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Summary Report of the Preliminary Findings of the

IAEA Mission on remediation of large contaminated areas off-site the Fukushima Dai-ichi NPP

7 – 15 October 2011, Japan

CONTENTS

The Team uses the term ‘remediation’ in accordance with the IAEA Safety Glossary. The Team understands that in the Japanese language there is only one word for both remediation and decontamination.

Executive Summary

In response to the request made by the Government of Japan, the IAEA organized a second fact-finding mission to support the remediation of large contaminated areas off-site the Fukushima Dai-chi Nuclear Power Plant (NPP). The Mission Team involved 12 international experts.

The Mission had the following three objectives:

(a) provide assistance to Japan in the plans to manage the remediation of large contaminated areas resulting from the accident at the Fukushima Dai-ichi NPP;

(b) review remediation-related strategies, plans and works, including contamination mapping, currently undertaken by Japan; and

(c) share its findings with the international community as lessons learned.

The Authorities of Japan have provided comprehensive information on their remediation program. The Mission was conducted through the assessment of the information provided to the Team, professional and open discussions with the relevant institutions in Japan, and visits to the affected areas and several demonstration sites.

This preliminary report presents an overview of the main results and conclusions of the Mission, including 8 (eight) acknowledgements and 12 (twelve) points of advice to improve strategy, plans and specific techniques for remediation, taking into account both the international standards and the experience from remediation programs in other countries. While Japan continues its current efforts of remediation, it is encouraged to take into account the Mission's advice for future full-scale remediation activities. The final report will be provided to Japan by 15 November 2011.

Based on the sequence of the ongoing activities, the Team focused on the remediation of the affected areas outside the 20 km restricted area. The Team agrees with the prioritization and the general strategy being implemented, and is of the opinion that additional missions would be beneficial at the appropriate time to (a) confirm the progress made and (b) to address the remediation challenges within the 20 km zone.

Main findings

The review team provides the following independent expert opinions, points of advice and acknowledgements.

Acknowledgements

The review team identified acknowledgements in recognition of good organization, arrangements or performance, which can contribute to the sharing of experience and exchange of lessons learned on an international basis.

Acknowledgement 1: The team appreciates that Japan has been going forward very quickly and with the allocation of the necessary resources (legal, economical and technological) to develop an efficient program for remediation, and therefore to bring relief to the people affected by the Fukushima Dai-ichi nuclear accident, with the priority being given to children and those areas where they typically spend most of their their time.

Acknowledgement 2: The Fukushima Decontamination Promotion Team, consisting of resident staff in Fukushima from the Ministry of Environment (MOE), the Local Emergency Response HQs and Japan Atomic Energy Agency (JAEA), shares information and coordinates with the relevant ministries and agencies, communicating with and providing technical support to the Fukushima prefecture and relevant municipalities. The Team welcomes Japanese efforts to establish a practical catalogue of remediation techniques.

Acknowledgement 3: The Mission Team acknowledges that the Act on Special Measures explicitly stipulates stakeholder involvement. The Mission Team appreciates that the Government is not waiting for the new Act to come into force, but has already started implementing this aspect.

Acknowledgement 4: The Team appreciates the strong commitment to remediation demonstrated at the Fukushima Prefecture and at local levels. The Team benefitted from visiting school sites, from which the contamination had been removed to a large extent by volunteers, mostly parents of the pupils. The Team in particular acknowledges the efforts of the municipal administration and large number of volunteers as an important and effective self-help method.

Acknowledgement 5: The Team acknowledges the practical measures taken by the JAEA in public information and its involvement in the program based on the needs of the local residents.

Acknowledgement 6: In the Team's view, the approach for using demonstration sites to test and assess various remediation methods is a very helpful way to support the decision-making process.

Acknowledgement 7: The Team acknowledges the impressive monitoring and mapping effort of the Japanese Authorities as a basis for a successful remediation program. The extensive, real-time monitoring system that is currently being set up and the transparent online availability of the resulting data are important measures to reassure the public and the international community.

Acknowledgement 8: The Team recognizes that in the early phase of the accident, conservatism was a good way to manage uncertainties and public concerns related to reference levels in the context of food and agriculture.

Acknowledgement 9: The Team appreciates the fact that some school sites were remediated mostly by volunteers with the technical support and guidance of JAEA. The team was informed that 400 school playgrounds have already been appropriately remediated (as of 30.09.2011).

Advice

Advice 1. The Japanese authorities involved in the remediation strategy are encouraged to cautiously balance the different factors that influence the net benefit of the remediation measures to ensure dose reduction. They are encouraged to avoid over-conservatism which could not effectively contribute to the reduction of exposure doses. This goal could be achieved through the practical implementation of the Justification and Optimization principles[1] under the prevailing circumstances. Involving more radiation protection experts (and the Regulatory Body) in the organizational structures that assist the decision makers might be beneficial in the fulfillment of this objective. The IAEA is ready to support Japan in considering revised, new and appropriate criteria.

[1] IAEA Safety Glossary 2007 STI/PUB/1355 (ISBN:978-9290-058908-9)

Advice 2. It is appropriate to consider to further strengthening coordination among the main actors, through the establishment of a more permanent liaison between the Organizational Structures of the Government of Japan and the Prefectural and Municipal authorities.

Advice 3: The central and local governments are encouraged to continue strengthening the involvement of and cooperation between various stakeholders. The Government might wish to strengthen the engagement of appropriate universities and/or academia in the process of further developing a stakeholder involvement strategy and implementation methods, which would be based on stakeholder needs and domestic cultural settings.

