Decontamination Guidelines

2nd Ed., 2013（Tentative Translation）

環境省
Ministry of the Environment

Tentative Translation

＜Attention＞

This material was translated temporarily and might be corrected in the future.

Introduction

The environmental pollution caused by radioactive materials discharged by the nuclear power plant accident associated with the Earthquake that Occurred off the Pacific Coast of the Tohoku Region on March 11, 2011has made it an urgent issue to promptly reduce the impact of this pollution on human health and the living environment.

In light of these circumstances, in August 2011 the Act on Special Measures Concerning the Handling of Environmental 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 (Act No. 110 of 2011; hereinafter the “Act on Special Measures concerning the Handling of Radioactive Pollution”) was passed and established as legislation by Diet members, and fully entered into effect starting in January 2012.

Pursuant to the Act on Special Measures concerning the Handling of Radioactive Pollution, initiatives for special decontamination areas in which the national government would carry out decontamination as well as intensive contamination survey areas wherein municipalities would implement decontamination were identified. As such, decontamination will be implemented in the following order, with the long-term target of bringing the additional exposure dose to no more than 1 millisievert per year (mSv/y).

1) Investigate and measure the status of the pollution and determine a decontamination zone in which decontamination and other measures are implemented (related to Articles 34 and 36 of the Act)
2) Then implement decontamination and other measures based on the decontamination plan (related to Article 40 of the Act)
3) Collect, transfer, and store the removed soil generated, in association with decontamination and other measures (related to Article 41 of the Act)

The Ministry of the Environment has formulated Decontamination Guidelines to explain these processes in a concrete and straightforward manner. These guidelines are divided into four parts, with the Guidelines for Methods for Investigating and Measuring the Status of Environmental Pollution in Intensive Contamination Survey Areas corresponding to process 1), the Guidelines Pertaining to Decontamination and Other Measures corresponding to process 2), and the Guidelines Pertaining to the Collection and Transfer of Removed Soil, and Guidelines Pertaining to the Storage of Removed Soil, both corresponding to process 3). There are some parts that are described collectively pertaining to the items that are related to each part, such as for measurements. Note that although these guidelines primarily cover decontamination in municipalities, they also cover decontamination by the national government. *

The first edition of these guidelines, which was formulated in December 2011, have been revised by incorporating knowledge and new technologies acquired since then in order to promote more effective decontamination. These guidelines were revised based upon responses to improper decontamination and by inquiring into the opinions of specialists, local governments, and others. In addition, they now also contain data that will be helpful in promoting the understanding among residents concerning the implementation of decontamination and related procedures.

At present, the methods given in these guidelines are deemed to be appropriate for implementing decontamination and related procedures, but the guidelines will be revised as needed in light of new knowledge accumulated along the way. In addition, a Decontamination Q&A has been formulated and released to serve as a supplementary explanation for the Decontamination Guidelines and other materials in order to promptly accommodate the implementation of decontamination in accordance with the actual circumstances of areas, and these will be added to and otherwise revised as needed.

* Excluding areas with especially high radiation doses.

Decontamination Guidelines

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Guidelines Pertaining to the Storage of Removed Soil

Definitions of Terms

Term	Explanation
The Act on Special Measures concerning the Handling of Radioactive Pollution	The Act on Special Measures Concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the NPS Accident Associated with the Tohoku District-Off the Pacific Ocean Earthquake that Occurred off the Pacific Coast of the Tohoku Region on March 11, 2011 (Act No. 110 of 2011)
Measures for decontamination of the soil, etc.	Measures taken for soil, vegetation, structures, etc. contaminated with radioactive materials discharged by the accident including the removal of the contaminated soil, fallen leaves and twigs, sludge accumulated in ditches, etc., preventive measures to keep the pollution from spreading, and other measures (Article 2, Paragraph 3 of the Act)
Removed soil	The soil generated from measures for decontamination of the soil, etc., implemented in a specific area for the decontamination zone (Article 2, Paragraph 4 of the Act)
The removed soil, etc.	The removed soil and waste generated from measures for decontamination of the soil, etc.
Decontamination and other measures	Measures for decontamination of the soil, etc., as well as the collection, transfer, storage and disposal of the removed soil (Article 25, Paragraph 1 of the Act)
Special decontamination area	An area found to have been significantly contaminated with radioactive materials discharged by the accident and where, taking other circumstances into account, the national government will implement decontamination and other measures. Such areas are designated by the Minister of the Environment. (Article 25, Paragraph 1 of the Act)
Decontamination plan for a specific area	A plan for the implementation of decontamination and other measures applicable to special decontamination areas. Such plans are formulated by the Minister of the Environment. (Article 28, Paragraph 1 of the Act)
Intensive contamination survey area	An area in which intensive investigation and measurement of the status of the environmental pollution from radioactive materials discharged by the accident shall be required. Such areas are designated by the Minister of the Environment. (Article 32, Paragraph 1 of the Act)
Decontamination plan	A plan formulated for the implementation of decontamination and other measures applicable to a zone that is located in an intensive contamination survey area and whose status of environmental pollution from radioactive materials discharged by the accident is found not to meet the requirements set forth in the relevant Ordinance of the Ministry of the Environment judging from the results of the investigation set forth pursuant to the Act, as well as other measurements. Such plans are formulated by the relevant prefectural governors or mayors of municipalities. (Article 36, Paragraph 1 of the Act)
Decontamination zone	A zone subject to a decontamination plan. (Article 35, Paragraph 1 of the Act)
Decontaminator	The executor of decontamination and other measures. The national government (Ministry of the Environment) in special decontamination areas, and the national, prefectural, or municipal government, etc. in decontamination zones. (Article 30, Paragraph 1 and Article 38, Paragraph 1 of the Act)

Units

Category	Unit	Explanation
Intensity of radioactivity	Bq (becquerel)	**Unit indicating the ability of a radioactive material to give off radiation** Indicates the number of atomic nuclei that decay (break down) * in one second (Bq=number of nuclei decay/second). For example, for radioactive potassium, which has 370 becquerels of radiation, 370 atomic nuclei decay every second and give off radiation, thereby changing into calcium or argon. * Decay (break down): The phenomena whereby atomic nuclei give off radiation and transform into different atomic nuclei or stable atomic nuclei.
	Bq/cm^2	The radioactive density of radioactive materials adhering to the surfaces of objects.
	Bq/kg	The radioactive concentration of radioactive materials contained within the soil, etc.
The amount of energy imparted by radiation	Gy (gray)	**Unit indicating the amount of radioactive energy absorbed within materials and human tissue** When radiation comes in contact with materials and the human body the energy that it contains is imparted to these materials. One gray indicates when one kilogram of a material has received one Joule* of energy from radiation (Gy=J/kg). * Joule (J): Unit indicating the magnitude of energy.
The effects from the radiation absorbed by people	Sv (sievert)	**Unit indicating the degree to which the human body is affected by radiation** This is used as an indicator for safely managing radiation. The extent of the impact that radiation has varies depending on differences in the type of radiation and its energy, as well as the type of human tissue and organ. Therefore, the differences in the type of radiation and its energy, as well as the degree to which radiation affects exposed tissue and organs, are corrected and calculated as a common scale (indicator).
	Sv/h	Radiation dose received per one hour.
	Sv/y	Radiation dose received per one year.
Indicator of the contamination of an object	cpm	**Unit indicating the count (count rate) for the radiation measured per one minute** Indicates the count for the radiation measured over one minute with a radiation measuring equipment. The acronym cpm stands for count per minute.

Part 1

Guidelines on the Methods for Investigation and Measurement of the Status of Environmental Pollution in Intensive Contamination Survey Areas

2nd Ed., 2013

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Ministry of the Environment

Part 1

Guidelines for Methods for Investigating and Measuring the Status of Environmental Pollution in Intensive Contamination Survey Areas

Guidelines for Methods for Investigating and Measuring the Status of Environmental Pollution in Intensive Contamination Survey Areas

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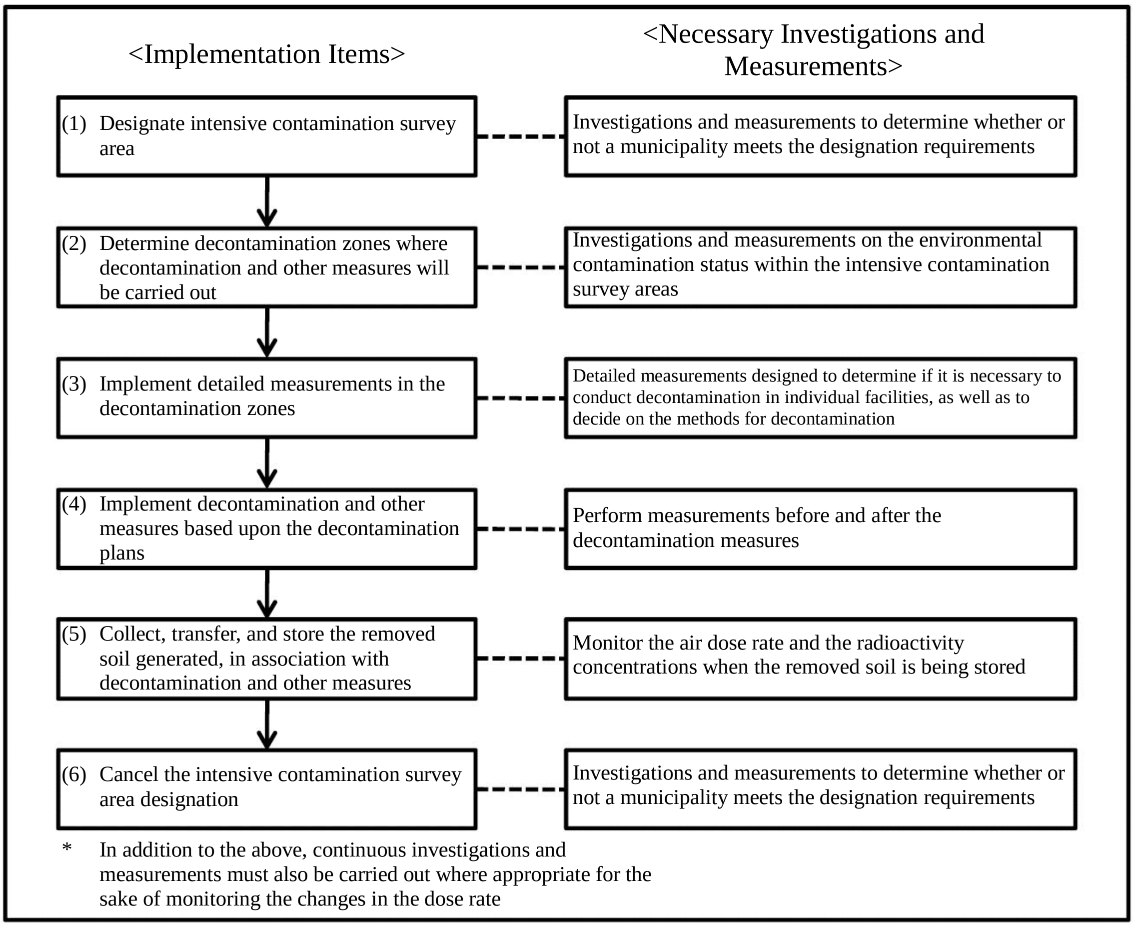
1. Basic Concept

In proceeding with measures for decontamination of the soil, etc. which was contaminated in areas where the additional exposure dose rate is 1 to 20 mSv/year in accordance with the Act on Special Measures Concerning the Handling of Environmental 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 (hereinafter the "Act on Special Measures concerning the Handling of Radioactive Pollution"), the necessary investigations and measurements will be implemented in order to carry out the matters listed in the implementation items in accordance with the following order.

Figure 1-1. The Implementation Items and Necessary Investigations and Measurements for Carrying Out Decontamination



* In addition to the above, continuous investigations and measurements must also be carried out where appropriate for the sake of monitoring the changes in the dose rate

The Minister of the Environment shall designate any area where the radiation dose is 0.23 μSv/hour or higher as an "intensive contamination survey area." The designated municipalities can subsequently conduct the investigation and measurement of the status of environmental pollution due to radioactive materials discharged by the accident in the intensive contamination survey area in accordance with the methods defined under the Ordinance of the Ministry of the Environment(Note). If the results of such investigation and measurement, etc. show that the area has a radiation dose of 0.23 μSv/hour or higher, such area shall be designated as a decontamination zone subject to a decontamination plan.

In addition to the above investigations and measurements, these guidelines introduce measurement methods that are necessary for each item of the detailed measurements within the decontamination zones, decontamination and other measures, and the storage of removed soil. They also introduce recommended measurement methods for performing accurate measurements. This is designed for correctly grasping the status of the decontamination and also for accurately assessing the effect of the decontamination. So strive to conduct accurate measurements, particularly in cases where the radiation dose targeted for measurement is low. If an investigation and measurements are conducted to determine whether a certain area falls under the requirements for designation as an intensive contamination survey area, basically employ the same methods as described in these guidelines. In intensive contamination survey areas, the investigation and measurements are expected to be conducted not only to determine the areas to be decontaminated, but also to continuously conduct investigations and measurements to monitor the changes in the dose rate. In the latter case, too, conduct the investigation and measurements according to these guidelines.

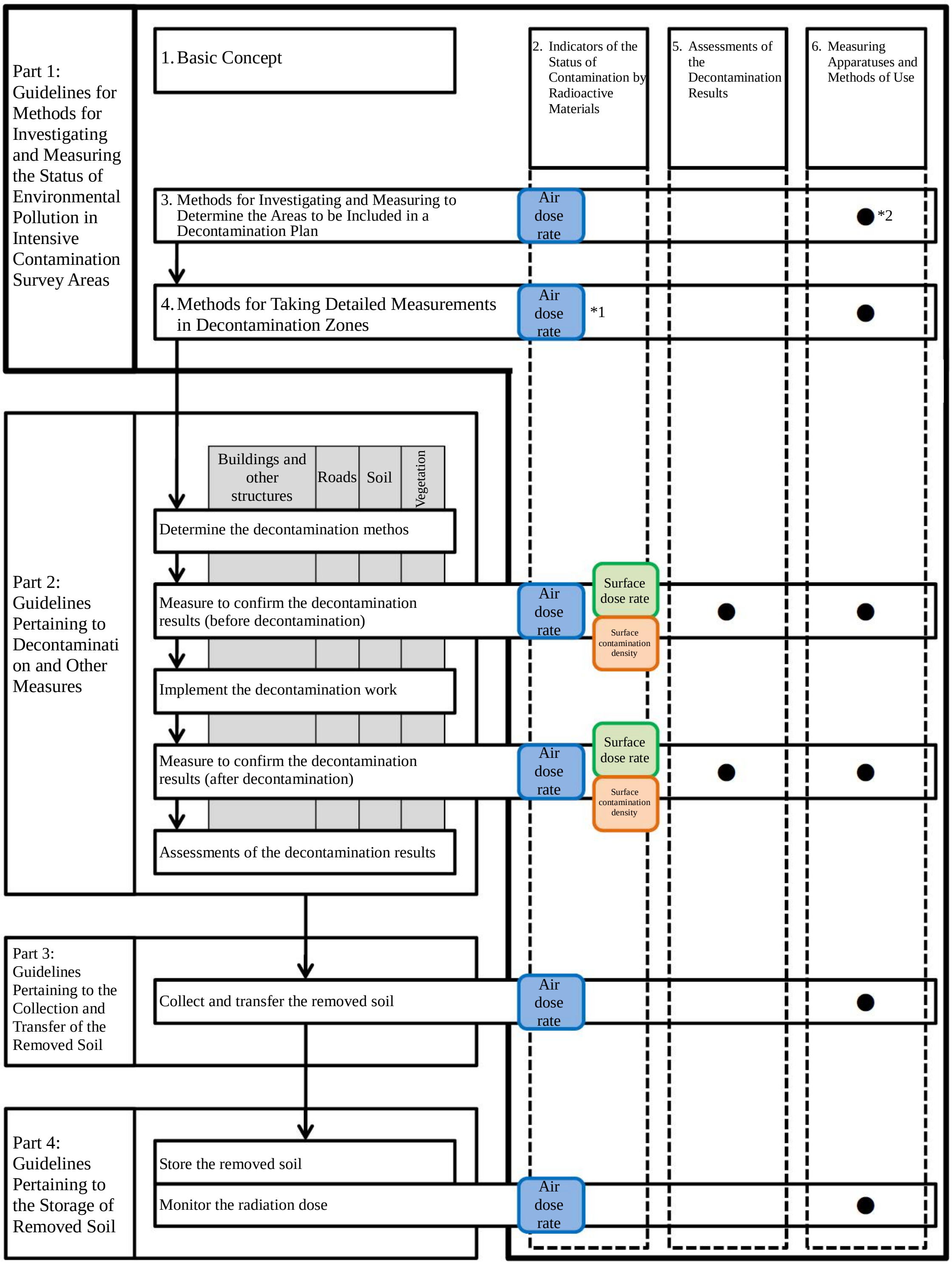
As for measurements to be conducted before and after implementing decontamination and other measures to confirm the effects of such decontamination and other measures, see “Part 2: Guidelines Pertaining to Decontamination and Other Measures.” Additionally, for measurements to be conducted to monitor the radiation dose when storing the removed soil, see “Part 4: Guidelines Pertaining to the Storage of Removed Soil,” and for measurements on the radiation dose from the waste generated in association with the decontamination and other measures, see the “Waste Guidelines” (March 2013, Vol. 2).

(Note) Ordinance for Enforcement of the Act on Special Measures concerning the Handling of Radioactive Pollution (Portion relevant to the Methods for Investigating and Measuring the Status of Environmental Pollution in Intensive Contamination Survey Areas)

Article 43: The investigation and measurements specified in Article 34, Paragraph 1 of the Act shall be conducted according to the following requirements:

1. The status of environmental pollution due to radioactive materials discharged by the accident shall be represented in terms of the radiation dose.
2. The radiation dose shall be measured using radiation measuring equipment that can accurately detect the measured value.
3. The radiation dose shall be measured at a point 50 to 100 cm above the ground.
4. The radiation measuring equipment shall be regularly calibrated at least once a year.

Figure 1-2. Descriptive Sections related to Measurements in the Decontamination Guidelines

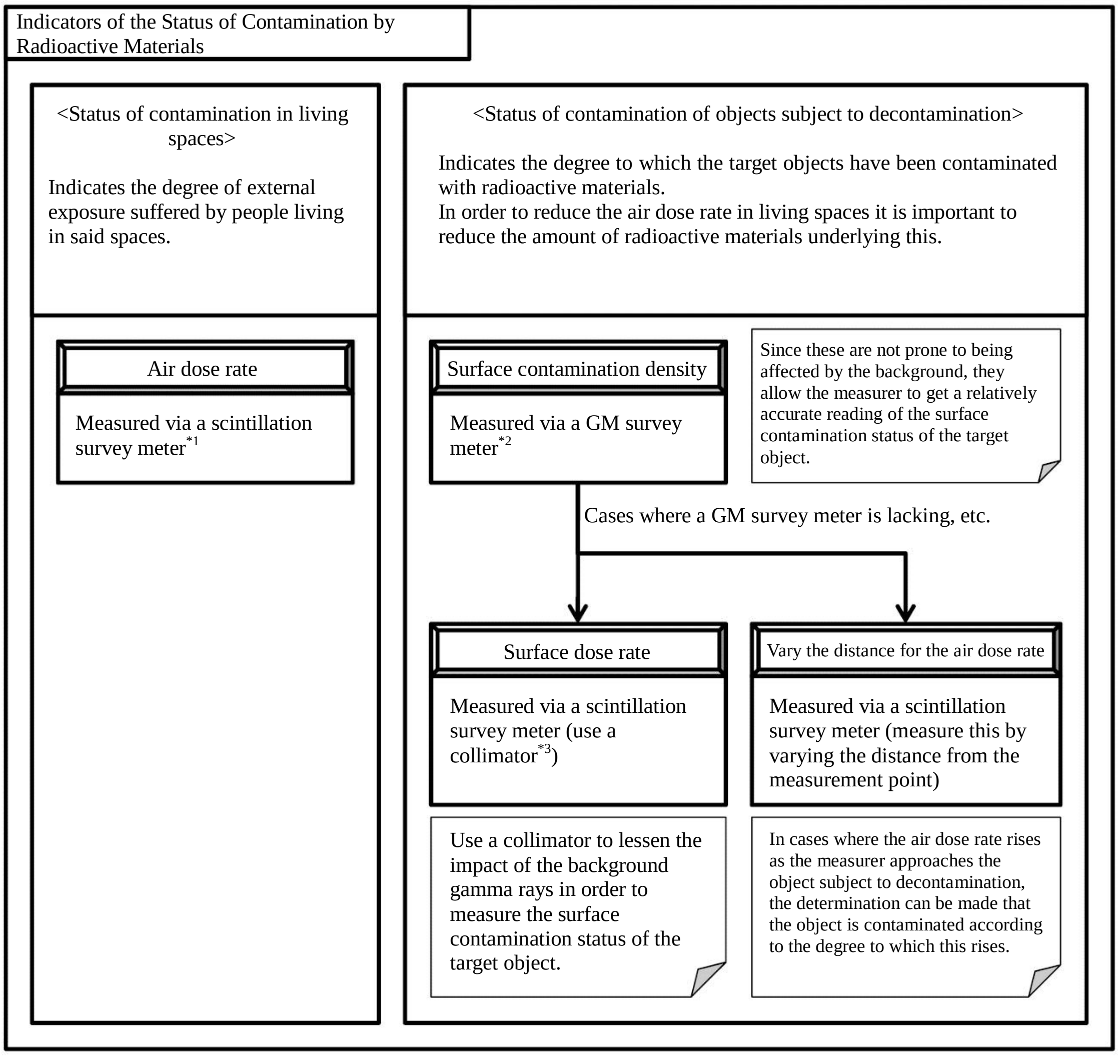


*1: If "4. Detailed Measurements in Decontamination Zones" concurrently serve as "Measure to confirm the decontamination results (before decontamination)", then measurements of surface dose rate and surface contamination density shall also be performed.

*2: Those parts related to "5. Assessments of the Decontamination Results" and "6. Measuring Apparatuses and Methods of Use" are indicated with a "●."

2. Indicators of the Status of Contamination by Radioactive Materials

Figure 1-3. Indicators of the Status of Contamination by Radioactive Materials



Indicators of the Status of Contamination by Radioactive Materials

<Status of contamination in living spaces>

Indicates the degree of external exposure suffered by people living in said spaces.

Air dose rate

Measured via a scintillation survey meter[*1]

<Status of contamination of objects subject to decontamination>

Indicates the degree to which the target objects have been contaminated with radioactive materials.
In order to reduce the air dose rate in living spaces it is important to reduce the amount of radioactive materials underlying this.

Surface contamination density

Measured via a GM survey meter[*2]

Since these are not prone to being affected by the background, they allow the measurer to get a relatively accurate reading of the surface contamination status of the target object.

Cases where a GM survey meter is lacking, etc.

Surface dose rate

Measured via a scintillation survey meter (use a collimator[*3])

Vary the distance for the air dose rate

Measured via a scintillation survey meter (measure this by varying the distance from the measurement point)

Use a collimator to lessen the impact of the background gamma rays in order to measure the surface contamination status of the target object.

In cases where the air dose rate rises as the measurer approaches the object subject to decontamination, the determination can be made that the object is contaminated according to the degree to which this rises.

*1: NaI scintillation survey meter, CsI scintillation survey meter, etc.

*2: Geiger-Müller counter tube survey meter

*3: A collimator refers to an instrument that prevents gamma rays from radiation sources located outside of the object measured from entering into the probe (detecting element) of the measuring apparatus. They are made of materials like lead that shield gamma rays (shielding material) (see “6. Measuring Apparatus and Methods of Use” regarding collimators).

(1) Indicators of the Status of Contamination in Living Spaces (Air Dose Rate)

Generally, indicators of the status of contamination by radioactive materials include “air dose rate,”[*1] “surface contamination density,”[*2] and “concentrations of radioactive material.” The first one represents the amount of radiation per unit time in a space to be measured, and it indicates the degree of external exposure. Accordingly, it can be used to indicate the status of contamination from a health protection point of view. In addition, the air dose rate can be directly measured in a relatively short period of time and so therefore it is a suitable method to promptly check the status of contamination of a wide area. Therefore, these guidelines use the air dose rate to indicate the status of contamination in an intensive contamination survey area.

These guidelines define the measurement points for determining the air dose rate in living spaces as "No. 1 measurement points." With No. 1 measurement points the air dose rate is to be measured at a point 1 m above the ground via an NaI scintillation survey meter* or other apparatus, in principle.

(2) Indicators of the Status of Contamination in Objects Subject to Decontamination (Surface Contamination Density, Surface Dose Rate, etc.)

In order to reduce the air dose rate in living environments it is important to take measures such as ascertaining the contamination status of objects subject to decontamination and reducing the amount of radioactive materials. For this reason, the status of objects subject to decontamination is estimated by using their surface contamination density or surface dose rate as indicators. When doing this it is crucial to exclude the effects of radiation sources other than the object being measured (background*3) to the extent possible as shown in "5. Assessments of the Decontamination Results."

These indicators are used for determining the decontamination methods and assessing the extent to which the radioactive materials have been reduced as a result of the decontamination work.

These guidelines define the measurement points for confirming the extent of contamination of objects subject to decontamination as "No. 2 measurement points." When measuring No. 2 measurement points it is recommended to use a Geiger-Müller counter tube survey meter (hereinafter "GM survey meter"*) to measure the surface contamination density of the objects subject to decontamination.

When a GM survey meter cannot be used, then the surface dose rate is to be measured via an NaI scintillation survey meter* or other apparatus on the condition that the gamma rays*4 from the outside be reduced by shielding it using lead or a similar material (collimator*). Furthermore, the air dose rate of the target object is to be measured at positions at the object's surface and at heights of 50 cm and 1 m. The target object will be deemed to be contaminated if the measured values at its surface (its surface dose rate) is significantly high.

* See "6. Measuring Apparatus and Methods of Use" regarding the various measuring apparatus and collimators.

Table 1-1. Summary of Indicators of the Status of Contamination by Radioactive Materials

<table>
<tr><td>Assessment perspectives</td><td>Status of contamination in living spaces</td><td colspan="3">Status of contamination of objects subject to decontamination</td></tr>
<tr><td>Category</td><td>No. 1 measurement points</td><td colspan="3">No. 2 measurements points</td></tr>
<tr><td>Measurement objective</td><td>• Determine the decisions of decontamination zones
• Determine if it is necessary to conduct decontamination within individual facilities in the decontamination zones through detailed measurements in the zones (determine by using mean dose rate)
• Determine the comprehensive results of the decontamination within the individual facilities from the decontamination and other measures (however, attention must be paid to the fact that this is affected by background radiation[*3])
• Monitor the radiation dose when the removed soil is stored</td><td colspan="3">• Determine the scope for the decontamination in individual facilities and determine the amount of radioactive materials (extent of the contamination) in conjunction with the detailed measurements carried out within the decontamination zones
• Confirm the degree to which the contamination of the objects subject to decontamination has abated due to the decontamination and other measures</td></tr>
<tr><td rowspan="2">Indicator (measurement position)</td><td rowspan="2">Air dose rate (1 m[*1])</td><td rowspan="2">Surface contamination density (1 cm)</td><td colspan="2">Surface dose rate (1 cm)</td></tr>
<tr><td>Use a collimator</td><td>Vary the distance and measure[*2]</td></tr>
<tr><td>Examples of measuring apparatus</td><td>• NaI scintillation survey meter
• CsI scintillation survey meter</td><td>- GM survey meter</td><td colspan="2">• NaI scintillation survey meter
• CsI scintillation survey meter</td></tr>
<tr><td>Methods for using the measurement results</td><td>• Determine the decontamination zones
• Assess the improvements in the contamination status in living spaces through the decontamination work</td><td colspan="3">• Determine the decontamination methods
• Assess the extent to which the radioactive materials have abated through the decontamination work</td></tr>
</table>

*1: For the contamination status in living spaces, in principle, measurements should be taken at a height of 1 m from the ground (it would also be fine to measure at a height of 50 cm at elementary and lower level schools, as well as special-needs schools, with consideration for the living spaces of infants and schoolchildren in the lower grades).

*2: The surface dose rate of the target object is to be measured at positions at the object's surface and at heights of 50 cm and 1 m, and then the measured values are to be compared.

3. Methods for Investigating and Measuring to Determine the Areas to be Included in a Decontamination Plan

(1) Basic Concept

As a rule, the decontamination zone (areas to be included in a decontamination plan) are determined by the units of areas such as "*aza*" and municipal blocks, and determination is made concerning whether the dose rate for each area falls under the planning requirement of 0.23 μSv/hour or higher.

Concerning the living environment for children, such as schools and parks, it is possible to determine a decontamination zone based on a facility rather than on an area such as municipal block.

(2) Methods for Investigating and Measuring by Unit of Area

Define the areas to municipal blocks as finely as possible in consideration of the circumstances of the municipality after selecting the mesh for actual investigation and measurement. If the results of existing surveys, such as aerial monitoring using aircraft, indicate that the blocks fall under (do not fall under) the planning requirements, it is not necessary to conduct any additional investigation and measurement.

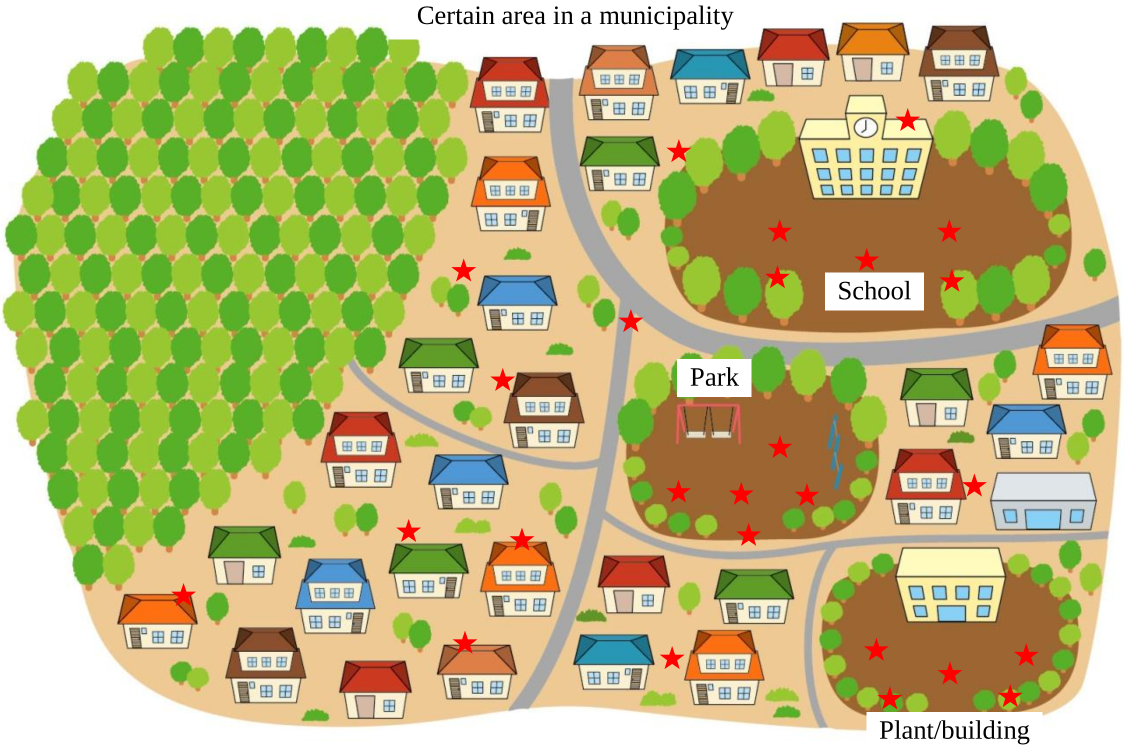
This subsection provides examples of how to investigate and measure each block and to determine whether it falls under the planning requirements. Different blocks have different conditions, so it may be necessary to divide a block into the given meshes to conduct the investigation and measurements or it may be possible to determine in a manner appropriate for the circumstances of each area in reference to the examples described below.

[Example 1: Determination based on the measurement results at various points]

a) Define the concrete measurement points and the number of points in each municipal block according to the land use type and surrounding conditions (see Figure 1-4). Make the determination according to the following points:
   - Compare the measurement points to identify any tendency for the whole area.
   - Avoid measurement points such as those that are under trees or in street drains, where the dose rate may be locally high, since the purpose of the measurement is to determine the average dose rate for the area as a whole.
   - It is recommended to increase the number of measurement points in living spaces that are used by many residents such as areas where there are many buildings.
   - It is not always necessary to conduct an investigation and measurements in such areas as forest areas since this does not automatically reduce the radiation dose affecting people.
   - If necessary, conduct the investigation and measurements efficiently, for example, by using such means as a monitoring car.

b) After the measurements have been taken at all the points, average the measured values to find the mean dose rate for the whole area.
c) Determine whether the area falls under the planning requirements according to the resulting mean dose rate.

Figure 1-4. Example of the determination of whether the area meets the planning requirements based on the measurement results at various points



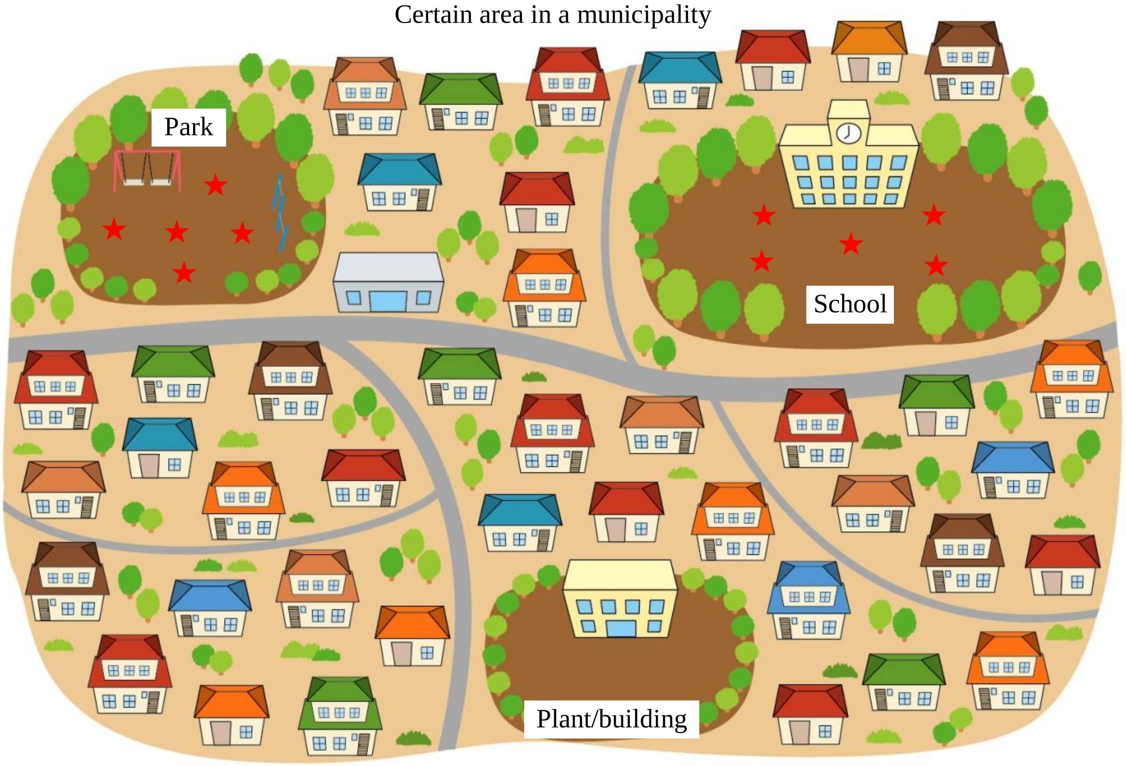
★: Measurement point

[Example 2: Determination based on the measurement results in schools and parks]

a) Define the concrete measurement points and the number of points in each municipal area (see Figure 1-5). Make the determination in consideration of the following points:
    - Take measurements mainly in the living environments used by children, such as schools and parks, in the area.
    - Avoid measurement points such as those that are under trees or in street drains, where the dose rate may be locally high, since the purpose of the measurement is to determine the average dose rate for the whole area.
    - Set up about five measurement points in each school or park.
b) After the measurements have been taken at all of the points, average the measured values to find the mean dose rate for the whole area.
c) Determine whether the area falls under the planning requirements according to the resulting mean dose.

Figure1-5. Example of the determination of whether the municipal area meets the planning requirements based on the measurement results for schools and parks

Certain area in a municipality



★: Measurement point

(3) Methods for Investigating and Measuring of the Living Environment of Children, such as Schools and Parks

Concerning the living environment for children, such as schools and parks, it is possible to determine a planning area based on a facility rather than on an area such as municipal block.

This subsection shows how to investigate and measure each of the schools and parks as well as to determine whether they fall under the planning requirements.

a) Define the concrete measurements points and the number of points in the facilities (see Figure 1-6). Determine these according to the following points:
   - Avoid measurement points such as those that are under trees or in street drains, where the dose rate may be locally high, since the purpose of the measurement is to determine the average dose rate for each facility.
   - Set up about five measurement points in each facility.

b) After the measurements have been taken at all the points, average the measured values to determine the mean dose rate for the facility.

c) Determine whether the facility falls under the planning requirements according to the resulting mean dose rate.

Figure 1-6. Example of the determination of whether the area meets the planning requirements based on the measurement results only from facilities used by children, such as schools and parks

Certain area in a municipality

★: Measurement point

4. Methods for Taking Detailed Measurements in Decontamination Zones

When implementing decontamination, detailed measurements must be carried out in order to confirm the targets and contents of the decontamination work for the individual facilities within the decontamination zone.

The measurement points for the detailed measurements shall be based on the locations exemplified as No. 1 measurement points that are stipulated in “Part 2: Guidelines Pertaining to Decontamination and Other Measures.” See “Part 2: Guidelines Pertaining to Decontamination and Other Measures” for specifics.

Moreover, for the detailed measurements it is necessary to list information like the measurement location, the measurement apparatus, the measurement time and date, the weather, a summary of the measurement results (measurement point number, the measured object, the measurement conditions (measurement height, etc.), the measurement results), a map of the measurement location (on which the measurement point number and measured object have been listed), and so forth.

It is also possible to combine the detailed measurements with the measurements prior to the start of the decontamination work (advance measurements). The pre-decontamination measurements are essentially carried out immediately before the decontamination work in order to accurately ascertain the decontamination results. Therefore, when the results of the detailed measurements and the pre-decontamination measurements are combined attention must be paid to ensure that there is not too much of a gap left between when they are performed (make sure that the gap from the day when the detailed measurements are taken until the targets and contents of the decontamination work are confirmed (public notice of the work, etc.) are no longer than roughly six months long).

In light of these results, the decontamination methods for the region in question are to be determined based around the decontamination methods indicated in “Part 2: Guidelines Pertaining to Decontamination and Other Measures.”

See “Part 2: Guidelines Pertaining to Decontamination and Other Measures” regarding the measurements before and after the decontamination is carried out.

5. Assessments of the Decontamination Results

The assessments of the decontamination results can largely be broken down into assessments of the air dose rate of the living spaces in the decontamination zone as a whole and the individual targeted facilities, as well as assessments of the surface concentration density of the objects subject to decontamination in the individual instances of decontamination work.

(1) Assessments of the Air Dose Rate in Living Spaces

After the decontamination has been carried out measurements of the air dose rates in living spaces are to be performed. When doing so, the question of: “To what extent has the exposure dose of the people living in said spaces been reduced through decontamination?” serves as the target for the results of the decontamination. As such, the “reduction rate” in the air dose rate can be used as an indicator to confirm the extent to which the exposure dose has fallen from before and after the decontamination.[*5]

(2) Assessments of the Surface Contamination Density on the Objects Subject to Decontamination

It is important to assess the “decontamination results for each object subject to decontamination” both when confirming the extent to which the radioactive materials have been removed through the individual cases of decontamination work, as well as when comparing and verifying the individual decontamination methods by conducting experiments. The “reduction rate” and “decontamination factor (DF)” can be used as indicators to confirm the extent to which the exposure dose has fallen from before and after the decontamination.[*5]

When assessing the decontamination results, attention should be paid to the possibility that the decontamination results will be assessed as being smaller than they actually are if any of the background radiation[*3] is contained in the measured values.

6. Measuring Apparatuses and Methods of Use

Here explanations will be provided of the necessary measurements throughout the Decontamination Guidelines in their entirety, including not only measurements for formulating decontamination plans but also measurements for confirming the results of radiation reductions through the decontamination work and more.

(1) Types of Measuring Apparatuses

i. Measuring Apparatuses for Air Dose Rates and Surface Dose Rates

A calibrated scintillation survey meter (of the energy compensation type[*6] as a rule) is used to measure the air dose rate and surface dose rate of gamma rays.[*4] Any other measuring apparatus can be used if it can measure the air dose rate of gamma rays, but be sure to use a measuring apparatus that has been calibrated.

Figure 1-7. Examples of Scintillation Survey Meters
(NaI scintillation survey meters)

ii. Measuring Apparatuses for Surface Contamination Density (*Used for measurements to confirm the degree of contamination in objects subject to decontamination (Part 2))

Use calibrated GM survey meters to primarily measure the beta rays[*7] from the surface of the target object. With a GM survey meter 100% of the beta rays that enter the probe (detecting element) will be detected, whereas the detection rate for the gamma rays will only be around several percent. What is more, since the beta rays can only enter via the entrance window at the tip of the probe[*8] it is resistant to being affected by the radiation entering from outside of the measured object. This gives it the characteristic of being effective for ascertaining the contamination status of the measured object.

Figure 1-8. Examples of GM Survey Meters

(2) Maintenance of the Measuring Apparatuses

Measuring apparatuses may give incorrect readings for reasons like changes in the sensitivity of the detector caused by the measuring environment or any degradation of components in the electrical circuit. It is therefore essential that the precision of a measuring apparatus be ensured by periodically conducting the calibration and adjustment of the measuring apparatus (confirmation of the readings).

i. Scintillation survey meter

Confirm whether the required performance is being satisfied by conducting the calibration in compliance with the calibration specified in the Japanese Industrial Standards (JIS Z4511, JIS Z4333)[*9] at least once a year.

If it is difficult to perform the calibration as described above, it is possible to substitute this with the adjustment method shown in Figure 1-9 as a means of confirming that the level of performance required of the apparatus subject to calibration is being met. For this adjustment method, prepare a separate calibrated energy compensation type scintillation survey meter as a reference and simultaneously measure the radiation dose about five times at the same point. Then confirm and record the ratio of the mean measured values from the calibrated reference apparatus to the mean measured values from the actual apparatus subject to calibration (average of the readings from the reference apparatus ÷ average of the readings from the actual apparatus subject to calibration), based upon which the actual measured values multiplied by this ratio shall be taken as the correct value (note that if the ratio of the mean measured values to the mean measured values from the calibrated reference apparatus differs by 20 percent[*10] or greater than 1, it shall be deemed that the apparatus is not sufficiently reliable). When doing this in a location where the dose is around the same level as in the region where the apparatus will actually be used, you can confirm and record the difference in the readings and find the correct value by adding or subtracting the mean value of the differences to or from the readings given by the actual apparatus. (note that if the mean value of difference from the mean measured values from the calibrated reference apparatus exceeds 20 percent, it shall be deemed that the apparatus is not sufficiently reliable.) If there is no other option but to measure the dose rate using a measuring apparatus that has not yet been calibrated, the measuring apparatus shall be calibrated later, and the measurement results shall be evaluated after correcting the values, if necessary. If the calibration results show that your apparatus is not reliable, do not utilize the results of such a measurement apparatus as information for making any decisions. Concerning measuring apparatuses with no energy compensation feature, it is recommended that an adjustment be performed using a calibrated energy compensation type scintillation survey meter for confirmation as an indicator to ensure that the required performance targets can be satisfied even if it is still less than one year since it was purchased.

In addition, perform daily inspections to check the remaining battery level, to detect any breakage of cables or connectors, to check the operation of switches and measure the background dose (confirm that there are no significant variations in readings compared to those in the past, by conducting measurement in the same area in which the resulting background value does not vary significantly.) The purpose of this is to judge if there are any abnormalities or breakages.

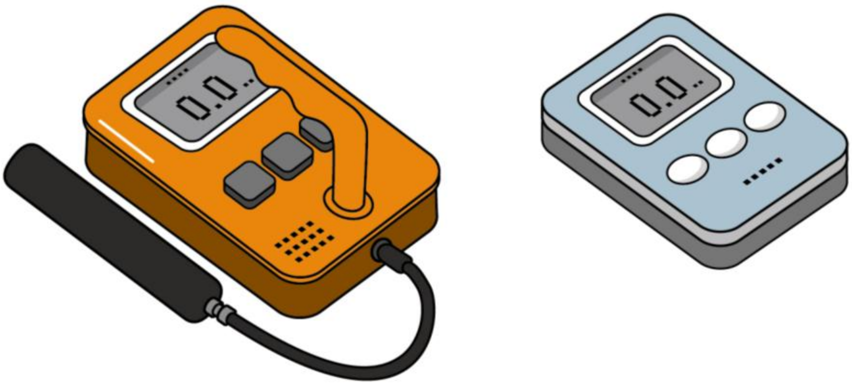
Figure 1-9. Method of Adjusting the Measuring Apparatus in the Field

Method for Adjusting via the Ratio in the Measured Values

1) Take about five measurements with the actual apparatus and a calibrated reference apparatus simultaneously.
2) Calculate the ratio of the mean measured values from the calibrated reference apparatus to the mean measured values from the actual apparatus (average of the readings from the reference apparatus ÷ average of the readings from the actual apparatus).
3) If the measurement is taken with the actual apparatus, the actual measured value multiplied by the ratio above shall be taken as the correct value.
(If the ratio of the mean measured values to the mean measured values from the calibrated reference apparatus differs by 20 percent or greater than 1, it shall be deemed that the apparatus is not sufficiently reliable)

Method for Adjusting via the Differences in the Measured Values

1) Take about five measurements with the actual apparatus and a calibrated reference apparatus simultaneously (do this in a location where the dose is around the same level as in the region where the instrument will actually be used).
2) Calculate the mean value of differences between the measured values from the calibrated reference apparatus and those of the actual apparatus.
3) Find the correct value by adding or subtracting the mean value of the differences to or from the measured values given by the actual apparatus.
(If the mean value of differences between the measured values from the calibrated reference apparatus exceeds 20 percent, it shall be deemed that the instrument is not sufficiently reliable).



ii. GM survey meter

Confirm whether the required performance is being satisfied by having the manufacturer perform maintenance[*11] at least once a year. In addition, perform daily inspections to check if there is any damage to the entrance window (cracks or holes) or any breakage of cables or connectors, the remaining battery level, to check the operation of switches and measure the background dose (confirm that there are no significant variations in readings compared to those in the past, by conducting measurement in the same area in which the resulting background value does not vary significantly.) The purpose of this is to judge if there are any abnormalities or breakages.

(3) Methods of Use of Measuring Apparatuses

i. Scintillation survey meter (air dose rate measurements)

Take the measurements by taking into account the following precautions (see Figure 1-10). For specific methods of use of measuring apparatuses, see the corresponding instruction, etc. for each measuring apparatus.

a) As the results of the investigations and measurements to determine the decontamination zones are based on the average air dose rate of the areas concerned, measurements in depressed areas and puddles, street drains, under rainwater guttering, water catchment wells, under or near trees, or in places where raindrops falling from buildings land, as radioactive materials tend to become concentrated in such places due to rainwater and drainage water.

Note: For the method of measurement to identify points that are responsible for relatively high radiation dose, see the Guidelines Concerning Radiation Measurement (issued by the Ministry of Education, Culture, Sports, Science and Technology on October 21, 2011).

b) Prevent the measuring apparatus from being contaminated by the subject to be measured by wrapping the main body and probe (detecting element) preferably in a thin plastic sheet.

c) Take the measurements at a point 1 m above the ground, in principle. Note that the height can be 50 cm if measurements are conducted at an elementary school, etc., while taking into account the living space for infants and schoolchildren in the lower grades.

d) For measuring apparatuses that allow you to set a time constant,[*12] perform the measurements after a span of time that is more than three times longer than the time constant has elapsed (see Figure 1-11).

e) Hold the probe (detecting element) parallel to the ground surface while keeping it as far away as possible from your body. When performing measurements in the same location for the measurements from before and after the decontamination, take the measurements with the probe and your body always in the same position and facing the same direction.

f) Wait for the readings to become stable before reading the values (make a single measurement at each point). The readings will change even after they have become stable, so take the mean value as the measured value.

---

* Since the measuring apparatus provide estimates of the times until a correct response can be obtained (time constants), the power to the measuring apparatus shall be turned on and the reading (measured value) shall be read off only after waiting until the readings stabilize. If the readings on the measuring apparatus disappear, switch the range

and take the measurements, and if the readings disappear in the maximum range, either interpret those readings as being in the maximum range or higher, or use another type of measuring apparatus to take the measurements.[*5] If readings vary, the average value shall be read. Please refer to the Ministry of Education, Culture, Sports, Science and Technology's Guidelines Concerning Radiation Measurement (issued by the Ministry of Education, Culture, Sports, Science and Technology on October 21, 2011) for more information about the handling of measuring apparatus.

g) Write the measured value on the record sheet.

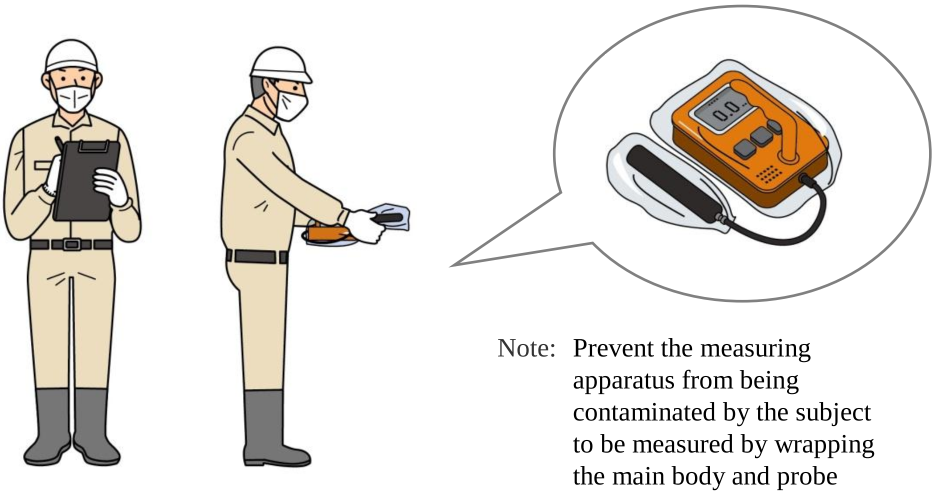
[Precautions]

- In cases where snow has accumulated at the measurement location there is the possibility that the measured values will diminished as a result of being shielded from the snow, so perform the measurements after the snow has melted. If you press ahead with performing the measurements when there is accumulated snow, clearly specify that there is accumulated snow and record the depth of the snow as needed.
-

Figure 1-10. Method of Use of a Measuring Apparatus (Scintillation Survey Meter)

■ Notes on measurement

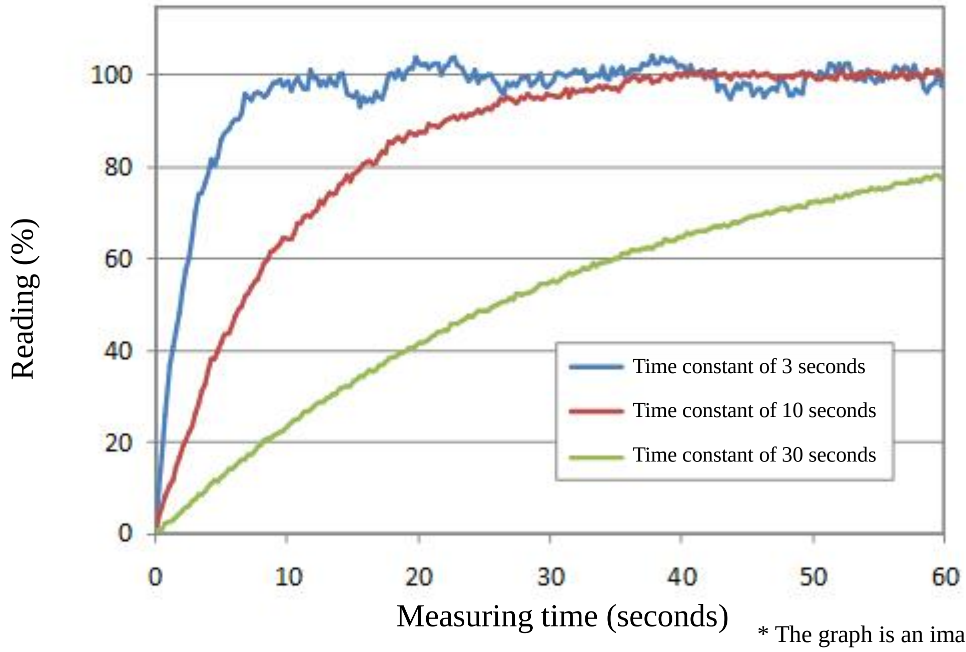
1) Determine the measurement points while avoiding any depressed areas and points in the vicinity of a building, etc.
2) Take the measurements at a point 1 m above the ground, in principle (the height may be 50 cm at elementary schools, etc.).
3) Hold the probe parallel to the ground surface while keeping it as far away as possible from your body.
4) Perform the measurements after a span of time that is more than three times longer than the time constant has elapsed (when you can set the time constant).
5) Wait for it to become stable before reading the measured value (mean value).
6) Write the measured value on the record sheet.



Note: Prevent the measuring apparatus from being contaminated by the subject to be measured by wrapping the main body and probe (detecting element) preferably in a thin plastic sheet.

Figure 1-11. Time Constant

- In order to accurately measure the radiation at the decontamination sites it is essential to take the measurements after the measured values have stabilized by allowing a span of more than three times as long as the time constant to elapse.



* The graph is an image

ii. Scintillation survey meter (surface dose rate measurements) (*Used for measurements to confirm the degree of contamination in objects subject to decontamination (Part 2))

Take the measurements by taking into account the following precautions. For specific methods of use of measuring apparatuses, see the corresponding instructions, etc. for each measuring apparatus.

a) For the investigations and measurements to ascertain the degree of contamination of the objects subject to decontamination, it is necessary to perform the measurements from before and after the decontamination in the same point, which can be achieved by such means as marking the measurement point.

b) Prevent the measuring apparatus from being contaminated by the subject to be measured by wrapping the main body and probe (detecting element) preferably in a thin plastic sheet.

c) Take the measurements at a point that is roughly 1 cm above the measured object, in principle.

d) Hold the probe (detecting element) parallel to the surface of the measured object while keeping it as far away as possible from your body. When performing measurements in the same location for the measurements from before and after the decontamination, take the measurements with the probe and your body always in the same position and facing the same direction.

e) For measuring apparatuses that allow you to set the time constant, perform the measurements after a span of time that is more than three times longer than the time constant has elapsed.

f) Wait for the readings to become stable before reading the values (make a single measurement at each point). The readings will change even after they have become stable, so take the mean value as the measured value.

g) Write the measured value on the record sheet.

[Precautions]

- There is the possibility of assessing the results of the decontamination as being lower than they actually were[*13] as a result of background[*3] radiation being measured together with the readings. Therefore, one way to deal with cases where the background radiation has a large impact on this is to use a collimator.

Figure 1-12. Example of a Collimator (Left) and an Example of Measurements Using a Collimator

Provided by: Japan Atomic Energy Agency (JAEA)

* Since collimators are used by being placed inside of probes (detecting elements) they are oftentimes cylindrical in shape, and the thicker the shielding material enveloping the probe the more that the gamma rays entering from the outside can be reduced. With an NaI scintillation survey meter the tip of the probe faces downwards when measurements are taken with the use of a collimator, so there are no particular problems with the measurements.

iii. GM survey meter (Measurements of the surface contamination density)

(*Used for measurements to confirm the degree of contamination in objects subject to decontamination (Part 2))

Take the measurements by taking into account the following precautions (see Figure 1-13). For specific methods of use of measuring apparatuses, see the corresponding instructions, etc. for each measuring apparatus.

a) For the investigations and measurements to ascertain the degree of contamination of the objects subject to decontamination, it is necessary to perform the measurements from before and after the decontamination in the exact same point, so mark the measurement point. GM survey meters are susceptible to being affected by changes in the measurement point, so extra care is required.

b) Prevent the measuring apparatus from being contaminated by the measured object by wrapping the main body and probe (detecting element) preferably in a thin plastic sheet.

c) Take the measurements at a point that is roughly 1 cm above the measured object, in principle.

d) Hold the surface of entrance window (window side) of probe (detecting element) toward the surface of the measured object. When performing measurements in the same location for the measurements from before and after the decontamination or the like, take the measurements with the probe and your body always in the same position and facing the same direction.

e) For measuring apparatuses that allow you to set the time constant, perform the measurements after a span of time that is more than three times longer than the time constant has elapsed (see Figure 1-11).

f) Wait for the readings to become stable before reading the values (make a single measurement at each point). The readings will change even after they have become stable, so take the mean value as the measured value.

g) Write the measured value on the record sheet.

