As the development of disposal facilities is still in a preliminary phase, the consequences of the actions and measures taken in the early stages of the management of contaminated material have not been addressed in detail.

Issues needing consideration include:

(i) With extremely large volume of contaminated material and waste and number of packages, either a large transport vehicle fleet or several years of transport is required – this may affect temporary storage period.

(ii) It is unclear if, and how, the reconditioning of the packages prior to interim storage and/or disposal has been taken into account. It is particularly important to consider the established acceptance criteria for disposal of the contaminated materials or the criteria that are anticipated for the most probable disposal option.

(iii) For the planning of the ISF (and other steps in waste management) an inventory of wastes and contaminated material of different type and activity is needed – characterization, segregation, and records of the contaminated material are important components to be taken into account as part of interdependencies.

(iv) Decaying organic material may increase Cs mobility in soil, organic material decay can also affect structural stability of temporary storage.

(v) Low activity contaminated material and waste may reach (conditional) clearance level as ^{134}Cs decays.

6.1.6. Incineration of Contaminated Material

As part of the strategy for volume reduction of the very large volumes of contaminated material generated from the disaster and subsequent decontamination activities, the Japanese authorities have planned incineration of combustible materials using either the existing municipal solid waste incineration facilities or new dedicated facilities to be constructed for this purpose. The Mission Team visited a newly constructed fluidized-bed incineration facility at Ken-Chu sewage treatment centre where trial runs are being conducted to demonstrate the incineration of sewage sludge. The results of one month’s trial runs show that the process is effective in reducing the volume by a factor of about 20 and that the bag filters are effective in trapping fly ashes and limiting the release of radiocaesium within stipulated limits.

The Mission Team’s opinion was sought on the appropriateness and safety of using incineration for volume reduction of contaminated materials.

In response, the Mission Team noted that Japan has extensive experience in incineration of municipal solid waste as well as in the safe operation of a large number of incinerators meeting relevant emission standards. Therefore, Japan has been successfully achieving the reduction of the volume of waste that goes for disposal. Incineration is also used in Japan for volume reduction of operational low level radioactive waste from nuclear power plants. In the opinion of the Mission Team, and as already noted in the report of the first mission, it would be appropriate and safe to use incineration for volume reduction of contaminated material generated in the off-site areas. This can be done by utilizing existing capacity, as is being done now. Meanwhile, new incinerators that incorporate measures for radiation protection of workers, off-gas treatment (to meet emission standards and thereby limiting public exposure) and management of radioactive ash and secondary waste from off-gas treatment could be constructed.

6.2. Highlights

Highlight 12: The Mission Team found significant progress in the development and implementation of temporary storage facilities by municipalities and the national government for contaminated materials generated by on-going remediation activities. In addition, the Mission Team notes the progress made towards the establishment of interim storage facilities by the national government with the cooperation of municipalities and local communities.

Highlight 13: The Mission Team acknowledges that incineration is being used as an effective technology for volume reduction of contaminated material, with the adoption of measures to meet emission standards for limiting public exposure.

6.3. Advice

Point 8:

The Mission Team encourages the responsible organization(s) to carry out appropriate demonstrations of the safety of the facilities and activities for the management of contaminated materials, in particular for long-term activities, and to allow for their independent evaluation.

7. CONCLUSIONS

This report presents the main results and conclusions of the Mission.

The Mission Team considers that the remediation of large contaminated areas represents a huge effort and recognizes that Japan is allocating enormous resources to developing strategies and plans and implementing remediation activities, with the aim of enhancing the living conditions of the people affected by the nuclear accident, including enabling evacuated people to return. The Team also considers that, as result of these efforts, Japan has achieved good progress in the remediation activities and, in general, has well considered the advice provided by the previous mission in 2011. The Team was pleased to see good progress in the coordination of remediation activities with reconstruction and revitalisation efforts.

The report also provides conclusions from the assessment of specific topics in the remediation programme, including the twelve points where the previous mission provided advice for improvement. It highlights important progress in all areas to date and offers advice on several points where the Team feels it is still possible to further improve current practices, taking into account both international standards and the experience of remediation programmes in other countries, which will further help to increase public confidence. While Japan continues its current remediation efforts, it is encouraged to take into consideration the Mission's advice for further optimization of remediation activities.

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