Advice 4: Access to the "Deliberate Evacuation Area" is free and unmarked. The team encourages considering the use of appropriate indications/markings in the routes and simple instructions for the public when entering or leaving these areas. These indications/markings are considered important tools for informing the public and avoiding unnecessary radiation exposures to individuals.

Advice 5: It is important to avoid classifying as "radioactive waste" such waste materials that do not cause exposures that would warrant special radiation protection measures. The Team encourages the relevant authorities to revisit the issue of establishing realistic and credible limits (clearance levels) regarding associated exposures. Residues that satisfy the clearance level can be used in various ways, such as the construction of structures, reclamations, banks and roads. The IAEA is ready to support Japan in considering revised, new and appropriate criteria.

Advice 6: The team draws the authorities' attention to the potential risk of misunderstandings that could arise if the population is only or mainly concerned with contamination concentrations (surface contamination levels Bq/m2 or volume concentrations Bq/m3) rather than dose levels. The investment of time and effort in removing contamination beyond certain levels (the so-called optmized levels) from everywhere, such as all forest areas and areas where the additional exposure is relatively low, does not automatically lead to reduction of doses for the public. It also involves a risk of generating unnecessarily huge amounts of residual material. The Team encourages authorities to maintain their focus on remediation activities that bring best results in reducing the doses to the public.

Advice 7: The management of the collected data should be formally described in a data management plan.

Advice 8: With respect to the remediation of agricultural areas, the team considers that for the next cropping season there is room for removing some of the conservatism (such as that in factors determining the transfer of radioactive caesium from soil to crops) by taking into account data and factors published by the IAEA and the results obtained from the demonstrations sites. The IAEA is ready to support Japan in considering new and more appropriate criteria.

Advice 9: With respect to waste in urban areas, the Team is of the opinion that it is obvious that most of the material contains very low levels of radioactivity. Taking into account the IAEA safety standards, and subject to safety assessment, this material might be remediated without temporary and/or interim storages. It is effective to utilize the existing municipal infrastructure for industrial waste. The IAEA is ready to support Japan in considering revised, new and appropriate criteria.

Advice 10: Before investing substantial time and efforts in remediating forest areas, a safety assessment should be done to indicate if such remediation has benefit in reducing doses in order to invest in areas of greater benefits. This safety analysis should make use of the results of the demonstration tests

Advice 11: The mission team encourages the Japanese authorities to continue the useful monitoring of freshwater and marine systems.

Advice 12: The IAEA Mission team encourages Japanese authorities to actively pursue appropriate end-points for the waste in close cooperation with stakeholders. The national and local governments should cooperate in order to ensure the provision of these facilities. A lack of availability of such an infrastructure would unduly limit and hamper successful remediation activities, thus potentially jeopardizing public health and safety.

1. Introduction

The accident at Fukushima Dai-ichi NPP led to the radioactive contamination of large areas. The Government of Japan has formulated a program for the recovery of these areas.

As a major part of this recovery program in the areas off-site the Fukushima Dai-ichi NPP, Japan is launching a remediation effort. The final aim of the recovery strategy, and therefore of the remediation program, is to improve the living conditions of the people affected by the accident.

The IAEA organized the "IAEA International Fact Finding Expert Mission of The Fukushima Dai-ichi NPP Accident Following The Great East Japan Earthquake And Tsunami", held on 24 May – 2 June 2011. The conclusions of this mission were presented in the International Ministerial Conference held in Vienna last June.

In response to the request made by the Government of Japan, the IAEA organized this second fact finding mission to support the remediation of large contaminated off-site areas. For this second mission an Expert Team of 12 international experts was assembled.

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

A final report will be provided to Japan by 15 November 2011.

2. Institutional Arrangements

On 26 September 2011, The Parliament (Diet) of Japan approved the *"Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials Discharged by the Nuclear Power Station Accident Associated with the Tohoku District – Off the Pacific Ocean Earthquake that Occurred on March 11, 2011"*. This Act is the main instrument adopted to deal with the remediation program of the areas affected by radioactive pollution, and will enter into force on 1 January 2012. The Government plans to develop this Act through specific policy documents including the basic principles and standards.

The Act establishes, among others things, the main purposes of the remediation program; the distribution of roles and responsibilities among the involved institutions, namely Central Government

and Prefectural and Municipal Governments; the role of stakeholders; basic lines for monitoring, decontamination and waste management; and provision of financial resources.

To properly implement the remediation activities under the Act, the Ministry of Environment is in charge of developing the basic principles regarding the handling of the environmental radioactive pollution, in consultation with the relevant administrative bodies and stakeholders.

These principles should be formally approved by the Cabinet. In the meantime, the Nuclear Emergency Response Headquarters have established the "Basic Policy for Emergency Response on Decontamination Work" on 26 August , which is in line with the Act and permits to start activities for remediation in advance.

The "Policy and Guidelines for environmental remediation" and guidelines for the decision-making process on decontamination to be conducted by local authorities have been prepared reflecting comments from relevant ministries and agencies as well as from the local authorities, so those comments were reflected in the decision-making process.

The Emergency Evacuation Preparation Zone was lifted on 30 September 30, taking into account technical advice from the relevant body, namely the Nuclear Safety Commission, the conditions of the NPP and the results of the radiological monitoring in the area. This is one example of shifting from emergency exposure situation to existing exposure situation.

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Advice 1. The Japanese authorities involved in the remediation strategy are encouraged to cautiously balance the different factors that influence the net benefit of the remediation measures to ensure dose reduction. They are encouraged to avoid over-conservatism which could not effectively contribute to the reduction of exposure doses. This goal could be achieved through the practical implementation of the Justification and Optimization principles[2] under the prevailing circumstances. Involving more radiation protection experts (and the Regulatory Body) in the organizational structures that assist the decision makers might be beneficial in the fulfillment of this objective. The IAEA is ready to support Japan in considering revised, new and appropriate criteria.