[Precautions]

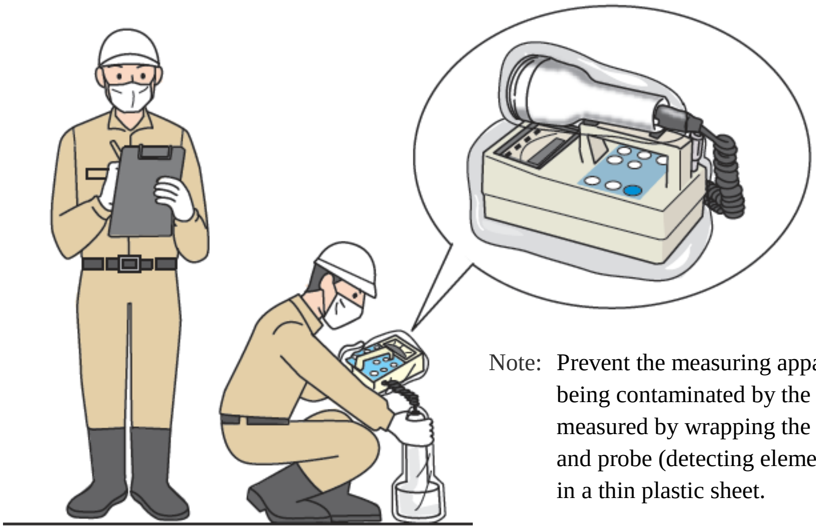
- GM survey meters are characterized by the fact that they are comparatively resistant to being affected by the background, but one way to carry out even more accurate measurements is to use a collimator.[*14]
- Depending on the circumstances, one way to assess the net beta ray dose emitted from the measured object is to subtract the dose of gamma rays that enter the probe (values measured by covering the entrance window with a plastic plate to exclude the beta rays) from the net dose of radiation that enters the probe (detecting element) (values measured without the use of shielding).[*14*15]
- If the surface of the measured object is wet some of the beta rays will be shielded,

which could potentially produce measured values that are somewhat lower than the actual values. Therefore, take measurement when the surface of measured objects is dry to the extent possible.

Figure 1-13. Method of Use of Measuring Apparatus (GM Survey Meter)

■ Notes on measurement

1) Determine the measurement points while avoiding any depressed areas and points in the vicinity of a building, etc.
2) Take the measurements at a point that is roughly 1 cm above the ground, in principle.
3) Hold the window side of the probe (detecting element) toward the surface of the measured object while keeping it as far away as possible from your body.
4) Perform the measurements after a span of time that is more than three times longer than the time constant has elapsed (when you can set the time constant).
5) Wait for it to become stable before reading the measured value (mean value).
6) Write the measured value on the record sheet.



Note: Prevent the measuring apparatus from being contaminated by the subject to be measured by wrapping the main body and probe (detecting element) preferably in a thin plastic sheet.

iv. Precautions on Measurements in General

■ Setting the measurement points

- Even when measured objects made of the same materials with the uniform configuration extending in an open space are measured there is the potential for inequalities in the degree of their surface contamination depending on the location. As such, for the measurements to confirm the decontamination results, it is necessary to perform the measurements from before and after the decontamination in the same point, which can be achieved by means of marking the measurement point in advance.

- To measure the surface dose rate and surface contamination density of playground equipment, trees, and other objects that lack flat, planar regions, perform the measurements by using a part where the decontamination results can be confirmed as the measurement point.

■ Shielding via collimators and plastic plates

- When using a collimator some of the gamma rays pass through the collimator, while some gamma rays also enter into it through the gaps in the shielding material. In light of these facts, you should take note that a collimator does not completely shield against the gamma rays coming from anything other than the measured object.
- When using a plastic plate to shield against beta rays, use spacers or the like to ensure that the distance between the measured object and the entrance window is the same to the extent possible.
- Correct measurements cannot be taken if the collimator and the plastic plate are contaminated, so cover them with plastic sheet when using them where appropriate and wipe away any radioactive material that may be adhering to them.

■ Causes for variance in the measured values

- The decay of radioactive materials occurs randomly, and so measured values for radiation doses are fraught with error.[*16]
- It is crucial to take into consideration the fact that houses and trees present in the vicinity around the measurement location, as well as the measurer and other people around the measurement location, have an effect on the measured values in that they serve as external radiation sources, shields, and scatterers.
- It is difficult to strictly maintain a distance of 1 cm between the probe (detecting element) and the measured object when measuring the surface dose rate and the surface contamination density, and so variance will arise in the measured values associated with the fluctuations in these distances. This tendency becomes particularly pronounced when there is unevenness in the surface of the measured object (one approach is to use spacers or the like to maintain a uniform distance).
- Discrepancies may arise in the measured values obtained from different measuring apparatuses due to the differing features of the apparatuses. Discrepancies may also arise in the measured values obtained when using collimators with different materials and thicknesses due to their different shielding capabilities.
- Even in cases where the amount of radioactive material found within a measured object is the same, when the depth at which this radioactive material is found differs the radiation dose emitted from the surface will also differ, and thus the measured values will not turn out the same.
- GM survey meters primarily measure beta rays[*7]. Therefore, you must keep in mind the possibility that the beta rays given off by a radioactive material found deeper in an object than the surface may be shielded by the material between it and the surface.
- GM survey meters primarily measure beta rays. Therefore, when the surface of the

measured object is wet these beta rays will be partially shielded, which could possibly produce measured values that are somewhat smaller than the actual values.

- Differences in the level of proficiency of the measurer are another source of variance. It is essential that the measurements be carried out by people who have a full understanding of the objective of the actual measurements being carried out, the measurement methods, notes of caution, and so on. For this reason, it is important that initiatives to preserve measurement precision be instituted, such as by having the work manager ascertain and confirm the capabilities of those involved in the measurements.

Table 1-2. Summary of Measuring Apparatuses and Methods of Use

Category	No. 1 measurement point	No. 2 measurement point	
Purpose of measurements	Contamination status of living spaces	Contamination status of objects subject to decontamination	
Object measured	Gamma rays	Gamma rays	Beta rays
Examples of measuring apparatuses	• NaI scintillation survey meter • CsI scintillation survey meter		• GM survey meter
Calibration	• Measuring apparatuses shall be calibrated at least once a year in accordance with JIS. (Agent performing the calibration work) • Businesses registered in accordance with the Measurement Act[*9] • Measuring apparatus manufacturer		
Daily check	• The remaining battery level, breakage of cables and connectors, and status of high voltage application shall be checked, and inspections of switch operability, etc. shall be carried out. • Measurements shall be performed at the same places where the background radiation does not vary substantially, and it shall be confirmed that there are no large variations by comparing with past values. • If it is difficult to perform the calibrations more than once a year as described in the above section, this can be substituted by a method (adjustment) to compare the results with those obtained in the same location where measurements were also taken by using a separate measuring apparatus that has been fully calibrated and checked (this excludes GM survey meters).		
Prevention of contamination	• The body and detecting element of the measuring apparatus shall be preferably covered with a thin plastic sheet, etc. • The plastic sheet, etc. shall be replaced with new material when it gets dirty or breaks.		
Measurement	• The air dose rate shall be measured at a height of 1 m from the ground. • The air dose rates on roads and pedestrian overpasses near schools may be measured at a height of 50 cm from the ground for elementary schools and below, as well as special-needs schools, with consideration for the living space of infants and schoolchildren in the	[Using a collimator] • The air dose rate shall be measured at a height of roughly 1 cm (a height where about one finger will fit between the detector element and the measurement point) from the surface of the measurement point while using a collimator to shield against external gamma rays. [Measurements by	• Measurements shall only be taken roughly 1 cm away from the surface.

	lower grades.	varying the distance] • The air dose rate shall be measured from positions on the surface and at heights of 50 cm and 1 m away from it, and the measured values shall be compared.	
	• Prior to measurement, it shall be confirmed whether the background value of the measuring apparatus is being displayed abnormally (no indicators appear, or indicators are unusually high or low). • When measuring the air dose rate, the measurements shall be taken with the detecting element parallel to the ground surface and as far away as possible from the body. • The power to the measuring apparatus shall be turned on and the reading (measured value) shall be read off after waiting until the reading stabilizes. In doing so, with measuring apparatuses on which a time constant can be set, the measurer shall wait until a period of time that is three times longer than the time constant has elapsed before performing the measurements. • If the readings on the measuring apparatus disappear, switch the range and take the measurements, and if the readings disappear in the maximum range, either interpret those readings as being in the maximum range or higher, or use another type of measuring apparatus to take the measurements. • If readings vary, the average value shall be read.		
Records	• The measurer shall record the air dose rate, etc. at each measurement point shown in the conceptual diagram, etc., along with the date and time of measurement and the measuring apparatus used (see Figures 1-14 through 1-18).		

Figure 1-14. Example of an Air Dose Rate Record Sheet

Air Dose Rate Recording Form

Measurement location	City: Town: District:
Measuring apparatus	Manufacturer: Model:

Measurement Status Entry Column						
	Before Decontamination			After Decontamination		
Date measured	Day: ( ) Month: Year:			Day: ( ) Month: Year:		
Time measured	: - :			: - :		
Measurer						
Weather						
Air Dose Rate Measurement Results Entry Section						
	Before Decontamination		Measurement height	After Decontamination		Measurement height
No. 1)-1 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-2 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-3 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-4 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-5 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-6 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-7 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-8 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-9 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-10 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
Notes						

Schematic Diagram of Air Dose Rate Measurement Points

* This is just a sample of a records form. These should be devised as appropriate depending on factors like the objects measured and the measurement methods.

Figure 1-15. Entry Sample of an Air Dose Rate Record Sheet

Air Dose Rate Record Sheet (Entry Sample)

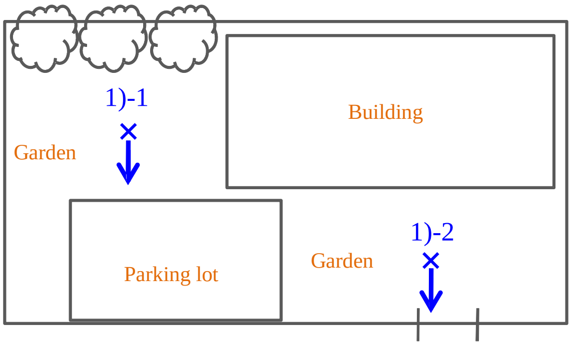
Measurement location	City: Town: District:
Measuring apparatus	Manufacturer: Model:

Measurement Status Entry Column		
	Before Decontamination	After Decontamination
Date measured	Mon., April 22, 2013	Fri., April 26, 2013
Time measured	9:20 – 9:40	13:20 – 13:40
Measurer	Josen Taro	Josen Taro
Weather	Cloudy	Clear

Air Dose Rate Measurement Results Entry Section						
	Before Decontamination		Measurement height	After Decontamination		Measurement height
No. 1)-1 measurement point	3.0	μSv/h	[✓ 1m] 50cm	0.51	μSv/h	[✓ 1m] 50cm
No. 1)-2 measurement point	0.55	μSv/h	[✓ 1m] 50cm	0.16	μSv/h	[✓ 1m] 50cm
No. 1)-3 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-4 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-5 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-6 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-7 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-8 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-9 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
No. 1)-10 measurement point		μSv/h	1m 50cm		μSv/h	1m 50cm
Notes						

Schematic Diagram of Air Dose Rate Measurement Points

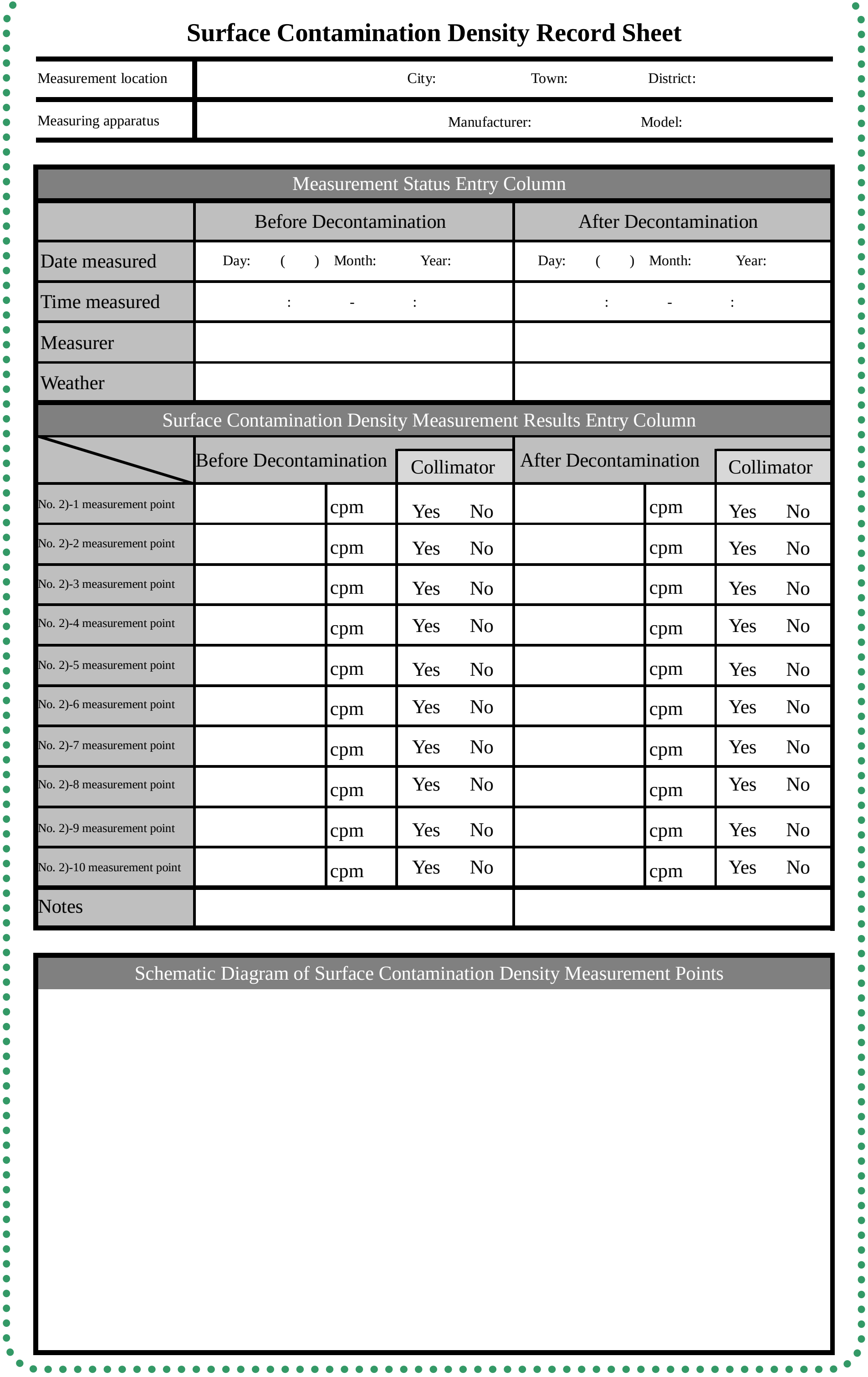
(Example)



*The arrows indicate the direction of the measurements.

* This is just a sample of a records form. These should be devised as appropriate depending on factors like the objects measured and the measurement methods.

Figure 1-16. Example of a Surface Contamination Density Record Sheet



Surface Contamination Density Record Sheet

Measurement location	City: Town: District:
Measuring apparatus	Manufacturer: Model:

Measurement Status Entry Column						
	Before Decontamination			After Decontamination		
Date measured	Day: ( ) Month: Year:			Day: ( ) Month: Year:		
Time measured	: - :			: - :		
Measurer						
Weather						
Surface Contamination Density Measurement Results Entry Column						
	Before Decontamination		Collimator	After Decontamination		Collimator
No. 2)-1 measurement point		cpm	Yes No		cpm	Yes No
No. 2)-2 measurement point		cpm	Yes No		cpm	Yes No
No. 2)-3 measurement point		cpm	Yes No		cpm	Yes No
No. 2)-4 measurement point		cpm	Yes No		cpm	Yes No
No. 2)-5 measurement point		cpm	Yes No		cpm	Yes No
No. 2)-6 measurement point		cpm	Yes No		cpm	Yes No
No. 2)-7 measurement point		cpm	Yes No		cpm	Yes No
No. 2)-8 measurement point		cpm	Yes No		cpm	Yes No
No. 2)-9 measurement point		cpm	Yes No		cpm	Yes No
No. 2)-10 measurement point		cpm	Yes No		cpm	Yes No
Notes						

Schematic Diagram of Surface Contamination Density Measurement Points

* This is just a sample of a records form. These should be devised as appropriate depending on factors like the objects measured and the measurement methods.

Figure 1-17. Example of a Surface Dose Rate Record Sheet

Surface Dose Rate Record Sheet

Measurement location	City: Town: District:
Measuring apparatus	Manufacturer: Model:

Measurement Status Entry Column		
	Before Decontamination	After Decontamination
Date measured	Day: ( ) Month: Year:	Day: ( ) Month: Year:
Time measured	: - :	: - :
Measurer		
Weather		

Surface Dose Rate Measurement Results Entry Column						
	Before Decontamination		Measurement height	After Decontamination		Measurement height
No. 2)-1 measurement point		μSv/h	1cm		μSv/h	1cm
No. 2)-2 measurement point		μSv/h	1cm		μSv/h	1cm
No. 2)-3 measurement point		μSv/h	1cm		μSv/h	1cm
No. 2)-4 measurement point		μSv/h	1cm		μSv/h	1cm
No. 2)-5 measurement point		μSv/h	1cm		μSv/h	1cm
No. 2)-6 measurement point		μSv/h	1cm		μSv/h	1cm
No. 2)-7 measurement point		μSv/h	1cm		μSv/h	1cm
No. 2)-8 measurement point		μSv/h	1cm		μSv/h	1cm
No. 2)-9 measurement point		μSv/h	1cm		μSv/h	1cm
No. 2)-10 measurement point		μSv/h	1cm		μSv/h	1cm
Notes						

Schematic Diagram of Surface Dose Rate Measurement Points

* Perform the measurements by using a collimator to reduce the impact of the background gamma rays.

* This is just a sample of a records form. These should be devised as appropriate depending on factors like the objects measured and the measurement methods.

Figure 1-18. Example of a Variable Distance Air Dose Rate Record Sheet

Air Dose Rate Record Sheet
(For Measurements where the Distance from the Measured Object Is Varied)

Measurement location	City:	Town:	District:
Measuring apparatus		Manufacturer:	Model:

Measurement Status Entry Column

	Before Decontamination	After Decontamination
Date measured	Day: ( ) Month: Year:	Day: ( ) Month: Year:
Time measured	: - :	: - :
Measurer		
Weather		

Dose Rate Measurement Results Entry Column

	Before Decontamination				After Decontamination			
	1m	50cm	Surface (1cm)		1m	50cm	Surface (1cm)	
No. 2)-1 measurement point				µSv/h				µSv/h
No. 2)-2 measurement point				µSv/h				µSv/h
No. 2)-3 measurement point				µSv/h				µSv/h
No. 2)-4 measurement point				µSv/h				µSv/h
No. 2)-5 measurement point				µSv/h				µSv/h
No. 2)-6 measurement point				µSv/h				µSv/h
No. 2)-7 measurement point				µSv/h				µSv/h
No. 2)-8 measurement point				µSv/h				µSv/h
No. 2)-9 measurement point				µSv/h				µSv/h
No. 2)-10 measurement point				µSv/h				µSv/h
Notes								

Schematic Diagram of Dose Rate Measurement Points

* This is just a sample of a records form. These should be devised as appropriate depending on factors like the objects measured and the measurement methods.

Endnotes

[*1]: The air dose rate is the radiation dose per unit time in the space in question, also known as the air absorbed dose rate, and is generally expressed in units of μSv/h (microsieverts per hour) or nGy/h (nano-Gray per hour).[*17] Since the air dose rate indicates the level of external exposure, from a health preservation perspective it is suitable to measure the air dose rate in a way that enables the ascertainment of the additional exposure dose. Moreover, since contamination is not all the same, numerous measurements are required in order to confirm the status of contamination as a whole, and this ability to perform direct measurements in a short time frame enables relatively simple handling even when there are numerous measurements to be made. Based on the foregoing, as a general rule it is suitable to use the air dose rate when confirming the decontamination effect. However, since the air dose rate normally measures gamma rays, which easily penetrate materials, and since the radiation from radioactive materials present around the measurement site and natural radiation from the earth are also readily detected (readily influenced by background radiation), the air dose rate is not suitable for confirmation of the contamination status of the surfaces or insides of objects to be decontaminated. When narrowing down the contamination sites that contain comparatively large amounts of radioactive materials or otherwise confirming the contamination status of the surfaces of objects to be decontaminated, methods that measure surface contamination density via beta rays are suitable as beta rays are not readily influenced by background radiation and have low penetrating power.

[*2]: The surface contamination density is an indicator that expresses the degree of surface contamination of the measured object and is expressed in units of Bq/cm^2. What is more, the unit with which surface contamination density is generally expressed by measuring apparatuses is count rate (cpm). Since the count rate (cpm) indicated by the measuring apparatus at the time of the measurement will vary for each apparatus even for the same measured object, it is necessary to perform assessments by rigorously converting the measurements from each apparatus into the unit of Bq/cm^2. It is essential to keep in mind that leaving the unit as cpm when dealing with the measured values could potentially cause discrepancies to arise in said values. However, there is no problem with calculating using the count rate when calculating the reduction rate from the measured values from before and after the decontamination.

[*3]: The radiation dose is the total of the radiation dose received from the contamination sources at a site and the radiation dose received from the background. The background radiation dose is the total of the radiation dose from the radioactive materials present in the vicinity around a measurement position and the radiation dose from the natural radiation from the earth.

[*4]: Gamma rays are measured by an NaI scintillation survey meter or similar apparatus. They have high penetrating power, and can even be measured when contamination has penetrated to within soil or other substances.

[*5]: The reduction rate expresses the percentage by which the radiation dose (air dose rate, surface dose rate, and surface contamination density, etc.) has been reduced via decontamination. It is used for assessments of No. 1 and No. 2 measurement points, and is expressed via the following formula.

$$\text{Reduction rate [\%]} = \left(1- \frac{\text{Radiation dose after decontamination}}{\text{Radiation dose before decontamination}}\right) \text{X } 100$$

Moreover, the decontamination factor (DF) expresses the extent to which the contamination has been removed from the objects subject to decontamination. It is used for assessments of No. 2 measurement points, and is expressed via the following formula.

$$\text{Decontamination factor [-]} = \left(\frac{\text{Surface contamination density before decontamination}}{\text{Surface contamination density after decontamination}}\right)$$

[*6]: Even under the same gamma rays, energy intensity varies depending on the types of radioactive

materials. Accordingly, for the accurate assessment of the air dose rate, it is appropriate to take measurement with measuring apparatuses that have energy compensation functions capable of taking into account the energy intensity. Measuring apparatuses with no such energy compensation function that have been calibrated for cesium radiation sources can only be expected to provide accurate measurements in places where cesium is the only type of radioactive material. However, the measured values will deviate if any radioactive materials other than cesium are measured. It is therefore necessary to keep in mind that if measurement is conducted in areas with low levels of cesium, the radioactive material discharged by the accident, or in areas where the natural radiation dose level is high, the accuracy of measurement may degrade.

[*7]: Beta rays are measured via a GM survey meter or similar apparatus. Since the penetrating power of beta rays is not high, they cannot be accurately measured when contamination has penetrated to within soil or other substances. In such cases it is necessary to first estimate the contamination status by measuring the gamma rays via an NaI scintillation survey meter or similar apparatus and then confirm the depth at which the contamination is found by separately scraping away the surface.

[*8]: The probe (detecting element) on a GM survey meter measures the beta rays that enter from the entrance window at its tip, and so the measured values from this are values that reflect the amount of radioactive materials found locally around the tip of the probe.

[*9]: A registered company or device manufacturer in accordance with the Measurement Act can calibrate measuring apparatuses (homepage address: http://www.meti.go.jp/policy/economy/hyojun/techno_infra/sokuteikikousei.html)

[*10]: JIS Z4333 specifies that the allowable range of relative intrinsic error for "Dose Equivalent Rate Meters for X and γ Rays" shall be within ± $(15 + U)$ percent. While U indicates the range of uncertainty of the reference dose rate and is considered to be within the range of about five percent, the allowance is determined to be 20 percent.

[*11]: The calibration of GM survey meters in accordance with Japanese Industrial Standards (JIS Z4329, JIS Z4505) relates to the method of calculating the surface contamination density (Bq/cm^2) using a count rate (cpm). Consequently, when dealing with the measured values in their original form as a count rate (cpm) the aforementioned calibration is not necessary. Conversely, in some cases the readings for the count rate (cpm) will deviate from the correct values for reasons such as the degradation of the GM counter tubes or electrical circuits, so maintenance must be performed at least once a year. Maintenance is performed by the apparatus manufacturers, but in some cases calibration service providers may perform the maintenance and calibration together, so you must confirm the details with each service provider.

[*12]: When it comes to measuring apparatuses for radiation, there are those that use time constants and those that use sampling times (the measuring time required to reduce statistical errors down to a certain degree when measuring radiation) as guides for the response time until accurate measured values are displayed.

[Measuring apparatuses that use time constants]

These display the mean values for the radiation dose over the most recent span of a fixed length of time (the time constant, for example ten seconds, etc.).

You only have to wait a length of time that is three times longer than the time constant in order to obtain an accurate response.

[Measuring apparatuses that use sampling times]

These display the radiation dose from integrated values (moving average) over a sampling time.

You only have to wait the length of the sampling time in order to obtain an accurate response.

[*13]: The probe (detecting element) on a scintillation survey meter measures the gamma rays coming from every direction. Therefore, the measured values not only strictly consist of radiation doses from localized radioactive materials near the probe, but also reflect the radiation from the radioactive materials present within the vicinity around the probe.

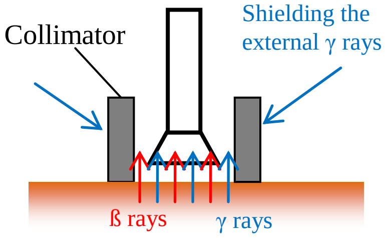
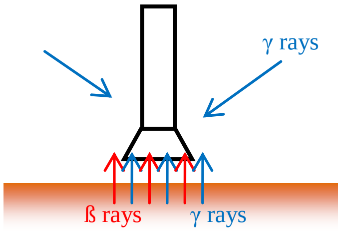
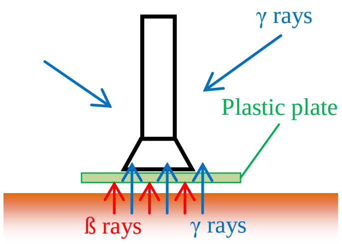
[*14]: Cs-134 and Cs-137 (hereinafter "radiocaesium") decay while emitting beta rays until they

become barium, which is unstable in terms of its energy, with this barium emitting gamma rays over its short half-life. It is commonly claimed that gamma rays are emitted from cesium, but to be precise these emissions come from the barium. In other words, the window surface of the probe (detecting element) on GM survey meters detects almost 100 percent of the beta rays given off by the cesium, as well as several percentage points of the gamma rays given off by the barium as well.

GM survey meters are characterized by the fact that they are comparatively resistant to being affected by background radiation (gamma rays) since they mainly measure beta rays. However, in cases where the impact from the background is thought to be significant, one conceivable way of performing more accurate measurements would be to perform the measurements by using a collimator as shown in Table 1-3. Another way would be to calculate the surface contamination density from the net beta rays using a beta ray collimator. These approaches are effective in cases such as correctly assessing the decontamination results when performing experiments, for example.

Beta ray collimators can be used for determining to what depth contamination has penetrated. More specifically, the determination can be made that the smaller the difference between the values measured when shielding against beta rays with a plastic plate and the unshielded values are, the deeper the depth of the contamination is.

Table 1-3. Correct Measurement Methods for Surface Contamination Density

Method	Gamma ray collimator (Beta ray dose + gamma ray dose assessments)	Beta ray collimator (Beta ray dose assessments)
Content	Use a collimator to make measurements by shielding the gamma rays from the objects other than the measured object.  	Calculate the surface contamination density (C) using the net beta rays through the following formula. C = C1 - C2 C1: Measured values measured with no shielding (beta rays + the gamma rays that are measured at the same time) C2: Measured values measured by shielding against beta rays by covering the entrance window with a plastic plate (gamma rays) [Measure C1]  [Measure C2]  The ß rays are shielded by the plastic plate

[*15]: Investigating the degree to which beta rays are contained within the radiation given off by the measured object allows you to estimate whether the contamination is found on the object's surface or inside of it. Materials like polypropylene and acrylic are used in plastic shield plates for assessing beta rays, and require a certain thickness in order to shield against the said beta rays. Figure 1-19 is an example of an instrument that was created so that a plate can be mounted on the probe (detecting element) of a GM survey meter on which the shield plate portion is 3 mm thick and made of polypropylene. When measurements are taken without a shield plate you should use a spacer or some other method to ensure that the distance between the measured object and the entrance window is as similar as possible to instances where a shield plate is used.

Figure 1-19. Example of a Plastic Shield Plate and Spacer (Left) and Mounting Configuration for the Shield Plate and Spacer (Center, Right)

Provided by: JAEA

[*16] The decay of radioactive materials occurs randomly, and so there will be some statistical variance in the number of radioactive nuclei detected by the measuring apparatus. The larger the number of radioactive nuclei detected the smaller this variance will be.

[*17] Gy (gray) is the unit for the “amount of energy radiation imparts to a material object,” while Sv (sievert) is the unit for the “dose at which radiation has a clear impact on the human body.” When converting from Gy to Sv the affects that each type of radiation has on the human body are weighted. In the Ministry of Education, Culture, Sports, Science and Technology’s Radiation in Everyday Life, conversions are performed wherein 1 Gy = 1 Sv for X-rays and gamma rays.

References

Ministry of Education, Culture, Sports, Science and Technology, Japan Atomic Energy Agency, *Guidelines Concerning Radiation Measurement* (October 21, 2011). (http://www.kantei.go.jp/jp/tyoukanpress/201110/__icsFiles/afieldfile/2011/10/21/21shiryou02.pdf)

Ministry of Education, Culture, Sports, Science and Technology, Japan Atomic Energy Agency, *Guide for Radiation Measurements at Schools and Other Public Buildings* (August 26, 2011). (http://www.city.ome.tokyo.jp/kankyo/documents/gakou.pdf)

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Japan Atomic Energy Agency, *Report on Experimental Decontamination Work* (Volume I, Section 3.2) (June 29, 2012) (http://www.jaea.go.jp/fukushima/kankyoanzen/d-model_report/3.2.pdf)

Part 2

Guidelines Pertaining to Decontamination and Other Measures

2nd Ed., 2013

環境省
Ministry of the Environment

Part 2

Guidelines Pertaining to Decontamination and Other Measures

I. Basic Concept

II. Decontamination and Other Measures for Buildings and Other Structures

III. Decontamination and Other Measures for Roads

IV. Decontamination and Other Measures for Soil

V. Decontamination and Other Measures for Vegetation

VI. Others

Guidelines Pertaining to Decontamination and Other Measures

Table of Contents

I. Basic Concept

1. The Role of these Guidelines

These guidelines use cases and examples to explain in a concrete fashion the Ordinance of the Ministry of the Environment (Note) pertaining to standards for the measures for decontamination of the soil, etc. provided in Article 40, Paragraph 1 of the Act on Special Measures Concerning the Handling of Environmental 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 (hereinafter the “Act on Special Measures concerning the Handling of Radioactive Pollution”).

Each municipality will formulate a decontamination plan based on prioritization and feasibility in light of the actual conditions in each area. Appropriate decontamination methods will be selected as needed from among those listed in these guidelines to advance the decontamination work based on each decontamination plan.

At present, the methods given in these guidelines are deemed to be appropriate for implementing decontamination and related procedures, but decontamination work and new technologies are currently being developed and verified by various actors. These guidelines will be revised as needed in light of trends in the development and verification of this knowledge and these technologies. In addition, a Decontamination Q&A has been formulated and released to serve as a supplementary explanation for the Decontamination Guidelines in order to rapidly accommodate the implementation of decontamination that is suited to the actual circumstances of local regions, and these will be added to and otherwise revised as needed.

(Note) Ordinance for Enforcement of the Act on Special Measures concerning the Handling of Radioactive Pollution (Portion relevant to Standards for Measures for Decontamination of the Soil, etc.)

Article 54: The standards provided in the Ordinance of the Ministry of the Environment for Article 40, Paragraph 1 of the Act are as follows.

1. The following shall be observed in executing measures for decontamination of the soil, etc.
    - A. Decontamination and other measures for structures and roads
        - (1) Cleaning
        - (2) Grass cutting or removal of sludge, fallen leaves, etc.
        - (3) Scraping away of surfaces
        - (4) In addition to (1) through (3), other decontamination and other measures that have similar or greater effects than (1) through (3)

B. Decontamination and other measures for soil
  (1) Scraping away of topsoil
  (2) Covering with soil (including the replacement of the soil in the topsoil with the soil in the layer below the topsoil)
  (3) Deep tillage
  (4) In addition to (1) through (3), other decontamination and other measures that have similar or greater effects than (1) through (3)

C. Decontamination and other measures for vegetation
  (1) Grass cutting (including trimming of lawns, pasture grass, etc.)
  (2) Removal of underbrush, fallen leaves, or fallen twigs
  (3) Pruning or logging of trees
  (4) In addition to (1) through (3), other decontamination and other measures that have similar or greater effects than (1) through (3)

D. Decontamination and other measures for other objects (excluding those in A through C)
  (1) Removal of sediment, etc.
  (2) In addition to (1), other decontamination and other measures that have similar or greater effects than (1)

2. The radiation dose shall be measured before and after implementing measures for decontamination of the soil, etc. However, this shall not interfere with the measurement of radioactivity concentrations in relation to radioactive materials discharged by the accident.
3. It shall be ensured that there is no dispersion or outflow of the removed soil, etc. in implementing measures for decontamination of the soil, etc.
4. The necessary measures shall be taken to ensure that no hindrances to conservation of the living environment arise due to offensive odors, noise, or vibrations associated with measures for decontamination of the soil, etc.
5. It shall be ensured that no damages pertaining to human health or the living environment arise due to the removed soil, etc.
6. The removed soil, etc. shall be separated from other objects to ensure that there is no danger of it mixing with other objects.
7. Records shall be created of the land for which measures for decontamination of the soil, etc. were implemented, the types and quantities of removed soil, etc., the dates of commencement and completion of the measures, and other information pertaining to decontamination and other measures, and these records shall be stored for a five-year period starting from the date of completion of the measures.

2. Important Points in Implementing Decontamination and Other Measures

There is a need to proceed with decontamination in the areas in which contamination was produced by radioactive materials discharged in association with the Fukushima Daiichi Nuclear Power Plant accident, in order to reduce human exposure doses*1 to radiation (see Figure 2-1).

The following aspects are important in implementing decontamination measures.

1) Measures shall be taken to prevent dispersion and outflow, as well as offensive odors, noise, and vibrations, and records of the quantities of removed soil and other necessary measures shall be taken with respect to consideration for the preservation of the health of surrounding residents and for the conservation of the living environment.
2) To effectively reduce the radiation doses due to contamination, places that are contaminated at comparatively high concentrations that contribute substantially to the radiation dose must be identified, and appropriate methods of decontamination must be used in accordance with the characteristics of the contamination. The effectiveness of these methods must also be confirmed by measurements before and after the decontamination to effectively reduce the radiation doses in human living environments.
3) The removed soil, etc. must be separated from other objects to ensure that there is no danger of it mixing with other objects, and the removed soil must also be separated from decontamination waste to the extent possible.
4) It is important to strive to minimize the quantity of removed soil, etc. generated during decontamination. It is also important to ensure that the contamination does not spread as a result of the decontamination work. For example, cleaning using water produces drainage that contains radioactive materials. The executors of decontamination and other measures shall, to the extent possible, remove in advance those radioactive materials that can be removed by methods other than cleaning with water, properly treat wastewater, and find other ways to avoid affecting outflow destinations due to cleaning, etc. as much as possible. Moreover, periodic monitoring shall be performed after the applicable measures are implemented when deemed necessary on account of the actual conditions in the area.

Moreover, the radioactivity of radioactive materials decays as time passes. In addition, the appropriate responses must be taken by fully taking into account the changes in the contamination status as a result of factors like the radioactive materials being moved around due to rainwater and other factors.

Note that depending on the impact of radiation from objects other than those subject to decontamination work, as well as on the characteristics of the contamination, the long-term target of bringing the additional exposure dose to no more than 1 millisievert per year may not be immediately achievable even in cases where decontamination has been carried out effectively. In such cases, it is important to judge whether to re-do decontamination work, considering the radioactive decay of the radioactive materials with the passage of time and the movement of the radioactive materials due to rainwater and other factors.

These guidelines indicate the measures and decontamination methods to be implemented before, during, and after decontamination, methods of confirming the air dose rate,[*2] etc., and other measures for each of the objects subject to decontamination: buildings and other structures, roads, soil, and vegetation.[*3]

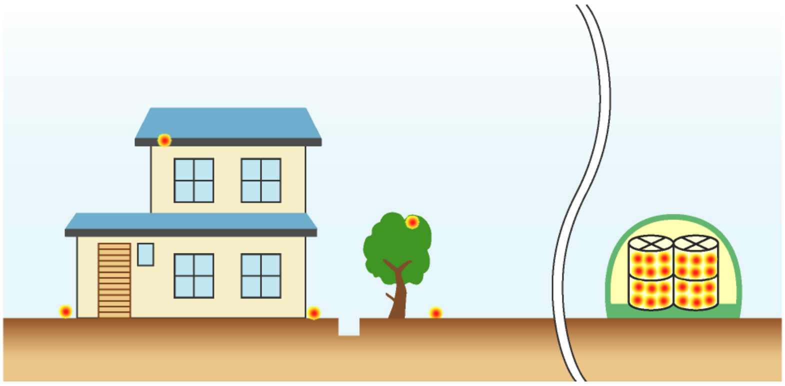
For the results of decontamination carried out in the past, the reduction rate for the radioactive materials via decontamination were compiled and announced as the Results of Decontamination Techniques in the Decontamination Work Carried Out thus Far by the National and Local Governments (January 2013). Even with the same techniques the results of decontamination differ depending on factors like the quality of the materials of the target object, the surface conditions, the time that decontamination was carried out, and so forth, so refer to the reference materials concerning the carrying out of decontamination.

Figure 2-1. Conceptual view of the removal of radioactive materials from the living environment through decontamination

[Before decontamination]

Radioactive materials settled on soil, vegetation, and buildings

[After decontamination]



Radioactive materials consolidated and shielded

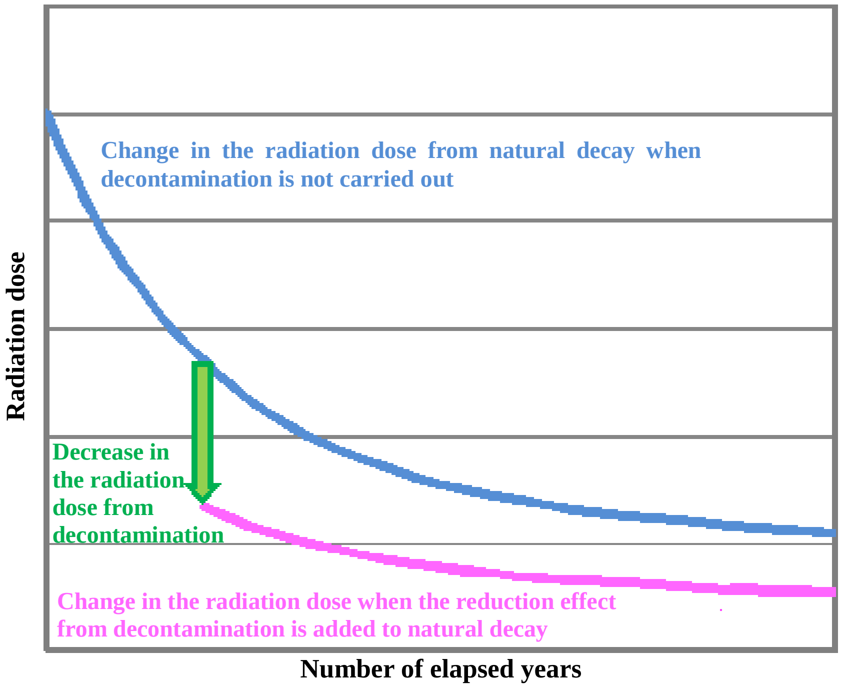
■ Natural decay of Cs-134 and Cs-137 (hereinafter “Radiocaesium”)

Since radioactive materials decay naturally over the course of time the radiation dose will continue to decrease even if decontamination is not performed, but this will take a long period of time (the half-life for Cs-134 is two years, while that for Cs-137 is 30 years).[*4]

Carrying out decontamination is effective for both reducing the radiation dose at a location as well as shortening the length of time before the dose falls compared to situations where decontamination is not carried out.

Furthermore, there is also a reduction effect via natural causes such as rain and wind (weathering), and so in actuality this results in the radiation dose declining even more quickly.

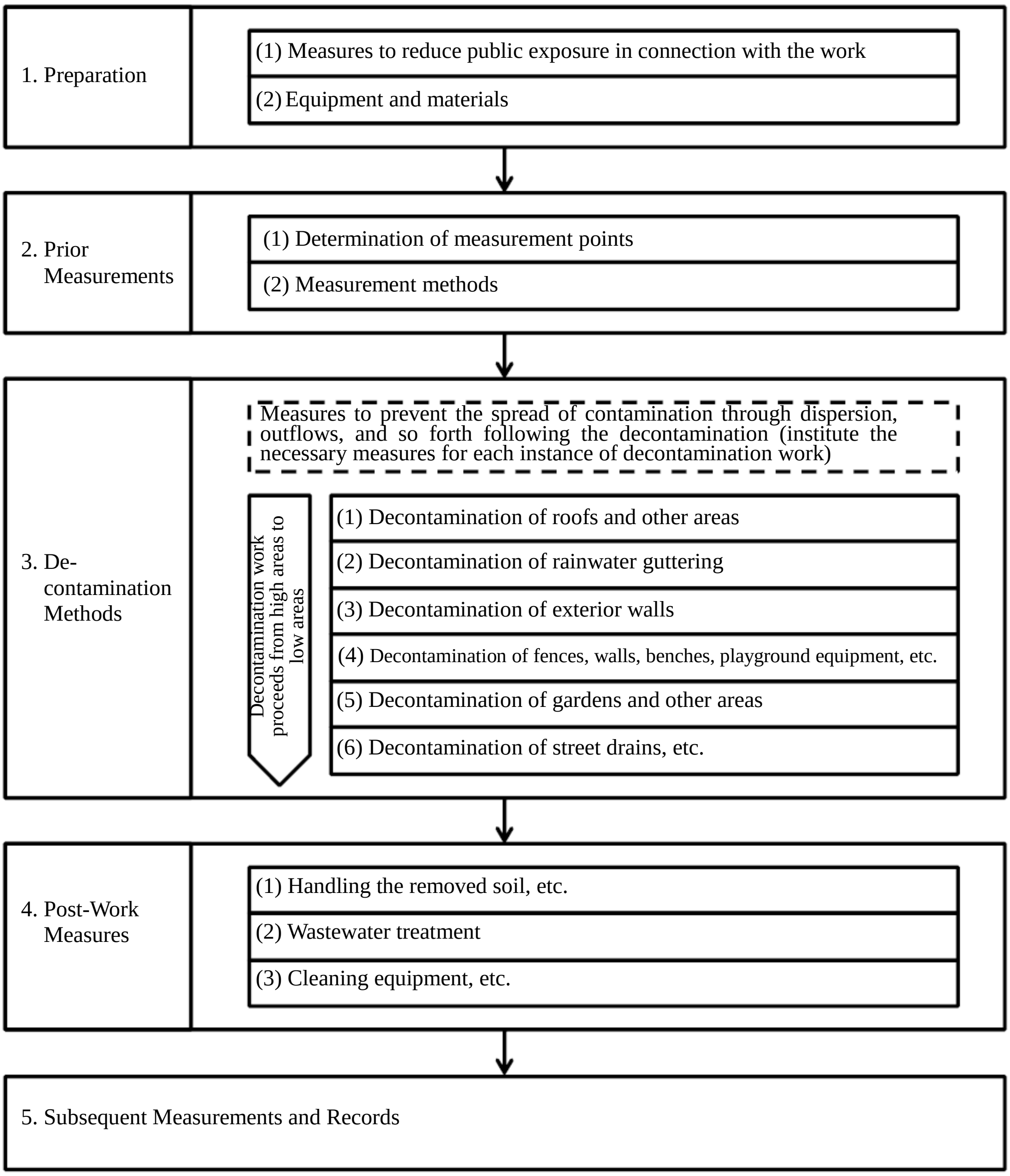
Figure 2-2. Decay of the radiation dose discharged by the accident



II. Decontamination and Other Measures for Buildings and Other Structures

This section explains 1. Preparation, 2. Prior Measurements, 3. Decontamination Methods, 4. Post-Work Measures, and 5. Subsequent Measurements and Records, in chronological order, pertaining to decontamination and other measures for houses, buildings, agricultural facilities, and other structures.

Figure 2-3. Basic flow for the decontamination and other measures for buildings and other structures



1. Preparation

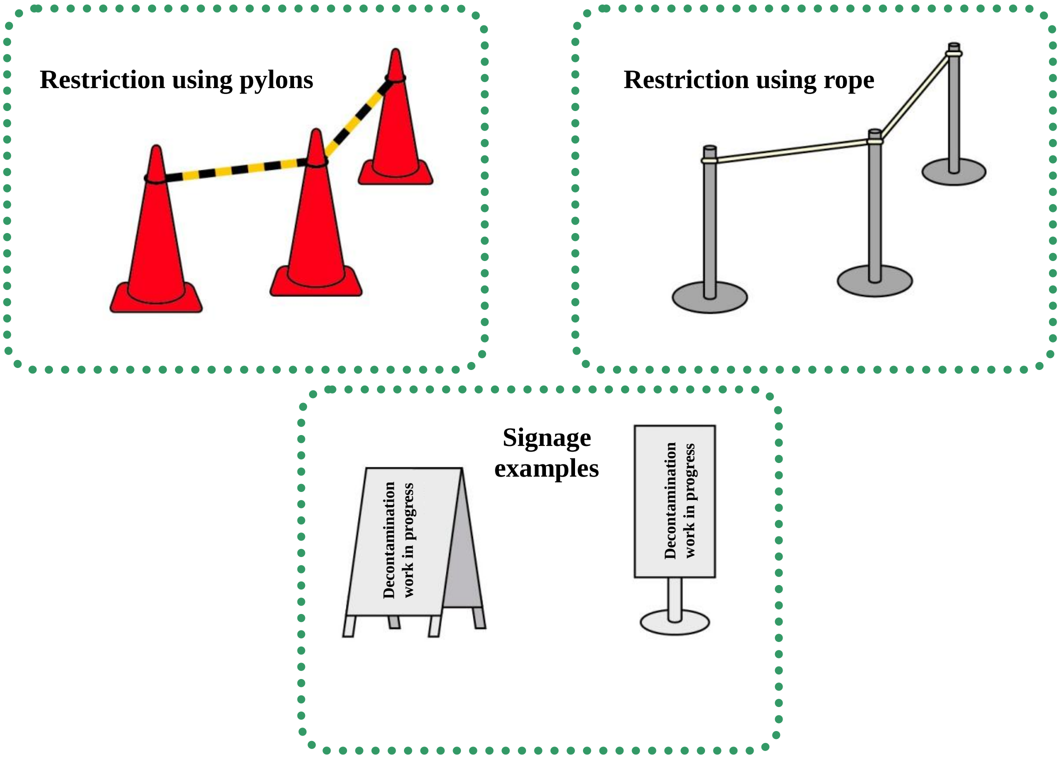
Before performing decontamination work, in addition to preparing the equipment required for the decontamination work, preparations must be made to ensure safety through means including prevention of exposure of the general public and workers such as by inhaling dust generated during decontamination work. Among these preparations, please refer to the Ministry of Health, Labour and Welfare's Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and its Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6 dated June 15, 2012) for the measures required to ensure the safety of workers.

(1) Measures to Reduce Public Exposure in Connection with Decontamination Work

Table 2-1. Measures to reduce public exposure in connection with decontamination and other work on buildings and other structures

Restriction of entry	• In cases where the general public is deemed likely to enter the area, the area shall be cordoned off with pylons or rope, etc. to prevent people from unnecessarily approaching the work site, and the entry of people and vehicles shall be restricted (see Figure 2-4). • In cases where radioactive materials may be dispersed in connection with the decontamination work, the perimeter of the decontamination area shall be fenced in with sheets, etc., water shall be sprayed, or other such measures shall be taken to prevent dispersion and the area shall be cordoned off with rope, etc.
Signage	• In cases where the general public is deemed likely to enter the area, signs, etc. shall be put up to alert the public that decontamination work is being performed.

Figure 2-4: Examples of restriction of entry and signage



(2) Equipment and Materials

The required equipment and materials shall be arranged for decontamination and other measures, as well as for collection of the removed soil, etc., in accordance with the objects to be decontaminated and the work environment.

Table 2-2. Examples of decontamination equipment and materials for buildings and other structures

Example of general equipment	Mower, hand shovel, grass sickle, broom, bamboo rake, dustpan, tongs, shovel, small shovel, metal rake, compact heavy machinery for scraping away topsoil, garbage bags (bags for burnable matter, burlap sacks for soil and sand (sandbags)), vehicles for transporting collected removed soil, etc. to the on-site storage location (truck, two-wheeled cart, etc.), ladder
Examples of equipment for cleaning with water	Hose, shower nozzle, high pressure water cleaner, brushes (scrub brush, brush for cleaning vehicles, brush for cleaning high places), scrubbing brushes (circular scrubber, steel wool brush, etc.), wire brushes, tools for pushing away water (broom, scraper, etc.), bucket, detergent, dustcloth, sponges, paper towels
Examples of equipment for cleaning metal surfaces	Brush, sandpaper, cloth, removing agents

Examples of equipment for cleaning wood surfaces	Brush, sandpaper, power sander, cloth, steam cleaner, water high pressure washer, tools for pushing away water (broom, scraper, etc.),
Examples of equipment for work in high places	Scaffold, mobile lift, aerial vehicle
Examples of equipment for scraping away	Grinding machine, equipment for scraping away, equipment needed to prevent dispersion (dust collector, curing mat)
Examples of equipment for covering the ground surface	Self-propelled surface compaction roller, plywood for surface compaction, sprinkling equipment

2. Prior Measurements

To confirm the decontaminating effects of the decontamination work, the air dose rate prior to the commencement of decontamination work and after the completion of decontamination work*2 and the surface contamination density of the objects subject to decontamination (hereinafter, “air dose rate, etc.,” which includes both the air dose rate and the surface contamination density) shall be measured. Specifically, places representative of living spaces, places contaminated at a comparatively high concentration that is deemed to contribute substantially to the radiation dose in the living space, etc. shall have their air dose rate, etc. measured in the same locations and by the same method both before contamination work starts and after it finishes, and the results shall be recorded. This section gives information on methods for measuring the air dose rate, etc. prior to the commencement of decontamination work.

Note that the air dose rate, etc. may also be measured near the surface of the objects subject to decontamination as needed when ascertaining the degree of reduction in the level of contamination of the objects subject to decontamination during the decontamination work. These measurements will be separately explained in “Section 3. Decontamination Methods.”

(1) Determination of Measurement Points

Prior to decontamination work, the locations at which the air dose rate, etc. will be measured (hereinafter, “measurement points”) shall be decided and a schematic diagram (see Figure 2-5) illustrating the range of the measuring object, the measurement points, structures to be used as markers, etc. shall be created.

There are two types of measurement points: those used to ascertain the average air dose rate in living spaces within buildings and other structures subject to decontamination (No. 1 measurement points) and those used to confirm the level of contamination of the objects that are to be decontaminated (No. 2 measurement points).

No. 1 measurement points are set primarily in a living space where residents, etc. spend large amounts of time. In setting these measurement points, so-called “hotspots” (locations where the soil has been contaminated in a highly concentrated manner by rainwater and the like containing radioactive materials where there is a high probability that radiocaesium has become concentrated compared to the surrounding areas) that contribute comparatively insubstantially to the radiation dose in the living space, and points near them, are not eligible to be measurement points unless the residents, etc. are deemed likely to spend relatively large amounts of time there.

Examples of hotspots include depressed areas and puddles, street drains, under rainwater guttering, rainwater chambers, under or near trees, or in places where raindrops falling from buildings land, as radioactive materials tend to become concentrated in such places due to rainwater and the like.

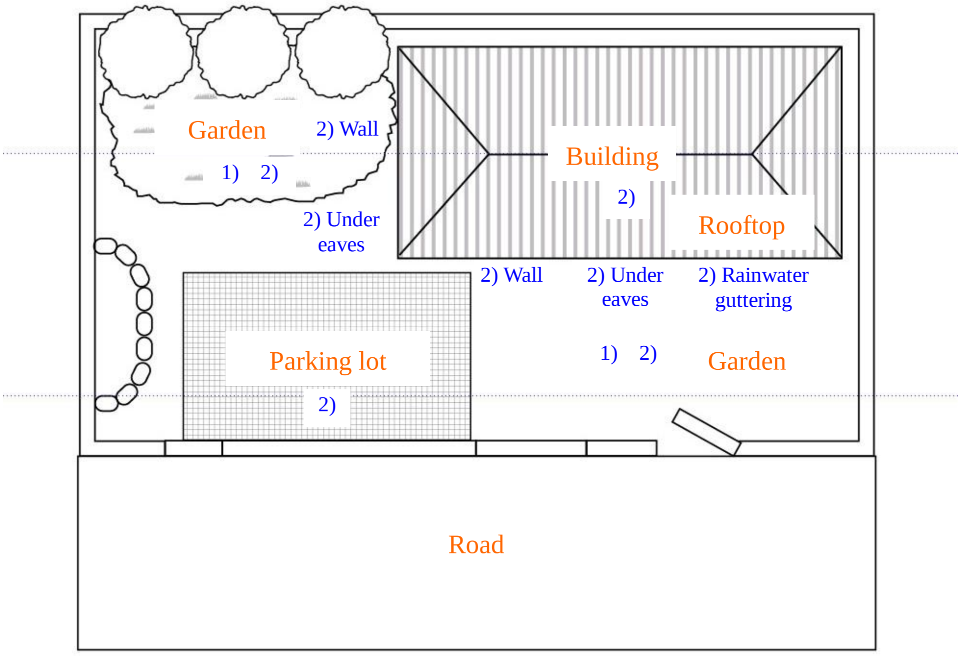
The purpose of No. 2 measurement points is fundamentally to measure the level of contamination at the surface of the objects subject to decontamination, and they are therefore set by considering places, etc. contaminated at comparatively high concentrations and that are deemed to contribute substantially to the radiation dose in the living space. When hotspots including areas under rainwater guttering are subject to decontamination, these are to be measured as No. 2 measurement points.

The specific methods are as provided in Table 2-3.

Table 2-3. Reasoning behind the measurement points for air dose rates and other measures for the decontamination of buildings and other structures

Measurement point	No. 1 measurement points	No. 2 measurement points
Measurement target	Air dose rate in living spaces	Surface contamination density, etc. for objects subject to decontamination
Reasoning behind the measurement points	• For detached housing, in gardens and other outdoor locations, approximately two to five measurement points shall be set from among places where people are deemed likely to spend relatively large amounts of time. • For collective housing, public facilities, and so forth, in gardens and other outdoor locations, approximately five measurement points shall be set from among places where people are deemed likely to spend relatively large amounts of time.	• Measurement points for roofs, rooftops, and the sides of buildings shall be set near the center of each surface. • Measurement points for gardens and other grounds shall be set near their centers. (Choose places along the centerline for grounds that are long and thin or otherwise not square.) • Measurement points for fences and walls shall be set at intervals that enable the distribution of the air dose rate, etc. to be ascertained. [Example] Pitch of 5 to 10 m • Measurement points for benches, playground equipment, etc. shall be set at places people will be in contact with.

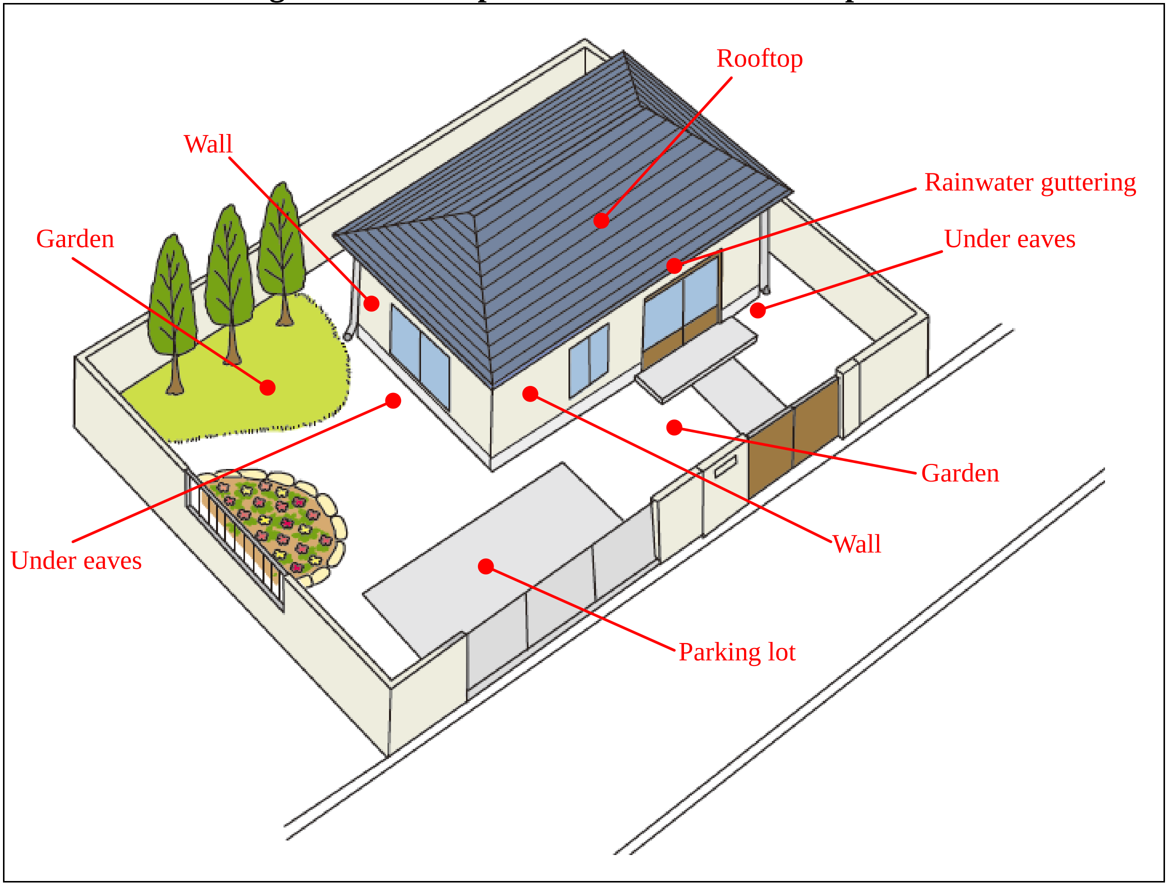
Figure 2-5. Example of a schematic diagram for reporting measurement points for use in decontamination and other measures for buildings and other structures



1): Contamination status for living spaces
(air dose rate: approximately two to five measurement points)

2): Contamination status for objects subject to decontamination
(surface contamination density, surface dose rate)

Figure 2-6. Examples of No. 2 measurement points



(2) Measurement Methods

When measuring the air dose rate at a No. 1 measurement point, a scintillation survey meter or other measuring apparatus able to measure gamma rays shall be used.

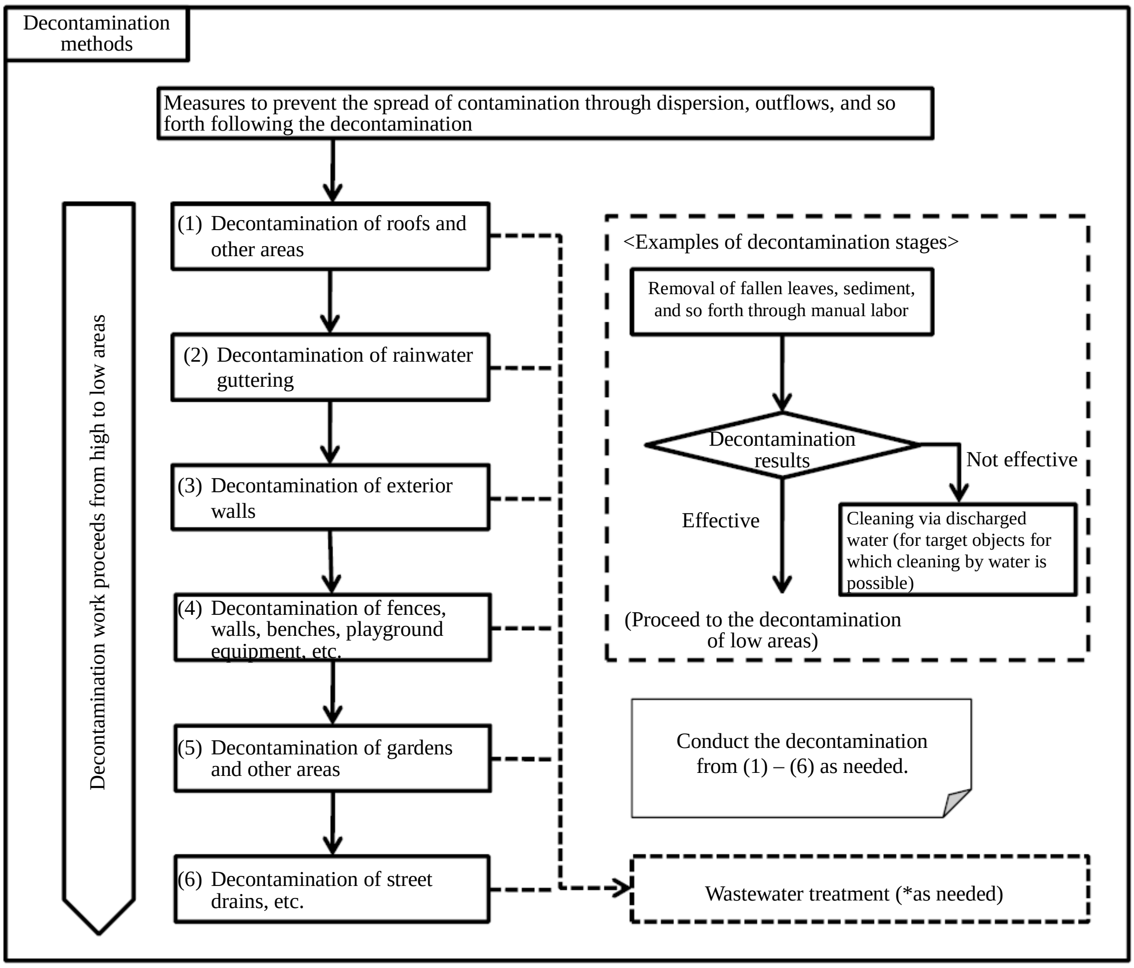
In contrast, to avoid the effects of background radiation when measuring the level of contamination on or near surfaces at a No. 2 measurement point, it is recommended to use a Geiger-Müller counter tube type survey meter (hereinafter, “GM survey meter”) able to measure beta rays, but it is also acceptable to perform the measurements using a dosimeter capable of measuring gamma rays. For example, one way to make specialized confirmation based on the levels of contamination at the relevant sites is to perform the measurements under conditions where a collimator is used to shield against gamma rays from the outside. In addition, for instance, it is possible to confirm the effect of the decontamination by determining the contamination status of the objects subject to decontamination from the air dose rate measured at the surface of the measurement points and at heights of 50 cm and 1 m, and then comparing the results with those of measurements taken in the same positions after the completion of the decontamination work.

In general, the same measuring apparatus shall be used when measuring at the same measurement points before and after decontamination work.

For the specific methods, see “6. Measuring Apparatuses and Methods of Use” in “Part 1: Guidelines on the Methods for Investigation and Measurement of the Status of Environmental Pollution in Intensive Contamination Survey Areas.”

3. Decontamination Methods

Figure 2-7. Basic flow for the decontamination of buildings and other structures



To decontaminate buildings and other structures effectively requires the decontamination work to be focused on places that are contaminated with comparatively high concentrations of radioactive materials that contribute substantially to the radiation dose. For example, there are radiocaesium-containing fallen leaves, moss, mud, etc. on the roofs (rooftops), rainwater guttering, street drains, etc. of houses and buildings open to the public, and therefore removing these can reduce the radiation dose.

In terms of decontamination stages, first the fallen leaves, etc., which contain large amounts of radiocaesium, shall be removed by hand provided they are relatively easy to remove. If this results in no observable decontamination effect, cleaning by spraying with water shall be used for those objects capable of being cleaned with water. Any radioactive materials that can possibly be removed by methods other than cleaning with water shall be removed in advance, and other measures shall be taken to prevent impact on the outflow destination of the drainage resulting from cleaning, etc. as much as possible.

In each stage, the air dose rates at the No. 1 measurement points shall be measured, and as a general rule no additional decontamination work shall be performed provided the air dose rate at a height of 1 m (a height of 50 cm from the measurement point is acceptable for elementary schools and below, as well as special-needs schools, with consideration for the living space of infants and schoolchildren in the lower grades) is less than 0.23 microsieverts per hour.

When water is used in decontamination work on houses and buildings, such work shall in principle be performed starting from high places and continuing to low ones, taking account of the possibility that radioactive materials could flow to gardens, etc. Specifically, it is effective to start from roofs/rooftops and rainwater guttering, proceed to exterior walls, and finally to gardens and other work on the ground and then street drains. When there are trees near the houses that are higher than the roofs, such trees shall be decontaminated first according to their contamination status. Depending on how the radioactive materials are settled onto the surfaces, decontamination work shall employ cleaning by hand, wiping, or cleaning with a scrubbing brush or brush.

The radioactivity of radioactive materials decays as time passes. What is more, this must be appropriately handled with due consideration given to the fact that the contamination status changes as a result of rainwater and other factors.

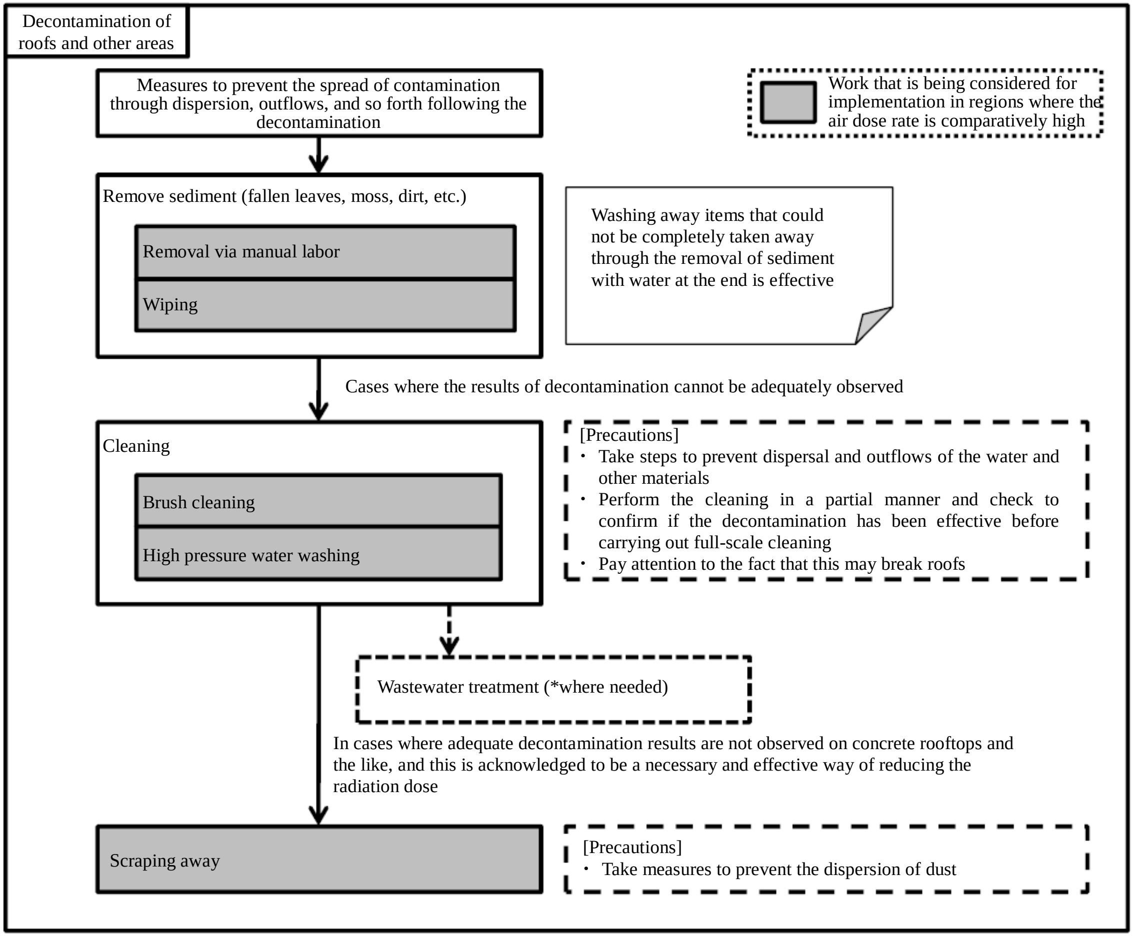
Moreover, when performing decontamination work, the necessary measures to secure the safety of the workers and the general public must be taken, and measures to prevent the spread of contamination due to dispersion, outflow, etc. associated with decontamination work must be implemented so as to minimize contamination being brought out from within the work zone, contamination being brought in from outside, or recontamination of the decontaminated zones. Among these preparations, please refer to the Ministry of Health, Labour and Welfare’s Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and its Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6 dated June 15, 2012) for the measures required to ensure the safety of workers.

See “4. Post-Work Measures” with regard to matters like the handling of the removed soil, the treatment of wastewater, and the cleaning of the equipment used for the decontamination.

This section covers methods of decontamination for roofs, rooftops, rainwater guttering, walls, gardens, street drains and other areas of buildings and other structures.

(1) Decontamination of Roofs and Other Areas

Figure 2-8. Basic flow for the decontamination of roofs and other areas



Any fallen leaves, moss, mud, or other sediments on roofs, etc. may have radiocaesium on or in them. Therefore, first the sediments that can be easily removed shall be removed by hand, the dirt shall be wiped away with thick paper towels (see Figure 2-9). Next, the roof, etc. shall be sprinkled with water and the sediments shall be removed by cleaning it off with a brush through the use of a deck brush or broom or the like. Special attention shall be paid to cleaning the overlapping sections of roofs, places where the metal is corroded, and around the drain for rooftops on large buildings, because these are places where there are comparatively large amounts of sediments (see Figure 2-10).

If no decontamination effect is adequately observed as a result it is presumed that there is radiocaesium settled onto the roofing materials. However, since any radiocaesium that was not washed away by rainwater will have permeated into the roofing materials, the radiocaesium shall be washed away by cleaning with high-pressure (example: 15 MPa) water spraying (hereinafter, “high pressure water cleaning”). Start by cleaning a portion of the roof, etc. and then confirm whether this produces a decontamination effect before cleaning the whole roof, etc., because the decontamination effect yielded by high pressure water cleaning depends on the surface materials of the roof and the like.

When conducting high pressure water cleaning or other decontamination that uses water, the appropriate countermeasures against wastewater shall be taken to prevent the secondary contamination of the environment (see ”4. (2) Wastewater Treatment”). Using a method of water recovery-type high pressure water cleaning is also effective for preventing the dispersal of radioactive materials. The advice of a specialist must also be obtained when pressure washing due to the possibility of damage to the roofs of houses, buildings, agricultural facilities, etc. depending on their constituent materials and structure.

In cases where no decontamination effect is observed as a result of cleaning and high pressure water cleaning, decontamination of concrete roofs and rooftops by scraping away or shot-blasting work shall be considered where deemed necessary and effective in the reduction of the radiation dose, with due attention given to the possibility of damage to the building. When implementing decontamination by shot-blasting work or similar methods, measures must be taken to prevent dispersion of dust into the surrounding environment that is generated by such processes.

The measures that are required in advance, specific decontamination methods, and notes of caution for the decontamination of roofs are as provided in Tables 2-4 and 2-5.

Figure 2-9. Example of the decontamination of roof tiles (wiping)

Figure 2-10. Example of the decontamination of roof tiles (cleaning)

Photo courtesy of: Fukushima City

Table 2-4. Necessary measures prior to the decontamination of roofs and other areas

Category	Decontamination methods and notes of caution
Safety measures	• When performing work in high places, appropriate safety measures shall be taken, such as erecting scaffolding and allocating aerial vehicles.
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent dispersion of water, etc. • Using a method of water recovery-type high pressure water cleaning is also effective for preventing the dispersal of radioactive materials.
Ensuring drainage channels and wastewater treatment	• When using water to clean, the channel for cleaning water to flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage. • See “4. (2) Wastewater Treatment” regarding the treatment of wastewater.

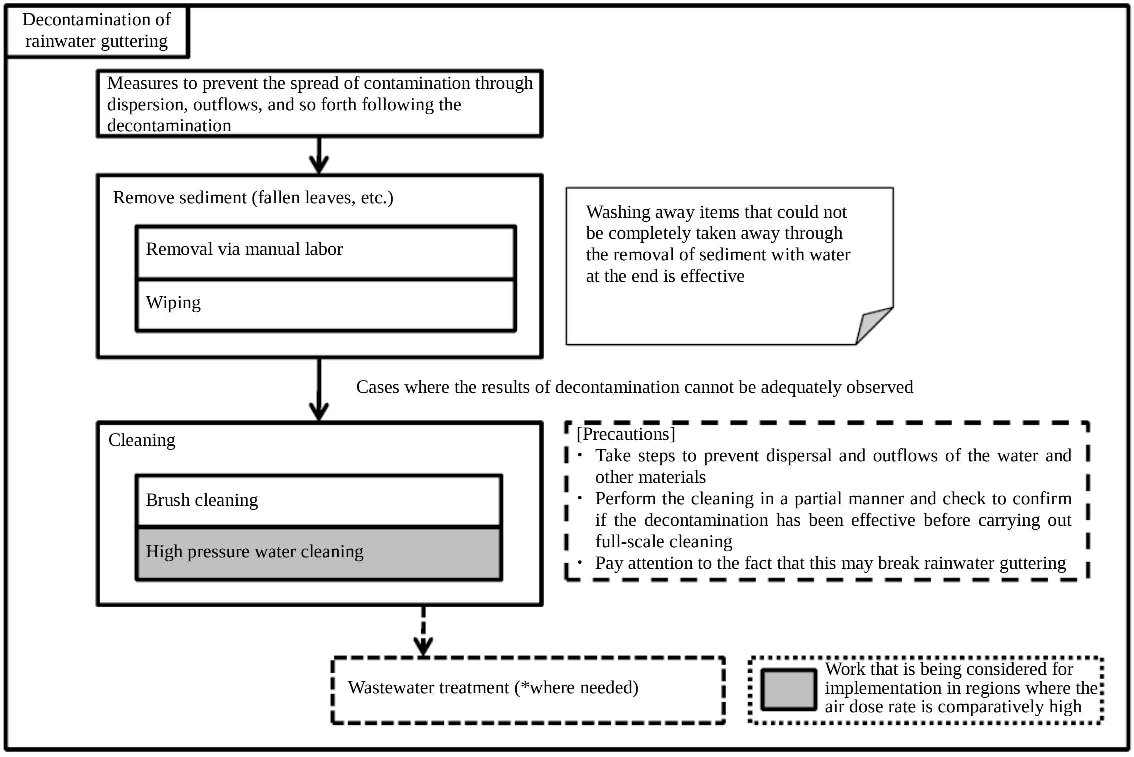
Table 2-5. Decontamination methods for roofs and other areas and notes of caution

Category		Decontamination methods and notes of caution
Removal of sediments	Decontamination through manual labor	• Fallen leaves, moss, mud, and other sediments shall be removed by hand by people wearing rubber gloves and by shovel, etc.
	Wiping	• Wiping shall be performed carefully through the use of paper towels or dustcloths that have been dampened with water. • All sides of folded paper towels, dustcloths, etc. used in wiping work shall be used. However, none of the surfaces that have already been used for decontamination (wiping) shall be touched with bare hands as these surfaces may have radiocaesium on them. • Consideration shall be given to preventing the contamination from re-adhering by such means as wiping it down with a new side of the cloth for each wipe according to the contamination status. • In some cases the results of the decontamination will be smaller due to effects from roofing materials like cement tiles, matte clay tiles, and painted steel sheets, as well as from rust. • When rust is present, the rust itself must be removed by being wiped away.
Cleaning	Brush cleaning	• Cleaning shall be thoroughly performed by using scrub brushes, scrubbing brushes, etc. • Cleaning shall be performed from high places to low ones so as to avoid dispersing water to the surroundings. • Rotary brushes shall not be used as they are not suitable for thatched or tiled roofs.
	High pressure water cleaning	• Any possibility of breakage or damage to roofs, etc. from high pressure water cleaning shall be checked in advance (obtaining advice from a specialist is recommended). • To prevent dispersion of soil, etc. by water pressure, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • To achieve a decontamination effect, the spray nozzle shall be brought near the place to be decontaminated. • Special attention shall be paid to cleaning the overlapping sections

		of roofs, places where the metal is corroded, and around the drain for rooftops, because these are places where there are comparatively large amounts of sediments. • Attention must be paid to the fact that there is the possibility of damaging property, such as by potentially peeling off the surface of objects.
Scraping away	Blast work	• Abrasive materials shall be shot at the surface with a shot blaster and scraped away from said surface uniformly. • In order to prevent dust from arising, curing, etc. shall be performed to prevent dispersion of dust to the surroundings and the dust shall be collected. • For blast work, curing shall be performed to ensure that abrasive materials and the like do not travel outside of the decontamination work area. What is more, after the abrasive materials and other materials have been used they shall be collected in a manner that ensures that they will not scatter the radioactive materials adhering to them to the surroundings.
	Scraping away	• Dispersion to the surroundings shall be prevented when scraping away contamination. (Example: use of dust collectors, sprinkling in advance, setting up simple plastic housings, etc.)

(2) Decontamination of Rainwater Guttering

Figure 2-11. Basic flow for the decontamination of rainwater guttering



[Precautions]
- Take steps to prevent dispersal and outflows of the water and other materials
- Perform the cleaning in a partial manner and check to confirm if the decontamination has been effective before carrying out full-scale cleaning
- Pay attention to the fact that this may break rainwater guttering

Fallen leaves, etc. with radioactive materials on or in them, which have flowed down from roofs, etc. due to rain will have collected in rainwater guttering. Particularly by removing the collected fallen leaves, etc., the radiation dose impinging on the surrounding environment can be reduced.

For the decontamination of rainwater guttering, the fallen leaves, etc. collected in said guttering shall be lifted out by hand using tongs, shovels, or other tools. The insides of rainspouts, rainwater pipes, and drain pipes shall be wiped by hand using pipe cleaners, thick paper towels, etc. (see Figure 2-12).

For cases where decontamination results are not adequately observed even when this is done, cleaning shall be performed with the use of water. Cleaning with water generates drainage that contains radioactive materials. To minimize the impact of the drainage produced by cleaning, etc. on the outflow destination, any radioactive materials that can be removed by a method besides cleaning with water shall be removed in advance whenever possible through workarounds that include wiping. When carrying out high pressure water cleaning, attention must be paid to the fact that this has the potential to damage rainwater guttering.

The measures that are required in advance, specific decontamination methods, and notes of caution for the decontamination of rainwater guttering are as provided in Tables 2-6 and 2-7.

Figure 2-12. Example of the decontamination of rainwater guttering (wiping)

Photo courtesy of: Date City

Photo courtesy of: Fukushima City

Figure 2-13. Example of the decontamination of rainwater guttering (brush cleaning)

Photo courtesy of: Date City

Table 2-6. Necessary measures prior to the decontamination of rainwater guttering

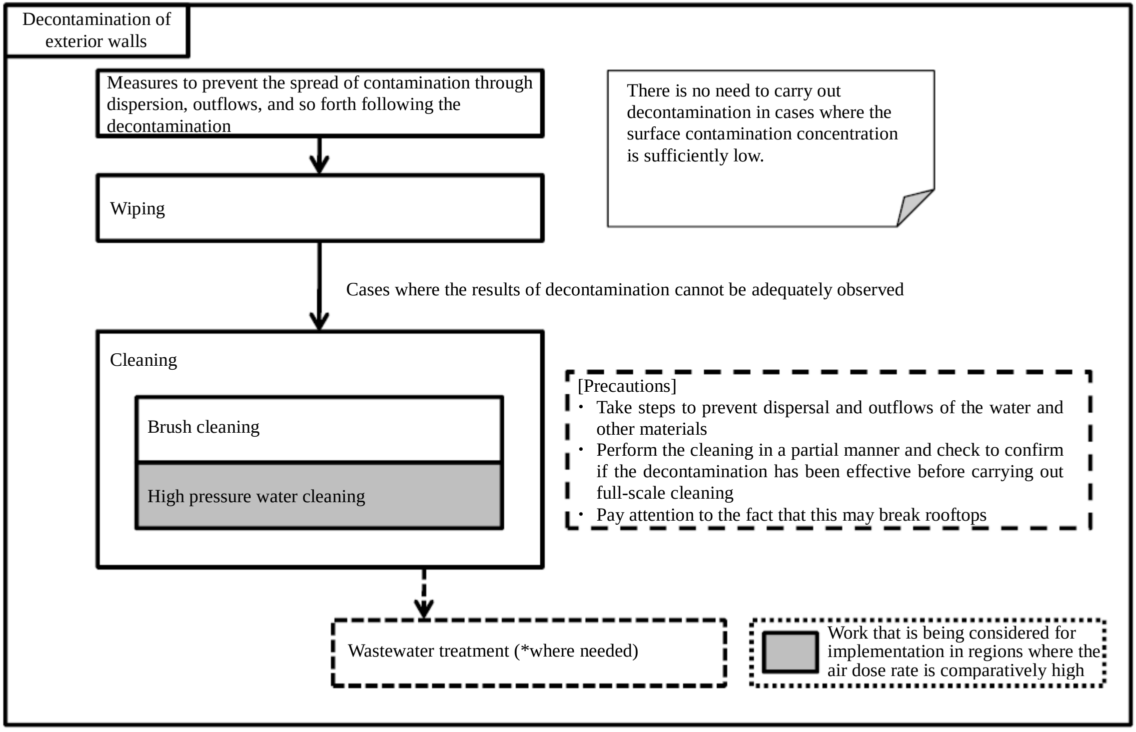
Category	Decontamination methods and notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent dispersion of water, etc.
Ensuring drainage channels and wastewater treatment	• When using water to clean, the channel for cleaning water to flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage. • Sediment in rainwater guttering shall be removed prior to cleaning with water. • See “4. (2) Wastewater Treatment” regarding the treatment of wastewater. • Damage to the end-flow sections of rainwater guttering or places where they are directly discharged into garden plots may result in high doses, so consideration shall be given to the decontamination of gardens and similar sites.

Table 2-7. Decontamination methods for rainwater guttering and points to keep in mind

Category		Decontamination methods and notes of caution
Removal of sediments	Decontamination through manual labor	• Fallen leaves, moss, and other sediments shall be removed by hand by people wearing rubber gloves and by shovel, etc.
	Wiping	• Wiping shall be performed carefully through the use of paper towels or dustcloths that have been dampened with water. • All sides of folded paper towels, dustcloths, etc. used in wiping work shall be used. However, none of the surfaces that have already been used for decontamination (wiping) shall be touched with bare hands as these surfaces may have radiocaesium on them. • Consideration shall be given to preventing the contamination from re-adhering by such means as wiping it down with a new side of the cloth for each wipe according to the contamination status. • Since large quantities of radioactive materials accumulate on the sediments in rainwater guttering, it is effective to remove said sediments.
Cleaning	Brush cleaning	• Cleaning shall be thoroughly performed by using scrub brushes or scrubbing brushes. • Sediment in downspouts (especially bend sections) tends to get overlooked, so these should be cleaned with a wire brush. • Cleaning shall be performed from high places to low ones so as to avoid dispersing water to the surroundings.
	High pressure water cleaning	• High pressure water cleaners shall be used to clean via pressure washing with a water pressure of generally 5 MPa or less and around 2 liters of water used per 1 m to ensure that rainwater guttering is not destroyed. This is primarily for narrow places where people cannot reach and other sections where it is difficult to perform wiping work. • The spray nozzle shall be brought near to the place being decontaminated (about 20 cm) in order to get results from the cleaning, and the cleaning shall be performed at the appropriate speed of movement. • Washing shall be performed from the upstream to the downstream of the drainage slope to ensure that water does not disperse to the surroundings.

(3) Decontamination of Exterior Walls

Figure 2-14. Basic flow for the decontamination of exterior walls



Since the exterior walls of buildings have lower levels of contamination than roofs or rainwater guttering in general, it is not necessary to perform decontamination on them in cases where the surface contamination density is sufficiently low compared with other places.

When decontaminating exterior walls, they shall be wiped or cleaned with water from high positions on the walls to low ones in order to prevent recontamination. To minimize the impact of the drainage produced by cleaning, etc. on the outflow destination, any radioactive materials that can be removed by a method besides cleaning with water shall be removed in advance whenever possible through workarounds that include wiping.

The advice of a specialist must be obtained when performing high pressure water cleaning due to the possibility of damage to the exterior walls depending on their constituent materials and structure. In particular, pressure washing is not suitable for wooden exterior walls.

The measures that are required in advance, specific decontamination methods, and notes of caution for the decontamination of exterior walls are as provided in Tables 2-8 and 2-9.

Table 2-8. Necessary measures prior to the decontamination of exterior walls

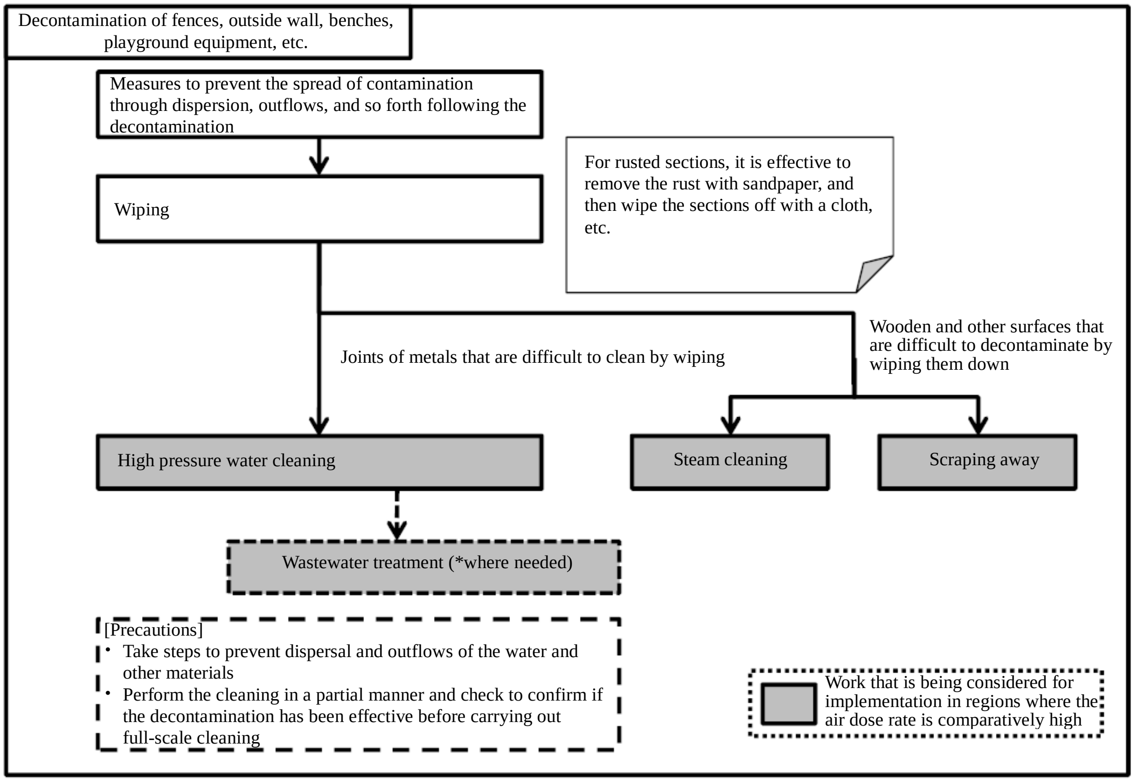
Category	Decontamination methods and points to notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent dispersion of water, etc.
Ensuring drainage channels and wastewater treatment	• When using water to clean, the channel for cleaning water to flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage. • See “4. (2) Wastewater Treatment” regarding the treatment of wastewater.

Table 2-9. Decontamination methods for exterior walls and notes of caution

Category		Decontamination methods and notes of caution
Wiping		• Wiping shall be performed carefully through the use of paper towels or dustcloths that have been dampened with water. • All sides of folded paper towels, dustcloths, etc. used in wiping work shall be used. However, none of the surfaces that have already been used for decontamination (wiping) shall be touched with bare hands as these surfaces may have radiocaesium on them. • Consideration shall be given to preventing the contamination from re-adhering by such means as wiping it down with a new side of the cloth for each wipe according to the contamination status.
Cleaning	Brush cleaning	• Cleaning shall be thoroughly performed by using scrub brushes or scrubbing brushes. • Cleaning shall be performed from high places to low ones so as to avoid dispersing water to the surroundings.
	High pressure water cleaning	• To prevent dispersion of soil, etc. by water pressure, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • The spray nozzle shall be brought near to the place being decontaminated (about 20 cm) in order to get results from the cleaning, and the cleaning shall be performed at the appropriate speed of movement. • Attention must be paid to the fact that there is the possibility of damaging the property, such as by causing walls to peel, or having water seep indoors.

(4) Decontamination of Fences, Outside Walls, Benches, Playground Equipment, etc.

Figure 2-15. Basic flow for the decontamination of fences, outside walls, benches, playground equipment, etc.



For rusted sections, it is effective to remove the rust with sandpaper, and then wipe the sections off with a cloth, etc.

[Precautions]
- Take steps to prevent dispersal and outflows of the water and other materials
- Perform the cleaning in a partial manner and check to confirm if the decontamination has been effective before carrying out full-scale cleaning

The metal and wooden surfaces of fences, outside walls, benches, playground equipment, etc. shall be wiped with water using a brush, cloth, etc. and then cleaned by wiping (see Figure 2-16). Neutral detergent, etc. shall be used as needed during this work, taking care not to affect the surfaces. For rusted sections, it is effective to remove the rust with sandpaper, and then wipe the sections off with a cloth, etc., but steps shall be taken to avoid recontamination as radioactive materials may settle on the tools used for wiping and scraping away.

Joints on playground equipment, etc. that are difficult to clean by wiping and wooden and other surfaces that are difficult to decontaminate by wiping shall be steam cleaned, washed by high pressure water cleaning (example: 15 MPa) (see Figure 2-17), or scraped away.

To minimize the impact of the drainage produced by cleaning, etc. on the outflow destination, any radioactive materials that can be removed by a method besides cleaning with water shall be removed in advance whenever possible among other workarounds.

When implementing decontamination of gardens as indicated in “II.3.(5) Decontamination of Gardens and Other Areas” or decontamination of sandboxes as indicated in “IV.3.(1) Decontamination of Soil in Schoolyards, Kindergarten Yards, and Parks” it is more efficient to perform such work after the decontamination work on fences, outside walls, benches, playground equipment, etc.

The measures that are required in advance, specific decontamination methods, and notes of caution for the decontamination of fences, outside walls, benches, playground equipment, etc. are as provided in Tables 2-10 and 2-11.

Figure 2-16. Example of decontamination of playground equipment (wiping)

Photo courtesy of: Hirono Town

Figure 2-17. Example of decontamination of playground equipment (high pressure water cleaning)

Photo courtesy of: JAEA

Table 2-10. Necessary measures prior to the decontamination of fences, outside walls, benches, playground equipment, etc.

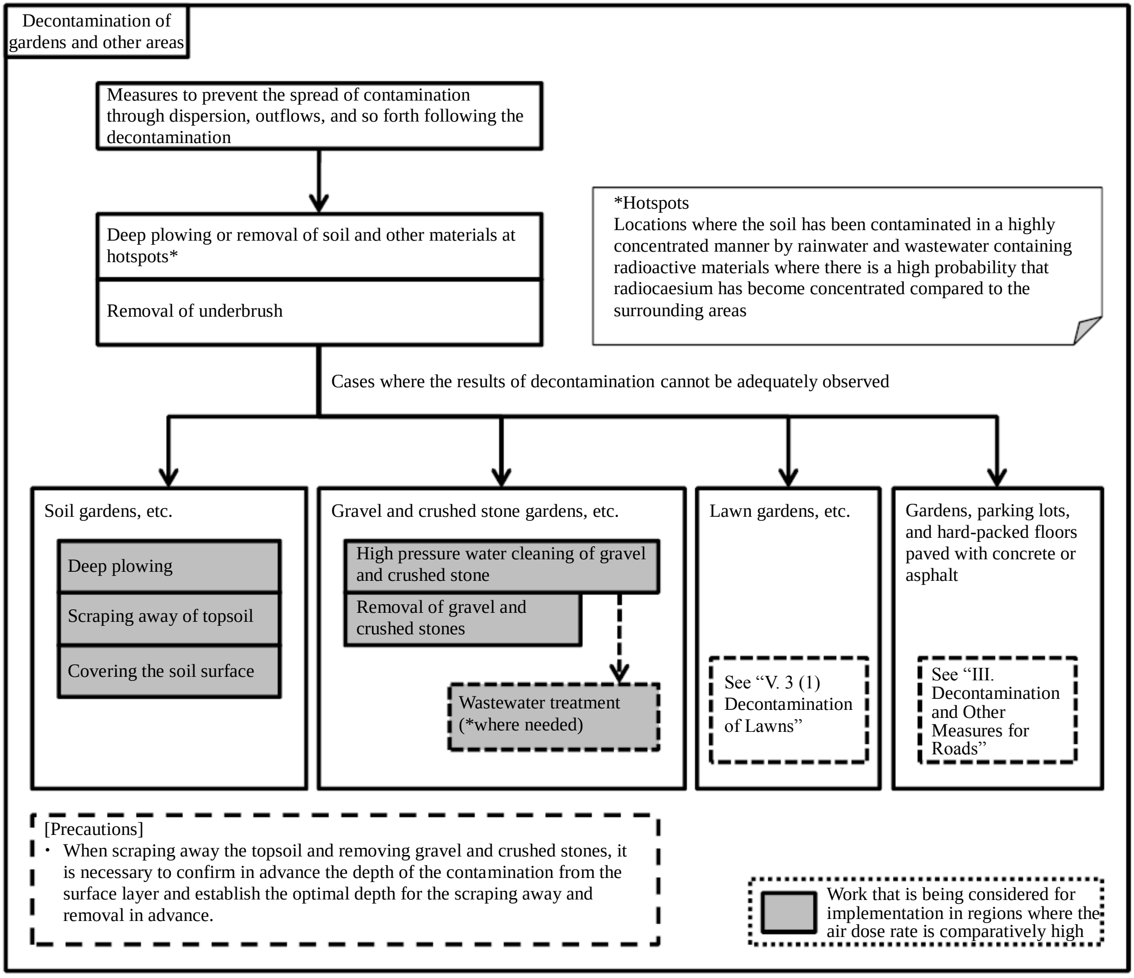
Category	Decontamination methods and notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent dispersion of water, etc.
Ensuring drainage channels and wastewater treatment	• When using water to clean, the channel for cleaning water to flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage. • See “4. (2) Wastewater Treatment” regarding the treatment of wastewater.

Table 2-11. Decontamination methods for fences, outside walls, benches, playground equipment, etc. and notes of caution

Category	Decontamination methods and notes of caution
Wiping	• All sides of folded paper towels, dustcloths, etc. used in wiping work shall be used. However, none of the surfaces that have already been used for decontamination (wiping) shall be touched with bare hands as these surfaces may have radiocaesium on them. • Consideration shall be given to preventing the contamination from re-adhering by such means as wiping it down with a new side of the cloth for each wipe according to the contamination status. • The rust on metal playground equipment shall be removed through the use of sandpaper, a metal brush, or the like before it is thoroughly wiped down. • Once a side of a paper towel or dustcloth has been used on decontamination (wiping) or a brush, waste cloth, or sandpaper has been used for wiping there is the possibility that it will have radiocaesium adhering to it, and so it must not be touched directly by hand.
High pressure water cleaning (metal joints)	• High pressure water cleaning shall be performed on the joints of playground equipment and the like that are difficult to wipe down. • To prevent dispersion of soil, etc. by water pressure, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • The spray nozzle shall be brought near to the place being decontaminated (about 20 cm) in order to get results from the cleaning, and the cleaning shall be performed at the appropriate speed of movement.
Steam cleaning	• Wooden playground equipment shall be cleaned using a steam cleaner.
Scraping away (wooden playground equipment, etc.)	• The surface wood of wooden playground equipment shall be scraped away with electric power tools or the like. • Dust collectors, etc. shall be used when scraping off wooden surfaces, etc. to prevent dispersion to the surroundings.

(5) Decontamination of Gardens and Other Areas

Figure 2-18. Basic flow for the decontamination of gardens and other areas



*Hotspots
Locations where the soil has been contaminated in a highly concentrated manner by rainwater and wastewater containing radioactive materials where there is a high probability that radiocaesium has become concentrated compared to the surrounding areas

[Precautions]
- When scraping away the topsoil and removing gravel and crushed stones, it is necessary to confirm in advance the depth of the contamination from the surface layer and establish the optimal depth for the scraping away and removal in advance.

In gardens, etc. outside houses, radiocaesium is settled onto fallen leaves, garden trees, and near the surface layer of the ground. Fallen leaves shall first be picked up and garden trees shall be pruned in accordance with the extent of the radioactive materials adhering to them. In places where weeding has not been carried out since after the accident the underbrush shall be removed as needed, while in places where moss and underbrush is being grown covering the surface it will be effective to scrape away underbrush by using a scythe or similar tool.

Furthermore, since there may be comparatively large amounts of radiocaesium settled onto rainwater guttering drains, drainage channels, rainwater chambers, and near the undereaves of roofs that have no rainwater guttering, as well as at the bases of trees, the soil at such places shall be removed via manual labor and the like (see Figures 2-20 and 2-21). If no decontamination effect is observed as a result of these measures, then decontamination shall be carried out via the methods indicated below.

■ Soil gardens, etc.

For soil gardens and the like, deep plowing, scraping away topsoil, or covering them with soil (hereinafter “covering the soil surface”) shall be taken into consideration.

Deep plowing is the method of covering the soil surface by replacing the radiocaesium-containing upper layer of the soil with a lower layer of the soil that does not contain radiocaesium (see Figure 2-19). Carrying out deep plowing can be expected to reduce the radiation dose and to inhibit the diffusion of radiocaesium by shielding with soil, etc. Moreover, these have the advantage of not generating removed soil, because they do not scrape away the topsoil. When performing deep plowing, approximately 10 cm of surface soil shall be placed at the lower layer and covered with approximately 20 cm of excavated soil from the lower layer. When performing this procedure, it is necessary to avoid scattering the surface soil or mixing it with the soil excavated from the lower layer. When implementing this over a large area, the implementation area shall be partitioned in an appropriate manner.

When scraping away topsoil, it is important to select an appropriate thickness for the soil to be scraped away in order to avoid generating too much removed soil. To be more specific, for the soil surfaces to be scraped away, it is recommended to start with small areas (an area of a size that enables the air dose rate, etc. of the soil surface to be measured with minimal interference from radiation outside the area) and scrape away about 1 to 2 cm of topsoil while measuring the air dose rate, etc., then determine the thickness of the layer to be scraped away (see Figure 2-52 2), 3), and 4)). According to conventional wisdom it is believed that adequate results can be achieved by scraping away at most about 5 cm of the soil surface. In places where the topsoil has been removed, topsoil shall be brought from another location by using uncontaminated soil as needed.

For covering the soil surface, the approach is to cover the top layer of soil that contains radiocaesium with soil that does not contain radiocaesium through the use of small heavy machinery. This can be expected to reduce the radiation dose via shielding and to inhibit the diffusion of radiocaesium by shielding it with soil. This has the advantage of not generating removed soil since the topsoil is not being removed. When performing this covering, it is important to select an appropriate covering thickness for purposes of shielding in order to avoid having the covering thickness become excessively large.

■ Gravel or crushed stone gardens, etc.

For gravel or crushed stone gardens, etc., place the gravel or crushed stones in a water tank and remove the radioactive materials from them by agitating and high pressure water cleaning, then lay them out again after they have been cleaned. See “4. (2) Wastewater Treatment” regarding the handling of wastewater when performing high pressure water cleaning.

For cases where results are not considered to have been adequately observed even after cleaning has been carried out, then the gravel and crushed stones shall be removed evenly with the use of a shovel or other instrument. When gravel or crushed stones are removed, the area shall be covered by using the same type of gravel or crushed stones as before as needed, and it shall be covered to the same standing height as before and to about the same compactness as before.

On ground where gravel and crushed stones have been laid out there is the possibility that radioactive materials have been accumulated in the soil below the gravel and crushed stones as time passes. As such, there may be cases where it will be necessary to make a determination on whether decontamination should be carried out on the gravel and crushed stones or the soil below them. In doing so, it will be necessary to decide on a decontamination method by properly performing measurements and conducting experiments.

■ Lawn gardens, etc.

See “V. 3. (1) Decontamination of Lawns” regarding decontamination methods for locations like lawn gardens, gardens where underbrush is growing thickly, or where residue from thatch and dried leaves and grass is found.

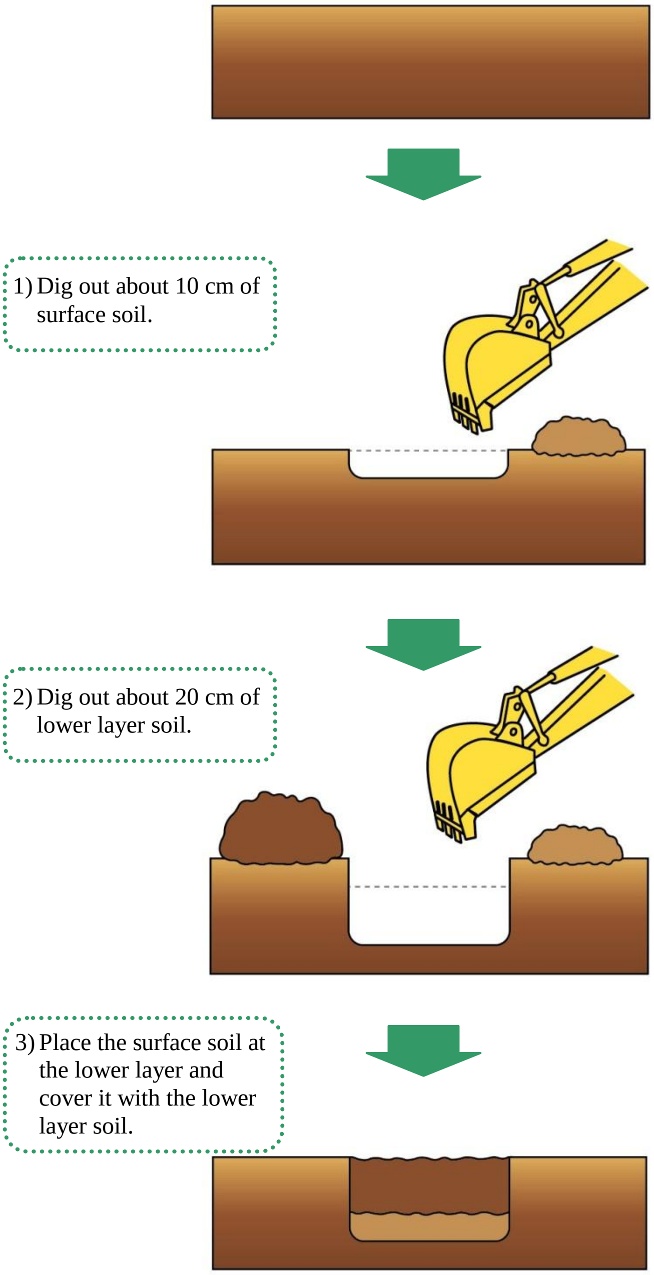
■ Gardens, parking lots, and hard-packed floors paved with concrete or asphalt

See “III. Decontamination and Other Measures for Roads” regarding decontamination methods for gardens, parking lots, and hard-packed floors paved with concrete or asphalt.

When water has been used for decontamination work on houses and buildings, it is more efficient to perform the decontamination work on gardens and surrounding sites, etc. after the work on the houses and buildings, because radioactive materials on the roofs, etc. could flow off in the process.

The measures that are required in advance, specific decontamination methods, and notes of caution for the decontamination of gardens and other areas are as provided in Tables 2-12 and 2-13.

Figure 2-19. Example of decontamination procedures via replacing the topsoil with subsoil (deep plowing)



1) Dig out about 10 cm of surface soil.

2) Dig out about 20 cm of lower layer soil.

3) Place the surface soil at the lower layer and cover it with the lower layer soil.

Figure 2-20. Example of decontamination of gardens, etc. (removal of underbrush, etc.)

Photo courtesy of: Date City

Figure 2-21. Example of the decontamination of gardens and other areas (removal of soil, etc.)

Photo courtesy of: Date City

Table 2-12. Necessary measures prior to the decontamination of gardens and other areas

Category	Decontamination methods and notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent dispersion of water, etc.

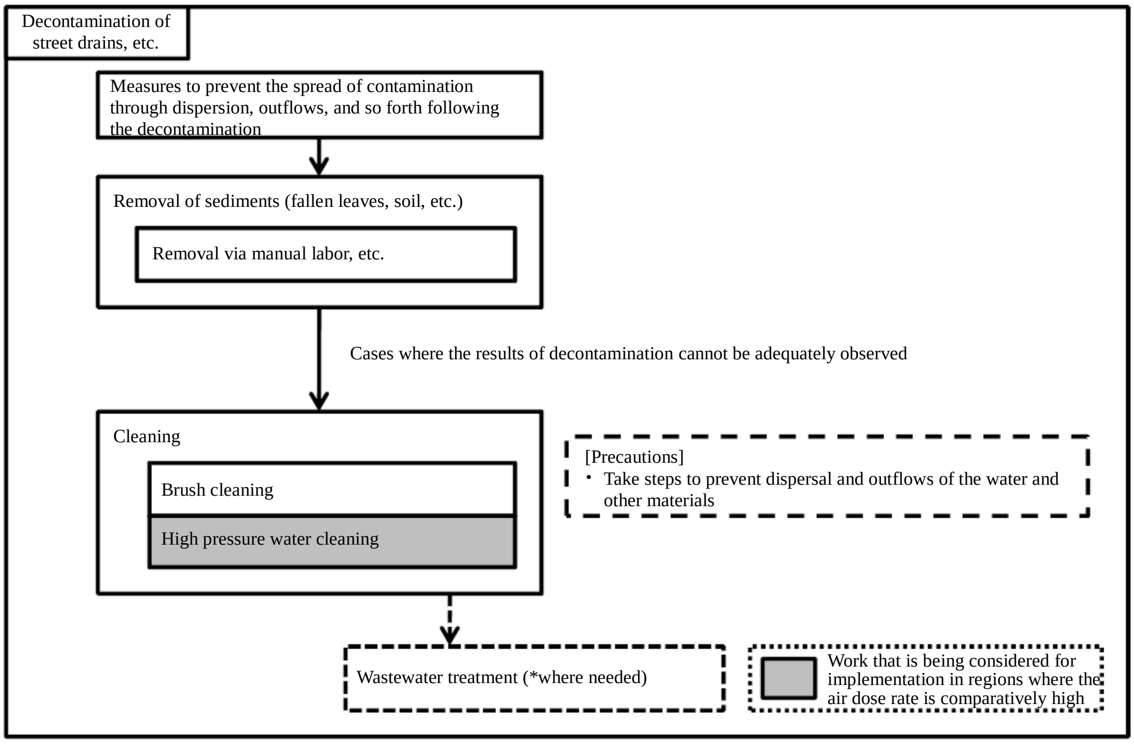
Table 2-13. Decontamination methods for gardens and other areas and notes of caution

Category		Decontamination methods and notes of caution
Deep plowing or removal of soil and other substances at hotspots		• Fallen leaves, moss, mud, and other sediments shall be removed by hand by people wearing rubber gloves and by shovel, etc. • The soil at hotspots below rainwater guttering and the like shall be deep plowed or removed. When this is implemented attention must be paid to the depth of the contamination. • In cases where it is difficult to perform deep plowing at a location, such as with soil that has been packed into rainwater chambers and the like, consideration shall be given to performing deep plowing in the vicinity of said rainwater chambers.
Removal of underbrush, etc.		• Before performing the deep plowing and the scraping away of topsoil, conduct weed removal and weeding on any weeds that would pose a hindrance to the work using a shoulder-type mower or human power. • In some cases the shielding effect for the beta rays by grass may be reduced by the grass cutting, and so the reduction rate may drop.
Soil gardens, etc.	Deep plowing	• About 10 cm of topsoil shall be uniformly scraped away and temporarily piled on top of a plastic sheet or the like. • About 20 cm of subsoil shall be uniformly scraped away and piled on top of a separate location from the topsoil. • After the topsoil has been uniformly spread out, the subsoil shall be uniformly spread on top of it and the land will be leveled. It shall be restored to its original height at a compactness that is about the same as it was before.
	Scraping away surface soil	• A bamboo winnow or similar instrument shall be used to uniformly scrape away the garden topsoil. • Attention shall be paid to the fact that due to the planted vegetation and unevenness relative to the ground there may be reduced certainty with the decontamination work.
	Covering the surface soil	• The surface soil shall be covered with soil that does not contain radiocaesium.
Gravel and crushed stone gardens, etc.	High pressure water cleaning of gravel and crushed stones	• A shovel or the like shall be used to place the gravel or crushed stones into a water tank and then perform high pressure water cleaning. • To prevent dispersion of soil, etc. by water pressure when performing high pressure water cleaning, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • See “4. (2) Wastewater Treatment” regarding the treatment of wastewater.
	Removal of gravel and crushed stones	• The gravel or crushed stones shall be uniformly removed with a shovel or the like. • When gravel or crushed stones are removed, the area shall be covered by using the same type of gravel or crushed stones as before as needed, and it shall be covered to the same standing height as before and to about the same compactness as before.

		• Attention shall be paid to the fact that because of the large air gaps when covering with crushed stones, density adjustments shall be performed via the appropriate surface compaction.

(6) Decontamination of Street Drains, etc.

Figure 2-22. Basic flow for the decontamination of street drains, etc.



Fallen leaves, dirt, etc. with radioactive materials on or in them, which have flowed down from roofs, etc. due to rain will have collected in street drains, rainwater chambers, and other fixtures for collecting water and drainage, so therefore these shall be removed with a shovel or the like (see Figures 2-23 and 24). When performing deep plowing at rainwater chambers it will be difficult to carry this out in such locations, and so deep plowing shall be carried out in the vicinity of said rainwater chambers (see Figure 2-25).

Furthermore, this shall be followed by cleaning with a brush or high pressure water cleaning (example: 15 MPa) as needed to reduce the radiation dose in the surrounding vicinity. When performing cleaning using water, attention must be given to the drainage channel, etc.

Cleaning with water generates drainage that contains radioactive materials. To minimize the impact of the drainage produced by cleaning, etc. on the outflow destination, any radioactive materials that can be removed by a method besides cleaning with water shall be removed in advance whenever possible through workarounds that include wiping. If the joints in the concrete of the street drain are thick, the decontamination effect will be reduced. With plastic rainwater chambers and the like, it is effective to wipe these down with sponges, waste cloth, or so forth.

The measures that are required in advance, specific decontamination methods, and notes of caution for the decontamination of street drains and similar infrastructure are as provided in Tables 2-14 and 2-15.

Figure 2-23. Example of the decontamination of a street drain (removal of sediments)

Photo courtesy of: Koriyama City

Figure 2-24. Example of the decontamination of a rainwater chamber (removal of sediments)

Photo courtesy of: Fukushima City

Figure 2-25. Example of the decontamination of a rainwater chamber (removal of sediments and deep plowing of the rainwater chamber sediments at the same site)

Photo courtesy of: Matsudo City

Figure 2-26. Example of the decontamination of a street drain (high pressure water cleaning)

Photo courtesy of: Fukushima City

Figure 2-27. Example of the decontamination of a rainwater chamber (sponge cleaning)

Photo courtesy of: Matsudo City

Table 2-14. Necessary measures prior to the decontamination of street drains, etc.

Category	Decontamination methods and notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent dispersion of water, etc.
Ensuring drainage channels and wastewater treatment	• When using water to clean, the channel for cleaning water to flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage. • See "4. (2) Wastewater Treatment" regarding the treatment of wastewater.

Table 2-15. Decontamination methods for street drains, etc. and notes of caution

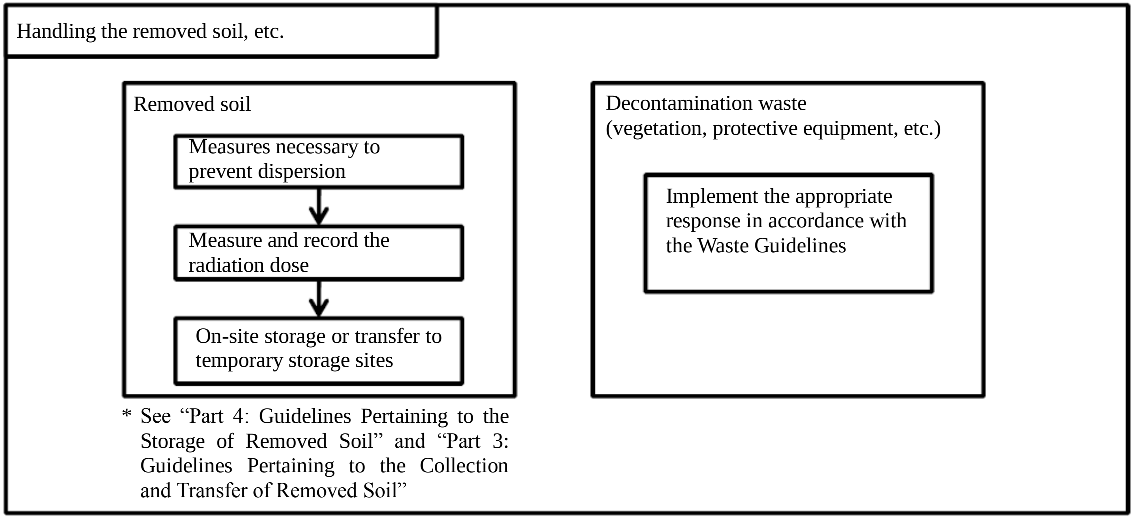
Category		Decontamination methods and notes of caution
Removal of sediments	Decontamination through manual labor	• Fallen leaves, moss, mud, and other sediments that are easy to remove shall be removed in advance by shovel, etc. • When the concrete joints of street drains are deep, a spatula or the like shall be used to remove the sediments from the joints. • When performing deep plowing at rainwater chambers it will be difficult to carry this out in such locations, and so deep plowing shall be carried out in the vicinity of said rainwater chambers. • In cases where sediment gets clogged in rainwater chambers and water overflows out of street drains like when it rains contamination will sometimes spread to the surroundings. In such cases the ground surface of the surroundings shall be measured and decontamination work shall be carried out in accordance with the configuration of the ground surface.
Cleaning	Brush cleaning	• Cleaning shall be thoroughly performed by using a deck brush or broom. • Cleaning shall be performed from high places to low ones so as to avoid dispersing water to the surroundings.
	High pressure water cleaning	• To prevent dispersion of soil, etc. by water pressure, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • The spray nozzle shall be brought near to the place being decontaminated (about 20 cm) in order to get results from the cleaning, and the cleaning shall be performed at the appropriate speed of movement.

4. Post-Work Measures

Post-work measures, which include handling the removed soil and treating the wastewater generated by the decontamination work, as well as cleaning equipment, are listed below.

(1) Handling the Removed Soil, etc.

Figure 2-28. Basic flow for handling the removed soil, etc.