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3. Stakeholder involvement

As stated in the IAEA safety standard "the decision making process shall provide for the involvement of a wide range of interested parties in the definition, implementation and verification of remediation programmes and for regular public information exchange on the implementation of these programmes." (WS-R-3)

Wide possibilities for the stakeholders to be involved and informed ensure that as remediation planning and implementation proceed, while stakeholder needs and concerns are properly addressed. This improves the credibility of the whole remediation process and increases the probability of success.

Managing expectations is essential from the onset of stakeholder engagement. It is important to clearly identify the objectives so that stakeholders can understand the extent of their involvement and responsibility.

Interactions with a wide variety of stakeholders should start as early as possible. When conducted well, the process normally yields indisputable benefits.

Relevant structures and processes

In the Japanese administrative system, municipalities and prefectures have strong autonomy and play significant roles in disaster management and environmental protection, including the remediation process. The national government provides legal framework, policies, standards, financial and technical support, and conducts remediation for areas which are in "emergency exposure situations"; in this case areas where citizens could be exposed to an annual dose above 20 mSv.

Local governments implement remediation plans for areas which are in"existing exposure situations", i.e. areas below 20 mSv/year. In these areas the ultimate decision whether to remediate or not rests with the landowner.

The "Act on Special Measures concerning the handling of Radioactive Pollution", which will enter into force 1.1.2012 but which the Government already implements to a large extent, recognizes explicitly stakeholder involvement. The purpose of the Act is to promptly reduce the impacts of environmental pollution by instituting measures taken by stakeholders, especially the national and local governments, as well as the relevant nuclear power producer.

Under the 'Basic Policy for Emergency Decontamination Work' established on 26.August 2011, several important policy, guidelines and documents have been issued. These include stipulations of how stakeholders are to be involved in the process.

Practical involvement of stakeholders

There is understandable anxiety in society about the current radiation situation. The Team noted that in the early phases of the accident many doubts were expressed about the accuracy and timeliness of the information provided by the central authorities.

The Team observed that revised ways and new efforts to inform and involve stakeholders, in particular the public, are implemented by the central authorities. At a local level, the Team was impressed by the strong commitment to the remediation efforts shown by the Fukushima prefecture and the municipalities.

The Mission Team recognized the following important players in the practical stakeholder involvement:

Fukushima Decontamination Promotion Team under the Ministry of Environment is tasked to communicate and coordinate activities with local municipalities, assisting them in their preparation of remediation plans, by dispatching experts and promoting model remediation projects in 12 municipalities affected by elevated radiation levels. JAEA, being a member of the Promotion Team plays an important role in interacting with the public and other stakeholders.

Having established a "Fukushima office", *JAEA* interfaces with relevant Fukushima prefecture organisations and citizens. With regard to technical issues, the Mission Team appreciated that JAEA provides a telephone hot-line for health consultations, dispatches experts to stakeholders (ministries, local Governments, city administration, etc.), sends researches to Fukushima prefecture schools from kindergartens to junior high schools at their request, holds briefings on radiation in schools, takes time and effort to answer questions from parents and teachers, and has prepared written material for the benefit of the local people. In the demonstration test sites described elsewhere in this report, the JAEA works in close cooperation with the residents and landowners, and carries out activities subject to their consent.

Cities, villages and their citizen: The Team benefitted from visiting two school sites, from which the contamination to a large extent had been removed in a well-organized manner by volunteers, mostly parents of the pupils. The Mission Team acknowledged the efforts of the city administration and large number of volunteers as an important and effective clean-up and self-help method.

Preliminary conclusions

Acknowledgement 3: The Mission Team acknowledges that the Act on Special Measures explicitly stipulates stakeholder involvement. The Mission Team appreciates that the Government is not waiting for the new Act to come into force, but has already started implementing this aspect.

Acknowledgement 4: The Team appreciates the strong commitment to remediation demonstrated at the Fukushima Prefecture and at local levels. The Team benefitted from visiting school sites, from which the contamination had been removed to a large extent by volunteers, mostly parents of the pupils. The Team in particular acknowledges the efforts of the municipal administration and large number of volunteers as an important and effective self-help method.

Acknowledgement 5: The Team acknowledges the practical measures taken by the JAEA in public information and its involvement in the program based on the needs of the local residents.

Advice 3: The central and local governments are encouraged to continue strengthening the involvement of and cooperation between various stakeholders. The Government might wish to strengthen the engagement of appropriate universities and/or academia in the process of further developing a stakeholder involvement strategy and implementation methods, which would be based on stakeholder needs and domestic cultural settings.

4. Radiation Protection

The Japanese government has defined a set of reference levels to control the exposure of the public. In areas where the annual effective dose is estimated to be above 20 mSv, the national government aims to reduce the estimated annual exposure dose to less than 20 mSv; in areas where an estimated annual exposure dose is less than 20 mSv, the national government will work with municipalities and local

residents to conduct effective remediation work, so that the estimated annual exposure dose will be less than 1 mSv.

Specific attention is being given to the exposure of children. Therefore, current efforts focus on measures to reduce exposures in schools and kindergartens, with the aim to reduce the exposure to children to an effective dose of 1 mSv per year during the time children are at or on the way to and from school.