* See “Part 4: Guidelines Pertaining to the Storage of Removed Soil” and “Part 3: Guidelines Pertaining to the Collection and Transfer of Removed Soil”

The removed soil, etc. shall be appropriately handled and transferred to on-site storage or a temporary storage site. Please refer to “Part 4: Guidelines Pertaining to the Storage of Removed Soil” and “Part 3: Guidelines Pertaining to the Collection and Transfer of Removed Soil” for information on transfer to on-site storage and temporary storage sites. Since the equipment and materials used for wiping and cleaning may have radioactive materials on them, appropriate management is required for these items as well.

The other constituents of the removed soil, etc. shall be divided into removed soil and decontamination waste (vegetation, protective equipment, etc.) to the extent possible and placed in separate bags or other containers, among other measures necessary to prevent dispersion. Since it will be necessary to ascertain the radiation dose when transferring these items to temporary storage sites and storing them, to facilitate this the air dose rate at the surface (1 cm from the surface) of the containers into which the removed soil, etc. has been placed shall be measured and recorded. Please refer to the Waste Guidelines (March 2013, Vol. 2) for information on the handling of the decontamination waste generated during the decontamination process.

Table 2-16. Methods for the handling of removed soil, etc. and notes of caution

Category	Decontamination methods and notes of caution
Handling the removed soil, etc.	• To prevent dispersion, the removed soil, etc. shall be placed in bags or other containers and closed or sealed, or wrapped in sheets or similar material. • The removed soil, etc. shall be separated from decontamination waste to the extent possible and placed in separate bags or other containers to ensure there is no mixing. Please refer to the Guidelines on the Storage of Decontamination Waste (promulgated at the end of December 2011) for details on the handling of waste. • The air dose rate at the surface (from 1 cm away) of each container or set of multiple containers holding the removed soil, etc. shall be measured, and the radiation dose of the removed soil, etc. generated by the decontamination work shall be recorded and displayed in a manner that roughly indicates the dose level (range). • Vegetation and the disposable masks, etc. used in the decontamination work shall be treated and disposed of as decontamination waste in accordance with the Waste Guidelines (March 2013, Vol. 2) and other relevant statutes.

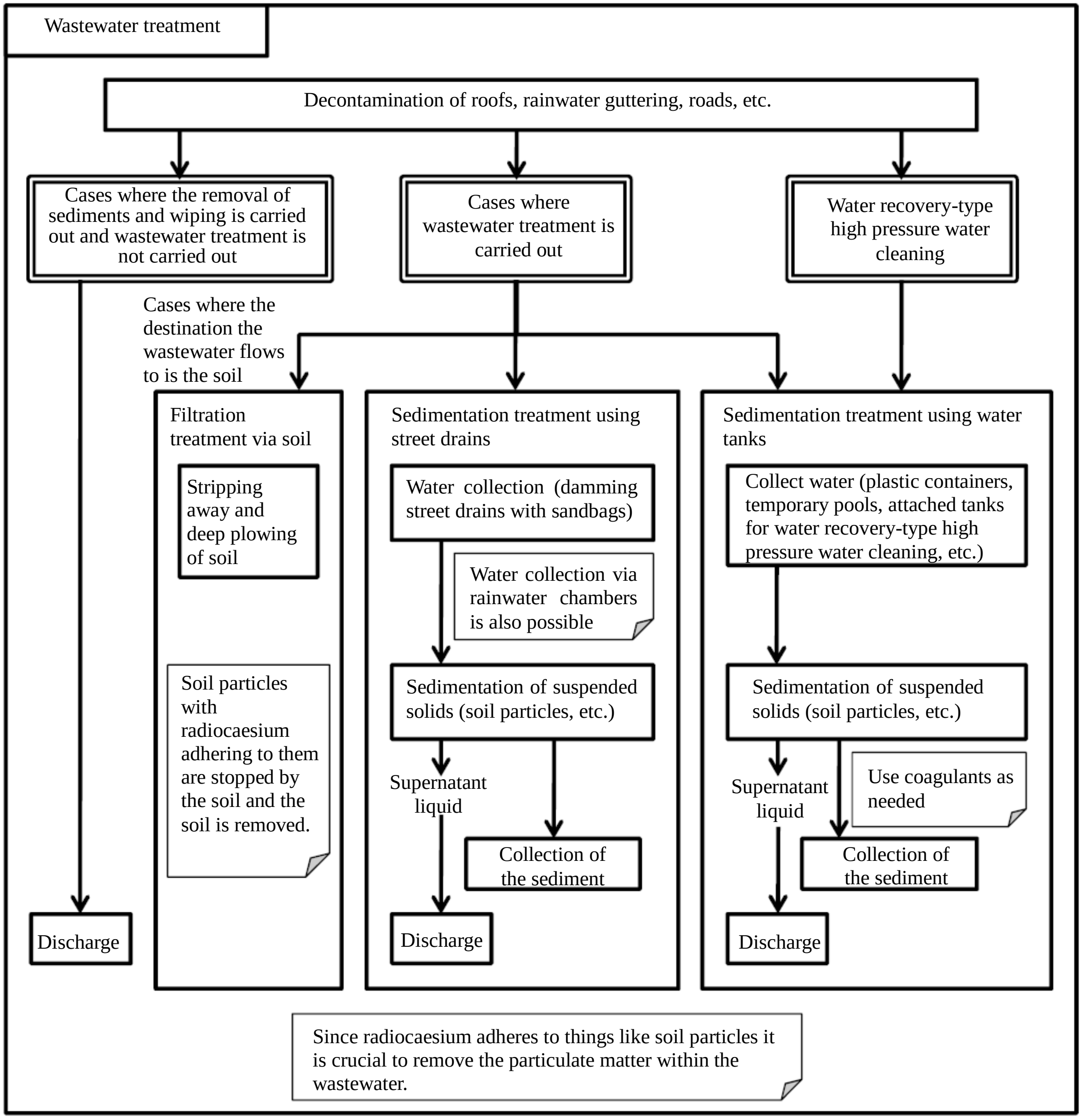
(2) Wastewater Treatment

In cases where wastewater is generated as a result of decontamination, wastewater treatment shall be carried out as needed.

Most radiocaesium exists in a configuration in which it is strongly adsorbed on soil particles, and it is characterized by the fact that it hardly elutes in water at all. Therefore, it is effective to carry out activities like the removal of sediments and wiping.

For decontamination in decontamination zones (zones subject to the decontamination plans established by municipalities) there is essentially no need to treat wastewater in cases where sediments are removed. However, wastewater treatment shall essentially be carried out in situations where the wastewater is highly turbid or for wastewater that has been recovered from water recovery-type high pressure water cleaning.

Figure 2-29. Basic flow for wastewater treatment



With regard to the wastewater from after the decontamination of rooftop rainwater guttering and the like, there will be cases where rooftops lack such rainwater guttering and cases where the areas under such guttering consist of soil. In such cases it will presumably be possible to filter the radioactive materials present within the wastewater through the soil found below since the destination to which it will flow will be soil. In these cases it will be possible to recover the radioactive materials by removing this soil after the decontamination of the rooftops and so forth by essentially adhering to decontamination work that proceeds from high places to low ones.

In cases where the discharge destination for the wastewater consists of street drains and the like, the water shall be collected by damming up the street drains using sandbags or similar equipment as needed, then sedimenting out the particulate matter, collecting the sediment, and discharging the supernatant liquid. As was stated above, since the radiocaesium adheres to the particulate matter found within the wastewater there are hardly any radioactive materials contained within the supernatant liquid.

Other wastewater that is generated as a result of decontamination shall be collected to the extent possible. Wastewater that has been collected via plastic containers and temporary pools, as well as that recovered by water recovery-type high pressure water cleaning shall have its particulate matter sedimented out, then the water in the supernatant liquid shall be discharged while the sediment is collected. For the sedimentation of the particulate matter, agents to cause the liquid to undergo coagulating sedimentation as well as filters for removing the particulate matter shall be used as needed.

Figure 2-30. Example of wastewater treatment (sedimentation treatment using street drains)

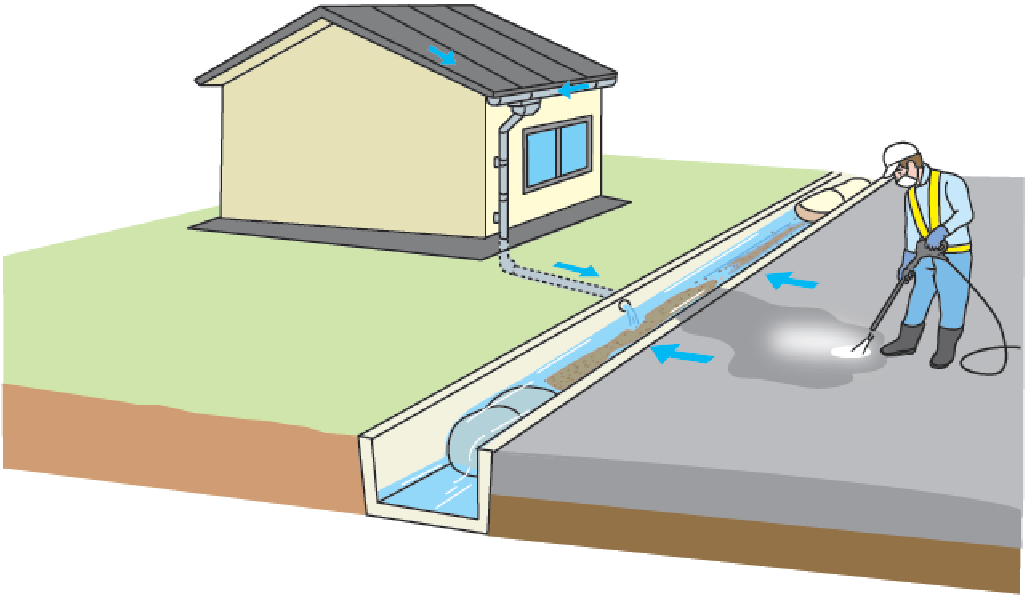


Figure 2-31. Example of wastewater treatment (sandbags installed in street drains)

Photo courtesy of: Fukushima City

Figure 2-32. Example of wastewater treatment (sedimentation treatment using water tanks)

Photo courtesy of: Koriyama City

Table 2-17. Necessary measures prior to wastewater treatment

Category	Decontamination methods and notes of caution
Ensuring drainage channels and wastewater treatment	• The channel down which the wastewater will flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage.

Table 2-18. Methods for wastewater treatment and notes of caution

Category	Decontamination methods and notes of caution
Filtration treatment via soil	• When the area under rainwater guttering consists of soil, radiation shall be captured by flushing wastewater generated on rooftops down to the soil via the rainwater guttering, and then said top layer of soil shall be removed after the decontamination of the rooftop.
Sedimentation treatment using water tanks	• Water shall be collected in plastic containers or temporary pools, then sedimenting out the particulate matter, and discharging the water from the supernatant liquid while collecting the sediment (agents to cause the liquid to undergo coagulating sedimentation shall be used). • The water in the supernatant liquid shall be checked to make sure there is no turbidity. • A simple filter will be installed and filtration shall be carried out as needed.
Sedimentation treatment using street drains	• The water shall be collected by damming up the street drains using sandbags, then sedimenting out the particulate matter, and discharging the supernatant liquid while collecting the sediment. • The water in the supernatant liquid shall be checked to make sure there is no turbidity. • A simple filter will be installed and filtration shall be carried out as needed.

■ Forms in which Radiocaesium Is Found

The radioactive materials that resulted from the accident at the Fukushima Daiichi Nuclear Power Plant were emitted, advectively diffused over a broad range in the form of aerosols and the like, and fell to and were deposited on the ground through rainfall. The radiocaesium that presently accounts for the majority of the environmental radiation is thought to have dissolved in rainwater and fallen in the form of ions.

Having fallen and been deposited on the ground's surface, this radiocaesium has currently strongly been absorbed primarily within soil particles (Table 2-19).

The radiocaesium in the water in rivers, lakes, marshes, and so on exists in trace amounts as dissolved bodies, with the majority of it present in a form in which it has been absorbed into soil particles and other turbid materials. It has been learned from the monitoring of the water in rivers, lakes, marshes, and so on that these largely do not contain radiocaesium (Table 2-20).

Moreover, it has also been learned that radiocaesium is largely not contained in the wastewater from when cleaning is carried out after the removal of sedimentation (Table 2-21).

◆ <u>The radiocaesium adhering to soil hardly elutes into water at all.</u>

Table 2-19. Elution of caesium from soil into water (results of an elution test)

	Radiocaesium content (Bq/kg – wet)	Moisture content	Radiocaesium elution concentration (Bq/L)
Soil (1)	16770	29.8%	Under the elution limit
Soil (2)	14250	13.0%	Under the elution limit

Test method: JIS K0058-1 Agitation test with soil present
Test limits: 17.2 Bq/L for Soil (1) and 16.9 Bq/L for Soil (2)
Source: National Institute for Environmental Studies, Japan: Proper Waste Disposal and Treatment from the Perspective of the Behavior of Radioactive Materials (Technical Data: Volume 3) (December 20, 2012)

◆ <u>Radiocaesium is hardly contained at all in the water of rivers, lakes, and marshes.</u>

Table 2-20. Monitoring data for public water areas

In a recent survey on the water quality in rivers, lakes, marshes, water sources, and the coasts of Fukushima Prefecture, radiocaesium was not detected (less than 1 Bq/L) at 201 locations out of the 216 tested. Of the 15 locations where it was detected, 14 had less than 10 Bq/L, and for the one location that is in an area where recovery will be difficult where the maximum value (100 Bq/L) was detected, the location has a shallow water depth and turbid water.

Source: Ministry of the Environment: Measurement Results on the Monitoring of Radioactive Materials in Public Water Areas within Fukushima Prefecture (extracted from December – March) (March 29, 2013)

◆ **When sediment is removed, there is almost no radiocaesium found within the wastewater that results from cleaning.**

Table 2-21. Radiocaesium concentration within wastewater generated as a result of cleaning

After the sediment was removed the radiocaesium concentration contained within the wastewater cleaned was 36 Bq/L on average (n=19, Minimum value: 4 Bq/L, Maximum value: 131 Bq/L).

* Air dose rate in regions subject to decontamination: 1.24 uSv/h (measurement height: 1 m)

Decontamination method: After the sediment was removed from rooftops and other places they were wiped down, cleaned with a brush, or washed by high pressure water cleaning according to the situation

Source: Fukushima City

(3) Cleaning of Equipment and Materials

With regard to the post-work handling of the equipment and materials used for decontamination, as a general rule the Ministry of Health, Labour and Welfare's Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and its Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6 dated June 15, 2012) are to be followed. Moreover, over and above these it is pertinent to keep in mind the items listed in the table below out of consideration for the impact on the surroundings.

Table 2-22. Methods for cleaning equipment and materials and notes of caution

Category	Details
Cleaning equipment and materials	• Heavy machinery, vehicles, and other objects used for which there is the possibility that a great deal of contaminated soil is adhering to them shall be checked to confirm the extent to which said soil is adhering to them. Those objects to which a great deal of contaminated soil is adhering shall be cleaned in a designated location, and other measures shall be taken to ensure that the contaminated soil, etc. is not spread around indiscriminately. • Likewise for shovels and other tools, shoes, and work clothes to which lots of contaminated soil is adhering, these shall be checked to confirm the extent to which said soil is adhering to them. Those objects to which a great deal of contaminated soil is adhering shall be cleaned in a designated location, and other measures shall be taken to ensure that the contaminated soil, etc. is not spread around indiscriminately. • The wastewater generated by the cleaning shall be treated as needed by referring to “(2) Wastewater Treatment.” • When cleaning, the workers shall take care to ensure that they are not bathed in the spray from this.

	• In addition, even equipment or materials with a low possibility of contamination shall be checked to confirm whether or not contaminated soil is adhering to them. • The equipment, materials, and work clothes used shall be washed, cleaned, and reused to the extent possible. [Washing/cleaning examples] ○ Steam cleaning is effective for cleaning machinery, but scrubbing it down with brushes and a detergent is also sufficient. ○ Normal methods are sufficient for washing work clothes and other clothing. • When carrying the clothing, etc. used in decontamination work, it shall be placed in a box or bag, etc. to minimize dispersal of the attached matter. • When going indoors after decontamination work, mud shall be removed from shoes, clothing shall be changed, and other measures shall be taken to avoid bringing indoors dust attached to the workers.

5. Post-Work Measures

To confirm the decontamination effect, the air dose rate, etc. after completion of the decontamination work shall be measured and compared with the air dose rate, etc. that was measured prior to the commencement of the decontamination work. Measurement of the air dose rate, etc. shall be performed in accordance with the measurement methods given in “Part 1: Guidelines for Methods for Investigating and Measuring the Status of Environmental Pollution in Intensive Contamination Survey Areas” for each measurement point indicated in Table 2-3 of “2. (1) Determination of Measurement Points.”

In addition to the air dose rate, etc. at each measurement point, any other information pertaining to the decontamination work shall be recorded and stored.

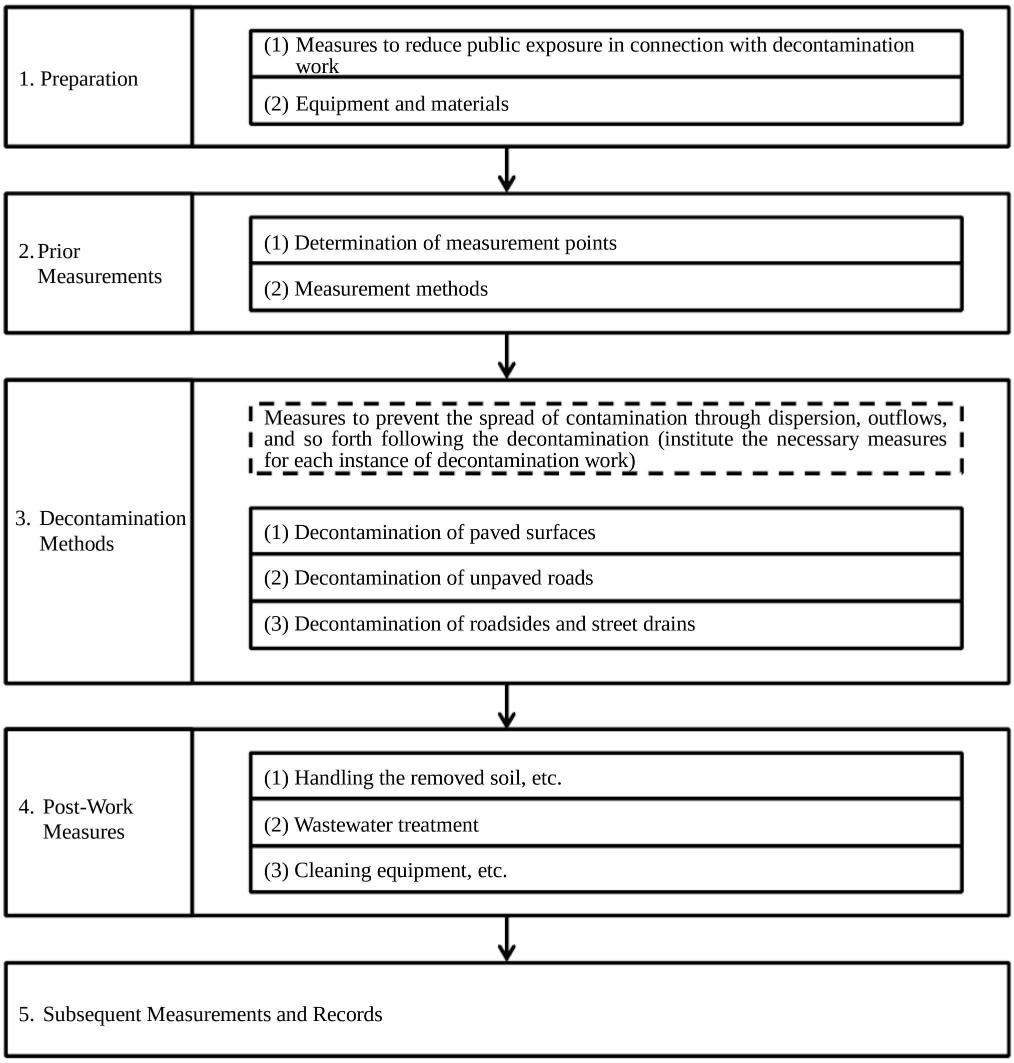
Table 2-23. Subsequent measurements and records for the decontamination of buildings and other structures

Measurement of air dose rate, etc.	• The air dose rate, etc. shall be measured at each measurement point. • Measurements shall be carried out in the same location as the prior measurements and under the same conditions to the extent possible. • For the measuring apparatus, the same apparatus as was used for the prior measurements shall be used to the extent possible.
Recordkeeping	• The air dose rate, etc. at each measurement point, places where decontamination work was performed, decontamination date, names of the decontaminators, type of objects decontaminated, decontamination methods, total decontamination area (of soil, etc.), the approximate weight of the removed soil, etc., and the status of storage and disposal. • The equipment used in decontamination and the method of disposal after use. • See “Part 4: Guidelines Pertaining to the Storage of Removed Soil” for details on the items to record with regard to the storage of removed soil.

III. Decontamination and Other Measures for Roads

This section explains 1. Preparation, 2. Prior Measurements, 3. Decontamination Methods, 4. Post-Work Measures, and 5. Subsequent Measurements and Records, in chronological order, pertaining to measures for decontamination of the paved surfaces of roads (including sidewalks), street drains, curbs, guardrails, and pedestrian overpasses.

Figure 2-33. Basic flow for the decontamination and other measures for roads



When it comes to roads, a distinction is made between roads immediately adjacent to urban or residential areas and roads built through farmland, pastureland, and other non-residential areas, and decontamination is implemented taking account of the level of impact on pedestrians and people using vehicles as modes of transport.

Furthermore, the gravel and dirt on sidewalks and curbs are prioritized in road decontamination, as are roadsides due to the higher radiation dose levels compared with road centers.

1. Preparation

Before performing decontamination work, in addition to preparing the equipment required for the decontamination work, preparations must be made to ensure safety through means including prevention of exposure of the general public and workers such as by inhaling dust generated during decontamination work. Among these preparations, please refer to the Ministry of Health, Labour and Welfare's Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and its Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6 dated June 15, 2012) for the measures required to ensure the safety of workers.

(1) Measures to Reduce Public Exposure in Connection with Decontamination Work

Table 2-24. Measures to reduce public exposure in connection with decontamination and other work for roads

Restriction of entry	• In cases where the general public is deemed likely to enter the area, the area shall be cordoned off with pylons or rope, etc. to prevent people from unnecessarily approaching the work site, and the entry of people and vehicles shall be restricted. • In cases where radioactive materials may be dispersed in connection with the decontamination work, the perimeter of the decontamination area shall be fenced in with sheets, etc., water shall be sprayed, or other such measures shall be taken to prevent dispersion and the area shall be cordoned off with rope, etc.
Signage	• In cases where the general public is deemed likely to enter the area, signs, etc. shall be put up to alert the public that decontamination work is being performed (see Figure 2-4).

(2) Equipment and Materials

The required equipment and materials shall be arranged for decontamination and other measures, as well as for collection of the removed soil, etc., in accordance with the objects to be decontaminated and the work environment.

Table 2-25. Examples of equipment and materials for the decontamination of roads

General examples	Mower, hand shovel, grass sickle, broom, bamboo rake, dustpan, tongs, shovel, small shovel, metal rake, compact heavy machinery for scraping away topsoil, garbage bags (bags for burnable matter, burlap sacks for soil and sand (sandbags)), vehicles for transporting collected removed soil, etc. to the on-site storage location (truck, two-wheeled cart, wheelbarrow, etc.), aerial vehicle, ladder, road sweeper

Examples for cleaning with water	Hose for water discharge, high pressure water cleaner, drainage pavement functional recovery car, brushes (scrub brush, brush for cleaning vehicles, etc.), tools for pushing away water (broom, scraper, etc.), bucket, detergent, dustcloth, sponge, paper towels
Examples for scraping off	Shot blaster, surface cutter, vibration drill, needlegun, grinding machine, equipment for scraping away, ultra high pressure water cleaner, equipment needed to prevent dispersion (dust collector, curing material)
Examples for removal of topsoil	Backhoe, bulldozer, hydraulic shovel
Examples of equipment for covering the soil surface	Self-propelled surface compaction roller, plywood for surface compaction, sprinkling equipment

2. Prior Measurements

To confirm the decontaminating effects of the decontamination work, the air dose rate prior to the commencement of decontamination work and after the completion of decontamination work*2 and the surface contamination density of the objects subject to decontamination (hereinafter, "air dose rate, etc.," which includes both the air dose rate and the surface contamination density) shall be measured. Specifically, places representative of living spaces, places contaminated at a comparatively high concentration that is deemed to contribute substantially to the radiation dose in the living space, etc. shall have their air dose rate, etc. measured in the same locations and by the same method both before contamination work starts and after it finishes, and the results shall be recorded. This section gives information on methods for measuring the air dose rate, etc. prior to the commencement of decontamination work.

Note that the air dose rate, etc. may also be measured near the surface of the objects subject to decontamination as needed when ascertaining the degree of reduction in the level of contamination of the objects subject to decontamination during the decontamination work. These measurements will be separately explained in "Section 3. Decontamination Methods."

(1) Determination of Measurement Points

Prior to decontamination work, the measurement points at which the air dose rate, etc. will be measured shall be decided and a schematic diagram illustrating the range of the measuring object, the measurement points, structures to be used as markers, etc. shall be created (see Figure 2-34).

There are two types of measurement points: those used to ascertain the average air dose rate on roads subject to decontamination (No. 1 measurement points) and those used to confirm the level of contamination of the objects that are to be decontaminated (No. 2 measurement points).

No. 1 measurement points are set primarily in a living space where residents, etc. spend large amounts of time. In setting these measurement points, so-called “hotspots” that contribute comparatively insubstantially to the radiation dose in the living space, and points near them, are not eligible to be measurements points unless the users, etc. are deemed likely to spend relatively large amounts of time there.

Examples of hotspots include depressed areas and puddles, street drains, water catchment wells, under or near trees, or in places where raindrops falling from buildings land, as radioactive materials tend to become concentrated in such places due to rainwater and the like..

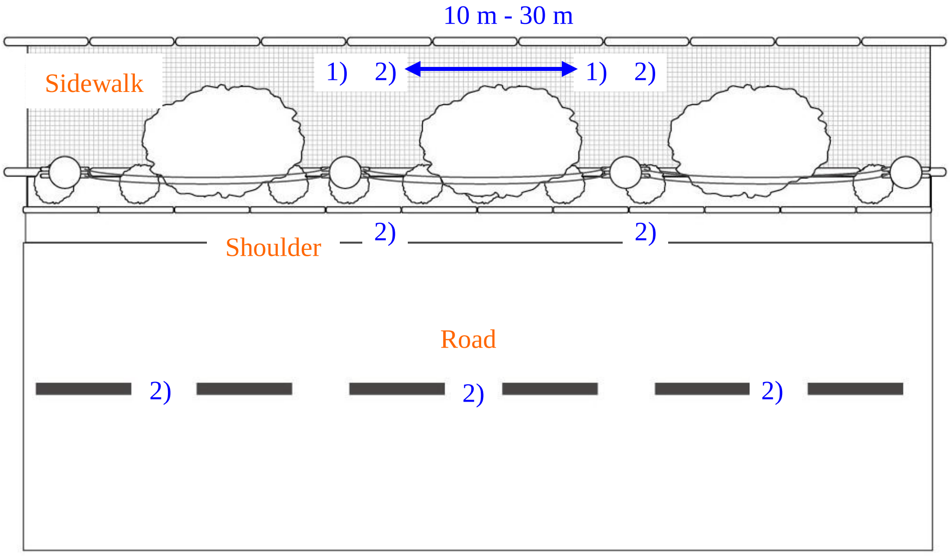
The purpose of No. 2 measurement points is fundamentally to measure the level of contamination at the surface of the objects subject to decontamination, and they are therefore set by considering places, etc. contaminated at comparatively high concentrations and that are deemed to contribute substantially to the radiation dose in the living space. When measuring street drains and other hotspots that are subject to decontamination, these are to be measured as No. 2 measurement points.

The specific methods are as provided in Table 2-26.

Table 2-26. Reasoning behind the measurement points for air dose rates and other measures for the decontamination of roads

Measurement points	No. 1 measurement point	No. 2 measurement points
Objects subject to measurement	Air dose rate in living spaces	Surface contamination density, etc. for objects subject to decontamination
Reasoning behind the measurement points	• Measurement points shall be set at intervals that allow the air dose rate distribution to be ascertained near the centerline of sidewalks. • If there are no sidewalks, appropriate points shall be determined by confirming the usage status of the road. (Example) Pitch of approx. 10 – 30 m	• Measurement points shall be set at intervals that allow the air dose rate, etc. distribution to be ascertained for each road surface, road shoulder, street drain, and sidewalk. (Example) Pitch of approx. 10 – 30 m

Figure 2-34. Example of a schematic diagram for reporting measurement points for use in decontamination and other measures for roads



1): Contamination status for living spaces
2): Contamination status for objects subject to decontamination
(surface contamination density, surface dose rate)

(2) Measurement Methods

When measuring the air dose rate at a No. 1 measurement point, a scintillation survey meter or other measuring apparatus able to measure gamma rays shall be used. With respect to the measurement locations, measurements shall be performed at one location roughly every 10 – 30 m in locations where people spend a lot of time, such as in the vicinity over the median line down sidewalks. In cases where there are sidewalks on both sides and decontamination and other measures are slated to be carried out on both sides, then measurement shall be carried out on both sidewalks as well. Moreover, when it comes to demarcating the measured sections, for those sections that are slated to be targeted for decontamination and other measures, demarcations are to be established by using markers such as units of areas, municipal blocks, city road numbers, or the like (for privately-owned land, use the grounds of said privately-owned land) as guideposts. The need to conduct decontamination and the contents of this shall be determined for each of these sections based on the mean values for multiple measured values within the sections. Please pay due consideration to the fact that in some cases road measurements are prone to being affected by things like the surrounding facilities on account of their unique characteristics.

In contrast, to avoid the effects of background radiation when measuring the level of contamination on or near surfaces at a No. 2 measurement point, it is recommended to use a GM survey meter able to measure beta rays, but it is also acceptable to perform the measurements using a dosimeter capable of measuring gamma rays. For example, one way to make specialized confirmation based on the levels of contamination at the relevant sites is to perform the measurements under conditions where a collimator is used to shield against gamma rays from the outside. In addition, for instance, it is possible to confirm the effect of the decontamination by determining the contamination status of the objects subject to decontamination from the air dose rate measured at the surface of the measurement points and at heights of 50 cm and 1 m, and then comparing the results with those of measurements taken in the same positions after the completion of the decontamination work.

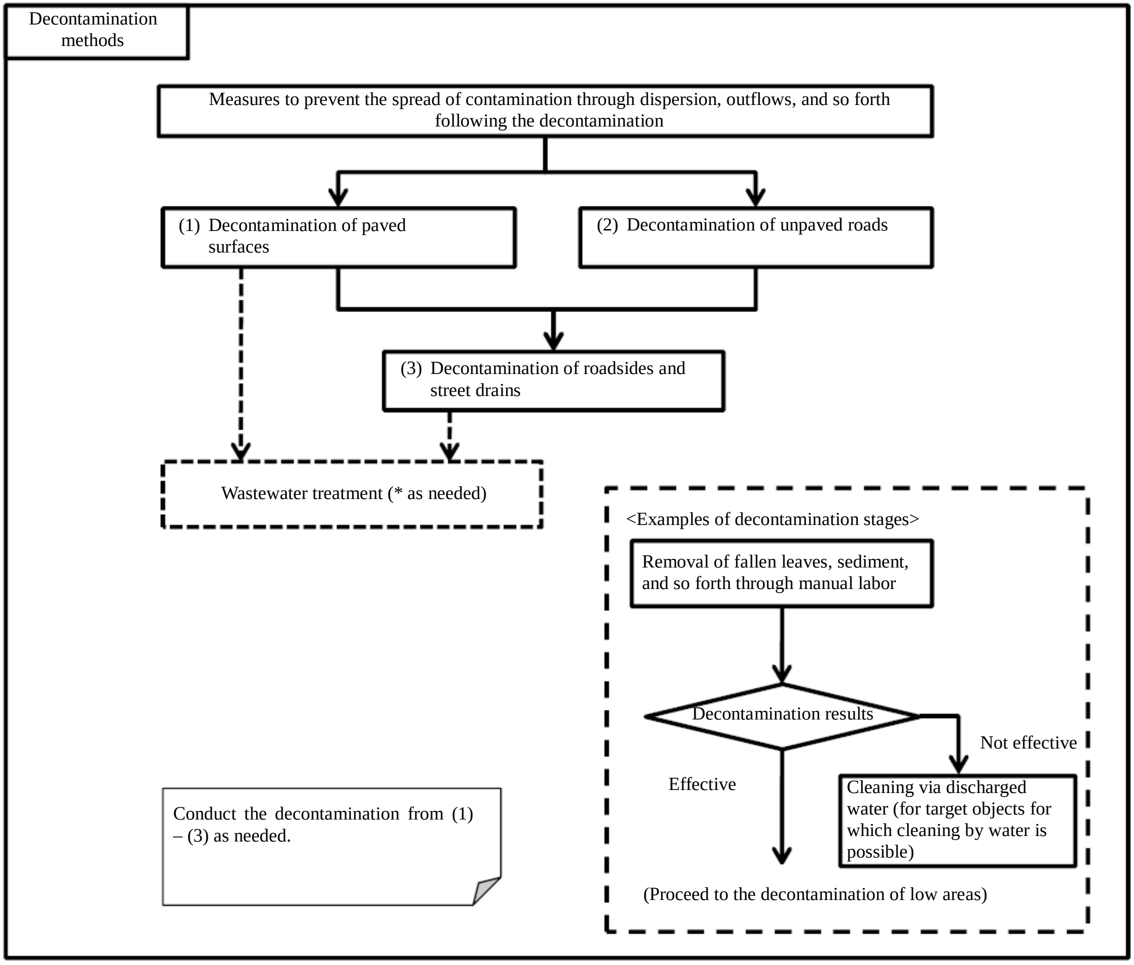
In general, the same measuring apparatus shall be used when measuring at the same measurement points before and after decontamination work.

When there are a large number of measurement points, the results of measurements, etc. previously taken by local authorities, along with other monitoring technologies (monitoring cars, etc.), shall be utilized as needed.

For the specific methods, see “6. Measuring Apparatuses and Methods of Use” in “Part 1: Guidelines for Methods for Investigating and Measuring the Status of Environmental Pollution in Intensive Contamination Survey Areas.”

3. Decontamination Methods

Figure 2-35. Basic flow for the decontamination of roads



To decontaminate roads efficiently requires the decontamination work to be focused on places that are contaminated with comparatively high concentrations of radioactive materials that contribute substantially to the radiation dose. For example, the radiation dose from roadsides, street drains, and curbs can be reduced by removing radiocaesium-containing mud, grass, fallen leaves, and other sediments, because these sediments frequently collect in such places.

In terms of decontamination stages, first the sediments that are relatively easy to remove by hand, etc. shall be removed, and if this results in no observable decontamination effect, high pressure water cleaning (example: 15 MPa), covering the soil surface, or scraping off shall be performed.

In each stage, the air dose rates at the No. 1 measurement points shall be measured, and as a general rule no additional decontamination work shall be performed provided the air dose rate at a height of 1 m (a height of 50 cm from the ground may be used for school routes, etc. used primarily by students of elementary schools and below, as well as those of special-needs schools, with consideration for the living space of infants and schoolchildren in the lower grades) is less than 0.23 microsieverts per hour.

When water is used in decontamination work on roads or for similar work, radioactive materials may be moved to the roadside or street drains. Therefore, when using water, it is more efficient to first remove the sediments from the roadside and street drains, then clean the road, and finally clean the roadside and street drains. Depending on how the sediments are settled, decontamination work of the road surface shall employ cleaning with a brush, drainage pavement functional recovery cars, high pressure water cleaning, or other methods.

Moreover, when performing decontamination work, the necessary measures to secure the safety of the workers and the general public must be taken, and measures to prevent the spread of contamination due to dispersion, outflow, etc. associated with decontamination work must be implemented so as to minimize contamination being brought out from within the work zone, contamination being brought in from outside, or recontamination of the decontaminated zones. Among these preparations, please refer to the Ministry of Health, Labour and Welfare’s Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and its Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6 dated June 15, 2012) for the measures required to ensure the safety of workers.

When cleaning using water, it is important to ensure that no puddles are formed and no water is splattered onto surrounding uncontaminated walls, etc., as well as to check the drainage channel after cleaning. Furthermore, cleaning using water produces drainage that contains radioactive materials. In such case, to avoid impact of the drainage on the outflow destinations due to cleaning, etc. as much as possible, any radioactive materials that can be removed by methods other than cleaning with water shall be removed in advance whenever possible among other workarounds. Furthermore, one approach to preventing the dispersion of radioactive materials is to perform damming and similar operations using sandbags and then remove the particulate matter from the wastewater as needed. Using drainage pavement functional recovery cars, water recovery-type high pressure water cleaning, and so on are also effective for preventing the dispersion of radioactive materials.

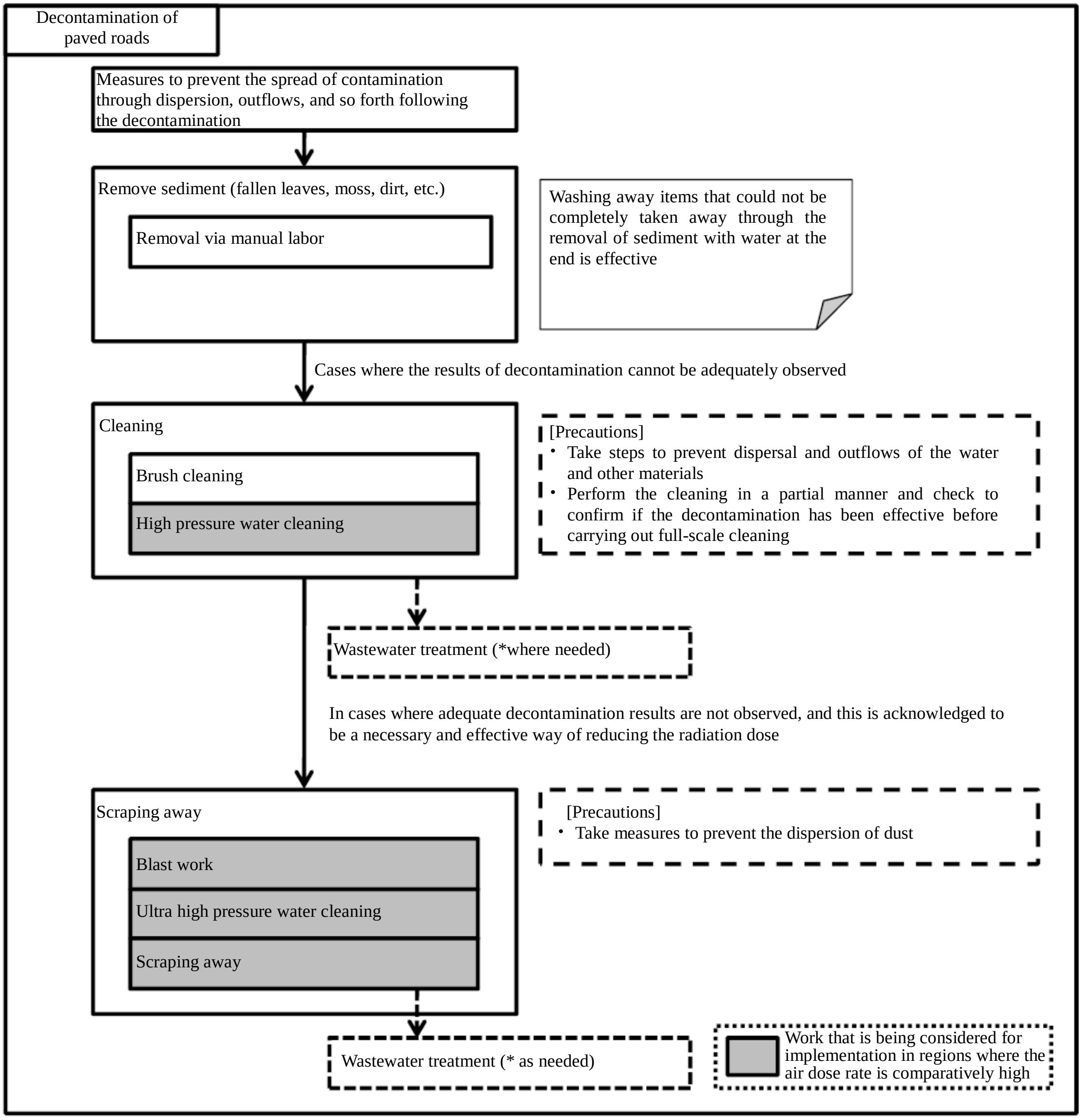
For example, when there is a concern that the drainage will flow into irrigation canals for agricultural use, it is recommended to involve agriculture-related persons in the area prior to the work and confirm that there is no impact by sampling at the irrigation canals or similar methods. Also please arrange the overall schedule so as to avoid a large zone undertaking decontamination within a municipality at the same time whenever possible, in the interest of minimizing the impact of decontamination outside the zone.

See “4. Post-Work Measures” with regard to matters like the handling of the removed soil, the treatment of wastewater, and the cleaning of the equipment used for the decontamination.

This section covers decontamination methods for roadsides and street drains, which are thought to be places that are contaminated at comparatively high concentrations, as well as paved surfaces and unpaved roads.

(1) Decontamination of Paved Surfaces

Figure 2-36. Basic flow for the decontamination of paved surfaces



After the prior removal of debris, etc. by hand or the like (fallen leaves, moss, grass, mud, dirt, etc.) from road and interlocking concrete surfaces, the asphalt joints and cracks shall be cleaned by brush. Curbs, guardrails, pedestrian overpasses, etc. shall be cleaned using brushes, etc. and neutral detergents or high pressure water cleaning (example: 15 MPa). High pressure water cleaning is particularly effective for decontamination of joints and cracked portions. There is a possibility that the radioactive materials will have decreased as a result of rain and ordinary cleaning, so first carry out cleaning in a partial manner and check to confirm that decontamination from brush cleaning and high pressure water cleaning is effective before performing overall cleaning.

After the cleaning work, the air dose rate, etc. shall be measured at the measurement points to confirm that there has been no spread of the contamination to the outflow destination for the drainage and that the decontamination has been effective.

In cases where the radiocaesium proves difficult to remove even with high pressure water cleaning, shot-blasting work or ultra-high pressure water cleaning can be used to scrape away the surfaces of roads or other paved surfaces and thereby remove radiocaesium in the joints of paved surfaces and in depressed areas that could not be removed by cleaning or similar work, and this is expected to reduce the radiation dose. However, this incurs greater costs than other decontamination methods, the work is extensive, and large amounts of asphalt and concrete will be generated as a constituent of the removed soil, etc. It is therefore recommended that consideration be given to the scraping away of paved surfaces only when the road is adjacent to an urban or residential area and the radiation dose cannot be sufficiently reduced using other decontamination methods. Whenever such work is performed, measures must be taken to inhibit the dispersion of dust.

Moreover, when scraping away the material on interlocking concrete blocks, the reduction rate may decrease as a result of scrapings and radioactive materials remaining behind in the gaps between the blocks. As such, using such methods as water recovery-type high pressure water cleaning or ultra-high pressure water cleaning is also effective for this. It is also effective to perform water recovery-type high pressure water cleaning on drainage pavement, rubber chip pavement, and similar types of paving (water permeable pavement, slab pavement, etc.).

The measures that are required in advance, specific decontamination methods, and notes of caution for the decontamination of paved roads are as provided in Tables 2-27 and 2-28.

Figure 2-37. Example of decontamination of paved surfaces (water recovery-type high pressure water cleaning)

Table 2-27. Necessary measures prior to the decontamination of paved surfaces

Category	Decontamination methods and notes of caution
Safety management	• If traffic cannot be stopped when the decontamination work is carried out, then adequate safety management shall be undertaken through measures like allocating traffic controllers or the like.
Prevention of dispersion	• When carrying out decontamination work that uses water, measures shall be taken to prevent the dispersion of the cleaning water.
Ensuring drainage channels and wastewater treatment	• Sediment on roads, on roadsides, and in street drains shall be removed before cleaning with water. • When using water to clean, the channel for cleaning water to flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage. • See “4. (2) Wastewater Treatment” regarding the treatment of wastewater.

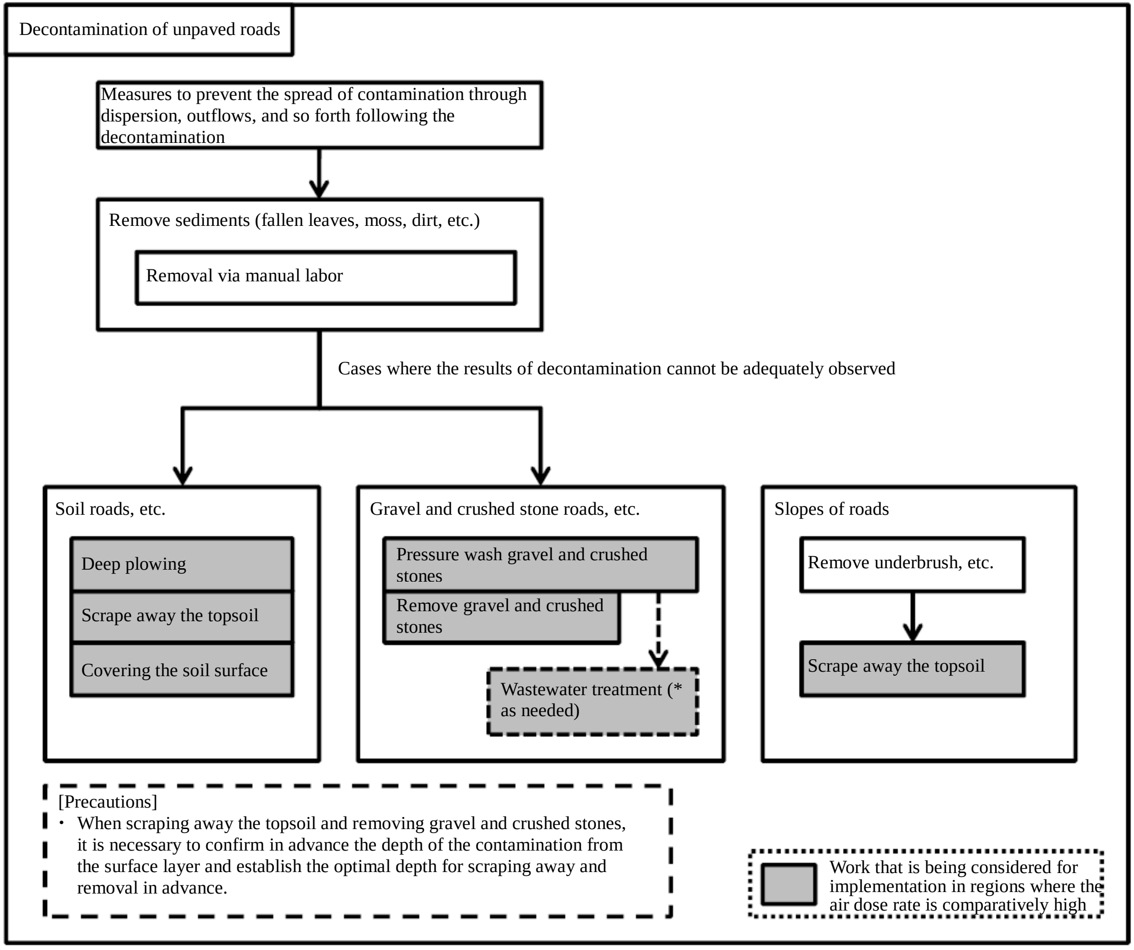
Table 2-28. Decontamination methods for paved surfaces and notes of caution

Category		Decontamination methods and notes of caution
Removal of sediments	Removal through manual labor	• Fallen leaves, moss, mud, and other sediments shall be removed by hand by people wearing rubber gloves, shovel, or road sweeper, etc.
Cleaning	Brush cleaning	• Cleaning shall be performed from high places to low ones so as to avoid dispersing water to the surroundings. • With drainage pavement functional recovery cars, attention must be paid to the fact that in some cases their cleaning and drainage recovery

		functions may decline on surfaces where distortion or wear has occurred due to the effects of earthquakes, etc.
	High pressure water cleaning	• To prevent dispersion of soil, etc. by water pressure, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • Water recovery-type high pressure water cleaning is also effective. • To achieve a decontamination effect, the spray nozzle shall be brought near the place to be decontaminated. • When decontamination is carried out over a wide range, attention must be paid to ensure that no variance occurs between the work methods at different points (height of the nozzle over the ground, work time per unit of surface area, etc.)
Scraping away	Blast work	• Abrasive materials shall be shot at the surface with a shot blaster and scraped away from said surface uniformly. • In order to prevent dust from arising, curing, etc. shall be performed to prevent dispersion of dust to the surroundings and the dust shall be collected. • For blast work, curing shall be performed to ensure that abrasive materials and the like do not travel outside of the decontamination work zone. What is more, after the abrasive materials and other materials have been used they shall be collected in a manner that ensures that they will not scatter the radioactive materials adhering to them to the surroundings. • When scraping away material on interlocking concrete blocks, attention must be paid to the fact that scrapings and radioactive materials may be left behind in the gaps between the blocks.
	Ultra-high pressure water cleaning	• Ultra-high pressure water cleaner (cleaning water recovery-type) of 150 MPa or higher shall be used for scraping material away on paved surfaces. • A powerful vacuum truck shall be used to collect any scrapings that arise.
	Scraping away	• A surface cutter or the like shall be used to scrape away the paved surface. • Dispersion to the surroundings shall be prevented when scraping away contamination. (Example: use of dust collectors, sprinkling in advance, setting up simple plastic housings, etc.)

(2) Decontamination of Unpaved Roads

Figure 2-38. Basic flow for the decontamination of unpaved roads



For unpaved roads surfaces, slopes, etc., first the debris, fallen leaves, moss, grass, mud, dirt, etc. shall be removed from the surface of the road, etc. by hand.

If this does not produce a decontamination effect, replacing the topsoil with subsoil (deep plowing), scraping away the topsoil, or covering the soil surface using heavy machinery, etc. can be expected to reduce the radiation dose, because the radiocaesium is settled near the surface. However, deep plowing, covering the soil surface, and scraping away the topsoil incurs greater costs than other decontamination methods and involves extensive work. It is therefore recommended that consideration be given to such methods only when the road is adjacent to an urban or residential area and the radiation dose cannot be sufficiently reduced using other decontamination methods.

- Soil roads, etc.

Deep plowing is the method of covering the soil surface by replacing the radiocaesium-containing upper layer of the soil with a lower layer of the soil that does not contain radiocaesium. Carrying out deep plowing can be expected to reduce the radiation dose and to inhibit the diffusion of radiocaesium by shielding with soil, etc. Moreover, these have the advantage of not generating removed soil, because they do not scrape away the topsoil. When performing deep plowing, approximately 10 cm of surface soil shall be placed at the lower layer and covered with approximately 20 cm of excavated soil from the lower layer. When performing this procedure, it is necessary to avoid scattering the surface soil or mixing it with the soil excavated from the lower layer. When implementing this over a large area, the implementation area shall be partitioned in an appropriate manner (see Figure 2-19).

When scraping away topsoil, it is important to select an appropriate thickness for the soil to be scraped away, in order to avoid generating too much removed soil, etc. Specifically, for the soil surfaces to be scraped away, it is recommended to start with small areas (an area of a size that enables the air dose rate, etc. of the soil surface to be measured with minimal interference from radiation outside the area) and scrape away about 1 to 2 cm of topsoil while measuring the air dose rate, etc., then determine the thickness of the layer to be scraped away (see Figure 2-52 2), 3), and 4)). According to conventional wisdom it is believed that adequate results can be achieved by scraping away at most about 5 cm of the soil surface. If the thickness of soil to be removed is thin, another effective method is to use a solidification agent that enables the thickness of the soil to be restricted to a level that is relatively easy to scrape away, depending on the type of topsoil: sandy soil, silt, clay, etc. In places where the topsoil has been removed, topsoil shall be brought from another location by using uncontaminated soil as needed.

For covering the soil surface, the approach is to cover the top layer of soil that contains radiocaesium with soil that does not contain radiocaesium. This can be expected to reduce the radiation dose and to inhibit the diffusion of radiocaesium by shielding it with soil. This has the advantage of not generating removed soil since the topsoil is not being removed. When performing this covering, it is important to select an appropriate covering thickness for purposes of shielding in order to avoid having the covering thickness become excessively large.

The geometric area of unpaved roads adjacent to urban or residential areas is expected to be relatively small, meaning that in some cases it will be more efficient to scrape away the soil than to cover the soil surface. Therefore, when employing either method, the optimal method shall be selected in consideration of the costs and the amount of removed soil, etc. expected to be generated by the two methods.

When the topsoil has been removed, soil from elsewhere shall be placed on the portions where the topsoil has been removed, and it shall be compacted to restore it to the condition it was in before the work. Care shall be taken to avoid landslides, etc. on the sides when adding on other soil and compacting it.

■ Gravel and crushed stone roads, etc.

For gravel or crushed stones, etc., place the gravel or crushed stones in a water tank and remove the radioactive materials from them by agitating and high pressure water cleaning, then lay them out again after they have been cleaned. See “II. 4. (2) Wastewater Treatment” regarding the handling of wastewater when performing high pressure water cleaning, etc.

For cases where results are not considered to have been adequately observed even after cleaning has been carried out, then the gravel and crushed stones shall be removed evenly with the use of a backhoe or other instrument. When gravel or crushed stones are removed, the area shall be covered by using the same type of gravel or crushed stones as before as needed, and it shall be covered to the same standing height as before and to about the same compactness as before.

On roads where gravel and crushed stones have been laid out there is the possibility that radioactive materials have been accumulated in the soil below the gravel and crushed stones as time passes. As such, there may be cases where it will be necessary to make a determination on whether decontamination should be carried out on the gravel and crushed stones or the soil below them. In doing so, it will be necessary to decide on a decontamination method by properly performing measurements and conducting experiments.

■ Slopes of roads

For the decontamination of the slopes of roads, decisions on carrying out the decontamination shall be made in view of factors like the contamination status, as well as the safety and usage status of the slope following the decontamination. During topsoil removal in particular, consideration must be given to the properties of the slope (incline, soil and rock quality) and the presence of any vegetation. If the slope has been sodded to protect it and after first removing plants or decontaminating the protective structural elements there is no decontamination effect, topsoil removal shall then be performed. Specific methods include collecting the soil by hand using small shovels, etc., using backhoes or other heavy machinery, and collecting the soil using an air suction pipe or other dedicated device. When implementing topsoil removal, the soil shall be removed from the top, proceeding downward. For topsoil removal on slopes, the area of topsoil removable in a single batch shall be removed and collected each time, but since the soil is deemed likely to slide down due to the removal work, the work shall only be performed after taking the necessary measures to prevent the outflow of soil. Since dust will be generated during the removal of topsoil, dispersion must be prevented by sprinkling with water.

The measures that are required in advance, specific decontamination methods, and notes of caution for the decontamination of unpaved roads are as provided in Tables 2-29 and 2-30.

Figure 2-39: Example of the decontamination of an unpaved road (scraping away)

Photo courtesy of: Date City

Table 2-29. Necessary measures prior to the decontamination of unpaved roads

Category	Decontamination methods and notes of caution
Prevention of dispersion	• When scraping away the topsoil when it comes to dried soil, efforts can be made to prevent the dispersion of dust by scattering solidification agents over the area in advance to solidify the soil surface.

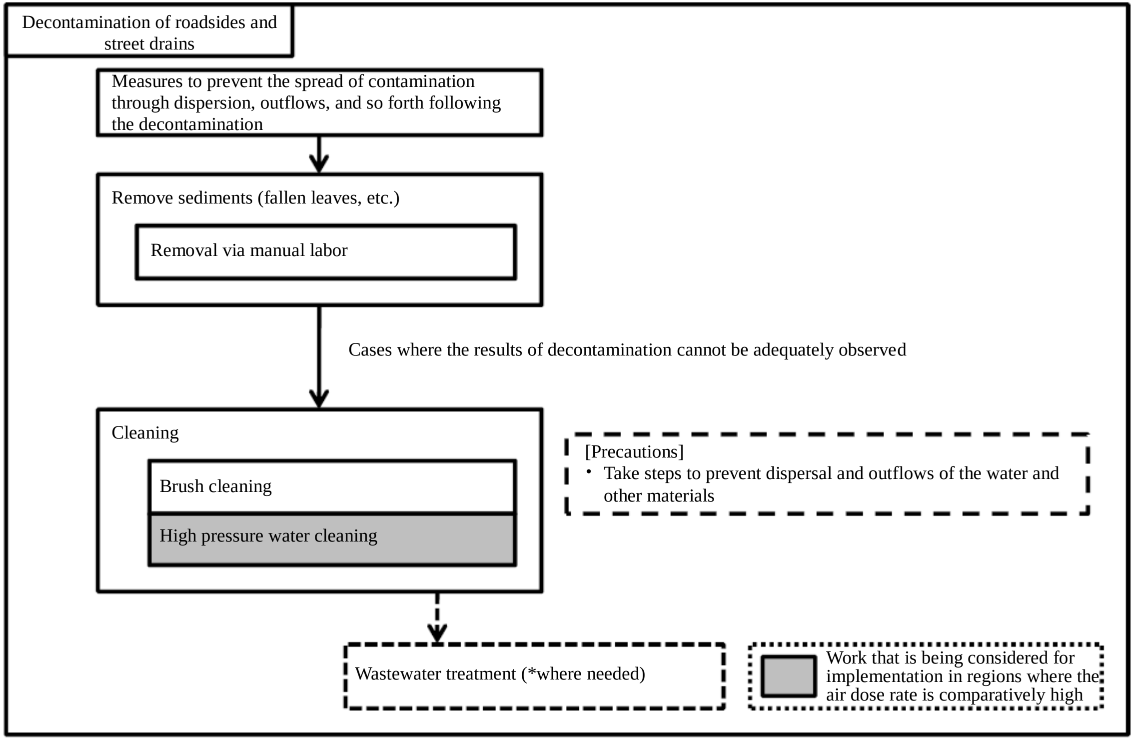
Table 2-30. Decontamination methods for unpaved roads and notes of caution

Category		Decontamination methods and notes of caution
Removal of sediments	Removal through manual labor	• Soil with fallen leaves, moss, mud, and other sediments shall be removed by hand by people wearing rubber gloves and by shovel, etc.
Soil roads, etc.	Deep plowing	• About 10 cm of topsoil shall be uniformly scraped away and temporarily piled on top of a plastic sheet or the like. • About 20 cm of subsoil shall be uniformly scraped away and piled on top of a separate location from the topsoil. • After the topsoil has been uniformly spread out, the subsoil shall be uniformly spread on top of it and the land will be leveled. It shall be restored to its original height at a compactness that is about the same as it was before.
	Scraping away topsoil	• A backhoe or the like shall be used to uniformly scrape away the surface. • Dispersion to the surroundings shall be prevented when scraping away contamination. (Example: use of dust collectors, sprinkling in advance, setting up simple plastic housings, etc.)
	Covering the surface soil	• The surface soil shall be covered with soil that does not contain radiocaesium.
Gravel and crushed stone roads, etc.	High pressure water cleaning of gravel and crushed stones	• A backhoe or the like shall be used to place the gravel or crushed stones into a water tank and then high pressure water cleaning will be performed. • To prevent dispersion of soil, etc. by water pressure when performing high pressure water cleaning, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • See “4. (2) Wastewater Treatment” regarding the treatment of wastewater.
	Removal of gravel and crushed stones	• The gravel or crushed stones shall be uniformly removed with a backhoe or the like. • When gravel or crushed stones are removed, the area shall be covered by using the same type of gravel or crushed stones as before, and it shall be covered to the same standing height as before and to about the same compactness as before. • Attention shall be paid to the fact that because of the large air gaps when covering with crushed stones, density adjustments shall be performed via the appropriate surface compaction.
Slopes of roads	Removal of underbrush	• Weed removal and weeding shall be conducted using a shoulder-type mower or human power.
	Removal of topsoil	• Human power, a backhoe, or the like shall be used to uniformly scrape away the surface. • Dispersion to the surroundings shall be prevented when scraping away contamination.

		(Example: use of dust collectors, sprinkling in advance, setting up simple plastic housings, etc.)

(3) Decontamination of Roadsides and Street Drains

Figure 2-40. Basic flow for the decontamination of roadsides and street drains



For places where rainwater readily collects, the roots of plants, places where moss is growing, etc., any fallen leaves, mud, dirt, etc. on the roadside shall be collected, grass and other plants shall be trimmed, and sediment shall be removed, after which cleaning shall be conducted with scrub brushes, scrubbing brushes, etc. using water (see Figure 2-41 and Figure 2-42).

In general, the decontamination of street drains shall be carried out in accordance with “II. 3. (6) Decontamination of Street Drains, etc.” In the case of street drains that are covered with thick concrete lids and closed conduits that do not have an impact on the air dose rate, it is not necessary to remove sediments. But in the case of street drains covered with lids that could conceivably have an impact on the air dose rate as a result of outflows or the like, consideration shall be given to performing decontamination through high pressure water cleaning or the like after measures such as damming up the way downstream have been carried out to prevent outflows and dispersion of sediments due to water discharge.

After the cleaning work, the air dose rate, etc. shall be measured at the measurement points to confirm that there has been no spread of the contamination to the outflow destination for the drainage and that the decontamination has been effective.

The measures that are required in advance, specific decontamination methods, and notes of caution for the decontamination of roadsides and street drains are as provided in Tables 2-31 and 2-32.

Figure 2-41: Example of decontamination of street drains (sweeping up dirt and dust)

Photo courtesy of: Date City

Figure 2-42: Example of the decontamination of street drains (removal of sediments)

Photo courtesy of: Fukushima City

Table 2-31. Necessary measures prior to the decontamination of roadsides and street drains

Category	Decontamination methods and notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent dispersion of water, etc.
Ensuring drainage channels and wastewater treatment	• When using water to clean, the channel for cleaning water to flow shall be checked beforehand and the drainage channel cleaned in advance to enable smooth drainage. • See "4. (2) Wastewater Treatment" regarding the treatment of wastewater.

Table 2-32. Decontamination methods for roadsides and street drains and notes of caution

Category		Decontamination methods and notes of caution
Removal of sediments	Removal through manual labor	• Fallen leaves, moss, mud, and other sediments that are easy to remove shall be removed in advance by shovel, etc. • When the concrete joints of street drains are deep, a spatula or the like shall be used to remove the sediments from the joints.
Cleaning	Brush cleaning	• Cleaning shall be thoroughly performed by using scrub brushes or scrubbing brushes. • Cleaning shall be performed from high places to low ones so as to avoid dispersing water to the surroundings.
	High pressure water cleaning	• To prevent dispersion of soil, etc. by water pressure, cleaning shall be performed at low pressure initially and the pressure shall be raised gradually while checking the flow of cleaning water and the dispersion conditions. • To achieve a decontamination effect, the spray nozzle shall be brought near the place to be decontaminated.

4. Post-Work Measures

Post-work measures, which include handling the removed soil and treating the wastewater generated by the decontamination work, as well as cleaning of equipment and materials, are listed below.

(1) Handling the Removed Soil, etc.

The removed soil, etc. shall be appropriately handled and transferred to on-site storage or a temporary storage site.

Please refer to "II. 4. (1) Handling the Removed Soil, etc." for specific methods for handling the removed soil.

(2) Wastewater Treatment

When carrying out decontamination that uses water, the appropriate countermeasures against wastewater shall be taken to prevent the secondary contamination of the environment.

See “II. 4. (2) Wastewater Treatment” for specific methods for treating wastewater.

(3) Cleaning of Equipment and Materials

With regard to the post-work handling of the equipment used for decontamination, the Ministry of Health, Labour and Welfare’s Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and its Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6 dated June 15, 2012) are to be followed.

See “II. 4. (3) Cleaning of Equipment and Materials” for specific methods for cleaning the equipment and materials.

5. Subsequent Measurements and Records

To confirm the decontamination effect, the air dose rate, etc. after completion of the decontamination work shall be measured and compared with the air dose rate, etc. that was measured prior to the commencement of the decontamination work. Measurement of the air dose rate, etc. shall be performed in accordance with the measurement methods given in “Part 1: Guidelines for Methods for Investigating and Measuring the Status of Environmental Pollution in Intensive Contamination Survey Areas for each measurement point indicated in Table 2-26 of “2. (1) Determination of Measurement Points.”

In addition to the air dose rate, etc. at each measurement point, any other information pertaining to the decontamination work shall be recorded and stored.

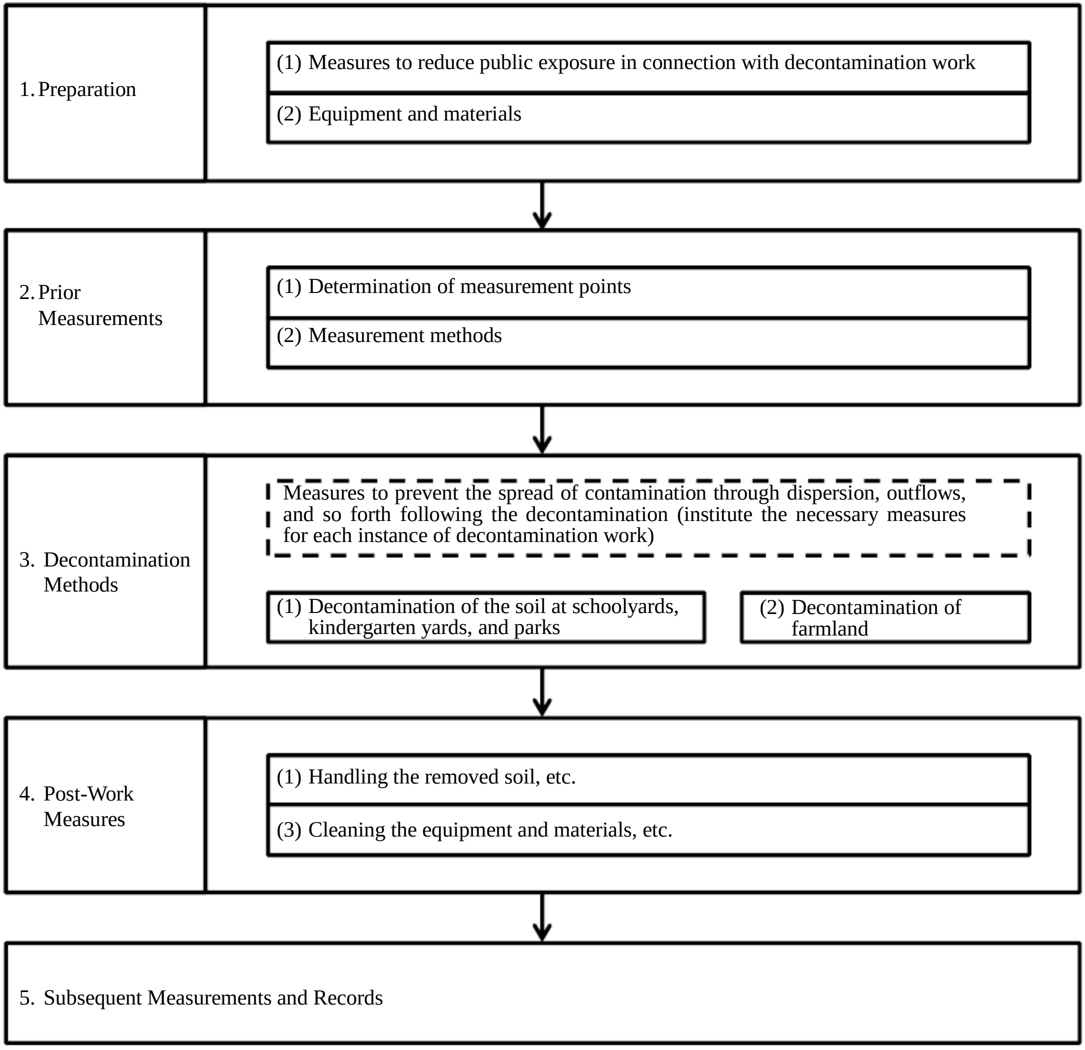
Table 2-33. Subsequent measurements and records for the decontamination of roads

Measurement of air dose rate, etc.	• The air dose rate, etc. shall be measured at each measurement point. • Measurements shall be carried out in the same location as the prior measurements and under the same conditions to the extent possible. • For the measuring apparatus, the same apparatus as was used for the prior measurements shall be used to the extent possible.
Recordkeeping	• The air dose rate, etc. at each measurement point, places where decontamination work was performed, decontamination date, names of the decontaminators, type of objects decontaminated, decontamination methods, total decontamination area (of soil, etc.), the approximate weight of the removed soil, etc., and the status of storage and disposal. • The equipment used in decontamination and the method of disposal after use. • See “Part 4: Guidelines Pertaining to the Storage of Removed Soil” for details on the items to record with regard to the storage of removed soil.

IV. Decontamination and Other Measures for Soil

This section explains 1. Preparation, 2. Prior Measurements, 3. Decontamination Methods, 4. Post-Work Measures, and 5. Subsequent Measurements and Records, in chronological order, pertaining to decontamination and other measures for soil in schoolyards, kindergarten yards, parks, farmland, and other comparatively large land spaces.

Figure 2-43. Basic flow for decontamination and other measures for soil



1. Preparation

Before performing decontamination work, in addition to preparing the equipment required for the decontamination work, preparations must be made to ensure safety through means including prevention of exposure of the general public and workers such as by inhaling dust generated during decontamination work. Among these preparations, please refer to the Ministry of Health, Labour and Welfare’s Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and its Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6 dated June 15, 2012) for the measures required to ensure the safety of workers.

(1) Measures to Reduce Public Exposure in Connection with Decontamination Work

Table 2-34. Measures to reduce public exposure in connection with decontamination and other measures for soil

Restriction of entry	• In cases where the general public is deemed likely to enter the area, the area shall be cordoned off with pylons or rope, etc. to prevent people from unnecessarily approaching the work site, and the entry of people and vehicles shall be restricted. • In cases where radioactive materials may be dispersed in connection with the decontamination work, the perimeter of the decontamination area shall be fenced in with sheets, etc., water shall be sprayed, or other such measures shall be taken to prevent dispersion and the area shall be cordoned off with rope, etc.
Signage	• In cases where the general public is deemed likely to enter the area, signs, etc. shall be put up to alert the public that decontamination work is being performed (see Figure 2-4).

(2) Equipment and Materials

The required equipment and materials shall be arranged for decontamination and other measures, as well as for collection of the removed soil, etc., in accordance with the objects to be decontaminated and the work environment.

Table 2-35. Examples of decontamination equipment and materials for soil

<table>
<tr><td colspan="2">General equipment examples</td><td>Mower, hand shovel, grass sickle, broom, bamboo rake, dustpan, tongs, shovel, small shovel, metal rake, compact heavy machinery for scraping away topsoil, garbage bags (bags for burnable matter, burlap sacks for soil and sand (sandbags), large sandbags, flexible containers), vehicles for transporting collected removed soil, etc. to the on-site storage location or temporary storage site (truck, two-wheeled cart, etc.), aerial vehicle, ladder</td></tr>
<tr><td colspan="2">Examples of equipment for cleaning with water</td><td>Hose for water discharge</td></tr>
<tr><td colspan="2">Examples of equipment for removal of topsoil</td><td>Bulldozer, hydraulic shovel</td></tr>
<tr><td colspan="2">Examples of equipment for covering soil surfaces</td><td>Self-propelled surface compaction roller, plywood for surface compaction, sprinkling equipment</td></tr>
<tr><td rowspan="3">Decontamination equipment for use on farmland</td><td>Examples of equipment for scraping away topsoil</td><td>Equipment required for scraping away topsoil, inversion tillage, and deep tillage (bulldozer, hydraulic shovel, tractor, vertical harrow and other attachments, rear blade, front loader), backhoe, grader, crane, vacuum car, mower, high pressure water cleaner, chipping machine, hammer knife mower, flexible containers</td></tr>
<tr><td>Examples of equipment for mixing with water</td><td>Tractor, vertical harrow and other attachments, drainage pump, backhoe, crane, mower, water shielding sheets, flexible containers</td></tr>
<tr><td>Examples of equipment for inversion tillage and deep tillage</td><td>Tractor, deep-tillage plow, deep-tillage rotary, mower</td></tr>
</table>

2. Prior Measurements

To confirm the decontaminating effects of the decontamination work, the air dose rate prior to the commencement of decontamination work and after the completion of decontamination work[*2] and the surface contamination density of the objects subject to decontamination (hereinafter, “air dose rate, etc.,” which includes both the air dose rate and the surface contamination density) shall be measured. Specifically, places representative of living spaces, places contaminated at a comparatively high concentration that is deemed to contribute substantially to the radiation dose in the living space, etc. shall have their air dose rate, etc. measured in the same locations and by the same method both before contamination work starts and after it finishes, and the results shall be recorded. This section gives information on methods for measuring the air dose rate, etc. prior to the commencement of decontamination work.

Note that the air dose rate, etc. may also be measured near the surface of the objects subject to decontamination as needed when ascertaining the degree of reduction in the level of contamination of the objects subject to decontamination during the decontamination work. These measurements will be separately explained in “Section 3. Decontamination Methods.”

Moreover, for farmland it is necessary to check the concentration of radiocaesium in the soil in the interest of inhibiting the absorption of radioactive materials, in addition to reducing the exposure dose for surrounding residents.[*5] This shall involve checking the concentration of radiocaesium in the plow layer[*6] of the soil, taking account of the depth of the roots of any crops that could absorb radiocaesium.

(1) Determination of Measurement Points

Prior to decontamination work, the measurement points at which the air dose rate, etc. will be measured shall be decided and a schematic diagram illustrating the range of the measuring object, the measurement points, structures to be used as markers, etc. shall be created (see Figure 2-44, Figure 2-45, and Figure 2-46).

There are two types of measurement points: those used to ascertain the average air dose rate in the space for soil, etc. subject to decontamination (No. 1 measurement points) and those used to confirm the level of contamination of the objects that are to be decontaminated (No. 2 measurement points).

No. 1 measurement points are set primarily in a living space where residents, etc. spend large amounts of time. In setting these measurement points, so-called “hotspots” that contribute comparatively insubstantially to the radiation dose in the living space, and points near them, are not eligible to be measurements points unless the residents, etc. are deemed likely to spend relatively large amounts of time there.

Examples of hotspots include depressed areas and puddles, street drains, under rainwater guttering, rainwater chambers, under or near trees, or in places where raindrops falling from buildings land, as radioactive materials tend to become concentrated in such places due to rainwater and the like.

The purpose of No. 2 measurement points is fundamentally to measure the level of contamination at the surface of the objects subject to decontamination, and they are therefore set by considering places, etc. contaminated at comparatively high concentrations and that are deemed to contribute substantially to the radiation dose in the living space.

Furthermore, the measurement points shall be set with a density that particularly takes work efficiency into account when measuring farmland and other spaces that have uniform conditions.

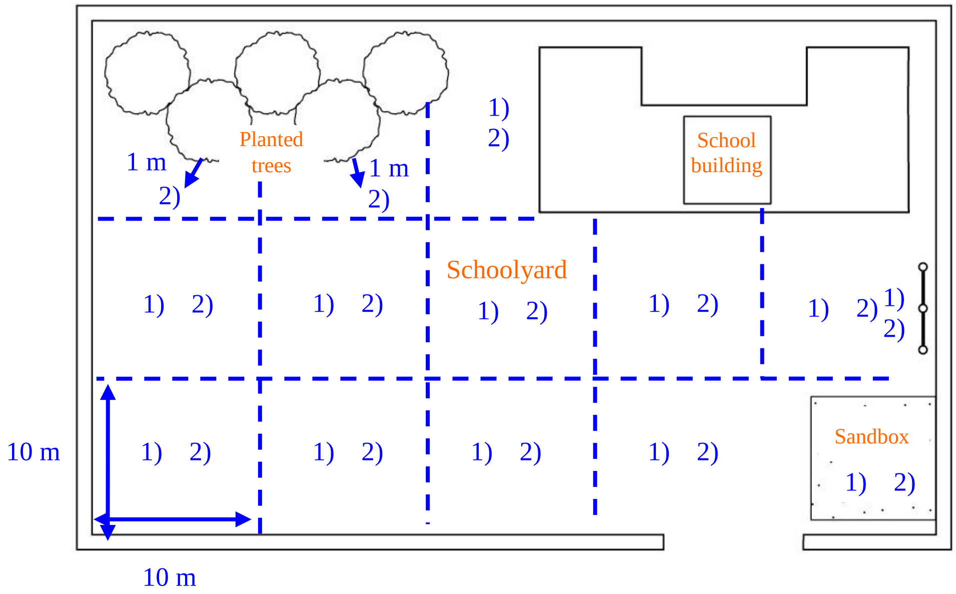
The specific methods are as provided in Table 2-36.

Table 2-36. Reasoning behind the measurement points for air dose rates and other measures for the decontamination of soil

Measurement point	No. 1 measurement points	No. 2 measurement points
Measurement target	Air dose rate in living spaces	Surface contamination density, etc. for objects subject to decontamination
Reasoning behind the measurement points	• Measurement points shall be set at intervals that allow the air dose rate distribution to be ascertained. ○ Schools (school buildings, schoolyards) • For schoolyards, the schoolyards shall be divided up into meshes of about 10 – 30 m and measurements shall be conducted at one spot in each mesh (in cases where there will presumably be little variance in the air dose rate, measurements may also be taken in approximately five locations that have been uniformly dispersed). The need to conduct decontamination and the contents of this shall be determined based on the mean values from this. • For school buildings, measurements shall be carried out in approximately five measurement points at places where people are deemed likely to spend relatively large amounts of time in the vicinity around school buildings. The need to conduct decontamination and the contents of this shall be determined based on the mean values from this. For the school building as a whole, measurements can be carried out at multiple points in places where people are deemed likely to spend relatively large amounts of time (roughly the total from the several measurement points in the schoolyard and school building mentioned above), and the need to conduct decontamination and the contents of this can be determined based on the mean values	• Same as with No. 1 measurement points.

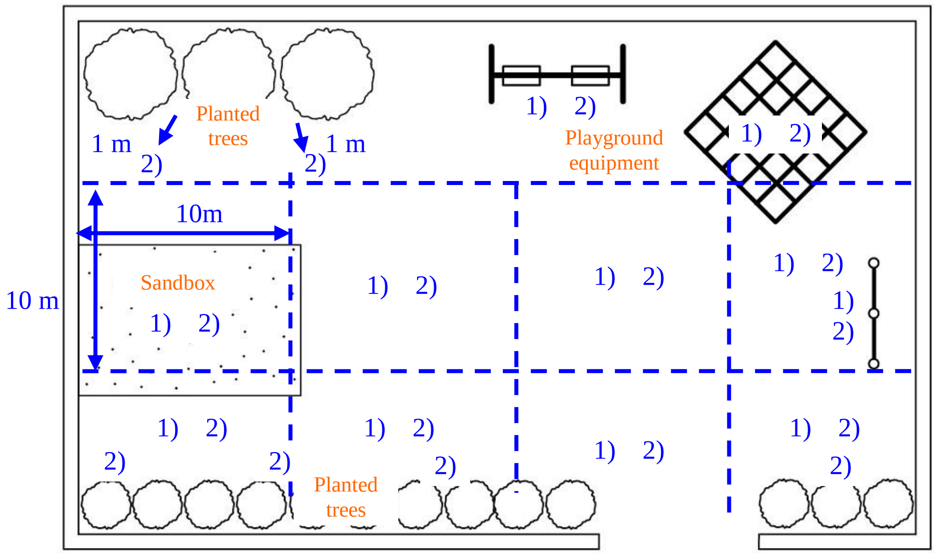
	from this. ○ Farmland and pastureland • Farmland and pastureland shall be divided up into meshes of about 10 – 30 m and measurements shall be conducted at one spot in each mesh. However, changes can be made to this in cases where said land has a vast surface area according to the conditions. The need to conduct decontamination and the contents of this shall be determined based on the mean values from this.	

Figure 2-44: Example of a schematic diagram for reporting measurement points for use in decontamination and other measures for soil (schoolyards)



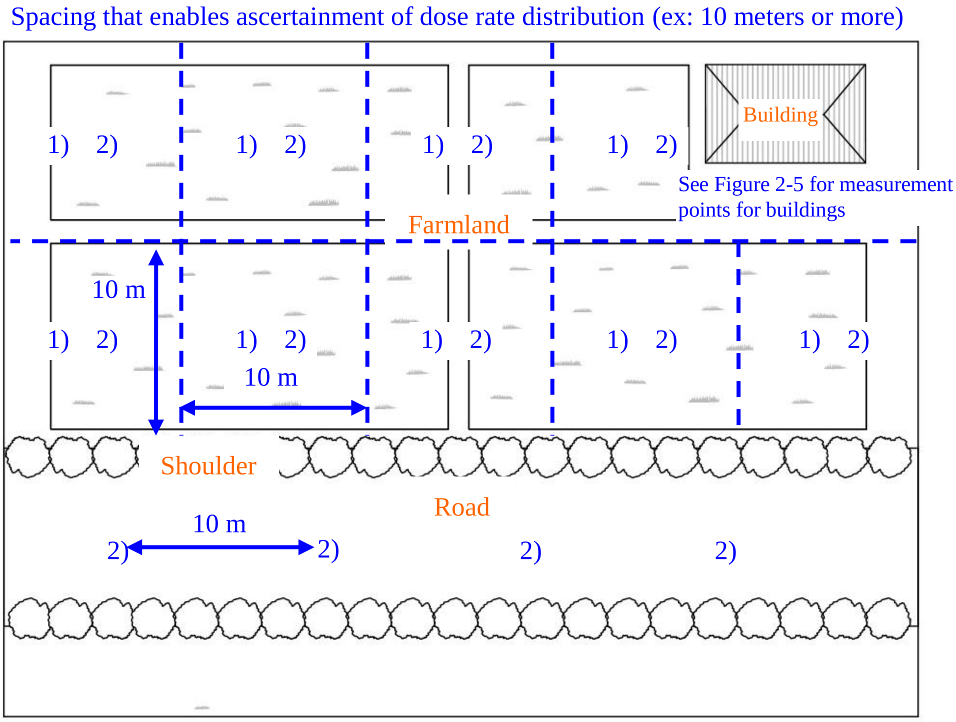
1): Contamination status for living spaces
2): Contamination status for objects subject to decontamination
(surface contamination density, surface dose rate)

Figure 2-45: Example of a schematic diagram for reporting measurement points for use in decontamination and other measures for soil (parks)



1): Contamination status for living spaces
2): Contamination status for objects subject to decontamination
(surface contamination density, surface dose rate)

Figure 2-46: Example of a schematic diagram for reporting measurement points for use in decontamination and other measures for soil (farmland)



1): Contamination status for living spaces
2): Contamination status for objects subject to decontamination
(surface contamination density, surface dose rate)

(2) Measurement Methods

When measuring the air dose rate at a No. 1 measurement point, a scintillation survey meter or other measuring apparatus able to measure gamma rays shall be used.

In contrast, to avoid the effects of background radiation when measuring the level of contamination on or near surfaces at a No. 2 measurement point, it is recommended to use a GM survey meter able to measure beta rays, but it is also acceptable to perform the measurements using a dosimeter capable of measuring gamma rays. For example, one way to make specialized confirmation based on the levels of contamination at the relevant sites is to perform the measurements under conditions where a collimator is used to shield against gamma rays from the outside. In addition, for instance, it is possible to confirm the effect of the decontamination by determining the contamination status of the objects subject to decontamination from the air dose rate measured at the surface of the measurement points and at heights of 50 cm and 1 m, and then comparing the results with those of measurements taken in the same positions after the completion of the decontamination work.

In general, the same measuring apparatus shall be used when measuring at the same measurement points before and after decontamination work.

When measuring the radiocaesium concentration in soil on farmland and similar areas, the measurements must be performed within a detector that is shielded to prevent influence from background gamma rays; generally germanium semiconductor detectors calibrated using standard radiation sources with known amounts of radioactivity are used for this purpose. However, measurement using germanium semiconductor detectors requires a fixed time period until analysis results are available, as well as sophisticated measurement technology. It is permissible to estimate the radiocaesium concentration from the air dose rate, for which measurement results can be obtained relatively easily on site, by establishing the correlation between the air dose rate and the radiocaesium concentration in advance. As such, a simplified method for calculating the radiocaesium concentrations in farmland soil may be used (see Figure 2-47)

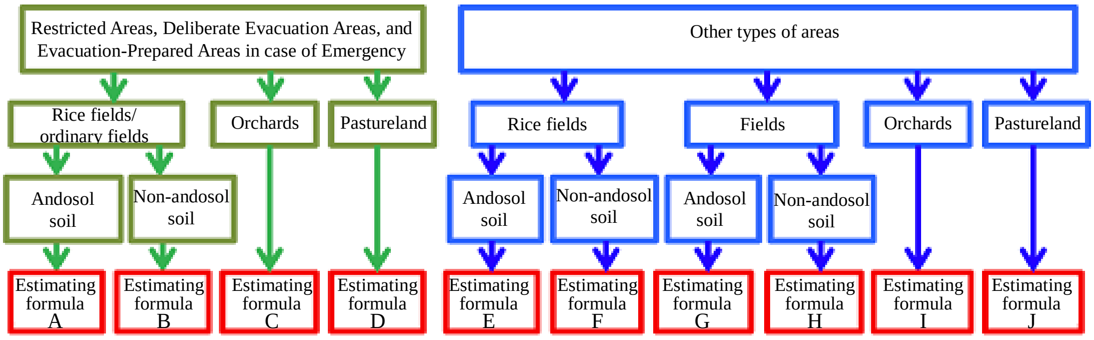
The specific calculation method for the radiocaesium concentration in soil shall be as shown in Table 2-37. For other specific methods, see “6. Measuring Apparatuses and Methods of Use” in “Part 1: Guidelines on the Methods for Investigation and Measurement of the Status of Environmental Pollution in Intensive Contamination Survey Areas.”

■ Simplified Method for Calculating the Radiocaesium Concentrations in Farmland Soil

The radiocaesium concentration (Bq/kg) of farmland soil can be simply calculated from the air dose rate (μSv/h) at a height of 1 m above the ground’s surface and the type of soil via the following formulas.

This method is prone to errors, so please take measurements with a germanium semiconductor detector or similar apparatus when taking accurate measurements.

Figure 2-47. Simplified method for calculating the radiocaesium concentrations in farmland soil



A Estimated figures = Air dose rate × 3210
B Estimated figures = Air dose rate × 2120
C Estimated figures = Air dose rate × 2790
D Estimated figures = Air dose rate × 1630

E Estimated figures = Air dose rate × 2760 -139
F Estimated figures = Air dose rate × 2390 -86
G Estimated figures = Air dose rate × 2280 -47
H Estimated figures = Air dose rate × 2270 -75
I Estimated figures = Air dose rate × 1360
J Estimated figures = Air dose rate × 800

- This is a method for estimating the average concentration in the soil from the surface down to a depth of 15 cm.
- The coefficients for the estimating formulas were current as of November 5, 2011, and will continue to change as time passes.

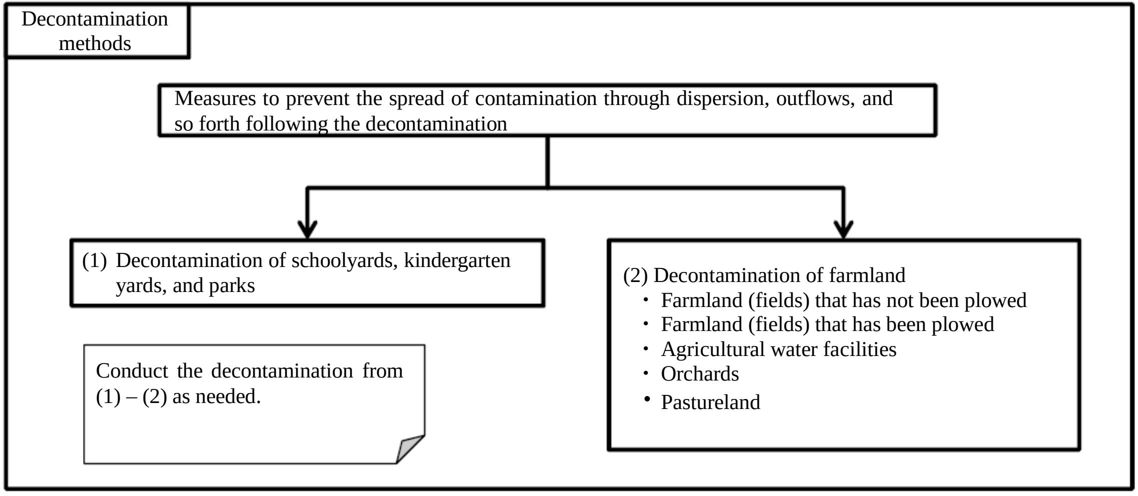
Provided by: Ministry of Agriculture, Forestry and Fisheries

Table 2-37. Measurement methods for the radiocaesium concentration in farmland soil

Measuring apparatus used	• Estimates from germanium semiconductor detectors, NaI scintillation spectrometers, $LaBr_3$ (Lanthanum bromide) scintillation spectrometers, and air dose rate
Calibration	• At least once a year, calibration shall be performed using standard radiation sources with known amounts of radioactivity.
Daily check	• The remaining battery level, breakage of cables and connectors, and status of high voltage application shall be checked, and inspections of switch operability, etc. shall be carried out. • Measurements shall be performed at the same places where the background radiation does not vary substantially, and it shall be confirmed that there are no large variations by comparing with past values.
Prevention of contamination	• The body and detecting element of the measuring apparatus shall be covered with thin plastic sheet, etc. • The plastic sheet, etc. shall be replaced with new material when it gets dirty or breaks.
Measurement	• For rice fields, soil shall be extracted from the surface of the measurement point down to 15 cm deep in the ground, and after the soil has been dried the radiocaesium concentration in the soil shall be measured using a germanium semiconductor detector. • For dry fields, soil shall be extracted from the surface of the measurement point down to the depth of the plow layer (15 to 30 cm), and after the soil has been dried the radiocaesium concentration in the soil shall be measured using a germanium semiconductor detector.
Records	• The measurer shall record the air dose rate, etc. and radiocaesium concentration at each measurement point shown in the conceptual diagram, etc., along with the date and time of measurement and the measuring apparatus used.

3. Decontamination Methods

Figure 2-48. Basic flow for the decontamination of soil



Efficient decontamination requires the decontamination work to be focused on places that are contaminated with comparatively high concentrations of radioactive materials that contribute substantially to the radiation dose.

If this does not yield an observable decontamination effect, the soil surface shall be covered or scraped away.

For soil other than that in farmland, in each stage the air dose rates at the No. 1 measurement points shall be measured, and as a general rule no additional decontamination work shall be performed provided the air dose rate at a height of 1 m (a height of 50 cm from the measurement point may be used for schoolyards, etc., with consideration for the living space of infants and schoolchildren in the lower grades) is less than 0.23 microsieverts per hour.

Moreover, when performing decontamination work, the necessary measures to secure the safety of the workers and the general public must be taken, and measures to prevent the spread of contamination due to dispersion, outflow, etc. associated with decontamination work must be implemented so as to minimize contamination being brought out from within the work zone, contamination being brought in from outside, or recontamination of the decontaminated zones. Among these preparations, please refer to the Ministry of Health, Labour and Welfare’s Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and its Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6 dated June 15, 2012) for the measures required to ensure the safety of workers.

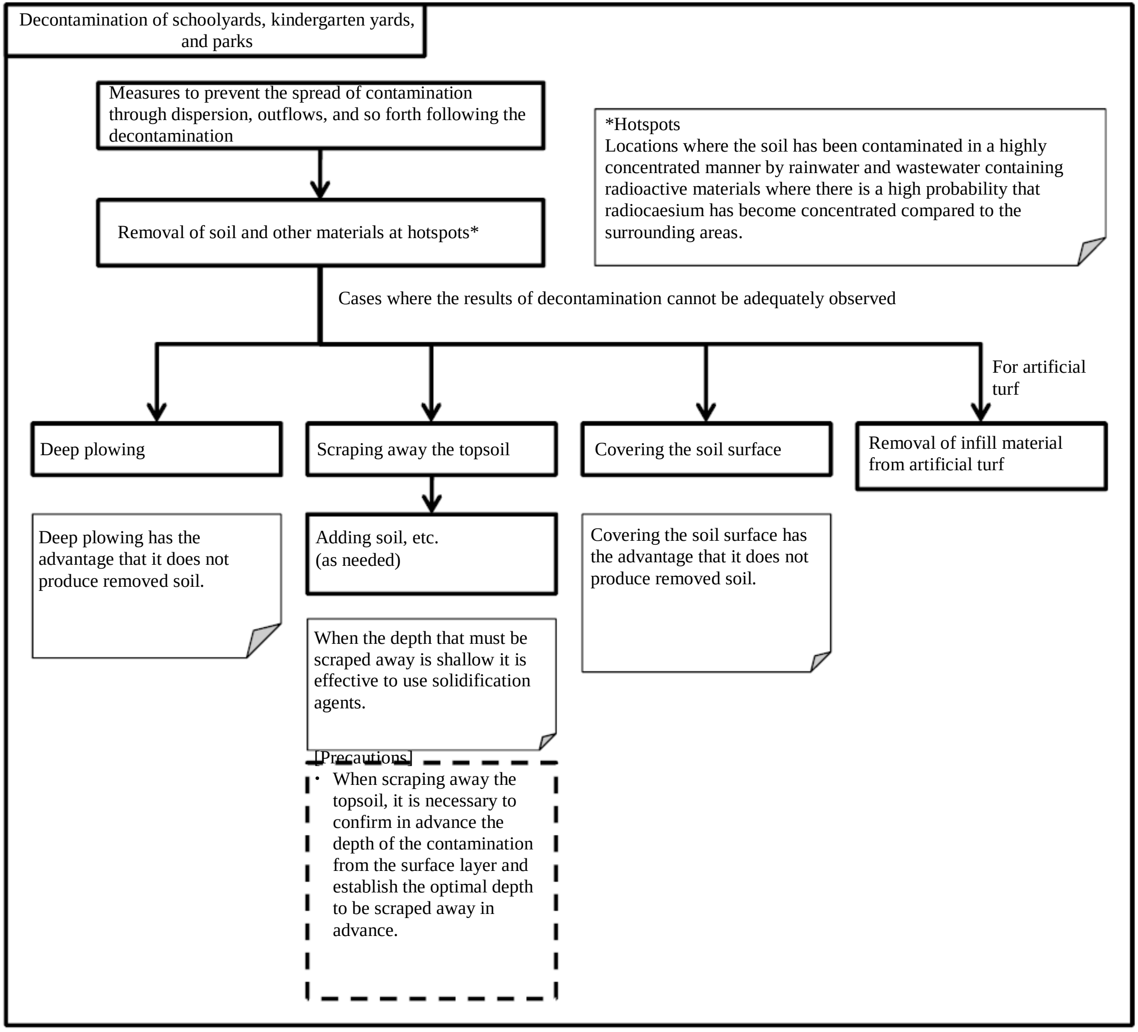
Also please arrange the overall schedule so as to avoid a large zone undertaking decontamination within a municipality at the same time whenever possible, in the interest of minimizing the impact of decontamination outside the zone.

See “4. Post-Work Measures” with regard to matters like the handling of the removed soil, the treatment of wastewater, and the cleaning of the equipment used for the decontamination.

This section covers methods of decontamination for soil in schoolyards, kindergarten yards, and parks, as well as farmland.

(1) Decontamination of Soil in Schoolyards, Kindergarten Yards, and Parks

Figure 2-49. Basic flow for the decontamination of schoolyards, kindergarten yards, and parks



*Hotspots
Locations where the soil has been contaminated in a highly concentrated manner by rainwater and wastewater containing radioactive materials where there is a high probability that radiocaesium has become concentrated compared to the surrounding areas.

Deep plowing has the advantage that it does not produce removed soil.

Covering the soil surface has the advantage that it does not produce removed soil.

When the depth that must be scraped away is shallow it is effective to use solidification agents.

[Precautions]

- When scraping away the topsoil, it is necessary to confirm in advance the depth of the contamination from the surface layer and establish the optimal depth to be scraped away in advance.

In schoolyards, kindergarten yards, and parks, radiocaesium is settled near the surface layer of the ground. Since the dose may be partially high near drains from rainwater guttering, and at the bases of trees, the soil at such places shall be removed by hand, etc. Please refer to “V. 3. (2) Decontamination of Trees in Living Spaces, such as Roadside Trees and the like.”

If no decontamination effect is observed as a result, the upper layer of the soil shall be replaced with a lower layer of the soil (deep plowing) using heavy machinery, etc. or the topsoil shall be scraped away (see Figure 2-19).

■ Deep plowing

Deep plowing is the method of covering the soil surface by replacing the radiocaesium-containing upper layer of the soil with a lower layer of the soil that does not contain radiocaesium. Carrying out deep plowing can be expected to reduce the radiation dose and to inhibit the diffusion of radiocaesium by shielding with soil, etc. Moreover, these have the advantage of not generating removed soil, because they do not scrape away the topsoil. When performing deep plowing, approximately 10 cm of surface soil shall be placed at the lower layer and covered with approximately 20 cm of excavated soil from the lower layer. When performing this procedure, it is necessary to avoid scattering the surface soil or mixing it with the soil excavated from the lower layer. When implementing this over a large area, the implementation area shall be partitioned in an appropriate manner (see Figure 2-19).

■ Scraping away topsoil

When scraping away topsoil, it is important to select an appropriate thickness for the soil to be scraped away, in order to avoid generating too much removed soil. Specifically, for the soil surfaces to be scraped away, it is recommended to start with small areas (an area of a size that enables the air dose rate, etc. of the soil surface to be measured with minimal interference from radiation outside the area) and scrape away about 1 to 2 cm of topsoil while measuring the air dose rate, etc., then determine the thickness of the layer to be scraped away (see Figure 2-52 2), 3), and 4)). According to conventional wisdom it is believed that adequate results can be achieved by scraping away at most about 5 cm of the soil surface. If the thickness of soil to be removed is thin, another effective method is to use a solidification agent that enables the thickness of the soil to be restricted to a level that is relatively easy to scrape away, depending on the type of topsoil: sandy soil, silt, clay, etc.

However, since children will be in direct contact with sandboxes in parks, and are likely to dig them up, and because park’s geometric areas are relatively small, a layer descending 10 to 20 cm below the surface shall be removed using small shovels, etc. If necessary, uncontaminated sand shall be used to cover the surface to restore it to how it was prior to the work. When scraping away the sand and dirt, water shall be sprinkled to prevent re-suspension of soil particles and the dispersion of dust.

In places where the topsoil, etc. has been removed, uncontaminated soil shall be added in from elsewhere.

■ Covering the soil surface

For covering the soil surface, the approach is to cover the top layer of soil that contains radiocaesium with soil that does not contain radiocaesium through the use of small heavy machinery. This can be expected to reduce the radiation dose via shielding and to inhibit the diffusion of radiocaesium by shielding it with soil. This has the advantage of not generating removed soil since the topsoil is not being removed. When performing this covering, it is important to select an appropriate covering thickness for purposes of shielding in order to avoid having the covering thickness become excessively large.

■ Removal of infill material from artificial turf

For tennis courts and other types of artificial turf, the infill materials (joint sand, etc.) for the artificial turf shall be removed.

For example, the infill material (joint sand, etc.) distributed throughout artificial turf shall be absorbed by running a tractor or other vehicle to which machinery capable of absorbing and removing the infill material has been affixed.

Furthermore, if the area to be decontaminated is large, the work shall be coordinated and the scheduling matched so that it is carried out all at the same time in order to ensure that there is no recontamination following the decontamination work.

The measures that are required in advance, specific decontamination methods, and notes of caution for the decontamination of schoolyards, kindergarten yards, and parks are as provided in Tables 2-38 and 2-39.

Figure 2-50. Example of the decontamination of a schoolyard (scraping away of topsoil)

Photo courtesy of: JAEA

Figure 2-51. Example of the removal of infill material from artificial turf

Photo courtesy of: JAEA

Figure 2-52: Procedure for determining the thickness of soil to be scraped away (1/2)

1) Measure the air dose rate at the surface of the place to be decontaminated

Photo courtesy of: Date City

2) Strip away a thin layer of topsoil

Photo courtesy of: Date City

Figure 2-52: Procedure for determining the thickness of soil to be scraped away (2/2)

3) Measure the air dose rate at the surface of the place where the topsoil was stripped away (using a collimator to reduce the effects of radiation from the surroundings)

Photo courtesy of: Date City

4) Measure the air dose rate at the surface at several points in the test area

Photo courtesy of: Date City

Table 2-38. Necessary measures prior to the decontamination of schoolyards, kindergarten yards, and parks

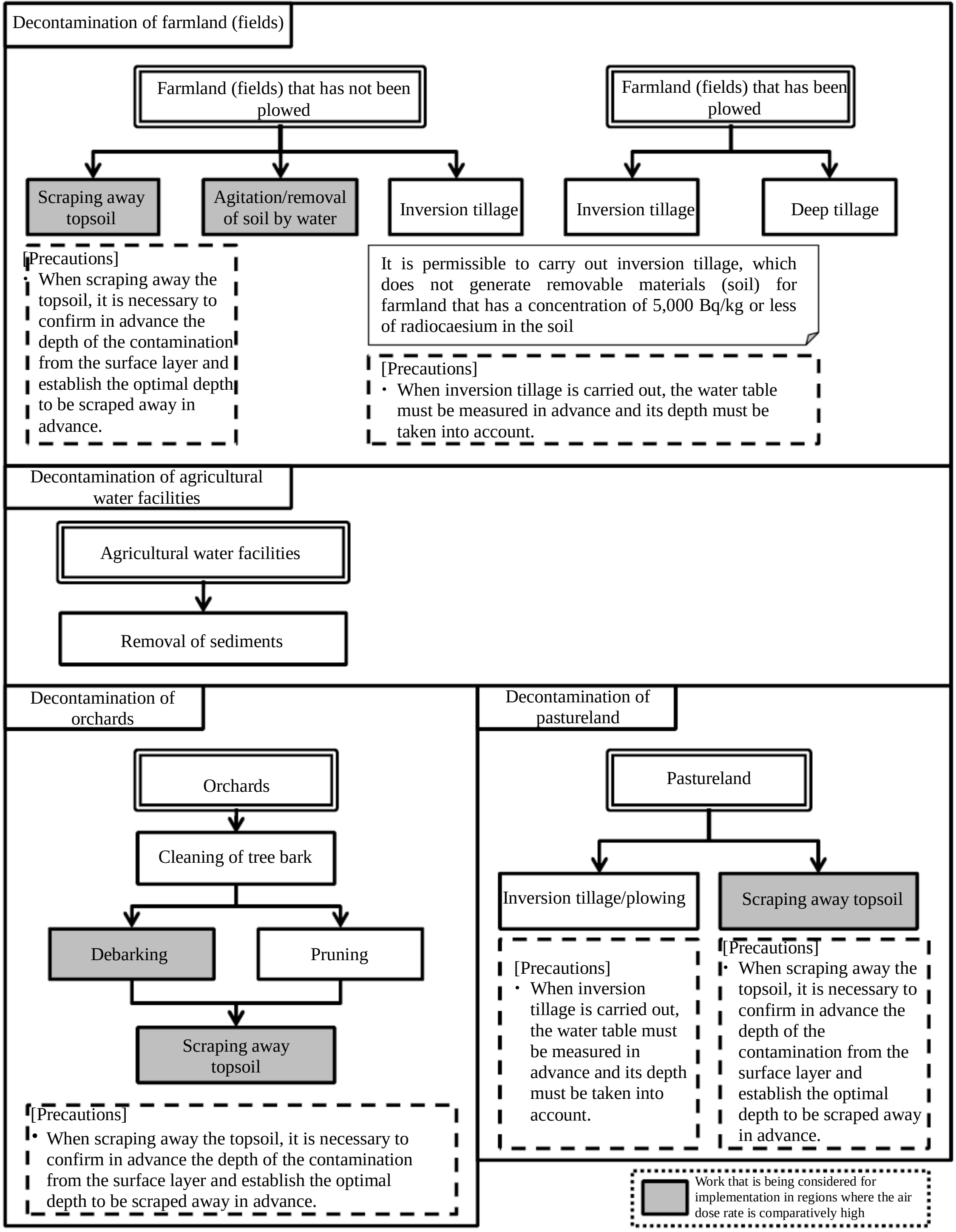
Category	Decontamination methods and notes of caution
Prevention of dispersion	• When scraping away the topsoil when it comes to dried soil, efforts can be made to prevent the dispersion of dust by scattering solidification agents over the area in advance to solidify the soil surface.

Table 2-39. Decontamination methods for schoolyards, kindergarten yards, and parks and notes of caution

Category	Decontamination methods and notes of caution
Removal of sediments	• Fallen leaves, moss, mud, and other sediments shall be removed by hand by people wearing rubber gloves and by shovel, etc.
Deep plowing	• About 10 cm of topsoil shall be uniformly scraped away and temporarily piled on top of a plastic sheet or the like. • About 20 cm of subsoil shall be uniformly scraped away and piled on top of a separate location from the topsoil. • After the topsoil has been uniformly spread out, the subsoil shall be uniformly spread on top of it and the land will be leveled. It shall be restored to its original height at a compactness that is about the same as it was before.
Scraping away topsoil	• A backhoe or the like shall be used to uniformly scrape away the surface. • The remaining topsoil can be confirmed by means of sprinkling lime around in advance. • Scraping away by using a surface cutter or hammer knife mower is an effective method for covering vast areas. • Dispersion to the surroundings shall be prevented when scraping away contamination. (Example: use of dust collectors, sprinkling in advance, setting up simple plastic housings, etc.)
Covering the surface soil	• The surface soil shall be covered with soil that does not contain radiocaesium. • Attention shall be paid to the fact that because of the large air gaps when covering with crushed stones, density adjustments shall be performed via the appropriate surface compaction.
Removal of infill material from artificial turf	• The infill material found in artificial turf and the like shall be taken out via machinery that can absorb and remove said infill material.

(2) Decontamination of Farmland

Figure 2-53. Basic flow for the decontamination of farmland



[Precautions]

- When scraping away the topsoil, it is necessary to confirm in advance the depth of the contamination from the surface layer and establish the optimal depth to be scraped away in advance.

It is permissible to carry out inversion tillage, which does not generate removable materials (soil) for farmland that has a concentration of 5,000 Bq/kg or less of radiocaesium in the soil

[Precautions]

- When inversion tillage is carried out, the water table must be measured in advance and its depth must be taken into account.

[Precautions]

- When scraping away the topsoil, it is necessary to confirm in advance the depth of the contamination from the surface layer and establish the optimal depth to be scraped away in advance.

[Precautions]

- When inversion tillage is carried out, the water table must be measured in advance and its depth must be taken into account.

[Precautions]

- When scraping away the topsoil, it is necessary to confirm in advance the depth of the contamination from the surface layer and establish the optimal depth to be scraped away in advance.

▨ Work that is being considered for implementation in regions where the air dose rate is comparatively high

Farmland soil has unique characteristics in that it has been cultivated through years of farming activities by farmers and has diverse aspects that include preservation of the ecosystem. Accordingly, when decontaminating farmland, it is important to restore the conditions that enable agricultural activities to be resumed and safe crops to be provided once again by reducing the concentration of radioactive materials in the soil, in addition to reducing the radiation dose reaching surrounding residents. To achieve this in the process of farmland decontamination, since farmland that has been decontaminated by scraping away topsoil or through inversion tillage and similar methods is expected to lose its fertilizer components and organic characteristics, as well as experience a degradation in permeability and other physical characteristics, care must be taken with post-decontamination farmland to ensure the conditions that enable resumption of agricultural production are restored, including soil analysis and diagnostics, followed by application of the necessary amount of soil from elsewhere, along with fertilizer, organic materials, or soil conditioners.

Most of the radiocaesium that has precipitated onto farmland that has not been plowed since the Fukushima Daiichi Nuclear Power Plant accident still remains on the surface of the farmland in large quantities. Therefore, even when farmland that has not been plowed since the accident has the same radiocaesium concentrations as farmland that has had its plow layer mixed by plowing, the former with its untouched topsoil will exhibit a higher value for its air dose rate. In this way, appropriate methods must be adopted for performing decontamination work on farmland depending on whether it has been plowed yet, as well as its current land category and concentration of contaminants.

■ Farmland (fields) that has not been plowed

For sections that have not been plowed, after weeding it is suitable to scrape away the surface layer of soil where radiocaesium is deposited (see Figure 2-52). However, in consideration of the concentration of radiocaesium in the soil, the current land category, the soil conditions, etc., in addition to scraping away the topsoil,[*7] it is also permissible to select soil agitation or removal by water,[*8] inversion tillage,[*9] or other methods. When scraping away the topsoil, it is recommended to commence work only after calculating the expected amount of soil that will be generated as removable material in advance because the amount will be large, and also after developing an outlook on securing temporary storage site, etc.

It is permissible to carry out inversion tillage, which does not generate removable materials (soil),[*10] for farmland that has a concentration of 5,000 Bq/kg or less of radiocaesium in the soil, while for farmland that has a concentration of greater than 5,000 Bq/kg of radiocaesium in the soil, it is suitable to scrape away the topsoil, implement soil agitation or removal by water, or perform inversion tillage.[*11] Among these methods, since inversion tillage entails moving the radiocaesium to a lower soil layer, which could result in radiocaesium being transported off the farmland through the groundwater, please measure the water table in advance and take account of its depth before performing inversion tillage as needed. Furthermore, the deeper the tillage, the greater the reduction in the radiation dose at the ground surface, but because of the danger of destroying the plow pan, especially for rice fields, it must be rebuilt if it is destroyed.

■ Farmland (fields) that has been plowed

For farmland that has already been plowed, inversion tillage, deep tillage, or similar methods shall be used, because presumably the radiocaesium has already been mixed into the whole plow layer by plowing. For example, for farmland with a plow layer of 15 cm, deep tillage of 30 cm will dilute the radioactive materials that had been distributed in the range from the surface to 15 cm deep into the range from the surface to 30 cm deep, which can be expected to reduce the radiocaesium concentration in the plow layer and reduce the radiation dose.

■ Agricultural water facilities

Decontamination and other measures shall be considered for agricultural drainage canals and other such facilities that meet all of the conditions in (1) – (3) below.

(1) Must be a facility on which soil is removed from canals near to paddy fields on which mud dredging is carried out primarily through manual labor by farmers or managers in ordinary years in order to ensure cross-sectional flow areas and flow volumes.

(2) Must be a region in which mud dredging that is carried out in ordinary years could not be carried out due to the impact from the accident.

(3) Facilities for which no shielding effect via the water is expected during the agricultural off season or other fixed periods of time for reasons like a lack of water in said canals, but which clearly contribute to the air dose rate in the surrounding areas.

■ Orchards, etc.

For fruit trees, tea plantations, or places where other perennial crops are cultivated, scraping away the topsoil in a range that will not harm tree bodies is deemed effective, while inversion tillage, deep tillage, and similar methods are not suitable as they could damage the roots and because the rooting zone is distributed into the lower layers of the soil. In decontaminating such farmland, fruit trees shall be debarked (old bark stripped away) or the bark shall be cleaned and the trees pruned, and tea trees shall have their branches pruned (old leaves and branches removed by deep pruning, medium pruning, truncation, etc., after tea picking) or similar treatments in order to reduce the radiation dose and minimize the concentration of radiocaesium contained in the products.

If these measures have been taken but have produced inadequate results, scraping away of all sections of topsoil, along with similar methods, shall be considered.

■ Pastureland

For pastureland, inversion tillage, deep tillage, or scraping away the topsoil shall be carried out. If the layers below the plow layer are rudaceous, pebbles will appear in the plow layer as a result of inversion tillage or deep tillage, and so in such cases measures to remove the pebbles will be necessary. When scraping away the topsoil an enormous amount of soil to be removed will be generated. Because of this, the amount that is expected to be generated must be estimated in advance and prospects must be established for securing temporary storage sites and the like before starting with the work.

Furthermore, there may be cases where it is difficult to perform inversion tillage on pastureland due to a shallow plow layer or lots of rocks and pebbles, and where it is difficult to store the soil following the removal of topsoil at storage sites. In such cases consideration shall be given to performing plowing via a disc harrow or a rotary tiller by confirming that adequate results can be achieved from the decontamination.

Weeding, etc. of ridges and slopes and other measures shall be implemented as needed.

The measures that are required in advance, specific decontamination methods, and notes of caution for the decontamination of farmland are as provided in Tables 2-40 and 2-41.

Figure 2-54: Example of scraping away of soil from farmland using farm machinery

1) Harrowing of farmland

Photo courtesy of: Ministry of Agriculture, Forestry and Fisheries

2) Scraping away of soil from farmland

Photo courtesy of: Ministry of Agriculture, Forestry and Fisheries

Table 2-40. Necessary measures prior to the decontamination of farmland

Category	Decontamination methods and notes of caution
Prevention of dispersion	• When scraping away the topsoil when it comes to dried soil, efforts can be made to prevent the dispersion of dust by scattering solidification agents over the area in advance to solidify the soil surface.

Table 2-41. Decontamination methods for farmland and notes of caution

Category		Decontamination methods and notes of caution
Unplowed	Scraping away topsoil	• A backhoe or the like shall be used to scrape away the surface. • The remaining topsoil can be confirmed by means of sprinkling lime around in advance.
	Soil agitation or removal by water	• After the upper layer of soil has been agitated (shallow puddled), the turbid water with fine soil particles floating in it shall be forcefully drained via a pump. Then solid-liquid separation shall be performed in a grit chamber or similar device that has been covered with a plastic sheet to collect the soil particles.
	Inversion tillage	• A plow shall be used to invert the soil so that the contaminated soil in the top layer is moved to the bottom layer and the uncontaminated soil from the bottom layer is placed on the top layer. • The tillage depth for inversion tillage shall be 30 cm in principal. However, in cases where soil that is not suitable for use as the plow layer will come to the surface, such as soil that contains pebbles, then the tillage depth shall be set shallowly after first confirming that adequate decontamination results will be obtained from this. • The water table shall be measured and its depth taken into account when performing inversion tillage as needed. • Attention must be paid to the fact that small tractors cannot be used to agitate the soil in cases where the topsoil is frozen due to cold temperatures.
Plowed	Inversion tillage	(Same as above)
	Deep tillage	• A deep tillage rotary tiller shall be used to deeply till cultivated land about two times. The tillage depth of deep tillage shall be about 30 cm in principal.
Water facilities	Removal of sediments	• Mud and other sediments that have accumulated in agricultural drainage canals and other such facilities shall be removed through the use of a shovel or the like.
Orchards	Debarking	• Tree bark shall be removed by primarily concentrating on the tops and sides of main trunks and main branches. • A dedicated chipping tool shall be used to scrape away so as to take off tree bark that has grown old.
	Cleaning tree bark	• Tree species that do not have a configuration in which old tree bark can be removed from their branches and trunks (peach trees, cherry trees, etc.) shall be subject to cleaning. • When cleaning bark or debarking with the use of a high pressure water cleaner, radiocaesium tends to easily disperse together with the water, and so the use of these procedures shall be avoided during the growing season and be carried out during dormant stages.
	Pruning	• Old branches to which it is thought that radiocaesium is directly

		adhering shall be removed. • The branches shall be removed during the tree's dormant stage so that this does not affect its growth.
	Scraping away topsoil	• The soil shall be removed by human power or via an earth blade on a small backhoe. Or a rotary tiller shall be attached to a small tractor and the soil shall be lightly tilled, after which the topsoil shall be removed by a method such as gathering up the topsoil through the use of a front loader (without a claw) on a tractor.
Pastureland	Inversion tillage / plowing	• A plow shall be used to invert the soil so that the contaminated soil in the top layer is moved to the bottom layer and the uncontaminated soil from the bottom layer is placed on the top layer. • The tillage depth for inversion tillage shall be 30 cm in principal. However, in cases where soil that is not suitable for use as the plow layer will come to the surface, such as soil that contains pebbles, then the tillage depth shall be set shallowly after first confirming that adequate decontamination results will be obtained from this. • The water table shall be measured and its depth taken into account when performing inversion tillage as needed. • Attention must be paid to the fact that small tractors cannot be used to agitate the soil in cases where the topsoil is frozen due to cold temperatures.
	Scraping away topsoil	• A backhoe or the like shall be used to scrape away the surface.