IAEA Safety Standards

This approach is in accordance with the Recommendations of the International Commission of Radiation Protection and the Basic Safety Standards (BSS) of the IAEA. The BSS define the requirements on protection of people and environment. These requirements reflect a broad international consensus on the requirements for safety.

For post-accidental conditions, the Basic Safety Standards recommend a reference level in the range of 1-20 mSv/year. It is international consensus that the reference levels have to be defined taking into account the specific circumstances of an exposure situation. This includes the level of activity in the environment, environmental conditions and the life style.

Any reasonable steps shall be taken to prevent doses remaining above the reference level. The exposure has to be assessed for the more highly exposed individuals in the population.

Radiation Protection Principles

The BSS require that any measure taken is justified to ensure that it does more good than harm and it is commensurate with the risk.

Usually, remediation actions also have social and economic implications and decisions have to take into account all aspects of a specific situation. The optimization of protection and safety – as required by the BSS - is a process for ensuring that exposures and the number of exposed individuals are as low as reasonably achievable, with economic, societal and environmental factors taken into account to ensure that the level of protection will be the best possible under the prevailing circumstances. It requires both qualitative and quantitative judgments to be made.

Exposure of remediation workers

According to IAEA standards for an existing exposure situation and for the remediation of areas with residual radioactive material, the exposure of workers undertaking remedial actions is controlled in accordance with the relevant requirements for occupational exposure in planned exposure situations. With regards to the available information on dose rates and radioactivity concentration levels present in the areas of decontamination operations, the requirements for occupational exposure of remediation workers can be fulfilled.

Residues

Remediation work may generate residues that contain enhanced levels of activities. According to the Basic Safety Standards, it is the responsibility of the government to set reference levels for the disposal of residues in municipal landfills or for landfills to be designed in particular for the disposal of those residues. In view of the strong absorption of cesium by the soil, the definition of the reference level should in particular focus on the longer-lived Cs-137 rather than on the relatively short-lived Cs-134.

Planning, construction and operation of landfills for the residues is a key element for the successful continuation of remediation measures.

Assessment of exposures

The decision on measures to be taken is currently based on the external exposure, other pathways as e.g. the intake of food are not taken into consideration explicitly. Although, due to the strict activity limits for foodstuffs, the intake of food is very likely not an important pathway, its contribution to the dose should be explicitly assessed. This is to achieve a comprehensive and transparent overview on the radiation sources and their magnitude. It is also an important input for the optimization of any remediation measures.

Information

Information of the public is a key issue for the involvement of the population in the remediation process. It is good practice to provide information on actual exposure levels on public places and on roads.

Access to the 'Deliberate Evacuation Area' is free, however, appropriate indications when entering or leaving these areas may be considered as an important issue for information of the public.

The team encourages the respective authorities to optimize all remediation measures to the extent possible in the context of ensuring that all the steps are integrated in the optimum way, as it is mentioned in Advice 1.

Advice 4: Access to the "Deliberate Evacuation Area" is free and unmarked. The team encourages considering the use of appropriate indications/markings in the routes and simple instructions for the public when entering or leaving these areas. These indications/markings are considered important tools for informing the public and avoiding unnecessary radiation exposures to individuals.

5. Remediation strategy implementation

Major nuclear and/or radiological accidents can affect large areas of land that need to be assessed in terms of eventual need for further remediation, i.e. actions that may be applied to reduce the ongoing or future doses to members of the public.

A wide range of options for the remediation of these affected sites are available. The implementation of one of them or a combination of different approaches need to be carefully considered including planning, coordination of efforts - when different agencies have a role to play – site characterization, derivation of applicable criteria, selection of appropriate technologies and, last but not least, involvement of stakeholders in the decision making process.

Since radiation is a natural part of our environment, the key issue is to establish reasonable and credible limits (reference levels) regarding exposures that need to be reduced. This has direct implications e.g. to the amount of material, including residues, that has to be managed and possibly be disposed of. It is therefore important to avoid classifying those materials that do not cause exposures that would warrant special isolation measures as "radioactive waste".

The justification principle as expressed in the international standards stipulates that the introduction of a remediation strategy needs to produce more good than harm, in other words, the benefits need to exceed the associated burden and costs. The reduction of the radiation doses also need to be optimized, i.e. the residual levels of radiation in the environment should be as low as reasonably achievable with social and economical aspects factored in. The simple reduction of existing doses by the application of any clean-up strategy *per se* may not produce the desired benefits, especially if they create additional problems (such issues as waste and negative social impact) and excessive cost. In other words, the burden may be disproportional to the benefits the remediation will bring.

Another factor that is very important in the context of environmental remediation is that solutions are also site-specific. Lessons learned with other events shall always be taken into account in the decision making process but they may not be readily transferable from one situation to another.

Last but not least, decisions in these circumstances are not based only on technical matters and evidence. Several socio-psychological elements play an important role in the decision making process. Therefore, the key issues include stakeholder involvement, which is discussed in section 2 of this report.

The remediation work in the affected areas

The accident in Fukushima affected a large area comprising farmlands (agricultural areas), inhabited areas and forests.

The team notes that the main strategy adopted by the Japanese authorities relates to the concept of decontamination. At this stage, it is important to stress that decontamination is only one of the many available options to be used to achieve the reduction of doses in the case of radioactivity concentrations in the environment caused by an accidental release. Other options need to be considered and the one (or ones) to be selected need to derive from a process of optimization of the protection, which the team wishes to identify more in the decision making process.

In the decontamination efforts perpetrated by the Japanese counterparts, the team observed that the major strategy being considered is the removal of top soil (up to 5 cm of the soil layer) due to the well-known behaviour that radiocesium accumulates in this part of the soil. While this strategy has the benefit to reduce radionuclide concentrations in the upper layer of soils and consequently the dose, it also involves a risk of generating unnecessarily huge amounts of residual materials.