4. Post-Work Measures

Post-work measures, which include handling the removed soil, etc. generated by the decontamination work, as well as cleaning of equipment and materials, are listed below.

(1) Handling the Removed Soil, etc.

The removed soil, etc. shall be appropriately handled and transferred to on-site storage or a temporary storage site.

Please refer to "II. 4. (1) Handling the Removed Soil, etc." for specific methods for handling the removed soil.

(2) Cleaning of Equipment and Materials

With regard to the post-work handling of the equipment used for decontamination, the Ministry of Health, Labour and Welfare's Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and its Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6 dated June 15, 2012) are to be followed.

See "II. 4. (3) Cleaning of Equipment and Materials" for specific methods for cleaning the equipment and materials.

5. Subsequent Measurements and Records

To confirm the decontamination effect, the air dose rate, etc. and concentration of radiocaesium in the soil (in the case of farmland) after completion of the decontamination work shall be measured, and the results shall be compared with the values measured prior to the commencement of the decontamination work. Measurement of the air dose rate, etc. and the radiocaesium concentration shall be performed in accordance with the measurement methods given in “Part 1: Guidelines for Methods for Investigating and Measuring the Status of Environmental Pollution in Intensive Contamination Survey Areas” and Table 2-37 of “2. (2) Measurement Methods” for each measurement point indicated in Table 2-36 of “2. (1) Determination of Measurement Points.”

In addition to the air dose rate, etc. and radiocaesium concentration at each measurement point, any other information pertaining to the decontamination work shall be recorded and stored.

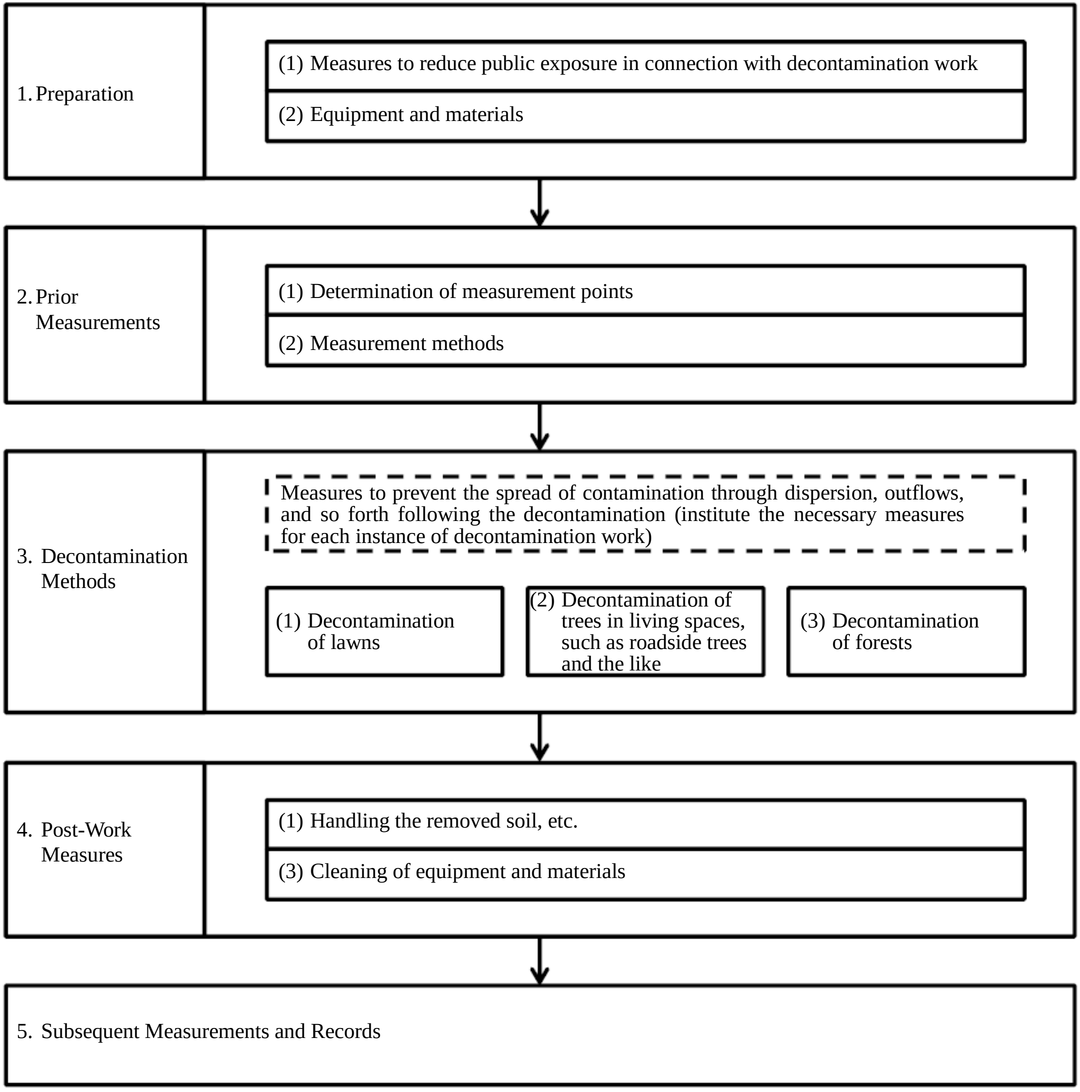
Table 2-42. Subsequent measurements and records for the decontamination of soil

Measurement of air dose rate, etc. and radiocaesium concentration, etc.	• The air dose rate, etc. and radiocaesium concentration in the soil (in the case of farmland) shall be measured at each measurement point. • Measurements shall be carried out in the same location as the prior measurements and under the same conditions to the extent possible. • For the measuring apparatus, the same apparatus as was used for the prior measurements shall be used to the extent possible.
Recordkeeping	• Air dose rate, etc. and radiocaesium concentration in the soil at each measurement point, places for which decontamination work was performed, date of decontamination, names of decontaminators, types of objects subject to decontamination, method of decontamination, total area decontaminated (soil, etc.), the approximate weight of the removed soil, etc., and the status of storage and disposal. • The equipment used in decontamination and the method of disposal after use. • See “Part 4: Guidelines Pertaining to the Storage of Removed Soil” for details on the items to record with regard to the storage of removed soil.

V. Decontamination and Other Measures for Vegetation

This section explains 1. Preparation, 2. Prior Measurements, 3. Decontamination Methods, 4. Post-Work Measures, and 5. Subsequent Measurements and Records, in chronological order, pertaining to measures for the decontaminations of lawns, roadside trees, trees in living spaces such as in parks and gardens, forests near residences, etc.

Figure 2-55. Basic flow for decontamination and other measures for vegetation



1. Preparation

Before performing decontamination work, in addition to preparing the equipment required for the decontamination work, preparations must be made to ensure safety through means including prevention of exposure of the general public and workers such as by inhaling dust generated during decontamination work. Among these preparations, please refer to the Ministry of Health, Labour and Welfare's Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and its Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6 dated June 15, 2012) for the measures required to ensure the safety of workers.

(1) Measures to Reduce Public Exposure in Connection with Decontamination Work

Table 2-43. Measures to reduce public exposure in connection with decontamination work for vegetation

Restriction of entry	• In cases where the general public is deemed likely to enter the area, the area shall be cordoned off with pylons or rope, etc. to prevent people from unnecessarily approaching the work site, and the entry of people and vehicles shall be restricted. • In cases where radioactive materials may be dispersed in connection with the decontamination work, the perimeter of the decontamination area shall be fenced in with sheets, etc., water shall be sprayed, or other such measures shall be taken to prevent dispersion and the area shall be cordoned off with rope, etc.
Signage	• In cases where the general public is deemed likely to enter the area, signs, etc. shall be put up to alert the public that decontamination work is being performed (see Figure 2-4).

(2) Equipment and Materials

The required equipment and materials shall be arranged for decontamination and other measures, as well as for collection of the removed soil, etc., in accordance with the objects to be decontaminated and the work environment.

Table 2-44. Examples of equipment and materials for the decontamination of vegetation

Example of general equipment	Mower, hand shovel, grass sickle, broom, bamboo rake, dustpan, tongs, shovel, small shovel, metal rake, compact heavy machinery for scraping away topsoil, garbage bags (bags for burnable matter, burlap sacks for soil and sand (sandbags)), vehicles for transporting collected removed soil, etc. to the on-site storage location (truck, two-wheeled cart, etc.)
Examples of equipment for pruning trees	Hatchet, pruner, chainsaw, stepladder, mobile lift

2. Prior Measurements

To confirm the decontaminating effects of the decontamination work, the air dose rate prior to the commencement of decontamination work and after the completion of decontamination work[*2] and the surface contamination density of the objects subject to decontamination (hereinafter, “air dose rate, etc.,” which includes both the air dose rate and the surface contamination density) shall be measured. Specifically, places representative of living spaces, places contaminated at a comparatively high concentration that is deemed to contribute substantially to the radiation dose in the living space, etc. shall have their air dose rate, etc. measured in the same locations and by the same method both before contamination work starts and after it finishes, and the results shall be recorded. This section gives information on methods for measuring the air dose rate, etc. prior to the commencement of decontamination work.

Note that the air dose rate, etc. may also be measured near the surface of the objects subject to decontamination as needed when ascertaining the degree of reduction in the level of contamination of the objects subject to decontamination during the decontamination work. These measurements will be separately explained in “Section 3. Decontamination Methods.”

(1) Determination of Measurement Points

Prior to decontamination work, the measurement points at which the air dose rate, etc. will be measured shall be decided and a schematic diagram illustrating the range of the measuring object, the measurement points, structures to be used as markers, etc. shall be created (see Figure 2-56 and Figure 2-57).

There are two types of measurement points: those used to ascertain the average air dose rate for roadside trees, trees in parks and other living spaces, forests near residences, etc. that are subject to decontamination (No. 1 measurement points) and those used to confirm the level of contamination of the objects that are to be decontaminated (No. 2 measurement points).

No. 1 measurement points are set primarily in a living space where residents, etc. spend large amounts of time. In setting these measurement points, so-called “hotspots” that contribute comparatively insubstantially to the radiation dose in the living space, and points near them, are not eligible to be measurements points unless the residents, etc. are deemed likely to spend relatively large amounts of time there.

Examples of hotspots include depressed areas and puddles, street drains, under rainwater guttering, rainwater chambers, under or near trees, or in places where raindrops falling from buildings land, as radioactive materials tend to become concentrated in such places due to rainwater and the like..

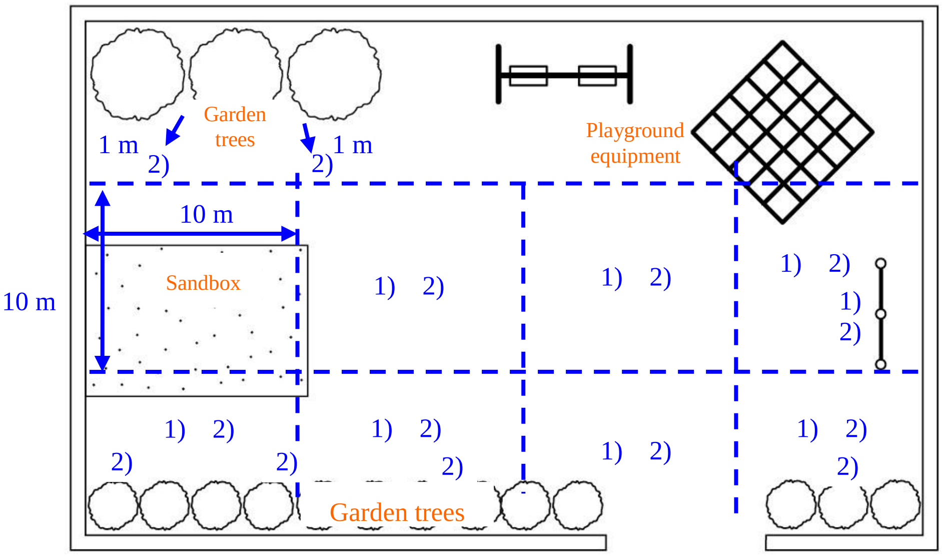
The purpose of No. 2 measurement points is fundamentally to measure the level of contamination at the surface of the objects subject to decontamination, and they are therefore set by considering places, etc. contaminated at comparatively high concentrations and that are deemed to contribute substantially to the radiation dose in the living space.

The specific methods are as provided in Table 2-45.

Table 2-45. Reasoning behind the measurement points for air dose rates and other measures for the decontamination of vegetation

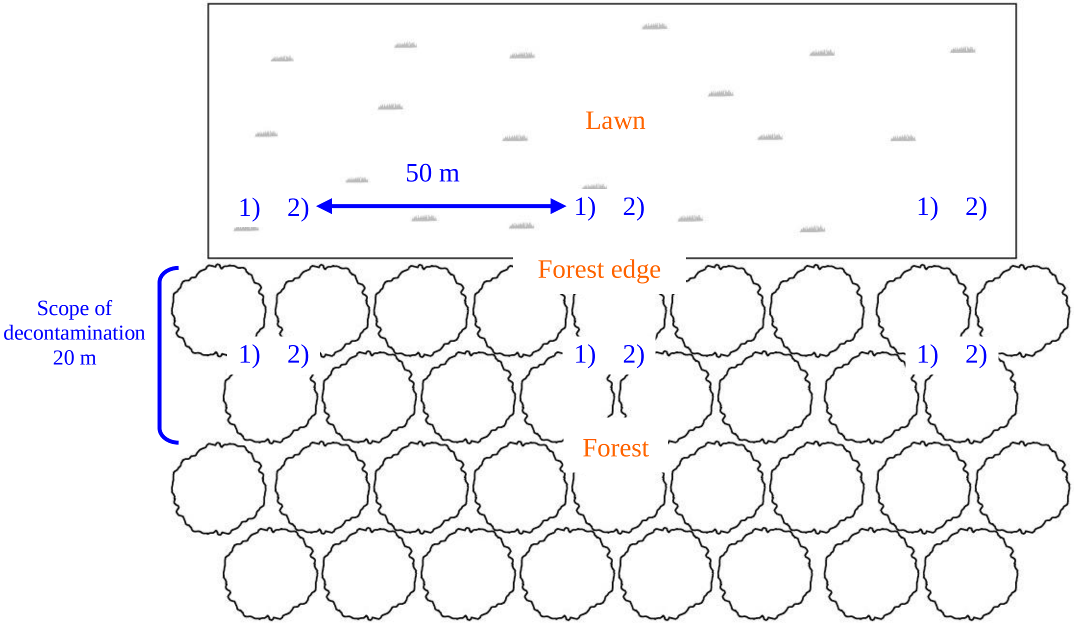
Measurement point	No. 1 measurement points	No. 2 measurement points
Measurement target	Air dose rate in living spaces	Surface contamination density, etc. for objects subject to decontamination
Reasoning behind the measurement points	• Measurement points shall be set at intervals that allow the air dose rate distribution to be ascertained. ○ Lawns • Lawns shall be divided up into meshes of about 10 – 30 m and measurements shall be conducted at one spot in each mesh. ○ Forests • Measurements shall be conducted at one spot about every 20 – 50 m[*12] near the forest edge and the geographical center of the forest where work will be performed.	• Same as with No. 1 measurement points for lawns. • For roadside trees, measurement points shall be established within a range that will presumably be affected by the roadside tree (example: a position that is about 1 m away from the side of the roadside tree). • For forests, the points shall be as with No. 1 measurement points.

Figure 2-56: Example of a schematic diagram (trees and grass) for reporting measurement points for use in decontamination and other measures for vegetation (parks)



1): Contamination status for living spaces
2): Contamination status for objects subject to decontamination (surface contamination density, surface dose rate)

Figure 2-57: Example of a schematic diagram for reporting measurement points for use in decontamination and other measures for vegetation (forests)



1): Contamination status for living spaces
2): Contamination status for objects subject to decontamination
(surface contamination density, surface dose rate)

(2) Measurement Methods

When measuring the air dose rate at a No. 1 measurement point, a scintillation survey meter or other measuring apparatus able to measure gamma rays shall be used.

In contrast, to avoid the effects of background radiation when measuring the level of contamination on or near surfaces at a No. 2 measurement point, it is recommended to use a GM survey meter able to measure beta rays, but it is also acceptable to perform the measurements using a dosimeter capable of measuring gamma rays. For example, one way to make specialized confirmation based on the levels of contamination at the relevant sites is to perform the measurements under conditions where a collimator is used to shield against gamma rays from the outside. In addition, for instance, it is possible to confirm the effect of the decontamination by determining the contamination status of the objects subject to decontamination from the air dose rate measured at the surface of the measurement points and at heights of 50 cm and 1 m, and then comparing the results with those of measurements taken in the same positions after the completion of the decontamination work.

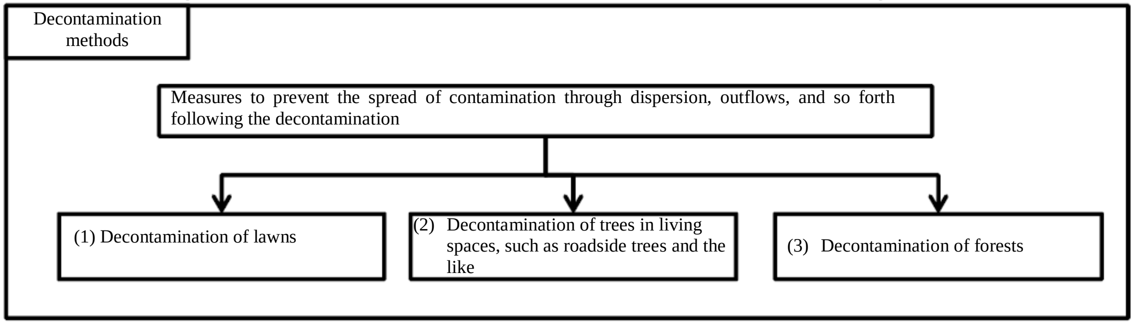
In general, the same measuring apparatus shall be used when measuring at the same measurement points before and after decontamination work.

When there are a large number of measurement points, the results of measurements, etc. previously taken by local authorities shall be utilized as needed.

For the specific methods, see "6. Measuring Apparatuses and Methods of Use" in "Part 1: Guidelines on the Methods for Investigation and Measurement of the Status of Environmental Pollution in Intensive Contamination Survey Areas."

3. Decontamination Methods

Figure 2-58. Basic flow for the decontamination of vegetation

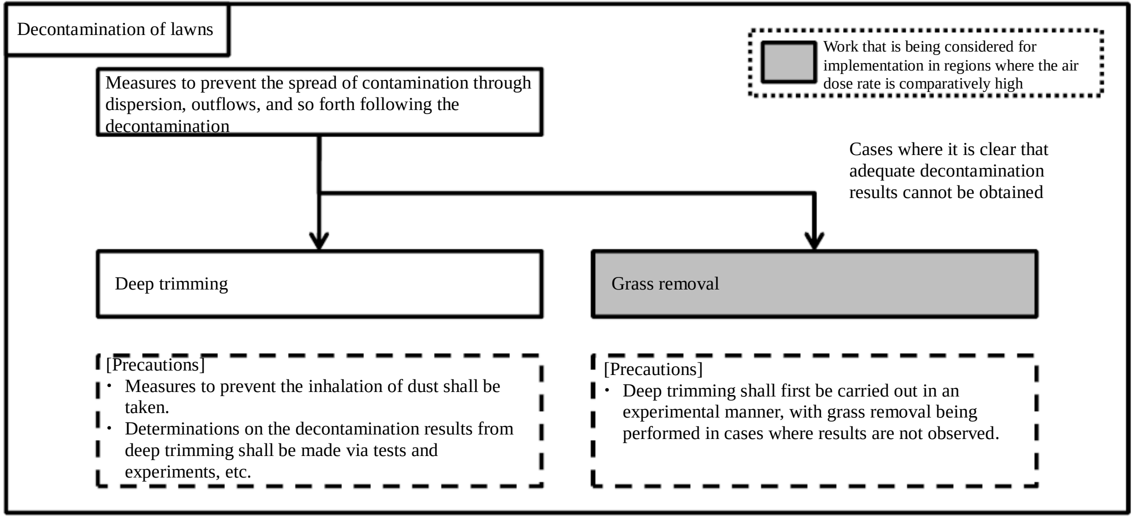


The decontamination of vegetation shall be implemented in accordance with the land use configuration (lawns, trees in living spaces, such as roadside trees and the like, or forests).

See "4. Post-Work Measures" with regard to matters like the handling of the removed soil, the treatment of wastewater, and the cleaning of the equipment used for the decontamination.

(1) Decontamination of Lawns

Figure 2-59. Basic flow for the decontamination of lawns



For lawns, what is different from immediately after the accident at the nuclear power plant is that there is the possibility that the radioactive materials currently on the surfaces of the grass may have decreased as a result of factors like the affects from precipitation. As a result, please determine the need for decontamination according to the extent to which radiocaesium is adhering to the lawn. On the other hand, rainwater may have run off the roofs of the structures and accumulated in grass near houses or buildings. As such, the appropriate decontamination will have to be carried out by taking the changes in the contamination status as a result of factors like precipitation into consideration.

When taking these measures, it is important to consider applying methods that enable the grass to be re-grown. Specifically, a grass removal method using “deep trimming” to remove the sediment layer of withered grass and clippings is recommended because it can limit the amount of removed soil, etc. that is generated, and is favorable from the perspective of re-growing the grass. Deep trimming is a technique whereby the leaves and thatch of turfgrass is removed. Since the underground rhizomes and roots of the turfgrass are left behind, this aims to encourage the germination of new sprouts in an effort to restore the grass while at the same time decontaminating it (see Figure 2-60 and Figure 2-61). In places where the radiation dose is high and it is clear from deep trimming tests and experiments that it will not produce a decontamination effect, turfgrass shall be removed by the roots.

In each stage, the air dose rates at the No. 1 measurement points shall be measured, and as a general rule no additional decontamination work shall be performed provided the air dose rate at a height of 1 m (a height of 50 cm from the measurement point may be used for lawns, etc. mainly used by students of elementary schools and below, as well as special-needs schools, with consideration for the living space of infants and schoolchildren in the lower grades) is less than 0.23 microsieverts per hour.

Dust is generated during grass removal, so the process requires equipment to prevent inhalation.

Furthermore, if the area to be decontaminated is large, the work shall be coordinated and the scheduling matched so that it is carried out all at the same time in order to ensure that there is no recontamination following the decontamination work.

After trimming the lawn, removing the topsoil, etc., the air dose rate, etc. at the measurement points shall be measured to confirm the decontamination effect.

In addition, in cases where the amount of removed soil, etc. to be generated is deemed likely to be enormous, in implementing measures for decontamination of the soil, etc., the soil scraped away must be kept to the minimum necessary thickness and otherwise care must be taken to minimize the generated quantity of removed soil, etc. whenever possible in order for the decontamination and other measures to be advanced in a speedy and efficient manner.

The measures that are required in advance, specific decontamination methods, and notes of caution for the decontamination of lawns are as provided in Tables 2-46 and 2-47.

Table 2-46. Necessary measures prior to the decontamination of lawns

Category	Decontamination methods and notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent the dispersion of dust, etc.

Table 2-47. Decontamination methods for lawns and notes of caution

Category	Decontamination methods and notes of caution
Deep trimming	• If large mowers will fit, then deep trimming shall be carried out using large mowers (shallow cutting down to approximately 3 cm, which is a level from which the grass can recover). • If large mowers will not fit, then the deep trimming of lawns shall be carried out using a hand guided mower (sod cutter, etc.)
Grass removal	• The flat claw for a backhoe bucket shall be installed and the grass and sod shall be removed (about 5 cm).

■ Decontamination via Deep Trimming (Lawns Where Rhizomes Are Growing)

The structure of grass starting from the top consists of the leaves of the grass, the thatch, and then the soil (which includes the grass rhizome and root). Thatch refers to the layer of withered turfgrass and clippings intermixed with soil, and it is believed that the vast majority of the radiocaesium is absorbed into this layer.

Deep trimming is a technique whereby the leaves and thatch of turfgrass is removed. Since the underground rhizomes and roots of the turfgrass are preserved, this aims to encourage the germination of new sprouts in an effort to restore the grass while at the same time decontaminating it.

As for the specific work, the grass shall be trimmed down to a depth of about 2 – 3 cm (*) and the remains from the thatch and withered leaves that have accumulated on the ground’s surface shall be removed.

The extent to which decontamination can be achieved through deep trimming will depend on the precision of the work. If the work is not carried out thoroughly then there is the risk that it will not be possible to perform adequate decontamination because the soil particles on the thatch will peel off and will not all be collected.

What is more, the time period in which it is carried out also has an effect on the regeneration of the grass, so please ask the opinion of experts on the matter as needed.

* The trimming depth is the depth from the ground line (the uppermost position when the turfgrass leaves are laid flat by being pushed over with one’s hand), not the depth from the uppermost position when the leaves are standing.

Figure 2-60. Example of decontamination work for a lawn (deep trimming)

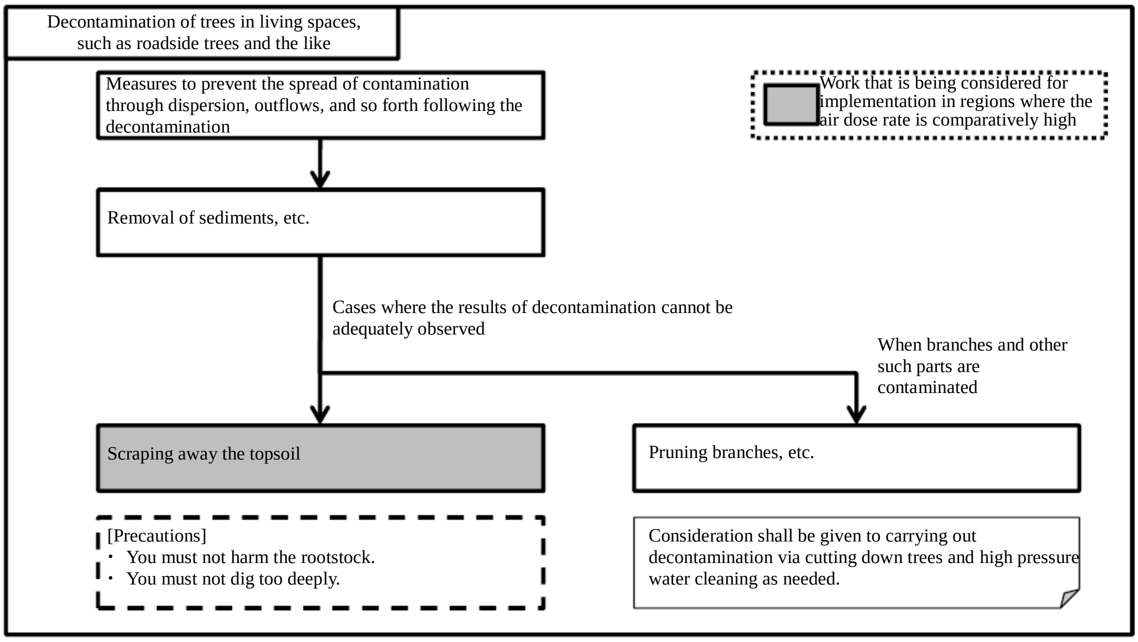
Photo courtesy of: Date City

Figure 2-61. Image of the cut section of the grass and topsoil subject to decontamination

Photo courtesy of: JAEA

(2) Decontamination of Trees in Living Spaces, such as Roadside Trees and the like

Figure 2-62. Basic flow for the decontamination of trees in living spaces, such as roadside trees and the like



One difference between now and immediately after the accident at the nuclear power plant is that now there is the possibility that the radioactive materials currently on the surfaces of roads may have decreased as a result of factors like the effects from precipitation and fallen leaves. As a result, please determine the need for decontamination for roadside trees according to the extent to which radiocaesium is adhering to the trees.

For roadside trees or trees in parks, gardens, and other living spaces, the radiation dose can be reduced by removing the radiocaesium that have settled down through the removal of fallen leaves and other sediment organic materials on the surrounding ground surfaces, cleaning and pruning the trees, or other methods.

First the fallen leaves, grass, and other vegetation on the ground surface near the trees shall be removed.

If this does not result in an observable decontamination effect, the top layer of the soil shall be removed to a depth of approximately 5 cm by hand or by using compact heavy machinery. Care shall be taken so as not to damage the rootstocks of the trees in the process. Care shall also be taken to avoid digging too deeply in order to prevent generating excessive amounts of removed soil, etc. For the sections from which the top layer of soil was removed, soil with straw or other organic matter shall be transplanted in from elsewhere, the soil shall be consolidated, or other measures shall be taken as necessary. Care shall be taken with sloped areas to prevent outflow of soil, sand, etc. or the collapse of the sides.

If removing the fallen leaves and weeding result in no observable decontamination effect and it is believed that the branches or other parts of the trees are contaminated, there are also methods that entail pruning the branches or other parts of the trees.

Since cutting down a tree generates a large amount of decontamination waste, the decision to do so shall be considered by taking into account the role of the tree, whether it is in a place that many people visit, and whether other methods can be expected to produce a decontamination effect. It is also permissible to decontaminate shrubs, garden trees, and other small trees by high pressure water cleaning.

In each stage, the air dose rates at the No. 1 measurement points shall be measured, and as a general rule no additional decontamination work shall be performed provided the air dose rate at a height of 1 m (a height of 50 cm from the measurement point may be used for facilities, etc. used by students of elementary schools and below, as well as special-needs schools, with consideration for the living space of infants and schoolchildren in the lower grades) is less than 0.23 microsieverts per hour.

The measures that are required in advance, specific decontamination methods, and notes of caution for the decontamination of trees in living spaces, such as roadside trees and the like are as provided in Tables 2-48 and 2-49.

Table 2-48. Necessary measures prior to the decontamination of trees in living spaces, such as roadside trees and the like

Category	Decontamination methods and notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent the dispersion of dust, etc.

Table 2-49. Decontamination methods for trees in living spaces, such as roadside trees and the like and notes of caution

Category	Decontamination methods and notes of caution
Removal of sediments	• Fallen leaves, moss, mud, and other sediments shall be removed by hand by people wearing rubber gloves and by shovel, etc.
Scraping away topsoil	• Accumulated fallen leaves and soil shall be picked up by using a shovel or rake, etc.
Removal of branches, etc.	• Delimbing and pruning shall be carried out on roadside trees by using a pruner and branch cutter to an extent that does not give rise to any pronounced impact for the growth of trees according to the tree species and their delimbing period.

(3) Decontamination of Forests

Much of the radioactive materials in forests reside in foliage, fallen leaves, and other sediment organic matter, with the contamination level dropping substantially at depths of 3 cm or more from the ground surface. However, forests cover large areas, and implementing decontamination methods that involve stripping away the leaf mulch generates an enormous amount of removed soil, etc. and could damage the multifaceted functions of forests, including disaster prevention. Forests, therefore, shall initially be decontaminated with a view to reducing the radiation dose in the living environment of the residents near the forest.

The discharge of radiocaesium associated with the Fukushima Daiichi Nuclear Power Plant accident concentrated in March when the earthquake occurred, which means that in deciduous broad-leaf forests where new leaves had not developed at that time, the radioactive materials fell to the forest floor and tended to settle onto fallen leaves and other sediment organic matter. Accordingly, removal of fallen leaves, etc. in such places is expected to yield a large decontamination effect (see Figure 2-63).

From the perspective of reducing the radiation dose in the living environment of residents near the forest, it is effective and efficient to remove fallen leaves, etc. up to about 20 m in from the edge of the forest, but this range shall be determined while confirming the status of the reduction in radiation dose after removal of the fallen leaves, etc.

In cedar, Japanese cypress, and other evergreen forests, a larger proportion of the radiocaesium tends to be settled onto the branches and leaves in comparison with deciduous broad-leaf forests. Into the future, it is recommended that the removal of fallen leaves, etc. be performed not just once but continually during a period of about three to four years, because that is how long it normally takes the radiocaesium settled onto branches, leaves, etc. to fall to the forest floor with rain or fallen leaves.

On the other hand, it is also important not to allow the exposed topsoil to run off due to rainfall, in the interests of preserving the forests and preventing the re-diffusion of radiocaesium. Radiocaesium moves into the soil as fallen leaves decompose, but since caesium has the property of being readily absorbed into clay, it is thought that most of the substance stays in the top layer of the soil.[*13] This means that rather than removing the fallen leaves, etc. in a wide area all at once, it is suitable to gradually expand the area while monitoring the situation.[*14] Lining up sandbags at the edge of the forest or other measures to prevent soil movement and runoff must be taken when removing fallen leaves and other sediment organic matter on steep slopes in forests and whenever soil runoff has been observed during rainfall after the removal.

Since the radiocaesium in cedar, Japanese cypress, and other evergreen forests is thought to be settled onto branches and leaves, the branches, leaves, etc. of standing trees around the edge of such forests shall be removed if the removal of fallen leaves, etc. alone does not produce a sufficient decontamination effect—that is, in cases where the radiation dose in the living environment of residents near the forest does not decrease. In particular, since the trees at the edge of an evergreen forest generally have more leaves on them and are therefore deemed to have comparatively high amounts of radiocaesium settled onto them, when feasible, it is recommended to remove branches and leaves up to as high a point on the trees as possible (see Figure 2-64). In such cases it is preferable to perform the removal over a range that does not significantly impact the growth of the trees; specifically, branches and leaves shall be removed up to about half the length of the tree canopy.

The measures that are required in advance, specific decontamination methods, and notes of caution for the decontamination of forests are as provided in Tables 2-50 and 2-51.

Figure 2-63: Example of the decontamination of a forest (removal of fallen leaves)

Photo courtesy of: JAEA

Figure 2-64. Example of the decontamination of a forest (decontamination of branches and leaves, etc.)

Photo courtesy of: Date City

Table 2-50. Necessary measures prior to the decontamination of forests

Category	Decontamination methods and notes of caution
Prevention of dispersion	• If sidewalks and buildings are immediately adjacent, curing shall be performed to prevent the dispersion of dust, etc.
Cutting	• The cutting of weeds, shrubs, and other vegetation shall be carried out using a chainsaw or shoulder-type mower, etc.

Table 2-51. Decontamination methods for forests and notes of caution

Category	Decontamination methods and notes of caution
Removal of fallen leaves, etc.	• Fallen leaves, moss, mud, and other sediments shall be removed by hand by people wearing rubber gloves and by shovel, etc. • Masks shall be worn to avoid inhaling suspended particulates produced during removal work.
Removal of branches, leaves, etc.	• The pruning of limbs and other tree parts shall be carried out to an extent that does not give rise to any pronounced impact for the growth of trees, and the felled leaves and branches shall be collected. • Generally , the very edges of the peripheral areas around forests contain a large volume of leaves affixed to trees, and so there is the possibility that a comparatively large amount of radioactive materials are adhering to them. Therefore, branches and leaves should be removed from as high up a position as possible (up to about half the length of the tree canopy). • Masks shall be worn to avoid inhaling suspended particulates produced during removal work.

4. Post-Work Measures

(1) Handling the Removed Soil, etc.

The removed soil, etc. shall be appropriately handled and transferred to on-site storage or a temporary storage site.

Please refer to “II. 4. (1) Handling the Removed Soil, etc.” for specific methods for handling the removed soil.

When it comes to handling the vegetation, transfer and storage can be carried out more efficiently by means of pre-treatment such as crushing, reducing the volume via compression, or drying the vegetation as needed.

(2) Cleaning of Equipment and Materials

With regard to the post-work handling of the equipment used for decontamination, the Ministry of Health, Labour and Welfare’s Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and its Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6

dated June 15, 2012) are to be followed.

See “II. 4. (3) Cleaning of Equipment and Materials” for specific methods for cleaning the equipment and materials.

5. Subsequent Measurements and Records

To confirm the decontamination effect, the air dose rate, etc. after completion of the decontamination work shall be measured and compared with the air dose rate, etc. that was measured prior to the commencement of the decontamination work. Measurement of the air dose rate, etc. shall be performed in accordance with the measurement methods given in “Part 1: Guidelines for Methods for Investigating and Measuring the Status of Environmental Pollution in Intensive Contamination Survey Areas” for each measurement point indicated in Table 2-45 of “2. (1) Determination of Measurement Points.”

In addition to the air dose rate, etc. at each measurement point, any other information pertaining to the decontamination work shall be recorded and stored.

Table 2-52. Subsequent measurements and records for the decontamination of vegetation

Measurement of air dose rate, etc.	• The air dose rate, etc. shall be measured at each measurement point. • Measurements shall be carried out in the same location as the prior measurements and under the same conditions to the extent possible. • For the measuring apparatus, the same apparatus as was used for the prior measurements shall be used to the extent possible.
Recordkeeping	• The air dose rate, etc. at each measurement point, places where decontamination work was performed, decontamination date, names of the decontaminators, type of objects decontaminated, decontamination methods, total decontamination area (of soil, etc.), the approximate weight of the removed soil, etc., and the status of storage and disposal. • The equipment used in decontamination and the method of disposal after use. • See “Part 4: Guidelines Pertaining to the Storage of Removed Soil” for details on the items to record with regard to the storage of removed soil.

VI. Others

(1) Decontamination and Other Measures for Sediment in Riverbeds

Radiocaesium that flowed into rivers as a result of the weather may have accumulated in the sediment of riverbeds.

Despite this, in a survey conducted from May to September, 2011, almost no radioactive materials were detected in river water,[*15] and even supposing radioactive materials have settled onto riverbeds, the impact on the exposure dose for residents is thought to be limited given the shielding effect of the river water as well.

Moreover, rivers have the characteristic that their bed conditions change due to floods and other natural phenomena, and the impact at sites downstream must be taken into account when performing decontamination work on a river.

Regarding the handling of riverbed sediment, considering the foregoing, it is suitable to consider implementation after the decontamination work detailed in chapters II through V has advanced to a certain level, while carrying out periodic monitoring. This section will be revised in light of monitoring performed in the future pertaining to riverbed contaminants and accumulated knowledge on the removal of riverbed sediment in various projects.

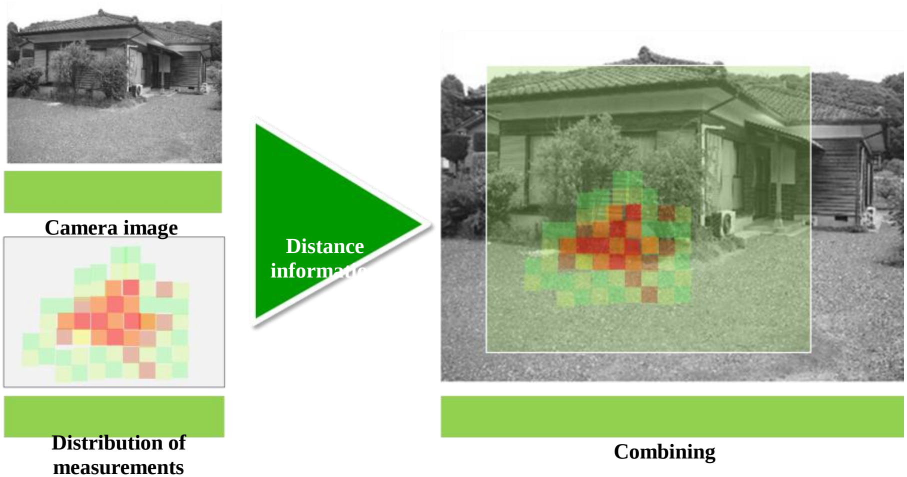
Column: Gamma Cameras

Gamma cameras are a new technology when it comes to decontamination. A gamma camera is a camera that combines images photographed via a camera with the distribution of measurements for the dose of radiation (gamma rays) emitted by radioactive materials to enable the user to color code how high or low the radiation dose is so that it can be confirmed via a visual image. Since gamma cameras can visualize radiation that is invisible to the naked eye, they make it possible to provide explanations of the contents and results of decontamination work and explanations regarding the safety of temporary storage sites in a more easy to understand manner. For these reasons, their use is being considered at venues for communicating risks to local residents.

Figure 2-65. Example of a gamma camera

Usage example

Figure 2-66. Image of the creation of a gamma camera visual image



(Allows the user to visually confirm the distribution of radioactive materials at sites where decontamination is carried out.)

Endnotes

[*1]: The additional exposure dose due to the radioactive materials discharged during the Fukushima Daiichi nuclear accident.

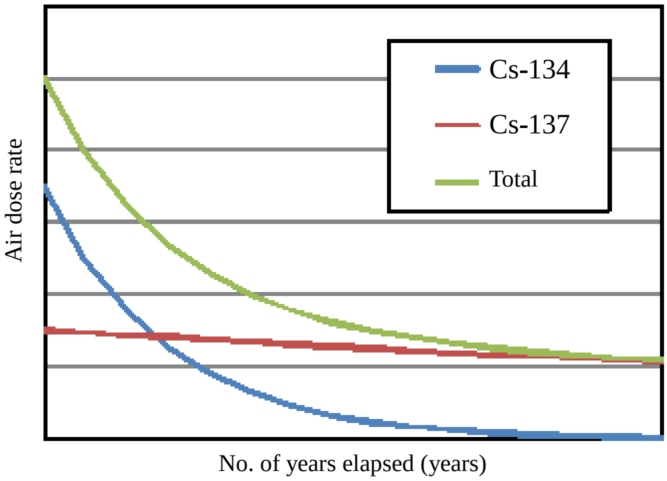
[*2]: The air dose rate is the radiation dose per unit time in the space in question, also known as the air absorbed dose rate, and is generally expressed in units of nGy/h (nano-Gray per hour) or μSv/h (microsieverts per hour). Since the air dose rate indicates the level of external exposure, from a health preservation perspective it is suitable to measure the air dose rate in a way that enables the ascertainment of the additional exposure dose. Moreover, since contamination is not all the same, numerous measurements are required in order to confirm the status of contamination as a whole, but measuring apparatus are available that are portable for the measurement of the air dose rate, and this ability to perform direct measurements in a short time frame enables relatively simple handling even when there are numerous measurements to be made. Based on the foregoing, as a general rule it is suitable to use the air dose rate when confirming the decontamination effect. However, since the air dose rate normally measures gamma rays, which easily penetrate materials, and since the radiation from radioactive materials present around the measurement site and natural radiation from the earth are also readily detected (readily influenced by background radiation), the air dose rate is not suitable for confirmation of the contamination status of the surfaces or insides of objects to be decontaminated. When narrowing down the contamination sites that contain comparatively large amounts of radioactive materials or otherwise confirming the contamination status of the surfaces of objects to be decontaminated, methods that measure beta rays are suitable as beta rays are not readily influenced by background radiation and have low penetrating power.

[*3]: This covers primarily decontamination work for regions in which the yearly dose is from 1 to 20 millisieverts. In such regions, since currently almost all of the radioactive materials discharged by the accident that are factors in contamination are deemed to be Cs-134 and Cs-137, the radioactive materials subject to decontamination are in basically radiocaesium. However, in the vicinity of the Fukushima Daiichi Nuclear Power Plant and in other regions where contamination by other radioactive materials is also possible, the decontamination work must also cover radioactive materials other than radiocaesium as necessary.

[*4]: The half-life refers to the length of time needed for a radioactive material to decay down to half of its starting size. Cs-134 halves over two years, while this takes 30 years for Cs-137.

Figure 2-67 shows an image of the decrease in the air dose rates from radiocaesium that has been separated out for Cs-134 and Cs-137. The horizontal axis indicates the number of years that have elapsed since the accident. It can be understood from the figure that even though the radiation dose (Bq) for both Cs-134 and Cs-137 were largely the same right after the accident, the air dose rate (Sv/h) for Cs-134 grew to more than twice as high as that for Cs-137. This is because the number of gamma rays emitted by Cs-134 is greater than that from Cs-137, and so as a result the impact that these have on the human body is more than twice as great. What is more, since Cs-134 decreases rapidly in the early stages, this speeds up the decline of radiocaesium on the whole.

Figure 2-67. Decline in the radiation doses of Cs-134 and Cs-137



[*5]: The concentration of radiocaesium in the soil must be measured within a detector that is shielded so as not to be influenced by background gamma rays, and for this purpose it is common to use a germanium semiconductor detector that has been calibrated using a standard radiation source with known amounts of radioactivity. It is therefore difficult to measure in a short time and directly on site, requiring more labor for measurement than what is required for the measurement of the air dose rate.

[*6]: Normally for rice fields the depth is 15 cm from the surface, while for dry fields the depth is 15 to 30 cm from the surface.

[*7]: Scraping away 3 to 5 cm of topsoil yields a reduction of radiocaesium concentration in the soil of 75 to 90% or more (*Radioactive Decontamination Technique for Farm Land Soil* (Ministry of Agriculture, Forestry and Fisheries press release dated September 14, 2011)).

[*8]: This results in a 30 to 70% reduction in the radiocaesium concentration in the soil, depending on the type of soil (*Radioactive Decontamination Technique for Farm Land Soil* (Ministry of Agriculture, Forestry and Fisheries press release dated September 14, 2011)).

[*9]: When using 30-cm reverse plowing, the surface-layer radiocaesium is placed between 15 and 20 cm beneath the surface, yielding a decreased concentration in the surface layer (*Radioactive Decontamination Technique for Farm Land Soil* (Ministry of Agriculture, Forestry and Fisheries press release dated September 14, 2011)).

[*10]: For instance, scraping away 4 cm of topsoil generates roughly 40 cubic meters of removed materials (soil) for every 10 ares.

[*11]: Based on *Radioactive Decontamination Technique for Farm Land Soil* (Ministry of Agriculture, Forestry and Fisheries press release dated September 14, 2011).

[*12]: Based on the results of decontamination verification tests and air dose rate reduction simulations conducted by the Ministry of Agriculture, Forestry and Fisheries, it was found that when the removal radius for fallen leaves, etc. from a certain measurement point exceeds about 20 m, the decontamination effect decreases. In other words, it is possible to assess the decontamination effect up to a radius of 20 m from the measurement point, which means that it is suitable to space the measurement points about 50 m apart. Also, when setting a location that is 20 m away from the outer edge of a forest as a measurement point, it is suitable to use the edge of the forest when residences, etc. are in contact with a hill behind them as it will not be possible to set measurement points 20 m away from the edge.

[*13]: In continuing monitoring since the Chernobyl nuclear power plant accident as well, it has come to light that much of the radiocaesium is deposited in the top layer of the soil and elsewhere within the forest ecosystem.

[*14]: Forests differ from farmland in that generally no fertilization management is carried out. Since fallen leaves and other sediment organic matter present are being relied upon for the supply of

nutrients, the removal of the sediment organic matter could degrade fertility. However, provided the area where this matter is to be removed is small, the fertility will be restored by nutrients supplied by newly fallen leaves and rainfall, which means that although the growth of the trees could decline temporarily, there should be no major impact on the functioning of the forest.

[*15]: *Results of the Measurement of Concentration of Radioactive Substances in Groundwater-Quality Monitoring in Fukushima (Preliminary Report)* by the Ministry of the Environment (released on June 3 and August 1, 2011) and *Results of the Measurement of Radioactive Substances Monitoring in Groundwater in Fukushima* (released on November 15, 2011) also by the Ministry of the Environment.

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(http://josen.env.go.jp/material/pdf/effects.pdf)

Comparative Survey on Radiation Dose Rates Before and After Topsoil Stripping, Burying, and Replacement in the Schoolyards of Fukushima University Attached Junior High School and Fukushima University Attached Kindergarten, Japan Atomic Energy Agency and Fukushima University (July 27, 2011)
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Part 3

Guidelines Pertaining to the Collection and Transfer of the Removed Soil

2nd Ed., 2013

環境省
Ministry of the Environment

Part 3

Guidelines Pertaining to the Collection and Transfer of Removed Soil

Guidelines Pertaining to the Collection and Transfer of the Removed Soil

Table of Contents

1. Basic Concept

These guidelines use cases and examples to explain in a concrete fashion the Ordinance of the Ministry of the Environment(Note) pertaining to standards for the collection and transfer of the removed soil provided in Article 41, Paragraph 1 of the Act on Special Measures Concerning the Handling of Environmental 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 (hereinafter the “Act on Special Measures concerning the Handling of Radioactive Pollution”).

The removed soil generated during decontamination will be transferred to facilities such as temporary storage sites by truck. When collecting and transferring the removed soil, safety measures are required to prevent radioactive materials contained in the removed soil from damaging human health and the living environment. The concrete necessary actions include 1) preventing the radioactive materials from dispersing or outflowing when the removed soil is loaded, unloaded, or transferred, and 2) preventing the public from being exposed to radiation emitted from the removed soil being collected or transferred.

Dispersion and outflow of radioactive materials as described in 1) can be prevented by putting the removed soil in containers, while radiation dose as described in 2) can be decreased by reducing the volume of the removed soil to be collected and transferred or shielding it. The nearer people are to the removed soil during transfer or the longer the period of time they are in its vicinity, the higher the exposure dose. It is therefore necessary to take measures to prevent people from recklessly coming close to the removed soil for long periods of time during transfer.

These guidelines organize and describe the requirements for collecting and transferring the removed soil as well as concrete actions to be taken in accordance with the safety measures mentioned above while also referring to[*2] the existing rules related to the transfer of radioactive materials[*1].

The guidelines do not apply to cases where decontaminators move the removed soil to facilities such as temporary storage sites as part of decontamination and other measures. For information about such cases, see Part 2: Guidelines Pertaining to Decontamination and Other Measures.

For information about necessary measures to ensure the safety of workers involved in the collection and transfer, see the Ministry of Health, Labour and Welfare’s Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and the Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6 dated June 15, 2012).

(Note): Ordinance for Enforcement of the Act on Special Measures concerning the

Handling of Radioactive Pollution (Portion relevant to the collection and transfer of the removed soil)

Article 57: The standards for the collection and transfer of the removed soil defined under the Ordinance of the Ministry of the Environment in accordance with Article 41, Paragraph 1 of the Act refer to the examples set forth in Article 23 (except Items 4C (3), 5, and 6, and Paragraph 2).

(Start of the excerpt)

Article 23

1. The collection or transfer shall be carried out as follows:
    - A. Prevent occurrence of any damage pertaining to human health or the living environment caused by the specified waste.
    - B. Take necessary measures, for example by putting the specified waste in containers, to prevent the specified waste (including wastewater resulting from the specified waste) from dispersing, outflowing, or leaking from the truck.
    - C. Take necessary measures to prevent rainwater from permeating the specified waste, for example by covering the surface of the specified waste with a water shielding sheet.
    - D. Take necessary measures to prevent adverse effects upon the conservation of the living environment from offensive odors, noise, or vibration caused in association with the collection or transfer.
    - E. Distinguish the specified waste from other refuse to eliminate the risk of the specified waste being mixed with other refuse.
2. When a facility is constructed for the collection or transfer of the specified waste, the necessary measures shall be taken so that the facility has no possibility of adversely affecting the conservation of the living environment.
3. Any truck and container to be used for the transfer shall not pose risk of dispersion or outflow of the specified waste, or leakage of offensive odors.
4. Collection and transfer of the specified waste by the use of a truck shall be conducted in the following manner:
    - A. The following matters shall be displayed on the exterior of the truck.
        - (1) Precautions to the effect that the truck is being used to collect or transfer the specified waste.
        - (2) Name of the person or entity in charge of the collection or transfer.
    - B. The information provided under A(1) and A(2) shall be indicated by easy-to-identify colors and letters. The letter size of the precautions as provided under A(1) shall be not less than 140 points as specified in JIS Z 8305, and the letter size of the precautions as provided under A(2) shall be not less than 90 points as specified in JIS Z 8305.
    - C. In accordance with the categories of entities or persons as set forth in (1) to (3) below, respective documents as defined in (1) to (3) shall be kept in the truck used.
        - (1) The national, prefectural, or municipal government and the carrier who collects or transfers the specified waste according to a contract with any of these governments shall keep a document that proves such fact and other documents that show the following information (referred to as the “necessary documents” in (2) and (3)):

(a) Name and address of the person or entity in charge of the collection or transfer, and the name of the representative if the carrier is a corporation.

(b) Type and amount of the specified waste to be collected or transferred (if such specified waste includes any specified waste specified in the following item, information to this effect shall be included).

(c) Date on which the collection or transfer has started.

(d) Names, addresses, and contacts for the site where the specified waste is loaded for collection or transfer, and of the destination where the waste is transferred to.

(e) Precautions in handling of the specified waste.

(f) Emergency measures in case of accidents.

(2) Any subcontractor who collects or transfers the specified waste according to a contract with a primary contractor who undertakes the work of collection and transfer from the national government shall keep: a document to this effect; a document proving the fact that such subcontractor is the person who has been listed as those to whom such primary contractor intends to subcontract the work of collection and transfer of the specified waste under the contract document pertaining to the agreement made between the national government and the primary contractor; and the necessary documents to show this.

(Item 4C(3) is excluded)

D. The necessary measures, for example shielding from radiation, shall be taken so that the maximum dose equivalent rate at 1 cm does not exceed 100 μSv/hour at a point 1 m from the front, rear, and both sides of the truck containing the specified waste. If the truck has an open cargo area, both vertical planes in contact with the external outline shall be used instead of both sides.

E. The tools and other materials for taking the measures specified in C(1)(f) shall be kept in the truck.

(Items 5 and 6 are excluded)

7. Records of the following information shall be prepared and retained for five years from the day on which the collection or transfer ends.

A. The type and amount of the specified waste collected or transferred (if such waste includes any specified waste specified in items 5A to 5C, information to this effect shall be included).

B. Dates on which the collection or transfer of each of the specified waste collected and transferred started and ended, the name of the person in charge of the collection or transfer, the names and addresses of the site where the waste is loaded and the destination where the waste is transferred to, and the registration or vehicle number of the truck if any truck is used for the collection or transfer of the specified waste.

(Paragraph 2 is excluded)

2. Requirements for Collection and Transfer of the Removed Soil

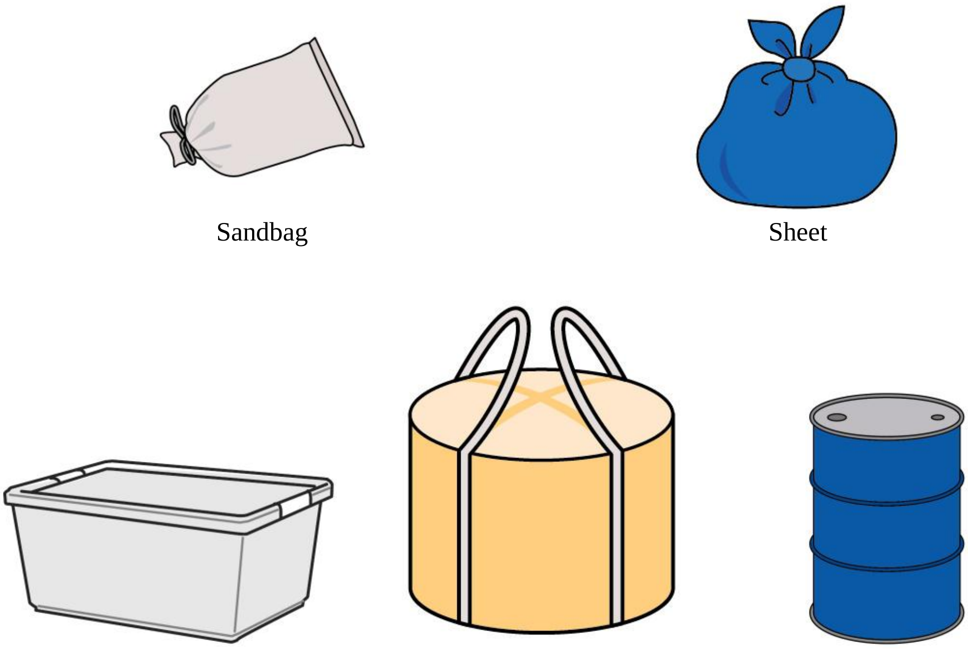
(1) Requirements for Preventing Dispersion, Outflow, and Leakage

It is possible to prevent the radioactive materials from dispersing by putting the removed soil in containers, such as sandbags, large sandbags, flexible containers, or drums (hereinafter “container”) (see Figure 3-1), or wrapping it in a sheet, or delivering it by boxcar[*3]. If the moisture content of the removed soil is high, prevent the water from outflowing or leaking by dehydrating the soil to the extent possible. When no waterproof container is used, lay a waterproof sheet or implement other necessary measures before transfer. To prevent the rainwater from penetrating the removed soil during collection and transfer, cover the soil with a waterproof sheet such as a water shielding sheet or implement other necessary measures if no waterproof container is used.

When the containers with the removed soil are being loaded or unloaded onto or from a truck, take care not to disperse or discharge the removed soil to the outside. Should any of the removed soil outflow during loading, unloading, or transfer due to the rollover or falling of a container, place a rope or tape barrier around the area to keep people out, quickly communicate with the operation site, collect the discharged removed soil, and carry out decontamination. Therefore, it is essential to carry the tools and equipment used for collecting the removed soil in the truck. Moreover, be sure to carry fire extinguishers in case of vehicle fires.

In addition, when the removed soil is being loaded onto the truck, take care not to place the soil directly on the surface of the truck. Before starting to drive the truck from an on-site or temporary storage site, wash the exterior and tires at a predefined vehicle washing area.

Figure 3-1. Examples of containers used for the collection and transfer



Sandbag

Sheet

Plastic case

Large sandbag
Flexible container

Drum

■ Storing Removed Soil in Large Sandbags and Flexible Containers

- Different varieties of large sandbags and flexible containers are shown in Table 3-1. In cases where the removed soil will be stored for a certain period of time (several years) or when said soil contains large amount of moisture, it is most effective to use highly durable containers such as cloth-type flexible containers that are weather resistant and lined with an inner pouch, running-type flexible containers, or weather resistant large sandbags lined with an inner pouch. In doing so, the properties and weight of the removed soil being stored and the storage period should be taken into consideration.

Table 3-1. Types of Large Sandbags and Flexible Containers

Type	Photograph	Characteristics
Flexible container (cloth-type)[*1]		• The assumption is that they will only be used once. • Not as good as the running-type in terms of weather resistance and waterproofness. • Some have improved weather resistance as a result of UV treatment and the like, while another type has improved waterproofness as a result of being lined with inner pouches and having an inner coating, etc.
Flexible container (running-type)[*1]		• The assumption is that they will be used by having soil repeatedly stored in and removed from them. • Outstanding weather resistance and waterproofness
Large sandbag	 *2	• Water permeable. • Some have improved weather resistance as a result of UV treatment and the like, while another type has improved waterproofness as a result of being lined with inner pouches, etc.

*1: Pursuant to JIS Z 1651.

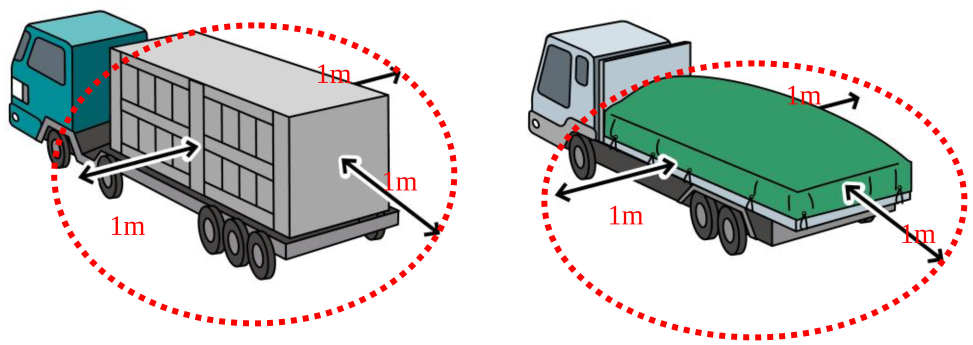
*2: The photograph shows a weather resistant container.

(2) Requirements for Radiological Protection

The intensity of the radiation varies depending on the concentration and amount of the radioactive materials. The maximum air dose rates at a position that is 1 m away from a relatively large truck when said vehicle has been loaded with removed soil and similar substances are shown in Table 3-2 for concentrations of both Cs-134 and Cs-137 (hereinafter “radiocaesium”), respectively.

Table 3-2. Examples of Trial Calculations for Air Dose Rates at a Point that Is 1 m Away from a Truck[*4]

	Mean radioactivity concentration (Bq/kg)						Maximum dose equivalent rate 1 m from the truck (vehicle transfer rules)
	3,000	8,000	30,000	150,000	500,000	1,000,000	
Air dose rate (μSv/h)	0.27	0.72	2.7	13	44	89	100



It is believed that since the truck will only be stopped at any one place for a short period of time, the exposure dose of residents and others in the vicinity around the road on which the truck is traveling will be minimal.[*5]

The Rules for Transferring Radioisotopes by Vehicle (Rule No. 33 by the Ministry of Transport, November 17, 1977) and the Rules for Transferring Nuclear Fuel Materials by Vehicle (Rule No. 72 by the Ministry of Transport, December 28, 1978; hereinafter the “Vehicle Transfer Rules”) stipulated as the standard for appropriate shielding measures during transfer specify that the maximum air dose rate shall not exceed 100 μSv/hour at a point 1 m from the exterior surface of the truck.[*6] This criterion is thought to be reasonable from a public protection point of view. Therefore, when the removed soil is being transferred, confirm that the maximum dose rate is not more than 100 μSv/hour at a point 1 m from the surface of the truck carrying the removed soil. If the dose is beyond the limit, take shielding measures or reduce the amount of the removed soil to be transferred. Since the truck must comply with the related laws, if it is modified for shielding, consult the nearest transport bureau as appropriate.

Assuming that removed soil with a radiocaesium concentration of as high as about 1 million Bq/kg is loaded on a relatively large truck, the maximum air dose rate should be less than 100 μSv/hour at a point 1 m from the truck. When using a truck to carry the removed soil generated during the decontamination of areas whose dose does not exceed 200 mSv/year,[*7] it is not necessary to measure the dose rate around the truck.

(3) Transfer Route Requirements

When selecting the route for transfer, it is necessary to avoid residential areas, shopping streets, school routes, and narrow roads to the extent possible in order to prevent any damage pertaining to human health or the living environment as well as to reduce any effects on local residents. Moreover, it is also necessary to collect and transfer the removed soil while avoiding peak times for heavy traffic and the periods when children are going to schools or kindergartens. When the removed soil is being loaded onto the truck, use low-noise heavy machinery in an effort to reduce noise and vibration.

(4) Other Requirements

When the removed soil is collected and transferred by truck, the related laws including the Road Traffic Act must be followed and it is not allowed to carry the soil together with other dangerous materials, such as explosives or flammable waste. If the removed soil is mixed with other soil or similar materials, even if they are not dangerous materials, it becomes unclear whether the material is removed soil requiring storage at the destination storage facility. If it is necessary to load the removed soil and other waste together on a truck, clearly distinguish both from each other and make certain they cannot become mixed. To ensure that the removed soil is reliably delivered to the storage facility, the person in charge of the transfer or those who are instructed by such person shall load and unload the removed soil.

To prevent people from being exposed to radiation due to them approaching recklessly during the transfer of the removed soil, put a sign on the exterior of the truck that shows the following information: precautions to the effect that the truck is being used to collect or transfer the removed soil and the name of the person or entity in charge of the collection or transfer. Secure the sign to a place where it can easily be seen in such a manner that it cannot easily be removed.

In addition, keep the following documents in the truck: a copy of the contract and the form that shows the name of the person in charge of collection or transfer, the amount of the removed soil, the dates on which the collection or transfer started, the name of the destination to be transferred to, precautions for handling, and emergency measures to take in case of an accident.

3. Concrete Actions

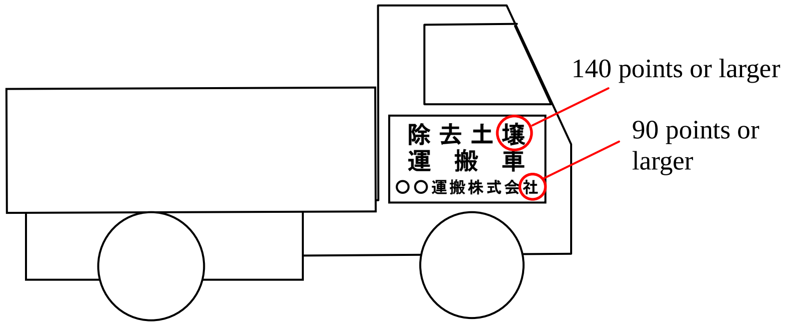
Table 3-3 shows the concrete actions to be taken in the collection and transfer of the removed soil by truck in consideration of the requirements shown in Part 2, "Section 2. Requirements for Collection and Transfer of the Removed Soil".

If the condition of the collection and transfer exceeds the upper limit of radioactivity concentration of the removed soil or the capacity of the container of respective containers, it is necessary to make the shielding calculation separately and prepare shielding in accordance with the results.

Table 3-3. Requirements for collecting and transferring the removed soil

Prevention of dispersion, outflow, and leakage	• When collecting and transferring the removed soil, put it in sandbags, flexible containers, or drums with a lid, or wrap it in sheets. No special measures are necessary if the soil is transferred by boxcar. • If the removed soil contains sharp or heavy materials such as relatively large stones, prevent the container from being torn, for example by using a container with an inner liner. • Before the transfer of removed soil with a high water content, dehydrate it to the extent possible and take measures such as putting the soil in an impermeable container or laying down a waterproof sheet. • When using a non-waterproof container, measures shall be taken such as covering the removed soil with a waterproof sheet to prevent rainwater from permeating the soil during collection and transfer. No such measures are necessary when using a truck such as a boxcar to which necessary measures are taken to prevent rainwater from penetrating the removed soil. • Visually check each container for tears or cracks and securely close the mouths of any sandbags or flexible containers to prevent the contents from being discharged if the container collapses or falls down, or a fire breaks out. Be sure to select drums that have locking mechanisms. • Before starting the truck from the on-site area in which removed soil is stored or temporary storage site for removed soil and traveling on public roads, wash the exterior and tires at a car wash if soil is adhering to the truck. If water is used for washing, check the channel for the cleaning water in advance and clean the drainage channel to ensure smooth drainage. • Keep fire extinguishers in the truck as a means of controlling any fires. Moreover, for the handling of any removed soil that has spilled out, prepare cleanup implements, bags for collection, a barrier rope or tape to indicate the area where people should keep out, a flashlight, and communication device such as a mobile phone. Note that if the carrier is a business operator, it is recommended to carry a measuring apparatus to check for radioactive contamination (calibrated[*8] scintillation survey meter).

Shielding	• When transferring the removed soil from areas where the radioactive dose rate exceeds 200 mSv/year, use a calibrated[*8] scintillation survey meter (hereinafter referred to as the "measuring apparatus") to measure the air dose rate around the truck loaded with containers.
	  • Cover the measuring apparatus with a plastic bag to avoid contamination.
	  • Hold the detecting element parallel to the ground surface during measurement.

	• Turn the power of the measuring apparatus ON and wait until the reading becomes stable. After this, take the reading five times and the average of those values will be the measured value. • Take the measurements at a point 1 m from the front, rear, and both sides of the vehicle. If it has an open cargo area, use both vertical planes in contact with the external outline instead of both sides. • Conduct measurement at the point that shows the highest air dose rate after implementing screening on each surface of the vehicle. If the point of highest air dose rate is unknown, take the measurements at the center of each face. • Make sure that the maximum of the measured values (dose equivalent rates at 1 cm) does not exceed 100 μSv/hour, and record the results. • If the maximum dose exceeds 100 μSv/hour, reduce the amount of the removed soil to be transferred or add shielding materials to the containers holding the soil or to the truck.
Loading limitations	• If loading the removed soil together with other waste on the truck, distinguish them from each other during the collection and transfer.
Signage	• Collection and transfer of the removed soil by the use of a truck shall be conducted in the following manner: A. The following matters shall be displayed on the exterior of the truck. (1) Precautions to the effect that the truck is being used to collect or transfer the removed soil. (2) Name of the person or entity in charge of the collection or transfer. B. The information provided under (1) and (2) above shall be indicated by easy-to-identify colors and letters. The letter size of the precautions as provided under (1) shall be not less than 140 points as specified in JIS Z 8305, and the letter size of the precautions as provided under (2) shall be not less than 90 points as specified in JIS Z 8305. • Avoid transfer during the night as much as possible. This is for conceivable reasons like the fact that visibility generally deteriorates at night, and so for example it would be harder to see the signage that is being displayed. **Figure 3-2. Examples of Signage** 
Other matters	• Keep documents showing the following information in the truck. (When any of the national, prefectural, and municipal governments conducts or commissions a carrier to conduct the collection or transfer of the removed soil) • As a document to prove this fact, a copy of the contract between the government and the contractor (concerned party). • Name and address of the person in charge of the collection or transfer and the name of the representative if the carrier is a corporation. • Amount of the removed soil to be collected or transferred. • Date on which collection or transfer is started. • Names, addresses, and contacts of the sites where the removed soil is loaded for the collection or transfer, and of the destination where the soil is transferred to. • Cautions pertaining to handling the removed soil.

- Emergency measures in case of an accident.

(When the carrier (primary contractor) that has been commissioned by the national government to collect or transfer the removed soil commissions such work to another carrier)

- As a document to prove this fact, a copy of the contract between the primary contractor and the carrier (subcontractor).
- A document proving the fact that such subcontractor is the person who has been listed as those to whom such primary contractor intends to subcontract the work of collection and transfer of the removed soil under the contract document pertaining to the agreement made between the national government and the primary contractor.
- Name and address of the person in charge of the collection or transfer and the name of the representative if the carrier is a corporation.
- Amount of the removed soil to be collected or transferred.
- Date on which collection or transfer is started.
- Name, address, and contact for the site where the removed soil is loaded for collection or transfer.
- Name, address, and contact for the destination to which the removed soil is transferred.
- Cautions pertaining to handling the removed soil.
- Emergency measures in case of an accident.

- The carrier shall load and unload the removed soil by itself or instruct another worker to do this.
- If there are records on the decontamination[*9], keep the document showing the air dose rate on the surface of each bag or container in the truck.
- When selecting the transfer route, avoid residential areas, shopping streets, school routes, and narrow roads to the extent possible in order to prevent damage to human health and the living environment as well as to reduce any effects on local residents. Moreover, collect and deliver the removed soil while following the legally permitted speeds and avoiding the peak times for heavy traffic and the time periods when children are going to or returning from schools or kindergartens. When the removed soil is being loaded onto the truck, use low-noise heavy machinery to reduce noise.
- Record the amount of the removed soil collected or transferred, the dates on which each arrangement for the collection or transfer of the removed soil starts and ends, the name of the person in charge of the collection or transfer, the names and addresses of the sites where the removed soil is loaded and unloaded, and the registration or vehicle number of the truck if one is used for the collection or transfer, and retain the resulting records for five years from the date when the collection or transfer ends.

Endnotes

[*1:] These rules include the following two ministerial ordinances based on the Act on the Regulation of Nuclear Source Materials, Nuclear Fuel Materials and Reactors (hereinafter the "Reactor Regulation Act"), which are the "Rules Related to the Transfer of Nuclear Fuel Materials Outside Plants or Operating Sites (hereinafter the "external transfer rules")" and "Rules for Transferring Nuclear Fuel Materials by Vehicle (hereinafter the "vehicle transfer rules")," as well as the ministerial ordinance based on the Act on the Prevention of Radiation Hazards Due to Radioisotopes, etc. (hereinafter the "Prevention Act"), which is the "Rules for Transferring Radioisotopes by Vehicle (hereinafter the "vehicle transfer rules")".

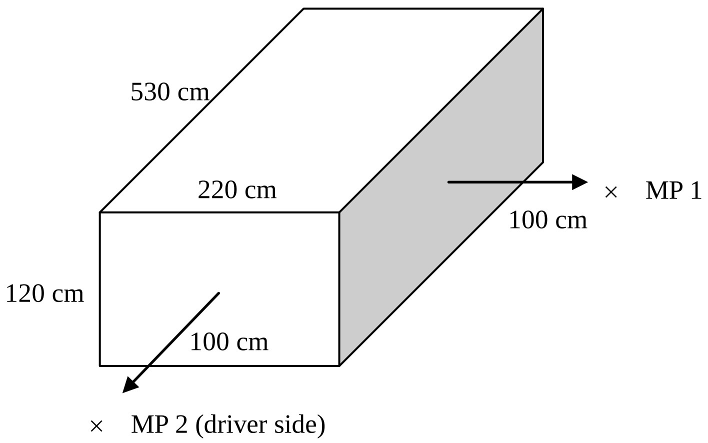
[*2:] The removed soil described in these guidelines shall meet the criteria set forth in the ministerial ordinance based on the Act on Special Measures, but the Reactor Regulation Act and the Prevention Act do not apply to it. Moreover, the external and vehicle transfer rules do not apply as they are because of the following concept: the removed soil is collected and transferred from the living environment, so even if the soil is discharged into the environment for certain unlikely reasons including traffic accidents, it may be collected appropriately. However, these guidelines have been developed in consideration of the concept of protecting the public from radiation as set forth in the existing rules.

[*3:] The external transfer rules define some types of materials to be transferred according to the maximum radioactive dose stored. The removed soil has characteristics and radiocaesium concentrations similar to the concept of material type LSA-2. Applicable materials fall under package type IP-2. The rules specify that at the design stage, it is necessary to check whether the containers used have a technical performance that meets the standard of an IP-2 package. To put it concretely, it must be proven that the container can endure any possible adverse event during transfer, such as exposure to heavy rain, falling due to mishandling when the material is loaded on or unloaded from a truck, and being left standing exposed to the hot sun. Meanwhile, the basic concept described in endnote *2 above is that the soil described in these guidelines is collected and transferred from the living environment, and even if the soil is discharged into the environment, it may be collected appropriately. Therefore, in light of this point, when collecting and transferring the removed soil, based on a concept that a container shall be selected from the perspective of preventing dispersion or outflowing mainly at the time of loading, the container is not required to meet the level of performance of an IP-2 package.

[*4:] According to the results of evaluation of the exposure dose during transfer with a 20-ton truck whose container is filled with the removed soil, the maximum dose rate is 89 μSv/hour at a point 1 m from the surface of the container if the radioactivity concentration of the soil is not more than 1 million Bq/kg and the container is not exceeding 530 cm long, 220 cm wide, and 120 cm high.

Key parameters for this analysis

- The truck without a lid has a container filled with the removed soil (the density is 2.0 g/cm^3 and the radioactivity ratio of Cs-134 and Cs-137 is 1:1).
- The container is 530 cm long, 220 cm wide, and 120 cm high (this is based on the inner dimensions of the platform), and no shielding effect by the container is considered.
- The measurement points (MP) are 100 cm from the centers of the side face (530 cm × 120 cm) and front face (220 cm × 120 cm) of the container.



Analysis results

		Mean radioactivity concentration (Bq/kg)						Maximum dose equivalent rate 1 m from the truck (vehicle transfer rules)
		3,000	8,000	30,000	150,000	500,000	1,000,000	
Air dose rate (μSv/h)	MP 1	0.27	0.72	2.7	13	44	89	100 (front, rear, and both sides of the container)
	MP 2	0.20	0.53	2.0	10	33	66	20 (front of the truck)

(In cooperation with the Japan Atomic Energy Agency)

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*5: At the 16th Review Meeting on Safety Assessment of Disaster Waste (which was held on March 4, 2013), the results of calculations were submitted that indicated that residents 3 m to 10 m in the vicinity around street corners along the transfer routes would receive an annual additional exposure dose of 0.0047 mSv to 0.040 mSv from the external exposure received from the waste loaded into the vehicles. This was based on an assumed scenario in which there were 1,050 trucks loaded with waste with a radiocaesium concentration of 50,000 Bq/kg running each month, of which half of the vehicles would be stopped at red lights for one minute.

*6: The vehicle transfer rules specify that the maximum dose equivalent rate shall not exceed 100 μSv/hour at a point 1 m from the front, back, and both sides of the container, and 20 μSv/hour at a point 1 m from the front of the truck. The latter is defined to protect the carrier from exposure to radiation. For more information about measures for protecting workers from exposure to radiation, see the Ministry of Health, Labour and Welfare’s Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and the Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6 dated June 15, 2012).

*7: The radioactivity concentration of the soil corresponding to an air dose rate of about 40 μSv/hour corresponding to 200 mSv/year is about 700,000 Bq/kg, which is given by converting the soil monitoring data shown by the Ministry of Education, Culture, Sports, Science and Technology as well as soil monitoring results including air dose rates obtained at elementary schools in Fukushima Prefecture to the value on June 1, 2011, and using the resulting regression formula “Log (Air dose rate) = 0.815 × Log (radiocaesium concentration) − 3.16” (Japan Nuclear Energy Safety Organization).

*8: See Part 1: Guidelines on the Methods for Investigation and Measurement of the Status of Environmental Pollution in Intensive Contamination Survey Areas. It is possible to not only ask a registered company to calibrate your measuring apparatus, but also to use another calibrated instrument to perform measurements at the same particular location as a way of adjusting the apparatus.

*9: See Part 2: Guidelines Pertaining to Decontamination and Other Measures, which specify that the air dose rate shall be measured at a point 1 cm from each container with the removed soil, and the results shall be recorded so that the radioactive dose distribution (range) of the removed soil generated during decontamination can be roughly determined.

Part 4

Guidelines Pertaining to the Storage of the Removed Soil

2nd Ed., 2013

環境省
Ministry of the Environment

Part 4

Guidelines Pertaining to the Storage of Removed Soil

1. Basic Concept
2. Safety Measures and Requirements Necessary for Storage
3. Concrete Examples of Storage Methods in Light of the Facility/Management Requirements

Guidelines Pertaining to the Storage of Removed Soil

Table of Contents

1. Basic Concept

(1) Outline

These guidelines use cases and examples to explain in a concrete fashion the Ordinance of the Ministry of the Environment (Note) pertaining to standards for the storage of the removed soil provided in Article 41, Paragraph 1 of the Act on Special Measures Concerning the Handling of Environmental Pollution by Radioactive Materials Discharged by the NPS Accident Associated with the Tohoku District-Off the Pacific Ocean Earthquake That Occurred on March 11, 2011 (hereinafter the “Act on Special Measures concerning the Handling of Radioactive Pollution”).

It is necessary to properly store the soil that is removed during operations to decontaminate radioactive materials discharged in association with the Fukushima Daiichi Nuclear Power Plant accident (hereinafter, “removed soil”) until its final disposal.

The following three forms are considered as the forms of storage.

1) The form in which removed soil is stored at the decontaminated sites, etc. (hereinafter “on-site storage”).
2) The form in which removed soil is stored in temporary storage sites established in each municipality or community.
3) The form in which removed soil is stored in interim storage facilities (established only in Fukushima Prefecture where a large amount of the removed soil, etc. is expected to be generated.)

For 1) on-site storage and 2) storage in temporary storage sites, these guidelines organize the facility requirements and management requirements necessary for storing the removed soil safely in accordance with its quantity and radioactivity concentration. In light of the above, these guidelines illustrate by example concrete facility specifications that are considered to meet such requirements as well as details and methods of safety management continuing beyond the end of the storage period. When storing the removed soil together with decontamination waste, see the “Waste Guidelines” (March 2013, Vol. 2).

For the prevention of the effect of radioactive materials on human health and the living environment, the following two safety measures are required:

- ○ Construction of storage facilities (hereinafter “facilities”) that can ensure safety according to the radioactivity concentration and amount of the removed soil (<u>facility design</u>).
- ○ Carrying out proper safety management of the removed soil during and after its delivery. If any trouble occur, take measures (<u>safety management</u>).

Sections below demonstrate the concepts of the facility design and safety management, two measures for storing the removed soil safely.

(2) Facility Design

There are two methods of constructing facilities that are able to ensure safety: one is a method of evaluating the safety of each facility designed,[*1] and the other is a method to evaluate the safety of a typical virtual facility to predefine the facility requirements and to require each facility to meet such requirements. In light of the current situation where prompt design and installation of many temporary storage sites are required, the latter method is basically considered reasonable but the former can also be employed.

(3) Safety Management

The removed soil is monitored to ensure that radiation and radioactive materials will not have any effect on human health or the living environment by carrying out safety management in accordance with management requirements during the period from the start of bringing in the removed soil until the time when the removed soil is taken out after the end of the period of storage. If any problems occur, safety will be promptly ensured by taking response measures such as carrying out the repair of the facility.

Another important practice of safety management is to confirm that after temporarily storing the removed soil in on-site storage or temporary storage sites, no contamination remains at sites from which the facilities have been removed.

The following section clarifies the specifications required for the facility to carry out safe storage (hereinafter “facility requirements”) and the details required for safety management (hereinafter “management requirements”).

(Note) Ordinance for Enforcement of the Act on Special Measures concerning the Handling of Radioactive Pollution (Portion relevant to Standards for Storage of the Removed Soil)

Article 58: The standards of storage provided in the Ordinance of the Ministry of the Environment for Article 41, Paragraph 1 of the Act are as follows.

1. Temporary storage of the removed soil (hereinafter simply referred to as “storage”) shall be subject to the examples specified under the provisions of Article 15 (except Items 1, 6, 8, 9, and 11-13).

(Following is the excerpt from the portion relevant to the above)

Article 15

(Item 1 is excluded)

2. The following measures shall be taken to prevent the designated waste from dispersing or outflowing from the storage space.
    - A. Take necessary measures, including placing the waste in containers or wrapping it.
    - B. If the designated waste is stored outdoors with no containers, the height of the designated waste shall not exceed the value specified in (1) or (2) below in accordance with the category provided under (1) or (2).
        - (1) If there is no structural part on which the weight of the designated waste to be stored is directly loaded on any part of the fence of the

storage space (hereinafter referred to as “direct loading part”), the height is given by defining an arbitrary point in such storage space, drawing a vertical line passing through such arbitrary point from the ground, making a plane that includes the lower end of the fence of such storage space and with a grade of 50% respective to the horizontal surface, and finding the intersection point of the line and the plane. If the lower end of the fence does not reach the ground, the intersection line of a vertical plane passing through the end and the ground surface is defined as the lower end. If two or more intersection points are found, the nearest one to the ground is selected.

(2) If the fence has a direct loading part, the height is defined in (a) and (b) shown below in accordance with the part provided under (a) and (b).

  (a) In an area within a horizontal distance of 2 m toward such storage space from the line of a vertical distance of 50 cm below the upper end of the direct loading part (or the bottom end if the fence with respect to the direct loading part is less than 50 cm high) (hereinafter referred to as the “reference line”), the height at an arbitrary point in the area is specified in (i) shown below. Note that if the fence of the storage space has a part that is not a direct loading part, the height is either (i) or (ii), whichever is lower.

    (i) Height from the ground surface to the intersection point of a vertical line passing through the arbitrary point and a horizontal plane including the reference line having the shortest horizontal distance from the vertical line.

    (ii) Height specified in (1).

  (b) In an area more than 2 m from the reference line toward the storage space, the height at an arbitrary point within such area more than 2 m is specified in (i) shown below. Note that if the fence of the storage space has a part that is not a direct loading part, the height is (i) or (ii), whichever is lower.

    (i) Height from the arbitrary point to the intersection point of a vertical line passing through the point and a plane that includes a line of horizontal distance of 2 m from the reference line toward the storage space and that forms a grade of 50% with respect to the horizontal surface. If two or more intersection points are found, the nearest one to the ground is selected.

    (ii) Height specified in (1).

3. To prevent public water areas and the groundwater from being contaminated with wastewater generated in association with the storage of the designated waste, necessary measures shall be taken, for example by covering the bottom of the storage space with a water shielding sheet.
4. To prevent rainwater or groundwater from permeating the designated waste, necessary measures shall be taken, for example by covering the

surface of the designated waste with a water shielding sheet.

5. To prevent emanation of offensive odor from the storage space, necessary measures shall be taken.

(Item 6 is excluded)

7. To prevent the designated waste from being mixed with other objects in the storage space, necessary measures shall be taken, for example by installing partitions.

(Items 8 and 9 are excluded)

10. To avoid the adverse effects of radiation, necessary measures shall be taken, for example by prohibiting people from unnecessarily entering the storage place, by constructing fences or signboards along the boundary, or by covering the surface of the designated waste with soil for shielding radiation.

(End of the excerpt)

2. The storage shall be carried out at a site surrounded by a fence (if the fence directly receives a load of the removed soil to be stored, the structural strength shall be sufficient to safely support the load). However, this shall not apply to cases where the removed soil generated in association with measures for decontamination of the soil, etc. pertaining to a special decontamination area or decontamination zone is stored on the land in which measures for decontamination of the soil, etc. were implemented.
3. The storage shall be carried out in an area where signboards meeting the following requirements are posted at a place easily visible to the public. However, this shall not apply in cases stipulated under the exceptional clause of the preceding item.
   A. The length and width shall be at least 60 cm each.
   B. The signboard shall indicate the following matters:
      (1) Precautions to the effect that the area is the place for the storage of the removed soil.
      (2) Contact details in the event of an emergency.
      (3) Maximum height specified in Article 15, Item 2B that shows examples in accordance with Item 1 if the removed soil is stored outdoors without using containers.
4. In accordance with the following matters, water quality inspections shall be conducted to check the quality of the groundwater sampled from a place where it is possible to determine the presence or absence of any impact of wastewater generated in association with the storage of the removed soil upon the water quality of the groundwater in the periphery of the place of storage. However, this shall not apply to the exceptional clause of Item 2.
   A. Before the commencement of the storage, radioactive materials discharged by the accident shall be measured and recorded according to the method defined by the Minister of the Environment as provided in Article 24, Paragraph 1, Item 3A.
   B. After the commencement of the storage, radioactive materials discharged by the accident shall be regularly measured and recorded according to the method defined by the Minister of the Environment as provided in Article 24, Paragraph 1, Item 3A.

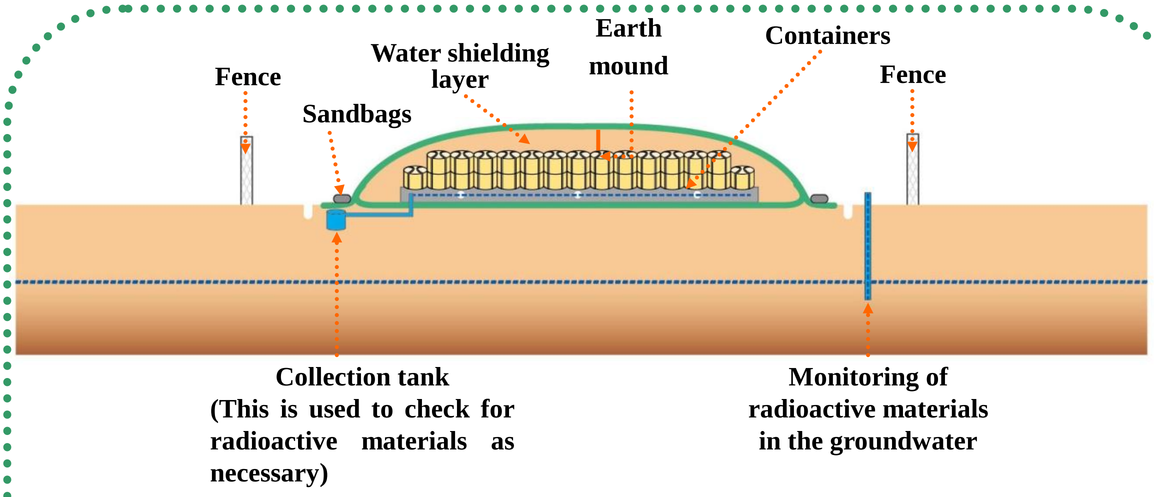
5. The radiation dose shall be regularly measured and recorded at the boundaries including the place of storage according to the method defined by the Minister of the Environment as provided in Article 15, Item 11. Note that if the exceptional clause of Item 2 applies, the radiation dose shall be measured and recorded immediately before and after the commencement of storage.
6. The record of following matters shall be made and kept until abolishment of such place of storage. Note that if the exceptional clause of Item 2 applies, the record of measurement in accordance with the exceptional clause of the preceding item shall be made, and kept until the storage of the removed soil ends.
   - A. Amount of the removed soil stored.
   - B. Dates on which the storage starts and ends for each batch of the removed soil stored, and the names and addresses of the receiving site and destination of the removed soil after storage.
   - C. Concerning delivery and receipt of the removed soil, names of the persons in charge of receiving and delivering such removed soil, and the registration or vehicle number of any truck in case where such truck was used for the transfer pertaining to the delivery.
   - D. Measurements, inspections, tests, and other measures (including water quality checks specified in Item 4 and measurements defined in the preceding item) carried out to maintain and control the storage place.

2. Safety Measures and Requirements Necessary for Storage

When storing the removed soil, proper safety measures shall be taken in accordance with the radioactivity concentration, the amount, and the storage method to reduce the dose of radiation that people receive.

In light of the concepts of related regulations,[*3] this section organizes the facility and management requirements based on the safety measures that are considered to be required to be commonly applied when storing the removed soil.[*4] (see Figures 4-1 and 4-3). For information about necessary measures for the safety of workers, see the Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and the Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6 dated June 15, 2012).

Figure 4-1: Basic diagram of the safety measures for on-site and temporary storage sites



Basic diagram of the safety measures for on-site and temporary storage sites

1) Prevent radioactive materials from dispersing, outflowing, or penetrating the ground. ● ● ● ●▶ (e.g. water shielding layer and containers)

2) Block radiation by shielding. ● ● ● ●▶ (e.g. earth mounds and sandbags)

3) Install fences to prevent intrusion. ● ● ● ●▶ (e.g. fence)

4) Monitor the air dose rate and groundwater continuously. ● ● ● ●▶ (e.g. monitoring of radioactive materials)

5) Take prompt measures when any abnormality is found.

Note: (3) and (4) apply only to temporary storage sites.

(1) Facility Requirements

Cs-134 and Cs-137 (hereinafter, “radiocaesium”) are expected to account for most of the radioactive materials contained in the removed soil generated from decontamination zones where the dose is 1 to 20 mSv/year. Therefore, the design of a facility requires taking account of the characteristics of the radiocaesium as shown below.

- Radiocaesium emits gamma rays, so, according to the concentration, it requires proper radiation shielding or securing of distance from residential areas.

- In general, adsorptive property of radiocaesium relative to soil is high, so it is expected to stay close to the topsoil and it is considered highly unlikely to be transferred by groundwater within several years.

- There is a possibility that the removed soil to which radiocaesium has become adsorbed may itself be transferred due to wind or rain.

1) Shielding and isolation

Because the removed soil emits gamma rays,[*5] measures to reduce additional exposure dose of radiation to the public are needed. Said measures include performing shielding by covering facilities with uncontaminated soil (hereinafter “covering with soil”) and properly isolating them so as to prohibit people from unnecessarily entering the storage place by means of constructing fences or signboards. Moreover, it may also be necessary to isolate the facilities from residential areas depending on the circumstances.

The facility shall be designed so that the additional exposure dose of radiation from the removed soil to which the public is exposed does not exceed 1 mSv/year even during the delivery of the removed soil, while the radiation dose outside of the site boundary of facility is almost the same as that of the surrounding environment after the delivery is completed.

To put it concretely, a site boundary shall be set up around the facility while maintaining the necessary isolation distance, and shielding materials, such as covering with soil, earth mound, sandbags, and flexible containers filled with soil, shall be installed as necessary during and after the delivery of the removed soil in order to shield the facility. If the scale of the facility is relatively large, promptly install the shielding materials on the sides and the top of the facility during the delivery of the removed soil to minimize radiation emitted from it. When using sandbags as a shielding material, distinguish them from bags containing the removed soil. If various types of removed soil with different radioactivity concentrations are stored in the same facility, it is possible to put the one with the higher radioactivity concentration in the center or on the bottom, and emplace the other type with a lower concentration in such a way as to enclose or cover the former type to reduce the radiation dose .

Table 4-1 and Table 4-2 show estimates of the required isolation distances according to the radioactivity concentration and amount of the removed soil, storage methods, and facility configuration.

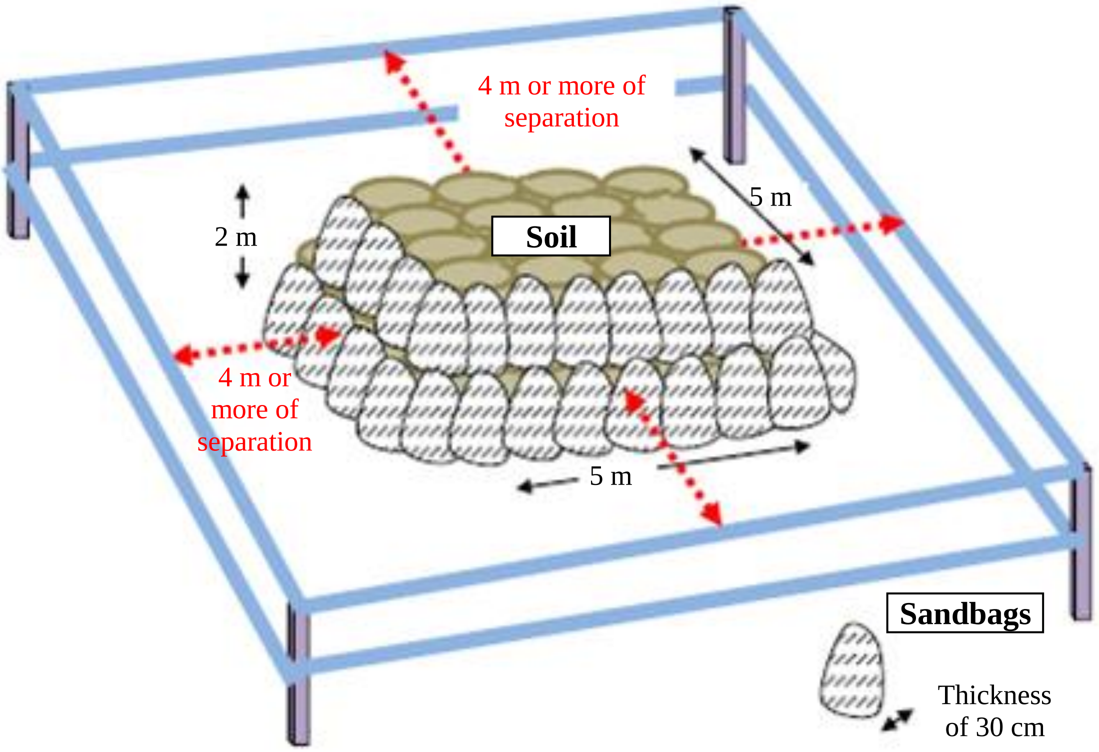
Table 4-1. Relationship between shielding measures and site boundary positions according to the radioactivity concentration of the removed soil and the configuration of the facility (additional exposure dose: 1 mSv/year or less) (above ground method) ^{*6*7} (1/2)

Storage configuration			Shielding	Mean radioactivity concentration (Cs: Bq/kg)				Capacity
				Up to 3,000	3,000 – 8,000	8,000 – 30,000	30,000 – 100,000	
				Estimates of the air dose rate in regions where removed soil has been generated^{*7}				
Length	Width	Height		App. 0.5 µSv/h/or less	App. 0.5 – 1 µSv/h	App. 1 – 3 µSv/h	App. 3 µSv/h or higher	
2 m ×	2 m ×	1 m	No shielding	1 m	2 m	4 m	8 m	4 m^3
			Successive lateral shielding	1 m	1 m	4 m	4 m	
			After covering with soil of 30 cm in thickness	0 m	0 m	1 m	2 m	
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	1 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	
5 m ×	5 m ×	2 m	No shielding	4 m	6 m	10 m	20 m	50 m^3
			Successive lateral shielding	1 m	2 m	4 m	8 m	
			After covering with soil of 30 cm in thickness	0 m	0 m	1 m	4 m	
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	1 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	
10 m ×	10 m ×	1 m	Successive lateral shielding	1 m	4 m	6 m	10 m	100 m^3
			After covering with soil of 30 cm in thickness	0 m	0 m	1 m	4 m	
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	1 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	
20 m ×	20 m ×	2 m	Successive lateral shielding	1 m	4 m	8 m	20 m	800 m^3
			Successive lateral shielding, with an area without covering with soil not exceeding 10 m × 10 m	1 m	4 m	6 m	10 m	
			After covering with soil of 30 cm in thickness	0 m	0 m	1 m	6 m	
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	1 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	
20 m ×	20 m ×	4 m	After covering with soil of 30 cm in thickness	0 m	0 m	2 m	10 m	1,600 m^3
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	4 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	
50 m ×	50 m ×	2 m	Successive lateral shielding	2 m	4 m	20 m	-	5,000 m^3
			Successive lateral shielding, with an area without covering with soil not exceeding 20 m × 20 m	1 m	4 m	8 m	20 m	
			Successive lateral shielding, with an area without covering with soil not exceeding 10 m × 10 m	1 m	4 m	6 m	10 m	
			After covering with soil of 30 cm in thickness	0 m	0 m	1 m	6 m	
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	1 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	
50 m ×	50 m ×	4 m	After covering with soil of 30 cm in thickness	0 m	0 m	2 m	20 m	10,000 m^3
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	4 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	
100 m ×	100 m ×	2 m	Successive lateral shielding	2 m	6 m	-	-	20,000 m^3
			Successive lateral shielding, with an area without covering with soil not exceeding 20 m × 20 m	1 m	4 m	8 m	20 m	
			Successive lateral shielding, with an area without covering with soil not exceeding 10 m × 10 m	1 m	4 m	6 m	10 m	
			After covering with soil of 30 cm in thickness	0 m	0 m	2 m	8 m	
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	1 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	

Table 4-1. Relationship between shielding measures and site boundary positions according to the radioactivity concentration of the removed soil and the configuration of the facility (additional exposure dose: 1 mSv/year or less) [above ground method] [*6*7] (2/2)

Storage configuration			Shielding	Mean radioactivity concentration (Cs: Bq/kg)				Capacity
				Up to 3,000	3,000 – 8,000	8,000 – 30,000	30,000 – 100,000	
				Estimates of the air dose rate in regions where removed soil has been generated[*7]				
Length	Width	Height		App. 0.5 µSv/h/or less	App. 0.5 – 1 µSv/h	App. 1 – 3 µSv/h	App. 3 µSv/h or higher	
100 m ×	100 m ×	2 m	After covering with soil of 30 cm in thickness	0 m	0 m	2 m	20 m	40,000 m^3
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	4 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	
200 m ×	200 m ×	2 m	Successive lateral shielding	2 m	10 m	-	-	80,000 m^3
			Successive lateral shielding, with an area without covering with soil not exceeding 20 m × 20 m	1 m	4 m	8 m	20 m	
			Successive lateral shielding, with an area without covering with soil not exceeding 10 m × 10 m	1 m	4 m	6 m	10 m	
			After covering with soil of 30 cm in thickness	0 m	0 m	2 m	10 m	
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	1 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	

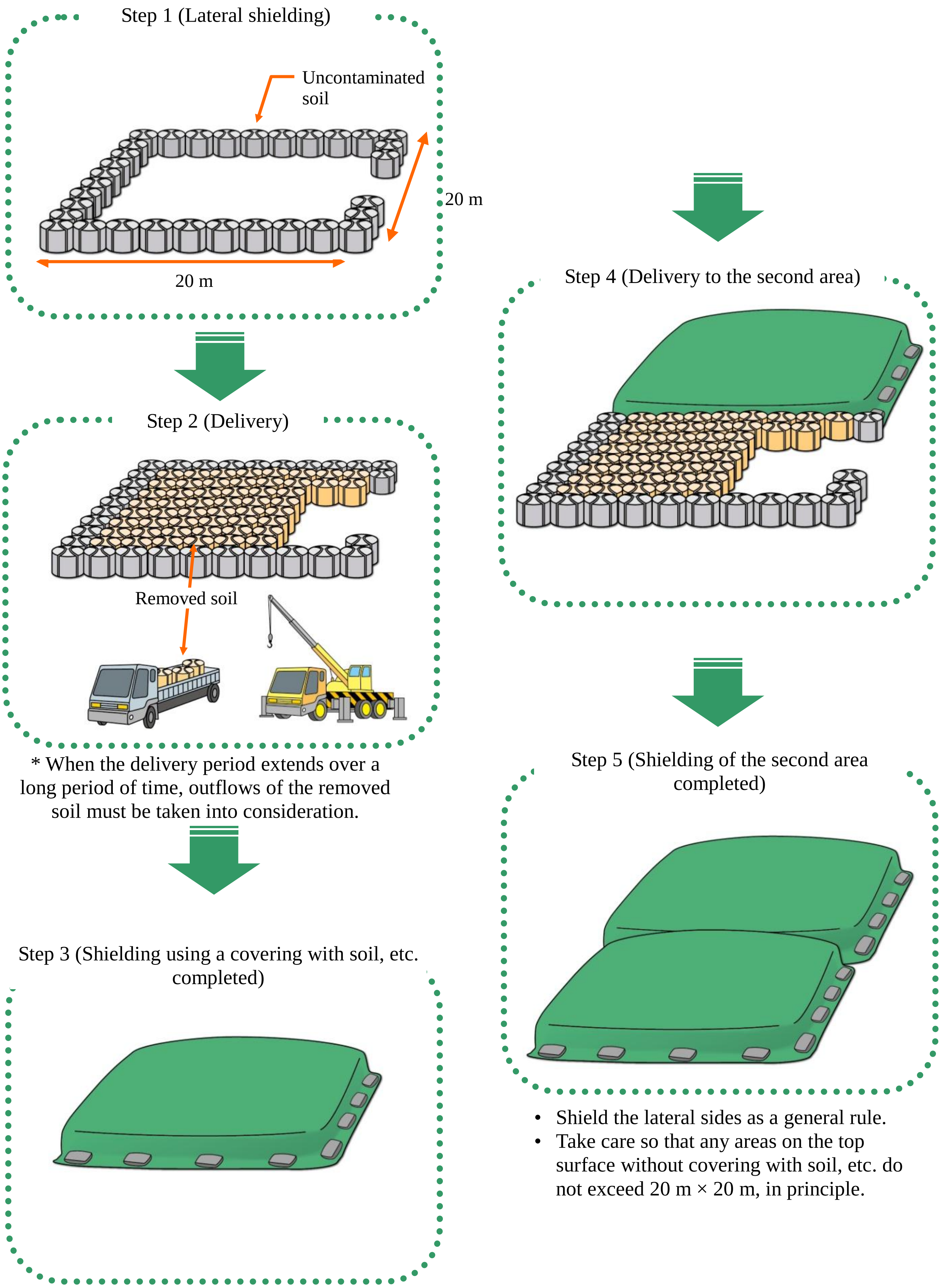
Figure 4-2. Example of the relationship between shielding measures via sandbags and site boundary positions



When shielding the lateral sides of removed soil of 20,000 Bq/kg
(5 m long × 5 m wide × 2 m tall) with sandbags (30 cm)

Table 4-2. Relationship between shielding measures and site boundary positions according to the radioactivity concentration of the removed soil and the configuration of the facility (additional exposure dose: 1 mSv/year or less) [underground method] [*6*7]

Storage configuration			Shielding	Mean radioactivity concentration (Cs: Bq/kg)				Capacity
				Up to 3,000	3,000 – 8,000	8,000 – 30,000	30,000 – 100,000	
				Estimates of the air dose rate in regions where removed soil has been generated[*7]				
Length	Width	Height		App. 0.5 µSv/h/or less	App. 0.5 – 1 µSv/h	App. 1 – 3 µSv/h	App. 3 µSv/h or higher	
2 m ×	2 m ×	1 m	No shielding	1 m	2 m	4 m	4 m	4 m^3
			After covering with soil of 30 cm in thickness	0 m	0 m	1 m	1 m	
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	1 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	
10 m ×	10 m ×	1 m	No shielding	1 m	4 m	6 m	10 m	100 m^3
			After covering with soil of 30 cm in thickness	0 m	0 m	1 m	1 m	
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	1 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	
20 m ×	20 m ×	2 m	No shielding	1 m	4 m	8 m	20 m	800 m^3
			After covering with soil of 30 cm in thickness	0 m	0 m	1 m	1 m	
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	1 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	
50 m ×	50 m ×	10 m	No shielding	2 m	4 m	20 m	-	25,000 m^3
			With an area without covering with soil not exceeding 20 m × 20 m	1 m	4 m	8 m	20 m	
			With an area without covering with soil not exceeding 10 m × 10 m	1 m	4 m	6 m	10 m	
			After covering with soil of 30 cm in thickness	0 m	0 m	1 m	1 m	
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	1 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	
100 m ×	100 m ×	10 m	No shielding	2 m	6 m	-	-	100,000 m^3
			With an area without covering with soil not exceeding 20 m × 20 m	1 m	4 m	8 m	20 m	
			With an area without covering with soil not exceeding 10 m × 10 m	1 m	4 m	6 m	10 m	
			After covering with soil of 30 cm in thickness	0 m	0 m	1 m	2 m	
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	1 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	
200 m ×	200 m ×	10 m	No shielding	2 m	10 m	-	-	400,000 m^3
			With an area without covering with soil not exceeding 20 m × 20 m	1 m	4 m	8 m	20 m	
			With an area without covering with soil not exceeding 10 m × 10 m	1 m	4 m	6 m	10 m	
			After covering with soil of 30 cm in thickness	0 m	0 m	1 m	2 m	
			After covering with soil of 40 cm in thickness	0 m	0 m	0 m	1 m	
			After covering with soil of 50 cm in thickness	0 m	0 m	0 m	0 m	



* When the delivery period extends over a long period of time, outflows of the removed soil must be taken into consideration.

- Shield the lateral sides as a general rule.
- Take care so that any areas on the top surface without covering with soil, etc. do not exceed 20 m × 20 m, in principle.

Figure 4-3: Diagram of the delivery to a large-scale temporary storage site (with lateral shielding)

2) Prevention of dispersion of the removed soil

To prevent radioactive materials from dispersing during the delivery of the removed soil to the facility, it is required to put it into bags whose opening can be closed or in drums with a lid, or wrap it in a dustproof sheet before delivery. Using a highly durable container[*8] makes it possible to prevent dispersion when the removed soil is taken out of the facility after the period of storage ends.

After the delivery of the removed soil, it is required to prevent any dispersion of the removed soil by covering with a sheet or with soil.

3) Prevention of penetration of rainwater, etc.

If rainwater penetrates the removed soil, there is a possibility of an outflow of radioactive materials. Accordingly, during and after the delivery of the soil, cover it with a waterproof sheet such as a water shielding sheet to avoid exposure to the rain. Take measures to ensure that the cover will not be lifted or turned over by a typhoon or heavy rain, and, if possible, raise the center slightly to prevent the rainwater from forming stagnant pools on the surface. If the removed soil is stored in waterproof containers or kept in a facility with a roof, such special measures are unnecessary.

If using a waterproof sheet or container without taking measures to shield them from UV light, such as by covering with soil or protection mats, it is necessary to replace or repair them as necessary if any deteriorated parts are identified, while taking the weatherability[*9] into consideration. From the viewpoint of protecting the waterproof sheet or the like, it is effective to cover the waterproof sheet, etc. with soil, etc.

In addition, when a water shielding sheet, etc. is spread to prevent the rainwater from accumulating on the bottom surface of the removed soil, arrange the soil to be placed on a position higher than the water shielding sheet in order to provide good drainage, and install a drainage facility to drain it as necessary during the delivery. Note that none of these measures are necessary when the removed soil is stored in waterproof containers or kept in a facility with a roof.

As a rule, it is necessary to prevent groundwater including spring water from permeating the removed soil by constructing any underground facility on a position higher than the water table.

■ Storing Removed Soil in Large Sandbags and Flexible Containers

- Types of large sandbags and flexible containers are shown in Table 4-3. In cases where the removed soil will be stored for a certain period of time (several years) or when the removed soil to be stored has a high water content, it is effective to use highly durable containers such as cloth-type flexible containers that are weather resistant and lined with an inner pouch, running-type flexible containers, or weather resistant large sandbags lined with an inner pouch. In doing so, the properties and weight of the removed soil being stored and the storage period should be taken into consideration.
- In cases where removed soil with high water content is stored in large sandbags, flexible containers, and other such containers, as well as cases where a large amount of water content such as snow is mixed with the removed soil, etc., water may soak out under the containers' own weight if they are piled on top of one another. Therefore, storing the containers by piling them up must be avoided to the extent possible.
- In cases where the removed soil, etc. is stored in large sandbags, flexible containers, and other containers that are piled up, an appropriate height for piling up the containers must be established from the viewpoint of preventing collapses and breakage.

Table 4-3 Types of large sandbags and flexible containers

Type	Photograph	Characteristics
Flexible container (cloth-type)*1		• The assumption is that they will only be used once. • Not as good as the running-type in terms of weather resistance and waterproofness. • Some have improved weather resistance as a result of UV treatment and the like, while another type has improved waterproofness as a result of being lined with inner pouches and having an inner coating, etc.
Flexible container (running-type)*1		• The assumption is that they will be used by having soil repeatedly stored in and removed from them. • Outstanding weather resistance and waterproofness
Large sandbag	 *2	• Water permeable. • Some have improved weather resistance as a result of UV treatment and the like, while another type has improved waterproofness as a result of being lined with inner pouches, etc.

*1: Pursuant to JIS Z 1651.

*2: The photograph shows a weather resistant container.

4) Prevention of outflow of the removed soil and radioactive materials

It is required to take measures to prevent soil, public water areas, and the groundwater from being contaminated due to an outflow of wastewater containing the removed soil and radioactive materials. It is known that radiocaesium generally has high adsorption to soil, so it is thought that radiocaesium will not easily transfer through the soil. However, when the removed soil is kept in an on-site or temporary storage site for several years, a water shielding layer should be placed, for example, by spreading a weatherproof or waterproof sheet such as a water shielding sheet over the bottom in order to prevent the radiocaesium from outflowing. Water shielding sheets come in different types with thicknesses of 0.5 mm, 1.0 mm, 1.5 mm, and so on. The appropriate type of water shielding sheet and thickness shall be selected by taking into consideration factors like the conditions at the storage site and the envisioned storage period. If a water shielding sheet, etc. is laid, place a protective layer by putting soil between the removed soil and the water shielding sheet as necessary to prevent the sheet from breaking apart during the delivery. If heavy machinery is used, provide curing by such means as laying protective steel plates as necessary. In this case, mixing clay or zeolite that easily absorbs radiocaesium with the protective layer makes it possible to better restrain the movement of the radioactive substances. When the removed soil is stored in containers that can maintain their waterproof capabilities over the period of storage, it is not necessary to place a water shielding layer such as laying of a waterproof sheet.

There is the risk that contaminated water will emerge and flow out as a result of a large amount of water content such as snow mixed with the removed soil, and so it is necessary to reduce the water content within the removed soil as much as possible.

5) Prevention of effect from substances other than radioactive materials

It is assumed that removed soil generated by scraping away of the soil where vegetation grows may contain organic substances including roots of vegetation. Because grass cutting is mandatory before scraping away of soil (see “Part 2: Guidelines Pertaining to Decontamination and Other Measures”), the removed soil is expected to only contain a small amount of roots and weeds. Accordingly, it is not necessary to take any special measures against the generation of combustible and corrosive gases, a rise in the temperature, or the emission of offensive odors due to decaying of organic matter. However, if the facility has a structure that does not allow for the discharge of gases due to its airtightness, or the mixtures have a high proportion of organic matter and this is unavoidable for certain reasons, take any necessary measures such as gas venting to prevent generation of foul odors or fires.

What is more, when piling up containers containing the removed soil, attention shall be paid when setting out containers that may possibly contain vegetation in order to avoid subsidence and collapses as a result of the decay of such materials.

For information about these measures including gas venting, see the “Waste Guidelines” (March 2013, Vol. 2).

6) Resistance to earthquakes, etc.

Any facility that is expected to have functions such as shielding and containment is required to have a design that will not lose such functions in the event of expected earthquakes, and established countermeasures are required for the event of collapse of the facility. In particular, if containers containing the removed soil are piled up outdoors for the purpose of storage, it is required to ensure that the side slope is gradual. For concrete information, see the provisions of Article 15, Item 2B of the Ordinance for Enforcement of the Act on Special Measures concerning the Handling of Radioactive Pollution among the standards for storage as shown in "1. (3) Safety Management" (Note).

7) Other necessary measures

To control radioactive materials properly, store the removed soil separately from any other waste to eliminate the risk of cross-contamination.

(2) Management Requirements

1) Restriction of entry

Prevention of radiation hazards requires certain measures. Firstly, define a point where the additional exposure dose from the removed soil does not exceed 1 mSv/year during the delivery as the boundary of the temporary storage site.

Secondly, for temporary storage sites construct a fence along the site boundary to prevent people from unnecessarily entering the facility. Thirdly, install signboards that give precautions to the effect that the site is the place for storage of the removed soil and contact details in the event of an emergency.

In the case of on-site storage at home or at the site of a school, the installation of fences and signboards are not mandatory. In addition, in cases where there are risks such as unspecified people coming and going and land being dug up at the site of on-site storage, it is preferable to inform people to the effect that storage is being carried out.

2) Monitoring the radiation dose and carrying out repairs

To ensure that the removed soil is stored safely during and after delivery, regularly monitor the air dose rate along the site boundary (see 1)), check that the additional exposure dose due to removed soil does not exceed 1 mSv/year during the delivery and that it is of similar level as that of the surrounding environment after delivery, and record the results. Furthermore, visual inspection to confirm that there are no abnormalities with its external appearance shall be conducted to ensure that the facility has not been pierced by bamboo or other plants and that it has not suffered damage from animals.

As for on-site storage to be conducted at decontamination sites, monitor and record the additional dose when the on-site storage starts after the delivery of removed soil. As for storage at a temporary storage site, take these measurements at least once a week[*10] and conduct measurements whenever heavy rain or a typhoon affects the site. To measure the air dose rate, use a scintillation survey meter in principle. For information about how to handle the meter and take the measurements, see "Part 1: Guidelines on the Methods for Investigation and Measurement of the Status of Environmental Pollution in Intensive Contamination Survey Areas."

Moreover, to monitor any outflow of radioactive materials from the facility, conduct monitoring of the groundwater around the facility at an appropriate frequency and record the results. If necessary, also consider monitoring of the leachate from the bottom of the facility.

As a concrete groundwater monitoring method, install a sampling pipe on the periphery of the facility to sample the groundwater from a place where it is possible to determine the presence or absence of any effect on the quality of the groundwater , and conduct quality inspections (measure the concentration of radiocaesium, etc. in the groundwater) of the groundwater sampled at least once a month after the start of the delivery of the removed soil.

In addition, while not being a standard for storage, when monitoring leachate, insert a collection/drainage pipe into the protective layer at the bottom of the facility in order to collect the leachate and to check whether water has accumulated in the tank at least once a month. If water has accumulated, sample the leachate to measure the radiocaesium concentration in the sampled leachate. For information about how to take the measurements, see the "Waste Guidelines" (March 2013, Vol. 2).

Compare the air dose rate and the radiocaesium concentration of the groundwater measured in the temporary storage site after commencement of the delivery (the storage) of the removed soil with a variation range of the air dose rate and radioactivity concentration measured before commencement of the delivery (storage) (hereinafter "background values"). As an indication of the upper limit of variation, the measured value[*11] shall be basically such that the "Mean background value + (3 × Standard deviation)." Therefore, it is important to assess the background value before the removed soil is delivered to the temporary storage site. In particular, it is known that the air dose rate varies depending on measurement points and that radiation dose from naturally-occurring radioactive materials increases during rain. Accordingly, to assess the background value accurately, acquire the data at many points on various days including rainy ones.

If it is difficult to acquire sufficient number of background values, determine the variation range by subtracting the minimum value from the maximum value of the background value acquired.