If removal of the top layers of the soil is one of the selected options for wider use, a similar system would be useful that is in place for naturally occurring radioactive material residues (so-called NORM residues) in many countries and is based on safety assessments. This would allow the removed material to be used in selected applications, e.g. together with clean material in the construction of structures, banks, reclamations or roads that will not pose undue risks to members of the public. This system is known as clearance and specifically in the present situation conditional clearance could be considered. This is recognized as an applicable strategy also in the IAEA Safety Standards. The classification of the material resulting from the remediation operations as radioactive waste should not be automatic. In fact, the Team finds that doing so could create unnecessary major challenges for the Japanese authorities without providing any benefit to the dose reduction of the public.

It has been also reported to the team that the application of phytoremediation did not produce the desired results. The team recognizes the limitation of this technique in removing considerable amounts of radionuclides from the soil. On the other hand, the team noted that that the only trial so far was restricted to the cultivation of sun-flower.

The team recognizes and values the strategy of involving local people to help themselves with the decontamination of their properties. However, it has been noticed that for more complex work the need of specialized services will be required and this will obviously add costs to the remedial actions. Whenever local residents become involved in the cleanup of their properties it is important to observe that appropriate training, supervision and technical assistance are given. Radiation protection measures and monitoring should also be in place, when integrating local people in remediation work.

Acknowledgement 6: In the Team's view, the approach for using demonstration sites to test and assess various remediation methods is a very helpful way to support the decision-making process.

Advice 5: It is important to avoid classifying as "radioactive waste" such waste materials that do not cause exposures that would warrant special radiation protection measures. The Team encourages the relevant authorities to revisit the issue of establishing realistic and credible limits (clearance levels)

regarding associated exposures. Residues that satisfy the clearance level can be used in various ways, such as the construction of structures, reclamations, banks and roads. The IAEA is ready to support Japan in considering revised, new and appropriate criteria.

Advice 6: The team draws the authorities' attention to the potential risk of misunderstandings that could arise if the population is only or mainly concerned with contamination concentrations (surface contamination levels Bq/m2 or volume concentrations Bq/m3) rather than dose levels. The investment of time and effort in removing contamination beyond certain levels (the so-called optmized levels) from everywhere, such as all forest areas and areas where the additional exposure is relatively low, does not automatically lead to reduction of doses for the public. It also involves a risk of generating unnecessarily huge amounts of residual material. The Team encourages authorities to maintain their focus on remediation activities that bring best results in reducing the doses to the public.

5.1 Monitoring and Mapping

The monitoring of radiation levels and the mapping of the distribution and level of radioactive contamination are necessary tools for both the preparation and the verification of a successful remediation effort. The Japanese government has outlined the responsibilities of the different government agencies regarding radiation monitoring and mapping in the Comprehensive Monitoring Plan from 2. August 2011. The overall responsibility and coordination falls to the Ministry of Education, Culture, Sport, Science and Technology (MEXT), but the Ministry of the Environment (MOE), Ministry of Health Labour and Welfare (MHLW), Ministry of Agriculture Forestry and Fisheries (MAFF) and Ministry of Land, Infrastructure, Transport and Tourism (MLIT), as well as a number of other agencies and organisations, are also involved. The Japanese Atomic Energy Agency (JAEA) is playing a key role as keeper of the data base, technology provider and liaison to the universities.

Radiation levels are monitored at different scales using the appropriate technology for each case: airborne and vehicle based surveys for the large scale overview (up to 160 km from Fukushima Dai-ichi NPP), soil samples (2200 locations, every about 2 km up to 80 km from the NPP) and hand-held dosimeters and spectrometers for local radiation maps and decontamination test sites. Typically, the data are given as aerial dose rate 1 m above ground, but often the surface dose rate and the concentration in Bq/kg or Bq/m^2 are also used.

Three airborne surveys around Fukushima Dai-ichi NPP have been carried out in April, May and June 2011 by MEXT (in cooperation with the DOE). These surveys have been expanded to further prefectures since then and the next airborne survey planned for November 2011 will cover the entire Eastern part of Japan, from Aichi to Aomori prefecture. The importance of this mapping effort and the impact that it has already had is perhaps best illustrated by the creation of the deliberate evacuation area North-West outside of the 20 km exclusion zone, which was based on these results.

MEXT is currently in the process to set up a real-time monitoring system, that will eventually cover all of Japan with about 2700 monitoring stations. The first 20 have been deployed in Fukushima prefecture and the information is available online at www.r-monitor.jp. Almost every school, from nursery to university, will be equipped with an online monitor. This system represents an unprecedented amount of readily available, real-time information for the citizens of Japan.

JAEA is making efforts to fill the gap between large area airborne monitoring and hand-held dosimeters through the introduction of an unmanned aerial vehicle (UAV) system, which can be used

in areas that are impossible to reach by car. In addition, JAEA is developing and improving detector technology for local applications. The use of modern technologies (e.g. GPS) that have only become available in the last 25 years since Chernobyl is already of great importance for radiological mapping. JAEA should be encouraged, together with research institutes and universities, to continue on this path and to expand the use of modern technology.

There are additional examples of monitoring efforts, e.g. local maps with 1 km grid provided by municipalities with copies freely available at city hall and solar powered LED dose rate displays visible from the car, similar to those that give the temperature or indicate your speed. These activities are not yet all coordinated and MEXT only collects the data down to prefecture level. More and closer coordination of the monitoring and mapping would enable the spreading and application of the best ideas and practices and the collection of locally generated data.

Acknowledgement 7: The Team acknowledges the impressive monitoring and mapping effort of the Japanese Authorities as a basis for a successful remediation program. The extensive, real-time monitoring system that is currently being set up and the transparent online availability of the resulting data are important measures to reassure the public and the international community.

5.2 Data Management

The environmental monitoring data from Japan after the Fukushima Dai-ichi accident are not only a crucial input for any remediation activity, but they also represent an immensely valuable scientific resource for future analysis. The collected data will be more complex and detailed then those collected following the Chernobyl accident 25 years ago, due to the technological progress in the intervening time.

The management of the collected data should be formally described in a data management plan. In a scientific experiment such a plan would be drawn up in advance. In this case, however the time for action is now, as there is a transition from emergency measures to long-term monitoring.

The data management plan has to cover a series of items, including technical details of the database, metadata, archiving and preservation, quality assurance, data security and access policy. In particular, the data management plan has to conform to applicable legislation, e.g. the "Law Concerning Access to Information Held by Administrative Organs" from 2001.

Individual pieces of a data management plan already exist or are emerging: quality assurance was discussed at the Conference for the Preparation of the Distribution Map of Radiation organised by MEXT in August 2011 and the real-time access to monitoring data since September 2011 constitutes a de-facto policy of transparency. However, a formal and comprehensive data management plan does not yet exist.

Advice 7: The management of the collected data should be formally described in a data management plan.

5.3 Agricultural areas

The Team was informed that the target for remediation of farm land is the reduction of the radioactive air dose level by 50% in the next two years. In the long term this level should be reduced to under

1mSv/year. This refers only to the areas where the current radioactive air dose level is between 1 and 20 mSv/year.

Since the provisional regulation value for radioactivity in rice is 500 Bq/kg, the conservative transfer factor of 0.1 implies that the limit of cultivation for the rice field soil is 5000 Bq/kg. The transfer factor of 0.1 was derived using data from long term research on the transfer of cesium from soil to rice. However, the first preliminary results from the demonstration sites established by the Japanese authorities in the affected areas indicate that the actual transfer factor is likely significantly lower. This would also be consistent with the transfer factors in the IAEA Tecdoc 1616 from 2009. The Team is of the opinion that the conservatism in the transfer factor can be removed when the tests are completed and realistic factors have been firmly established.

More testing is needed to fine-tune the reference level for the coming cropping season, and this for a wide range of soils and crops in the affected area.

Planning agricultural countermeasures to remediate affected farmland is a task that needs to take into account radiological, food safety, ecological, socio-economic and cultural issues within a holistic and interdisciplinary frame.

An area-wide landscape approach is crucial as soil redistribution in mountainous catchments, such as in specific areas of Fukushima prefecture, can lead to the redistribution of radionuclides from the uplands to rice paddies and river systems in the lowlands through erosion of soil from steep uncovered hillslopes or forest tracks, in particular after extreme rainfall events.

Besides physical remediation, such as topsoil removal and deep ploughing, which are currently the most important focus of the remediation of agricultural land, the adaptation of potassium (K) and nitrogen (N) fertilization techniques, land use/management and agricultural water management practices may be agronomic options to minimize radioactive cesium in the local foodchain.

To identify the best agronomic options to remediate affected agricultural land, it is advised to link radioactivity levels of soil with soil properties. In particular, information on K status of the soil will be essential to predict the efficiency of K fertilizer application in reducing the transfer of cesium from soil to crop.

The Team agrees with the purpose of continuing in the same intensive and successful way to screen radioactivity levels in foodstuff samples. However, foodstuff analysis should be integrated in all test sites as a parameter to assess the efficiency of the remediation. In addition, it will encourage people to start farming their lands again, and will further increase the confidence of the local, national and international consumers.

Acknowledgement 8: The Team recognizes that in the early phase of the accident, conservatism was a good way to manage uncertainties and public concerns related to reference levels in the context of food and agriculture.

Advice 8: With respect to the remediation of agricultural areas, the team considers that for the next cropping season there is room for removing some of the conservatism (such as that in factors determining the transfer of radioactive caesium from soil to crops) by taking into account data and factors published by the IAEA and the results obtained from the demonstrations sites. The IAEA is ready to support Japan in considering new and more appropriate criteria.

5.4 Urban areas

The Team's visits to sites have shown that decontamination of urban areas is actively pursued in contamination affected areas. The priorities are clearly established starting with the deliberate evacuation area and so called "hot spot" areas, kindergartens and schools, then community centers followed by individual settlements.

The contributions of different urban surfaces to human external doses and the associated opportunities for dose reduction are determined by settlement and building design, the construction materials, the habits of the populations, the mode of radionuclide deposition (dry or wet), the radionuclide and physico-chemical composition of the fallout, and time.

The analysis of the sources of external exposure in different population groups living in contaminated areas indicated that a significant fraction of the dose that would be received by people results from sources located in soil, on coated surfaces like asphalt and concrete and to a smaller extent on building walls and roofs.

The sites visited have shown the utilization of proven technologies for the decontamination of roofs, building walls, play grounds, swimming pools, parking lots, and asphalt covered areas. Thorough measurements and mapping of the contamination are carried out to ensure the most effective results and the elimination of hot spots. The most effective decontamination technologies that are pursued involve the removal of the upper soil layer. The tests performed indicate the use of different methods to achieve a significant reduction of dose rates.

It should be noted that in order to ensure high decontamination effectiveness and keep the associated costs low, validated models of urban decontamination were already developed by the international community and provided with sets of model parameters and practical recommendations for cleanup. The mission team was not in a position to understand to what extent these models are utilized.

The contaminated material that is removed and collected was temporally stored at sites because of the removal option used and the absence of interim storages. The current practice is either to bury the material in near surface trench and to cover it with a layer of clean topsoil or to collect it in a pile on the ground and to cover it with plastic sheets and sand bags to provide additional shielding. Both measures were considered as temporary measures before transport to interim storage.

The measurements indicate that a large part of the contaminated material collected from clean-up actions at urban demonstration sites is only slightly contaminated. The adequate pathways for such material could be found outside of the category of radioactive waste.

The portion of the removed material that qualifies as radioactive waste generated from urban decontamination should be disposed of in accordance with established regulatory requirements.

Acknowledgement 9: The Team appreciates the fact that some school sites were remediated mostly by volunteers with the technical support and guidance of JAEA. The team was informed that 400 school playgrounds have already been appropriately remediated (as of 30.09.2011).

Advice 9: With respect to waste in urban areas, the Team is of the opinion that it is obvious that most of the material contains very low levels of radioactivity. Taking into account the IAEA safety standards, and subject to safety assessment, this material might be remediated without temporary and/or interim storages. It is effective to utilize the existing municipal infrastructure for industrial waste. The IAEA is ready to support Japan in considering revised, new and appropriate criteria.

5.5 Forest areas

Based on lessons learned from the Chernobyl accident, forest countermeasures are labour-intensive and expensive, cannot be implemented quickly and have to be planned carefully. They are likely to be long-term activities and their beneficial effects take time to be realized.

The forest countermeasures tested in the aftermath of the Chernobyl accident can be broadly categorized into: (a) management; and (b) technological countermeasures.

Among management-based countermeasures, restrictions of various activities normally carried out in forests have been successfully implemented:

- Restricted access, including restrictions on public and forest-worker access.
- Restricted harvesting of food products by the public. The most commonly obtained food products include berries and mushrooms.
- Restricted collection of firewood by the public.
- Alteration of hunting practices.
- Fire prevention that is important in order to avoid secondary contamination of the environment.

The technologically-based countermeasures include the use of machinery and/or chemical treatments to alter the distribution or transfer of cesium in the forest. However, the cost-effectiveness of many technological countermeasures is questionable, especially when applied on a large scale. Thus, it is to be expected that such countermeasures will be restricted to small-scale cases only, if they are feasible at all. Such cases might include small areas of urban woodland, such as parkland, which is likely to be visited by many more people, rather than extensive and remote forest areas.

Technological countermeasures might include the mechanical removal of leaf litter or scraping of soil layers, clear cutting and ploughing, and the application of calcium and potassium containing fertilizers. However, any of these methods can damage the ecological functioning of the forest when applied outside of the normal schedule of forestry operations. These factors and the high economic costs of such operations, means that the practical use of such techniques as countermeasures remains largely speculative. Therefore, such measures have not been applied after the Chernobyl accident other than in small-scale experiments.

The results of cost-benefit calculations indicate that the management options likely to result in the least overall detriment are those which limit access and consumption of forest foods. Options, which involve technological intervention, application of chemicals, or altering the harvesting patterns in forests are unlikely to be used in practice.

The Mission Team understands that authorities in Japan are considering three possible options for remediation of the forest areas. The option that is considering remediation of the forest in the neighbourhoods of urban settlement and agriculture lands looks most realistic for implementation

Advice 10: Before investing substantial time and efforts in remediating forest areas, a safety assessment should be done to indicate if such remediation has benefit in reducing doses in order to invest in areas of greater benefits. This safety analysis should make use of the results of the demonstration tests

5.5 Aquatic areas

Aquatic environments include rivers, irrigation reservoirs, fish ponds, lakes and coastal areas. The last are being directly affected by the release of radionuclides from the affected NPP. Freshwater environments receive radionuclides from erosion and runoff of the soils in the watersheds. This contribution has a long term source of activity; the accumulation of the relevant radionuclides will preferentially take place in sediments. Organisms feeding from them may incorporate cesium to different degrees depending on the individual species and environmental conditions.

The monitoring of river water, sediments and fish is being conducted by different organizations; a limit for fish of 500 Bq/kg is being applied. Remediation of these areas was not addressed in detail by the Japanese counterparts during the meeting with the mission team. However, the exposure to members of the public through this pathway generally is of minor importance.

Advice 11. The mission team encourages the Japanese authorities to continue the useful monitoring of freshwater and marine systems.

5.6 Waste Management

Large volumes of contaminated material will be generated from massive clean-up/remediation activities in urban, agriculture, forest and aquatic areas that are affected mostly by radioactive cesium release. The generated material is to be collected, characterized for clearance or processing as required, storage and final disposal. It would include soil, organic material, vehicles, building and road material, aqueous liquids, trees and stumps contaminated with Cs-134 and Cs-134. The quantity of contaminated material from clean-up depends on the extent and depth of the contamination, the characteristics of the affected environment (urban, forest, agriculture, etc.) and the decision on the kind of management of the contamination in the affected area, e.g. stabilization, interdiction or clean-up. Clean-up criteria and methods applied determine generated volumes.

The authorities in Japan are considering nine reference decontamination cases that are based on annual effective dose and the type of area. The preliminary estimate of the volume of contaminated material from clean-up is anywhere between 5 and 29 million m^3. The contaminated debris (wood, concrete, and metal) from the destruction caused by the tsunami that has already been collected amounts to 2.3 million tonnes which needs to be added to this volume.

The current waste management strategy is considering the collection of contaminated material in dispersed temporary storages prior to consolidation in a smaller number of interim storages, pursuing large scale incineration of combustible material in available municipal solid waste incinerators equipped with electro-static precipitators and bag house. An inventory of collected material is planned to be done to keep track of the activity and the actually generated amounts. It is also understood that various volume reduction technologies for rubble, soil and other contaminated materials are under consideration to minimize volumes for storage and disposal.

The main challenge in waste management strategy implementation as well as in the implementation of clean-up campaigns is the management of very large volumes of generated material and the determination of site locations for interim storages for such volumes, the time frame for storage prior to disposal and the establishment of disposal locations.

It should be noted that a major proportion of the very large volumes of generated material that is to be collected will likely be only slightly contaminated. At the outset, it is imperative to have clear criteria

for what constitutes radioactive waste and which kind of waste can be cleared (either conditionally or unconditionally) from the regulatory control. The adequate characterization of collected material will then allow the distinction between material that can be unconditionally cleared, conditionally cleared and material that has to be managed as nuclear waste. The pathways for management of these three categories are significantly different depending on the results of safety assessment for each case.

The unconditionally cleared material can be considered for recycling and reuse or conveniently managed as municipal solid waste utilizing existing infrastructure for transportation, handling and disposal in municipal solid waste landfills. The management of conditionally cleared material would require certain arrangements for handling and disposal in designated municipal landfills equipped with systems for leachate collection, control of gases and adequate monitoring.

Only the fraction designated as radioactive waste would be required to meet the corresponding requirements for transportation, adequate processing, packaging, facilities for storage and disposal.

At present, it is not possible to estimate the relative proportions of these three categories of contaminated material and the consequences of the adoption of the proposed management options. For example, it is not clear to what extent municipal solid waste landfills can accommodate additional quantities from clean-up campaigns, how many existing landfills could be designated to receive conditionally cleared material, or to what extent municipal solid waste management infrastructure is available to handle additional volumes.

Pursuing a management strategy for all of these contaminated materials as radioactive waste due to over-conservatism would lead to enormous challenges in the timely establishment of a completely new infrastructure with regard to human resources, transportation and large facilities for processing and storage. It would also imply huge costs to meet the requirements for radioactive waste management and it would probably result in delays in the clean-up to allow displaced citizens to return and continue with their lives as early as possible.

The other major issue in strategy implementation is the determination of site locations for interim storage. The storage facilities for nuclear waste management are to provide safe and secure storage pending easy retrieval of waste for disposal to a suitable repository.

Advice 12: The IAEA Mission team encourages the Japanese authorities to actively pursue appropriate end-points for the waste in close cooperation with stakeholders. The national and local governments should cooperate in order to ensure the provision of these facilities. A lack of availability of such infrastructure would unduly limit and hamper successful remediation activities, thus potentially jeopardizing public health and safety.

6. Technical meeting and visits

On 7 October 2011, the IAEA Mission Team held a preliminary meeting with all of Japan's relevant Government Offices, Ministries and Agencies involved in the effort to develop strategy and plans to implement countermeasures to remediate the areas affected by the consequences of the nuclear

accident in the Fukushima Dai-ichi nuclear power plant. The meeting was held in the Ministry Office of Foreign Affairs (MOFA) building.

On 8 October, the IAEA Mission Team held a day-long meeting with the Japanese counterparts in charge of assisting the lives of victims around the Fukushima Dai-ichi nuclear power plant. This meeting was also held in the MOFA building.

On 9 October, the IAEA Mission Team travelled to Fukushima to get first-hand experience of the work carried out in the area, as well as to meet local government officials.

On their arrival in Fukushima, the IAEA Mission Team met members of the Fukushima Decontamination Team as well as staff from the Japan Atomic Energy Agency's (JAEA) Fukushima office and representatives from the Fukushima Prefecture for a briefing on the environmental remediation efforts underway in the area.

In the afternoon of the same day, the IAEA Mission Team visited the area surrounding the Haramachi thermal power plant in the city of Minami-Soma. The city, once a renowned holiday destination, was badly affected by the tsunami that hit Japan's east coast on 11 March 2011.

The IAEA Mission Team then visited a remediation model site located in the hills inland from the city of Minami-Soma, where methods and technologies for the remediation of forestry areas are being tested.

On 10 October 2011, the IAEA Mission Team visited four locations where model remediation projects are being carried out by the Fukushima Decontamination Team and JAEA. These include the Tominari Elementary school and the Shimooguni Central Assembly Hall, both located in the city of Date.

On the same day, the IAEA Mission Team also visited two sites where verification studies for the application of remediation technologies in agriculture are being conducted. Both sites are located in the territory of the village of Iitate.

At one agricultural site, rice has been planted in a paddy where a layer of earth with elevated levels of radiocaesium was removed from the top soil. In a near-by site known as Iitate village clear centre, the IAEA Mission Team received a briefing on a series of tests that are being carried out on the combustion of crops and soil with elevated levels of radioactivity.

In all of these demonstration sites, experts are evaluating the efficiency of a number of methods and technologies that can be used in environmental remediation strategies.

In the morning of 11 October 2011, the IAEA Mission Team paid a courtesy visit to the Governor of the Fukushima Prefecture.

In the afternoon of the same day, the IAEA Mission Team visited the accident site at TEPCO's Fukushima Dai-ichi nuclear power plant.

Following the conclusion of the visit to the Fukushima Prefecture, the IAEA Mission Team returned to Tokyo where it continued to meet with Japanese officials and draft its preliminary report.

On 12 October, the team met with officials from MEXT, the Atomic Energy Commission of Japan and the Nuclear Safety Commission.