If the measured value is within the variation range of the background value, this means that the removed soil has been delivered and is stored safely. If any measured value exceeding the variation range is observed, proceed to identify the possible cause. If it is found that the temporary storage site is the cause of such problem, take any necessary measures, such as adding shielding materials, repairing the facility, or collecting the removed soil.

For the storage to be conducted at a place such as decontamination sites where the volume of the removed soil to be stored is relatively less than that of a temporary storage site, measure and check the air dose rate once after each delivery and removal of the removed soil. It is not necessary to monitor the groundwater during the period of storage.

Table 4-4. Monitoring items for storage facilities

Category	Monitoring item	Notes
Site boundary	Air dose rate	
External appearance	Visual inspection	
Groundwater around the facility	Concentration of radiocaesium	- Samples of the groundwater should be taken when there is no turbidity
Leachate	Concentration of radiocaesium	- Performed as needed

■ Radioactivity concentration in groundwater

With the periodic monitoring* of the groundwater at temporary storage sites set up through the model demonstration project being carried out by the Cabinet Office, the measurement results for concentrations of radiocaesium came in at under the detection limits.

*Summary of monitoring by the Cabinet Office’s model demonstration project

No. of temporary storage sites	14 locations in 11 municipalities
Observation period	March 2012 – March 2013
Observation frequency	About once a month
Measurement results	All of the locations were either under the detection limit or under 10 Bq/L *Radiocaesium was detected in three of the data points, but this was detected as a result of performing measurements on turbid water. It was reported that there is the possibility that topsoil or surface water was mixed with the groundwater, and that it was the intermixed materials that were detected.

3) <u>Keeping records</u>

The entities that store the removed soil shall record the items listed in Table 4-5 and retain it until use of the facility is discontinued.

The records have an important role in ensuring traceability when the removed soil is transferred to and kept in temporary storage sites or interim storage facilities. It is also possible to record the air dose rate on the surface of each container by keeping such record during decontamination, collection, and transfer. For information about how to record the air dose rate on the surface, see “Part 1: Guidelines on the Methods for Investigation and Measurement of the Status of Environmental Pollution in Intensive Contamination Survey Areas” and “Part 3: Guidelines Pertaining to the Collection and Transfer of Removed Soil.”

Table 4-5. Items to record pertaining to the storage of removed soil

Category	Items
Basic matters	• Amount of removed soil stored • Dates on which the storage starts for each batch of removed soil stored • Dates on which the storage ends for each batch of removed soil stored • Names and addresses of the receiving sites* • Names and addresses of the destinations of the removed soil after the storage
Information on delivery and receipt	• Names of the persons in charge of delivering the removed soil • Names of the persons in charge of receiving the removed soil • Registration or vehicle number of any trucks • (In case where such trucks were used for the transfer pertaining to the delivery)
Maintenance and control of storage sites	• Details of the measurement, inspection, and testing carried out to maintain and control the place for storage
Measurement of the air dose rate	• Position of the site boundary (fence) and position of the measurement points • Dates measured • Measuring methods • Measuring apparatuses used for the measurements • Measurement results (background and air dose rate along the site boundary) • Name of the inspector
Radioactive concentration of the removed soil, etc.	• Air dose rate on the surface of each container (On the surface of each container with the removed soil, or each group of multiple containers)

* The receiving sites indicate the locations prior to when the removed soil is transferred to the storage sites. They essentially correspond to the sites where the decontamination is carried out.

4) Confirmation that the vacant site is not contaminated

After the removed soil is collected and taken out after the period of storage ends, confirm that contamination does not remain at the vacant sites of the facilities. To put it concretely, sample the earth on which the removed soil had been placed, measure the concentration of radiocaesium contained in the sample, and check that the measured value is of similar level as that of concentration of radioactive materials in the soil, etc. before the delivery of the removed soil. In the case of on-site storage, the air dose rate may be measured instead.

3. Concrete Examples of Storage Methods in Light of the Facility/Management Requirements

This section provides concrete examples of details of the on-site and temporary storage specifications and safety management in light of the facility and management requirements described in “2. Safety Measures and Requirements Necessary for Storage.”

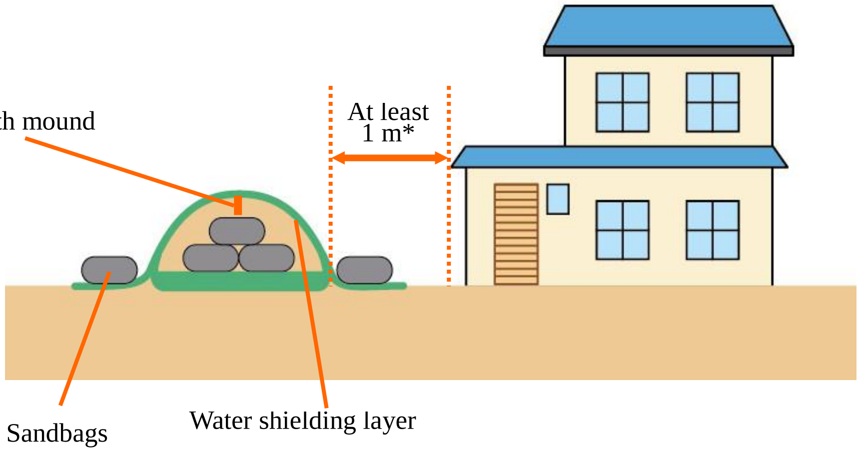
In these examples, the position of the site boundary takes into account the isolation distance corresponding to a mean radioactivity concentration of 8,000 Bq/kg as shown in Table 4-1. When setting up an isolation distance, select an appropriate distance from Table 4-1 in consideration of the radioactivity concentration of the removed soil and the scale of the facility.

When delivering the removed soil to the temporary storage site, conduct prescribed shielding and maintain an isolation distance so that the additional exposure dose does not exceed 1 mSv/year at the site boundary during delivery. In addition, strive to make sure that the radiation dose on the boundary (setting position of fence) is of similar level as that of the surrounding environment by delivering the removed soil while conducting shielding, putting removed soil with higher radioactivity concentration in the center or at the bottom of the facility, and surrounding it with removed soil with lower radioactivity concentration to reduce the radiation dose during delivery.

If the storage conditions of the facility exceed the upper limit of the radioactivity concentration of the removed soil or the facility size as shown in Table 4-1, it is required to design a facility that is deemed to be able to secure safety by conducting a safety evaluation in light of details of individual facility specifications and safety management.

On-site storage - 1): Above ground

Figure 4-4: Mound (2 × 2 × 1 m) of removed soil generated during the decontamination of an area whose air dose rate is about 1 μSv/hour



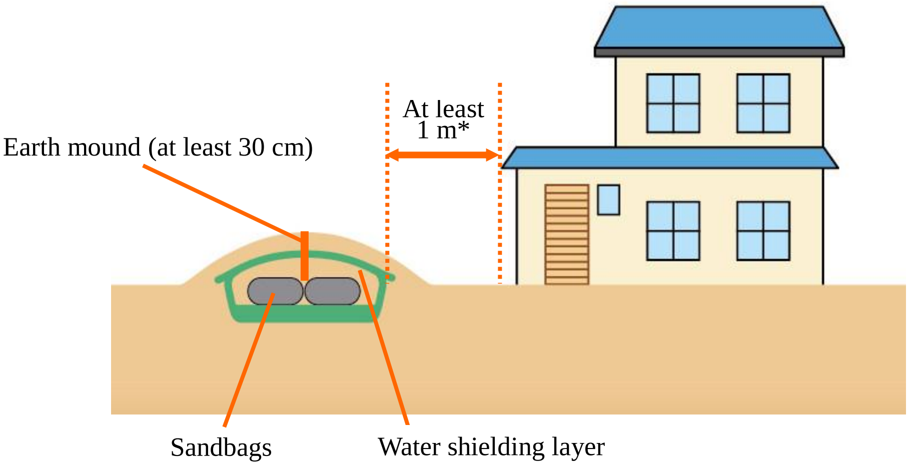
* Shielding distance(0) m if the covering with soil exceeds 30 cm.

Table 4-6. Examples of facility specifications and safety management details

Shielding and isolation	• After the delivery of the removed soil, shield it by putting sandbags containing uncontaminated soil on the sides and top or cover it with soil. The sandbags or covering with soil shall be at least 30 cm thick. In this case, it is not necessary to maintain an isolation distance from residential buildings such as private houses. • If the top surface is not shielded, place the removed soil at least 1 m away from residence buildings such as private houses.
Prevention of dispersion	• To prevent any radioactive material from dispersing, put the removed soil in sandbags or flexible containers whose openings can be closed, and close them securely. If the removed soil is not put into any containers such as sandbags, wrap it in a dustproof sheet.
Prevention of penetration of rainwater, etc.	• Cover the removed soil with a waterproof sheet and fix the ends so that the sheet cannot be blown by the wind. • Raise the center to prevent rainwater from accumulating on the surface of the sheet.
Prevention of outflow	• Spread a waterproof sheet over areas where the removed soil is placed. No special measures are necessary if the removed soil is stored in waterproof flexible containers, etc. • When placing the removed soil, take care not to damage the waterproof sheet, etc.
Monitoring	• After completing covering with soil, etc. for the removed soil, use a calibrated scintillation survey meter to measure the air dose rate at places 1 m apart from four spots on the outer perimeter of the area where the removed soil has been placed and at 1 m height (four spots), and record the results. • If it is impossible to conduct such measurements at a place 1 m apart from the outer perimeter, select other measurement points. • Record the measurement points by drawing a rough sketch to identify the place of measurement.
Record keeping	• Keep the records of measurement results of the air dose rates until the removed soil is taken out.

On-site storage - 2): Underground

Figure 4-5: Pit (2 × 2 × 0.5 m) of removed soil generated during the decontamination of an area whose air dose rate is about 1 μSv/hour



* Shielding distance(0) m if the covering with soil exceeds 30 cm in thickness.

Table 4-7. Examples of facility specifications and safety management details

Shielding and isolation	• After the delivery of the removed soil, shield it by putting sandbags containing uncontaminated soil on the top or cover it with soil. The sandbag or covering with soil shall be at least 30 cm thick. In this case, it is not necessary to maintain an isolation distance from residential buildings, such as private houses. • If the top surface is not shielded, place the removed soil at least 1 m away from residential buildings such as private houses.
Prevention of dispersion	• To prevent any radioactive material from dispersing, put the removed soil in sandbags or flexible containers whose openings can be closed, and close them securely. If the removed soil is not put into any containers such as sandbags, wrap it in a dustproof sheet.
Prevention of penetration of rainwater, etc.	• Cover the removed soil with a waterproof sheet and fix the ends so that the sheet cannot be blown by the wind as needed. For fixing, sandbags and blocks can be used. • Raise the center to prevent rainwater from accumulating on the surface of the sheet as needed.
Prevention of outflow	• Spread a waterproof sheet over areas where the removed soil is placed. No special measures are necessary if the removed soil is stored in waterproof flexible containers, etc. • When placing the removed soil, take care not to damage the waterproof sheet, etc.
Monitoring	• After completing covering with soil, etc. for the removed soil, use a calibrated scintillation survey meter to measure the air dose rate at the center (one spot) and places 1 m apart from four spots on the outer perimeter of the area where the removed soil has been placed and at a height of 1 m (four spots), and record the results. • If it is impossible to conduct such measurements at a place 1 m apart from the outer perimeter, select other measurement points. • Record the measurement points by drawing a rough sketch to identify the place of measurement.
Record keeping	• Keep the records of measurement results of the air dose rates until the removed soil is taken out.

Figure 4-6: Example of on-site storage (underground)

1) Delivery is complete.

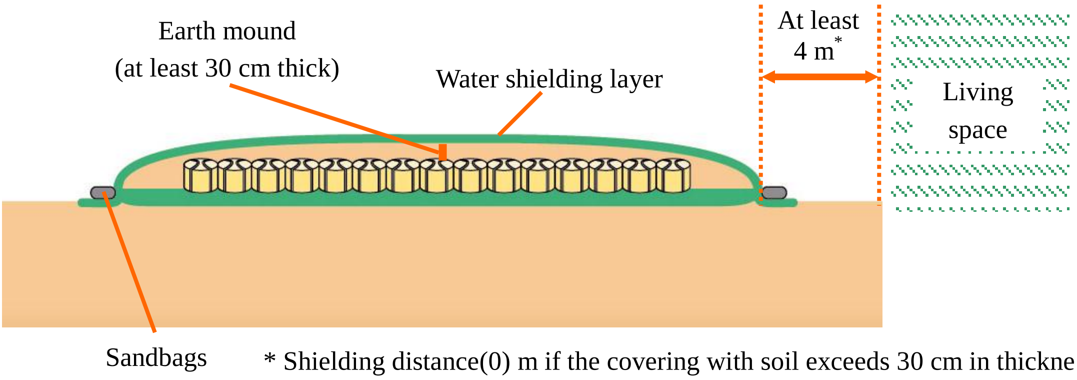
Photo courtesy of: Fukushima City

2) The entirety of the removed soil is covered with a sheet.

Photo courtesy of: Fukushima City

On-site storage - 3): Above ground

Figure 4-7: Mound (20 × 20 × 1 m) of removed soil generated during the decontamination of an area whose air dose rate is about 1 μSv/hour



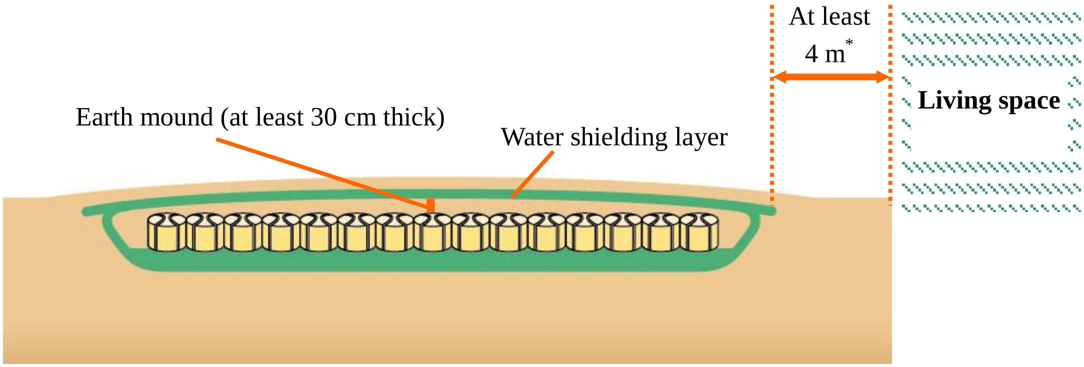
* Shielding distance(0) m if the covering with soil exceeds 30 cm in thickness.

Table 4-8. Examples of facility specifications and safety management details

Shielding and isolation	• After the delivery of the removed soil, shield it by putting sandbags containing uncontaminated soil on its sides and top or cover it with soil. The sandbag or covering with soil shall be at least 30 cm thick. In such cases it is not necessary to maintain a distance from residence buildings such as private houses.
Prevention of dispersion	• To prevent any radioactive material from dispersing, put the removed soil in sandbags or flexible containers whose openings can be closed, and close them securely. If the removed soil is not put into any containers such as sandbags, wrap it in a dustproof sheet.
Prevention of penetration of rainwater, etc.	• Cover the removed soil with a waterproof sheet and fix the ends so that the sheet cannot be blown by the wind. • Raise the center to prevent rainwater from accumulating on the surface of the sheet.
Prevention of outflow	• Spread a waterproof sheet over areas where the removed soil is placed. No special measures are necessary if the removed soil is stored in waterproof flexible containers, etc. • When placing the removed soil, take care not to damage the waterproof sheet, etc.
Monitoring	• After completing covering with soil, etc. for the removed soil, use a calibrated scintillation survey meter to measure the air dose rate at places 4 m apart from four spots on the outer perimeter of the area where the removed soil has been placed and at a height of 1 m (four spots), and record the results. • If it is impossible to conduct such measurements at a place 4 m apart from the outer perimeter, select other measurement points. • Record the measurement points by drawing a rough sketch to identify the place of measurement.
Record keeping	• Keep the records of measurement results of the air dose rates until the removed soil is taken out.

On-site storage - 4): Underground

Figure 4-8: Pit (20 × 20 × 1 m) of removed soil generated during the decontamination of an area whose air dose rate is about 1 μSv/hour



* Shielding distance(0) m if the covering with soil exceeds 30 cm in thickness.

Table 4-9. Examples of facility specifications and safety management details

Shielding and isolation	• After the delivery of the removed soil, shield it by putting sandbags containing uncontaminated soil on the top or cover it with soil. The sandbag or covering with soil shall be at least 30 cm thick. In such cases it is not necessary to maintain a distance from residence buildings such as private houses.
Prevention of dispersion	• To prevent any radioactive material from dispersing, put the removed soil in sandbags or flexible containers whose openings can be closed, and close them securely. If the removed soil is not put into any containers such as sandbags, wrap it in a dustproof sheet.
Prevention of penetration of rainwater, etc.	• Cover the removed soil with a waterproof sheet and fix the ends so that the sheet cannot be blown by the wind, as needed. For fixing, sandbags and blocks can be used. • Raise the center to prevent rainwater from accumulating on the surface of the sheet, as needed.
Prevention of outflow	• Spread a waterproof sheet over areas where the removed soil is placed. No special measures are necessary if the removed soil is stored in waterproof flexible containers, etc. • When placing the removed soil, take care not to damage the waterproof sheet, etc.
Monitoring	• After completing covering with soil, etc. for the removed soil, use a calibrated scintillation survey meter to measure the air dose rate at the center (one spot) and places 4 m apart from four spots on the outer perimeter of the area where the removed soil has been placed and at a height of 1 m (four spots), and record the results. • If it is impossible to conduct such measurements at a place 4 m apart from the outer perimeter, select other measurement points. • Record the measurement points by drawing a rough sketch to identify the place of measurement.
Record keeping	• Keep the records of measurement results of the air dose rates until the removed soil is taken out.

Figure 4-9: Example of on-site storage (school: underground storage) (Photo courtesy of: Shirakawa City)

1) Construction machineries such as graders are used to remove the soil from the ground surface.

2) A pit is excavated to bury the removed soil.

3) After the pit is excavated, a water shielding sheet is laid.

4) The topsoil is buried in the water shielding sheet.

5) The entire topsoil is covered by the water shielding sheet.

6) The pit is filled up with covering with soil and the whole schoolyard is leveled.

7) The schoolyard is put in place.

Temporary storage site - 1): Above ground

Figure 4-10: Mound (20 × 20 × 2 m) of removed soil generated during the decontamination of an area whose air dose rate is about 1 μSv/hour

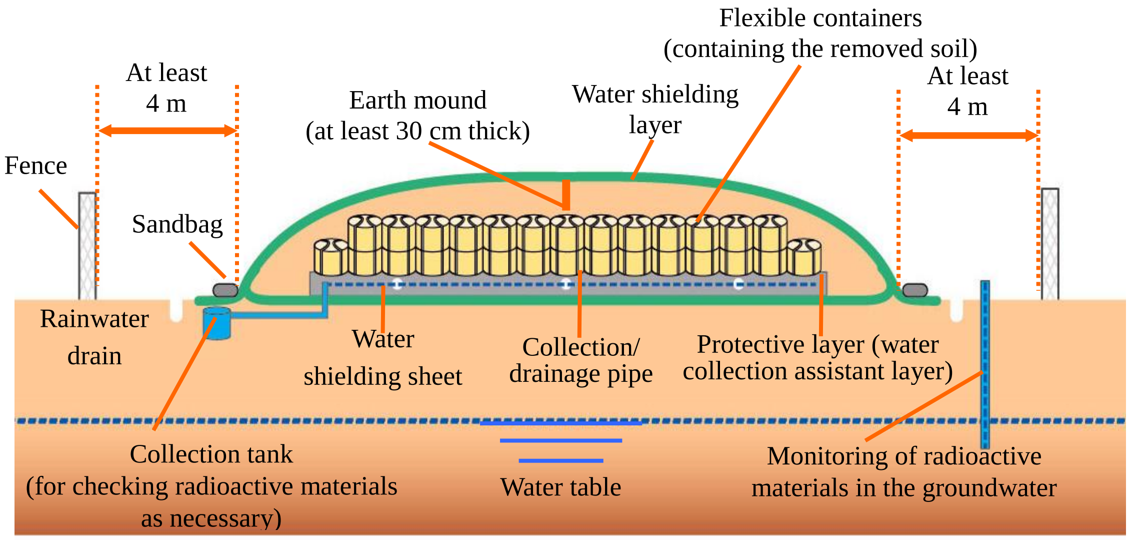


Table 4-10. Examples of facility specifications and safety management details

Shielding and isolation	• When the delivery work extends over a lengthy period of time, keep the removed soil at least 4 m away from residential buildings such as private houses from the viewpoint of curbing the public's additional exposure dose to not more than 1 millisievert per year during the delivery. • During the delivery of the removed soil, shield it by putting flexible containers, etc. containing uncontaminated soil on the side or cover it with soil. The sandbag or covering with soil shall be at least 30 cm thick. • After the delivery of the removed soil, shield it by putting sandbags containing uncontaminated soil on the top or cover it with soil. The sandbag or covering with soil shall be at least 30 cm thick.
Prevention of dispersion	• When delivering removed soil, to prevent any radioactive material from dispersing, put the removed soil into a flexible container, and close it securely. If the removed soil is not put into any containers such as flexible containers, wrap it in a dustproof sheet.
Prevention of penetration of rainwater, etc.	• During and after the delivery of the removed soil, cover it with a weatherproof and waterproof sheet such as a water shielding sheet to prevent the soil from being exposed to the rain as much as possible. Fix the end of the water shielding sheet so that it cannot be blown by the wind. For fixing, sandbags and blocks can be used. No special measures are necessary if the removed soil is stored in waterproof containers or kept in a facility with a roof. • Raise the center to prevent rainwater from accumulating on the water shielding sheet, etc. • Arrange the removed soil so that it is positioned higher than the water shielding sheet, etc. for good drainage. • Install drainage facilities during the delivery to discharge any accumulated rainwater.
Prevention of outflow	• Spread a weatherproof and waterproof sheet such as water shielding sheet over areas where the removed soil is placed. • When placing the removed soil, take care not to damage the waterproof sheet, etc. • Installation of water shielding layer such as laying waterproof sheet can be omitted if the removed soil is stored in waterproof containers and a waterproof cover is properly applied to prevent rainwater from coming in.

Background measurement	Air dose rate • Before the delivery of the removed soil, use a calibrated scintillation survey meter to measure the air dose rate at points along the site boundary and at 1 m height on both sunny and rainy days, and record the results. • The measurement points shall have an interval of about 2 m along the site boundary and include the points on the site boundary nearest to the place of storage of removed soil. • If it is impossible to conduct such measurements at a place 4 m apart from the outer perimeter, select other measurement points. • Record the measurement points by putting a mark on the ground or drawing a rough sketch to identify the place of measurement. • Derive the approximations for the upper limit of variation from the measured air dose rate values (at tens of points) and the following equation: $m+3\sqrt{\frac{(s_1-m)^2+(s_2-m)^2+\ldots+(s_k-m)^2+\ldots+(s_N-m)^2}{N}}$ where S_1, S_2, . . .S_K … S_N: Measured values, m: Average of the measured values, and N: Number of the measured values. Radioactivity concentration of the groundwater • Before the delivery of the removed soil, dig a water sampling hole near the planned temporary storage site, sample the groundwater, measure the radiocaesium concentration of the sample, and record the results. • For the installation of the water sampling hole, prevent the intermixing of topsoil and surface water. In addition, implement measures to prevent the intermixing of topsoil and the like as needed. Radioactivity concentration of the leachate (if necessary) • This is not a standard for storage, but if measuring the leachate, install pipes into the protective layer to sample the leachate, and install a collection tank (e.g. working water tank or concrete measuring tank) on the outside of the temporary storage site to collect the sampled leachate. Radioactivity concentration of soil • Before the delivery of the removed soil, sample the soil in the planned temporary storage site, measure the radiocaesium concentration of the sample, and record the results. • The measurement points shall be at the center and four corners of the area in which removed soil is placed.
Monitoring	Air dose rate • After the delivery of the removed soil starts, use a calibrated scintillation survey meter, to measure the air dose rate at a height of 1 m at four spots including a spot nearest to the place of storage of removed soil among the background measurement points, and record the results. • Take such measurements at least once a week. Radioactivity concentration of the groundwater • After the delivery of the removed soil starts, sample the groundwater from the sampling hole, measure the radiocaesium concentration of the sample, and record the results. • Samples of the groundwater should be taken when there is no turbidity. • Take such measurements at least once a month. Radioactivity concentration of the leachate (if necessary) • After the delivery of the removed soil starts, check whether water is accumulated in the collection tank at least once a month. • If water has accumulated, sample the leachate and measure the concentration of radiocaesium, etc. in the sampled leachate.
Record keeping	• Keep the following records until the period of operation of the facility ends. • The amount of the removed soil stored, dates on which the storage starts and ends

	for each batch of the removed soil stored, and the names and addresses of the receiving site and destinations of the removed soil after the storage. • The names of the persons in charge of receiving and delivering the removed soil concerning such removed soil received, and the registration or vehicle number of any truck in case where such truck was used for the transfer pertaining to the delivery. • The results of an air dose rate measurement and water quality test (measurement of the radioactivity concentration of groundwater).
Repair	• Confirm that the measured values of the air dose rate and the radiocaesium concentration of the groundwater are within the allowable variation range of the background values. (Note that during the delivery of the removed soil, the measured air dose rate shall not exceed the allowable variation range plus air dose rate equivalent to 1 mSv/year.) • If the measured value is observed to be exceeding the allowable variance range, etc., identify the cause. If it is found that the temporary storage site is the cause of such problem, take any necessary measures, such as adding shielding materials, repairing the facility, or collecting the removed soil.
Restriction of entry	• Construct fences (e.g. ropes, nets, or iron wire) at the periphery of the area at least 4 m away from the temporary storage site. • Install signboards at least 60 cm × 60 cm in visually obvious places to indicate precaution to the effect that the area is the place of storage of the removed soil, the contact details in the event of an emergency, and the height of the piled-up removed soil.
Vacant site check	• After the period of storage ends and the removed soil is taken out of the temporary storage spite, measure the Cs-134 and Cs-137 concentration of soil at the vacant site and confirm that the resulting values are within the variation range of the background concentration. • The measurement points shall be at the center and four corners of the area in which removed soil had been placed. • If the measured value is observed to be exceeding the allowable variation range, decontaminate the site.

Temporary storage site - 2): Above ground

Figure 4-11: Mound (100 × 100 × 2 m) of removed soil generated during the decontamination of an area whose air dose rate is about 1 μSv/hour

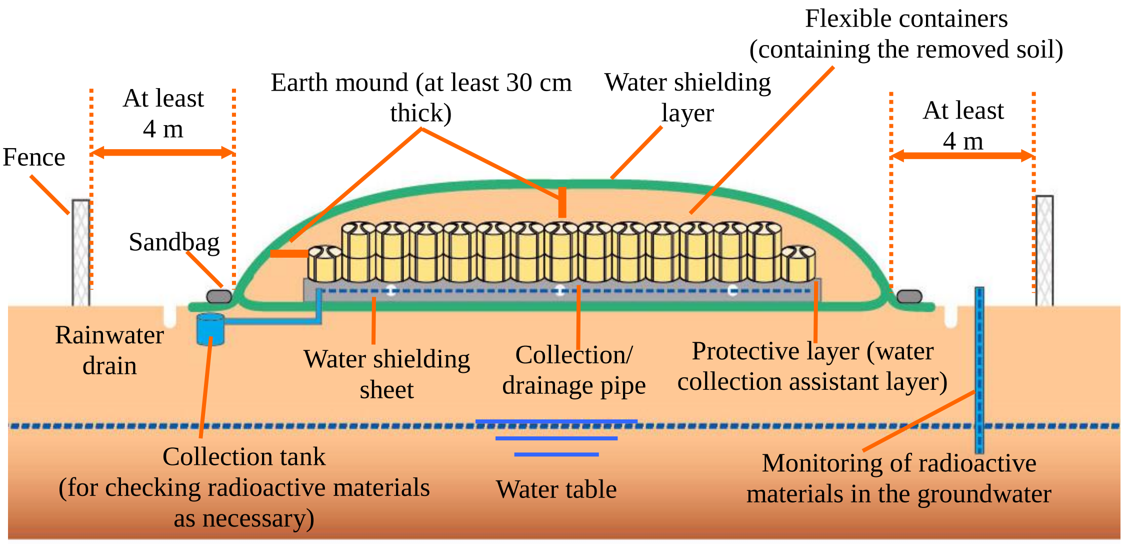


Table 4-11. Examples of facility specifications and safety management details

Shielding and isolation	• When the delivery work extends over a lengthy period of time, keep the removed soil at least 4 m away from residential buildings such as private houses from the viewpoint of curbing the public’s additional exposure dose to not more than 1 millisievert per year during the delivery. • During the delivery of the removed soil, shield it by putting flexible containers, etc. containing uncontaminated soil on the side or cover it with soil. The sandbag or covering with soil shall be at least 30 cm thick. • During the delivery of the removed soil, shield it by putting sandbags containing uncontaminated soil on the top or cover it with soil to prevent the uncovered area of the top from exceeding 20 m × 20 m. The sandbag or covering with soil shall be at least 30 cm thick. • After the delivery of the removed soil, shield it by putting sandbags containing uncontaminated soil on the top or cover it with soil. The sandbag or covering with soil shall be at least 30 cm thick.
Prevention of dispersion	• When delivering removed soil, to prevent any radioactive material from dispersing, put the removed soil into a flexible container, and close it securely. If the removed soil is not put into any containers such as flexible containers, wrap it in a dustproof sheet.
Prevention of penetration of rainwater, etc.	• During and after the delivery of the removed soil, cover it with a weatherproof and waterproof sheet such as a water shielding sheet to prevent the soil from being exposed to the rain as much as possible. Fix the end of the water shielding sheet so that it cannot be blown by the wind. For fixing, sandbags and blocks can be used. No special measures are necessary if the removed soil is stored in waterproof containers or kept in a facility with a roof. • Raise the center to prevent rainwater from accumulating on the water shielding sheet, etc. • Arrange the removed soil so that it is positioned higher than the water shielding sheet, etc. for good drainage. • Install drainage facilities during the delivery to discharge any accumulated rainwater.
Prevention of outflow	• Spread a weatherproof and waterproof sheet such as water shielding sheet over areas where the removed soil is placed.

	• Place a protective layer around ten to tens of cm thick by putting soil over the water shielding sheet. • If a heavy machine is used, use measures such as temporarily placing metal plates over the protective layer to avoid damage to the protective layer and water shielding sheet, etc. as much as possible when placing the removed soil. • Installation of water shielding layer such as laying waterproof sheet can be omitted if the removed soil is stored in waterproof containers and a waterproof cover is properly applied to prevent rainwater from coming in.
Background measurement	Air dose rate • Before the delivery of the removed soil, use a calibrated scintillation survey meter to measure the air dose rate at points along the site boundary and at 1 m height on both sunny and rainy days, and record the results. • The measurement points shall have an interval of about 10 m along the site boundary and include the points on the site boundary nearest to the place of storage of removed soil. • If it is impossible to conduct such measurements at a place 4 m apart from the outer perimeter, select other measurement points. • Record the measurement points by putting a mark on the ground or drawing a rough sketch to identify the place of measurement. • Derive the approximations for the upper limit of variation from the measured air dose rate values (at tens of points) and the following equation: $$m+3\sqrt{\frac{(s_1-m)^2+(s_2-m)^2+\ldots+(s_k-m)^2+\ldots+(s_N-m)^2}{N}}$$ where S_1, S_2, . . .S_K … S_N: Measured values, m: Average of the measured values, and N: Number of the measured values. Radioactivity concentration of the groundwater • Before the delivery of the removed soil, dig a water sampling hole near the planned temporary storage site, sample the groundwater, measure the radiocaesium concentration of the sample, and record the results. • For the installation of the water sampling hole, prevent the intermixing of topsoil and surface water. In addition, implement measures to prevent the intermixing of topsoil and the like as needed. Radioactivity concentration of the leachate (if necessary) • This is not a standard for storage, but if measuring the leachate, install pipes into the protective layer to sample the leachate, and install a collection tank (e.g. working water tank or concrete measuring tank) on the outside of the temporary storage site to collect the sampled leachate. Radioactivity concentration of soil • Before the delivery of the removed soil, sample the soil in the planned temporary storage site, measure the radiocaesium concentration of the sample, and record the results. • The measurement points shall be given by dividing the area in which removed soil is placed into a mesh of about 10 m intervals.
Monitoring	Air dose rate • After the delivery of the removed soil starts, use a calibrated scintillation survey meter, to measure the air dose rate at a height of 1 m at four spots including a spot nearest to the place of storage of removed soil among the background measurement points, and record the results. • Take such measurements at least once a week. Radioactivity concentration of the groundwater • After the delivery of the removed soil starts, sample the groundwater from the sampling hole, measure the radiocaesium concentration of the sample, and record the results. • Samples of the groundwater should be taken when there is no turbidity.

	• Take such measurements at least once a month. Radioactivity concentration of the leachate (if necessary) • After the delivery of the removed soil starts, check whether water is accumulated in the collection tank at least once a month. • If water has accumulated, sample the leachate and measure the concentration of radiocaesium, etc. in the sampled leachate.

Record keeping	• Keep the following records until the period of operation of the facility ends.
	  • The amount of the removed soil stored, dates on which the storage starts and ends, and the names and addresses of the receiving site and destinations of the removed soil after the storage.
	  • The names of the persons in charge of receiving and delivering the removed soil concerning such removed soil received, and the registration or vehicle number of any truck in case where such truck was used for the transfer pertaining to the delivery.
	  • The results of an air dose rate measurement and water quality test (measurement of the radioactivity concentration of groundwater).

Repair	• Confirm that the measured values of the air dose rate and the radiocaesium concentration of the groundwater are within the allowable variation range of the background values. (Note that during the delivery of the removed soil, the measured air dose rate shall not exceed the allowable variation range plus air dose rate equivalent to 1 mSv/year.) • If the measured value is observed to be exceeding the allowable variation range, etc., identify the cause. If it is found that the temporary storage site is the cause of such problem, take any necessary measures, such as adding shielding materials, repairing the facility, or collecting the removed soil.
Restriction of entry	• Construct fences (e.g. ropes, nets, or iron wire) at the periphery of the area at least 4 m away from the temporary storage site. • Install signboards at least 60 cm × 60 cm in visually obvious places to indicate precaution to the effect that the area is the place of storage of the removed soil, the contact details in the event of an emergency, and the height of the piled-up removed soil.
Vacant site check	• After the period of storage ends and the removed soil is taken out of the temporary storage site, measure the Cs-134 and Cs-137 concentration of soil at the vacant site and confirm that the resulting values are within the variation range of the background concentration. • The measurement points shall be given by dividing the area in which removed soil had been placed into a mesh of about 10 m intervals. • If the measured value is observed to be exceeding the allowable variation range, decontaminate the site.

Temporary storage site - 3): Underground

Figure 4-12: Pit (50 × 50 × 2 m) for removed soil generated during the decontamination of an area whose air dose rate is about 1 μSv/hour

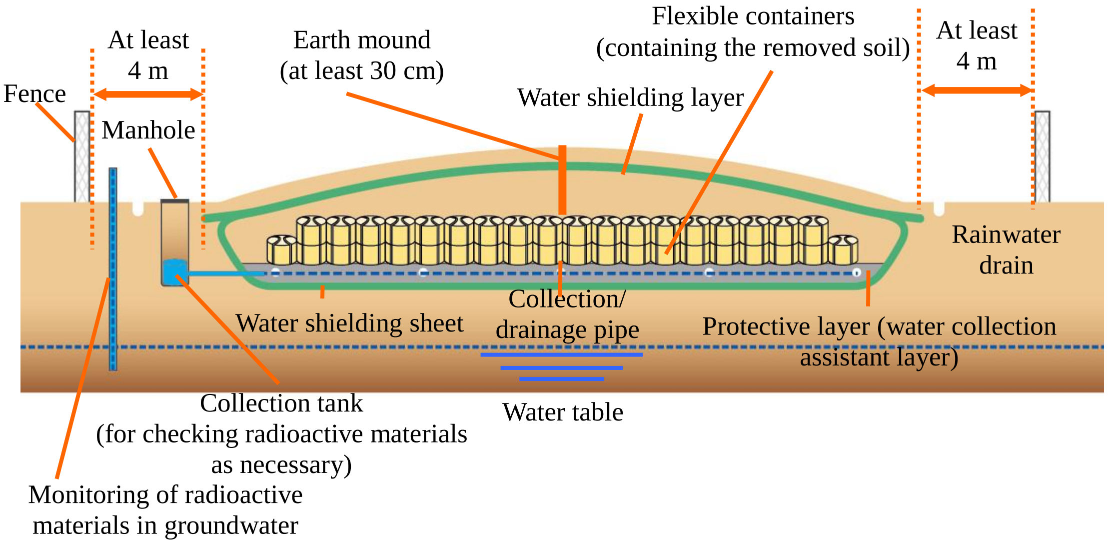


Table 4-12. Examples of facility specifications and safety management details

Shielding and isolation	• When the delivery work extends over a lengthy period of time, keep the removed soil at least 4 m away from residential buildings such as private houses from the viewpoint of curbing the public's additional exposure dose to not more than 1 millisievert per year during the delivery. • After the delivery of the removed soil, shield it by putting sandbags containing uncontaminated soil on the top or cover it with soil. The sandbag or covering with soil shall be at least 30 cm thick.
Prevention of dispersion	• When delivering removed soil, to prevent any radioactive material from dispersing, put the removed soil into a flexible container, and close it securely. If the removed soil is not put into any containers such as flexible containers, wrap it in a dustproof sheet.
Prevention of penetration of rainwater, etc.	• During and after the delivery of the removed soil, cover it with a weatherproof and waterproof sheet such as a water shielding sheet to prevent the soil from being exposed to the rain as much as possible. Fix the end of the water shielding sheet so that it cannot be blown by the wind. For fixing, sandbags and blocks can be used. No special measures are necessary if the removed soil is stored in waterproof containers or kept in a facility with a roof. • Raise the center to prevent rainwater from accumulating on the water shielding sheet, etc. • Arrange the removed soil so that it is positioned higher than the water shielding sheet, etc. for good drainage. • Install drainage facilities during the delivery to discharge any accumulated rainwater.
Prevention of outflow	• Spread a weatherproof and waterproof sheet such as water shielding sheet over areas where the removed soil is placed. • Place a protective layer around ten to tens of cm thick by putting soil over the water shielding sheet. • If a heavy machine is used, use measures such as temporarily placing metal plates over the protective layer to avoid damage to the protective layer and water shielding sheet, etc. as much as possible when placing the removed soil. • Installation of water shielding layer such as laying waterproof sheet can be omitted

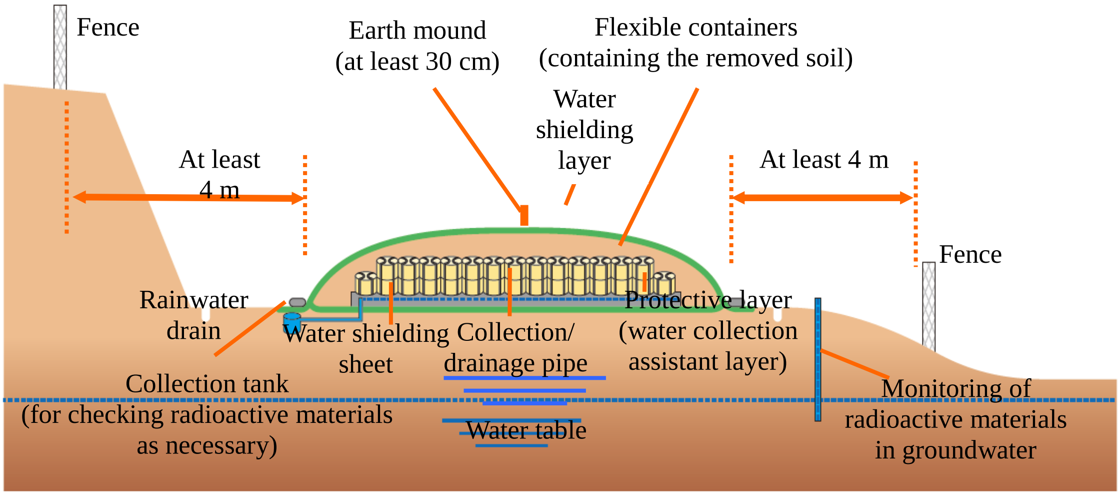
	if the removed soil is stored in waterproof containers and a waterproof cover is properly applied to prevent rainwater from coming in.
Background measurement	Air dose rate • Before the delivery of the removed soil, use a calibrated scintillation survey meter to measure the air dose rate at points along the site boundary and at 1 m height on both sunny and rainy days, and record the results. • The measurement points shall have an interval of about 5 m along the site boundary and include the points on the site boundary nearest to the place of storage of removed soil. • If it is impossible to conduct such measurements at a place 4 m apart from the outer perimeter, select other measurement points. • Record the measurement points by putting a mark on the ground or drawing a rough sketch to identify the place of measurement. • Derive the approximations for the upper limit of variation from the measured air dose rate values (at tens of points) and the following equation: $m+3\sqrt{\frac{(s_1-m)^2+(s_2-m)^2+\ldots+(s_k-m)^2+\ldots+(s_N-m)^2}{N}}$ where S_1, S_2, . . .S_K … S_N: Measured values, m: Average of the measured values, and N: Number of the measured values. Radioactivity concentration of the groundwater • Before the delivery of the removed soil, dig a water sampling hole near the planned temporary storage site, sample the groundwater, measure the radiocaesium concentration of the sample, and record the results. • For the installation of the water sampling hole, prevent the intermixing of topsoil and surface water. In addition, implement measures to prevent the intermixing of topsoil and the like as needed. Radioactivity concentration of the leachate (if necessary) • This is not a standard for storage, but if you measure the leachate, install pipes into the protective layer to sample the leachate, and install a collection tank (e.g. working water tank or concrete measuring tank) on the outside of the temporary storage site to collect the sampled leachate. Radioactivity concentration of soil • Before the delivery of the removed soil, sample the soil in the planned temporary storage site, measure the radiocaesium concentration of the sample, and record the results. • The measurement points shall be given by dividing the area in which removed soil is placed into a mesh of about 10 m intervals.
Monitoring	Air dose rate • After the delivery of the removed soil starts, use a calibrated scintillation survey meter, to measure the air dose rate at a height of 1 m at four spots including a spot nearest to the place of storage of removed soil among the background measurement points, and record the results. • Take such measurements at least once a week. Radioactivity concentration of the groundwater • After the delivery of the removed soil starts, sample the groundwater from the sampling hole, measure the radiocaesium concentration of the sample, and record the results. • Samples of the groundwater should be taken when there is no turbidity. • Take such measurements at least once a month. Radioactivity concentration of the leachate (if necessary) • After the delivery of the removed soil starts, check whether water is accumulated in the collection tank at least once a month. • If water has accumulated, sample the leachate and measure the concentration of radiocaesium, etc. in the sampled leachate.

Record keeping	• Keep the following records until the period of operation of the facility ends.
	  • The amount of the removed soil stored, dates on which the storage starts and ends, and the names and addresses of the receiving site and destinations of the removed soil after the storage.
	  • The names of the persons in charge of receiving and delivering the removed soil concerning such removed soil received, and the registration or vehicle number of any truck in case where such truck was used for the transfer pertaining to the delivery.
	  • The results of an air dose rate measurement and water quality test (measurement of the radioactivity concentration of groundwater).

Repair	• Confirm that the measured values of the air dose rate and the radiocaesium concentration of the groundwater are within the allowable variation range of the background values. (Note that during the delivery of the removed soil, the measured air dose rate shall not exceed the allowable variation range plus air dose rate equivalent to 1 mSv/year.) • If the measured value is observed to be exceeding the allowable variation range, etc., identify the cause. If it is found that the temporary storage site is the cause of such problem, take any necessary measures, such as adding shielding materials, repairing the facility, or collecting the removed soil.
Restriction of entry	• Construct fences (e.g. ropes, nets, or iron wire) at the periphery of the area at least 4 m away from the temporary storage site. • Install signboards at least 60 cm × 60 cm in visually obvious places to indicate precaution to the effect that the area is the place of storage of the removed soil, the contact details in the event of an emergency.
Vacant site check	• After the period of storage ends and the removed soil is taken out of the temporary storage site, measure the Cs-134 and Cs-137 concentration of soil at the vacant site and confirm that the resulting values are within the variation range of the background concentration. • The measurement points shall be given by dividing the area in which removed soil had been placed into a mesh of about 10 m intervals. • If the measured value is observed to be exceeding the allowable variation range, decontaminate the site.

Temporary storage site - 4): Storage on sloped ground

Figure 4-13. Mound on sloped ground (20 × 20 × 2 m) of removed soil generated during the decontamination of an area whose air dose rate is about 1 μSv/hour



The place of storage is essentially to be situated on level ground from the viewpoint of safety, but when the place of storage has to be situated on sloped ground for unavoidable reasons then particular attention must be paid to preventing the soil from collapsing. Specifically, install retaining walls or embankments along the lower areas according to the slope, perform cutting of earth and piling of earth mound according to the inclination of the sloped surface, and ensure a flat surface through creation of land.

Moreover, during installation, confirm information like the strength of ground and the water table in advance, and take countermeasures for matters such as ground maintenance or for surface water.

Table 4-13. Examples of facility specifications and safety management details

Shielding and isolation	• When the delivery work extends over a lengthy period of time, keep the removed soil at least 4 m away from residential buildings such as private houses from the viewpoint of curbing the public's additional exposure dose to not more than 1 millisievert per year during the delivery. • During the delivery of the removed soil, shield it by putting flexible containers, etc. containing uncontaminated soil on the side or cover it with soil. The sandbag or covering with soil shall be at least 30 cm thick. • After the delivery of the removed soil, shield it by putting sandbags containing uncontaminated soil on the top or cover it with soil. The sandbag or covering with soil shall be at least 30 cm thick.
Prevention of dispersion	• When delivering removed soil, to prevent any radioactive material from dispersing, put the removed soil into a flexible container, and close it securely. If the removed soil is not put into any containers such as flexible containers, wrap it in a dustproof sheet.
Prevention of penetration of rainwater, etc.	• During and after the delivery of the removed soil, cover it with a weatherproof and waterproof sheet such as a water shielding sheet to prevent the soil from being exposed to the rain as much as possible. Fix the end of the water shielding sheet so that it cannot be blown by the wind. For fixing, sandbags and blocks can be used.

	No special measures are necessary if the removed soil is stored in waterproof containers or kept in a facility with a roof. • Raise the center to prevent rainwater from accumulating on the water shielding sheet, etc. • Arrange the removed soil so that it is positioned higher than the water shielding sheet, etc. for good drainage. • Install drainage facilities during the delivery to discharge any accumulated rainwater. • Take any countermeasures against spring water that may be necessary in cases where spring water is a possibility.
Prevention of outflow	• Spread a weatherproof and waterproof sheet such as water shielding sheet over areas where the removed soil is placed. • When placing the removed soil, take care not to damage the waterproof sheet, etc. • Installation of water shielding layer such as laying waterproof sheet can be omitted if the removed soil is stored in waterproof containers and a waterproof cover is properly applied to prevent rainwater from coming in.
Background measurement	<u>Air dose rate</u> • Before the delivery of the removed soil, use a calibrated scintillation survey meter to measure the air dose rate at points along the site boundary and at 1 m height on both sunny and rainy days, and record the results. • The measurement points shall have an interval of about 2 m along the site boundary and include the points on the site boundary nearest to the place of storage of removed soil. • If it is impossible to conduct such measurements at a place 4 m apart from the outer perimeter, select other measurement points. • Record the measurement points by putting a mark on the ground or drawing a rough sketch to identify the place of measurement. • Derive the approximations for the upper limit of variation from the measured air dose rate values (at tens of points) and the following equation: $m+3\sqrt{\dfrac{(s_1-m)^2+(s_2-m)^2+\ldots+(s_k-m)^2+\ldots+(s_N-m)^2}{N}}$ where S_1, S_2, . . .S_K … S_N: Measured values, m: Average of the measured values, and N: Number of the measured values. <u>Radioactivity concentration of the groundwater</u> • Before the delivery of the removed soil, dig a water sampling hole near the planned temporary storage site, sample the groundwater, measure the radiocaesium concentration of the sample, and record the results. • For the installation of the water sampling hole, prevent the intermixing of topsoil and surface water. In addition, implement measures to prevent the intermixing of topsoil and the like as needed. <u>Radioactivity concentration of the leachate (if necessary)</u> • This is not a standard for storage, but if measuring the leachate, install pipes into the protective layer to sample the leachate, and install a collection tank (e.g. working water tank or concrete measuring tank) on the outside of the temporary storage site to collect the sampled leachate. <u>Radioactivity concentration of soil</u> • Before the delivery of the removed soil, sample the soil in the planned temporary storage site, measure the radiocaesium concentration of the sample, and record the results. • The measurement points shall be at the center and four corners of the area in which removed soil is placed.
Monitoring	<u>Air dose rate</u> • After the delivery of the removed soil starts, use a calibrated scintillation survey meter, to measure the air dose rate at a height of 1 m at four spots including a spot

	nearest to the place of storage of removed soil among the background measurement points, and record the results. • Take such measurements at least once a week. <u>Radioactivity concentration of the groundwater</u> • After the delivery of the removed soil starts, sample the groundwater from the sampling hole, measure the radiocaesium concentration of the sample, and record the results. • Samples of the groundwater should be taken when there is no turbidity. • Take such measurements at least once a month. <u>Radioactivity concentration of the leachate (if necessary)</u> • After the delivery of the removed soil starts, check whether water is accumulated in the collection tank at least once a month. • If water has accumulated, sample the leachate and measure the concentration of radiocaesium, etc. in the sampled leachate.

Record keeping	• Keep the following records until the period of operation of the facility ends.
	  • The amount of the removed soil stored, dates on which the storage starts and ends for each batch of the removed soil stored, and the names and addresses of the receiving site and destinations of the removed soil after the storage.
	  • The names of the persons in charge of receiving and delivering the removed soil concerning such removed soil received, and the registration or vehicle number of any truck in case where such truck was used for the transfer pertaining to the delivery.
	  • The results of an air dose rate measurement and water quality test (measurement of the radioactivity concentration of groundwater).

Repair	• Confirm that the measured values of the air dose rate and the radiocaesium concentration of the groundwater are within the allowable variation range of the background values. (Note that during the delivery of the removed soil, the measured air dose rate shall not exceed the allowable variation range plus air dose rate equivalent to 1 mSv/year.) • If the measured value is observed to be exceeding the allowable variance range, etc., identify the cause. If it is found that the temporary storage site is the cause of such problem, take any necessary measures, such as adding shielding materials, repairing the facility, or collecting the removed soil.
Restriction of entry	• Construct fences (e.g. ropes, nets, or iron wire) at the periphery of the area at least 4 m away from the temporary storage site. When it is physically impossible for people to enter the area then fences and the like are unnecessary. • Install signboards at least 60 cm × 60 cm in visually obvious places to indicate precaution to the effect that the area is the place of storage of the removed soil, the contact details in the event of an emergency, and the height of the piled-up removed soil.
Vacant site check	• After the period of storage ends and the removed soil is taken out of the temporary storage site, measure the Cs-134 and Cs-137 concentration of soil at the vacant site and confirm that the resulting values are within the variation range of the background concentration. • The measurement points shall be at the center and four corners of the area in which removed soil had been placed. • If the measured value is observed to be exceeding the allowable variation range, decontaminate the site.

Endnotes

*1: The evaluation assumes a variety of processes in which residents living around the facility (the public) and workers are exposed to radiation (exposure scenarios) in light of the radioactivity concentration and amount of the removed soil, facility specifications, and details of safety management, calculates exposure dose of the public and workers according to these exposure scenarios, and confirms that it satisfies predefined levels.[*2]

*2: The exposure in association with the storage of radioactive waste is the "Planned Exposure Situations" under ICRP Publ. 103, and the dose constraint for the public exposure during operation is a dose of 1 mSv/year or less. In addition, according to the "Near-term policy to ensure the safety for treating and disposing contaminated waste around the site of Fukushima Daiichi Nuclear Power Plant (June 3, 2011)" issued by the Nuclear Safety Commission, the dose of radiation to which the surrounding residents are exposed in association with the treatment, etc. shall not exceed 1 mSv/year.

*3: See the "Basic Guide for Safety Review of Category 2 Radioactive Waste Disposal (August 2010)" and the "Rules for the Category 2 Waste Disposal Activity of Nuclear Fuel Materials or Materials Contaminated with Nuclear Fuel Material" issued by the Nuclear Safety Commission. However, it is assumed that restrictions are put on specific activities, such as living, excavation activities, farming, and stockbreeding within the facility site as well as public access to the facility during the operation of the storage facility.

*4: For information about measures for protecting workers from radiation, see the Ministry of Health, Labour and Welfare's Ordinance on the Prevention of Ionizing Radiation Hazards related to Decontamination Work of Soil Contaminated by Radioactive Materials Resulted from the Great East Japan Earthquake and its Guidelines for Prevention of Radiation Hazards for Workers Engaged in Decontamination and Other Duties (Labour Standards Bureau Notification 0615 No. 6 dated June 15, 2012). In these guidelines, "Dose" or "Exposure" applies to the public. In addition, measures for protecting the public from radiation pertaining to the collection of the removed soil and the transfer to the facility are indicated in "Part 3: Guidelines Pertaining to the Collection and Transfer of Removed Soil."

*5: The gamma rays include radiation (skyshine gamma rays) that is emitted from the removed soil and that returns to the ground after scattering in the sky, and direct gamma rays that are emitted from the area surrounding the facility.

*6: In reference to the results of evaluating skyshine and direct radiation, Table 4-1 and Table 4-2 show two cases: one is when shielding is conducted by covering with soil (whose density is 1.5 g/cm^3 and whose thickness is 30 cm) and the other is when there is no shielding. For example, if removed soil having 30,000 Bq/kg is kept as a mound 20 m long, 20 m wide, and 2 m high (above ground facility), the isolation distance by which additional external exposure dose per year becomes 1 mSv or less is 8 m when the side is shielded (see the underground facility without a shield). However, the distance decreases to 6 m when the side is shielded and the uncovered area does not exceed 10 m × 10 m, to 1 m after completion of covering with soil 30 cm in thickness, and to zero (0) m when the covering with soil thickness increases to 40 cm. These values are based on the assumption that radionuclides included in the removed soil are Cs-134 and Cs-137 only, and the radioactivity ratio is 1:1. The average of the radiocaesium concentration of the removed soil is categorized into four ways: 3,000 Bq/kg, 8,000 Bq/kg, 30,000 Bq/kg, and 100,000 Bq/kg, and the facilities are classified into above ground facilities and underground facilities. The facility size (length × width × height (depth)) is classified into the following six types: 2 × 2 × 1 m, 5 × 5 × 2 m, 10 × 10 × 1 m, 20 × 20 × 2 m, 50 × 50 × 2 m (10m), and 200 × 200 × 2 m (10m). For above ground facilities, additional calculations were performed for three other types: 20 × 20 × 4 m, 50 × 50 × 4 m, and 100 × 100 × 4 m. Note that Japan Atomic Energy Agency cooperated in this work.

Table 4-2 also indicates the thickness of the covering with soil at which the isolation distance becomes zero (0) m (condition under which additional exposure dose per year on the covering with soil is 1 mSv or less) after the covering with soil is complete for underground storage. For example, if removed soil having an average radioactivity concentration of 8,000 Bq/kg is kept underground and the covering with soil is 30 cm thick, the additional exposure dose per year above the covering with soil does not exceed 1 mSv. This is based on the assumption that a cylinder of 500 m in radius acts as an infinite plane, measurements are made at 1 m above the ground, and the radioactivity ratio of Cs-134 and Cs-137 is 1:1 (JAEA-Data/Code 2008-003, "External Effective Dose Conversion

Factors for Activity Concentration Limit Evaluation for Disposal of Radioactive Waste”).
When the removed soil contains a significant amount of radioactive materials other than radiocaesium (e.g. soil contaminated in the vicinity of Fukushima Daiichi Nuclear Power Plant), it is necessary to evaluate its safety individually, to install the necessary shielding, and to maintain an appropriate isolation distance.

*7: The radioactivity concentration of soil at an air dose rate of 3.84 μSv/hour equal to 20 mSv/year is about 39,000 Bq/kg, which is obtained by converting soil monitoring data given by the Ministry of Education, Culture, Sports, Science and Technology as well as soil monitoring results including air dose rates obtained at elementary schools in Fukushima Prefecture to the value on June 1, 2011, and using the resulting regression formula “Log (Air dose rate) = 0.815 × Log (Cs concentration) – 3.16” (Japan Nuclear Energy Safety Organization).

*8: For example, the flexible container can be classified into running and cloth types (according to JIS Z 1651). In addition, bags similar to sandbags are commercially available although they are not certified by JIS. It is necessary to select containers after confirming that they meet the storage requirements. If the period of storage is relatively long or the waste has a high water content or is relatively heavy, it is recommended to double wrap in two cloth containers or use a running container featuring high durability. If the removed soil is kept in an outdoor space exposed to the wind, rain, and UV light, it is recommended to select containers that are highly weatherable such as a UV-resistant cloth or running container.

*9: Weatherability (UV rays)

Flexible container

- Flexible containers are defined in JIS Z 1651, and come in cloth, running, and other varieties. Their weatherability is tested by the weatherability tester defined in JIS B 7753, with those containers that have been confirmed as maintaining strength that is equivalent to or above a certain threshold being sold commercially. For example, under the Japan Flexible Container Association’s own standards, 900-hour weatherability tests are performed to confirm whether they can retain 70% of their initial strength, for instance, and they are designed to withstand being collected and transferred by heavy machinery even after being stored for about three years.

Large sandbags

- The weatherability of large sandbags is tested by the weatherability tester defined in JIS B 7753, with those sandbags that have been confirmed as maintaining strength that is equivalent to or above a certain threshold being sold commercially. For example, those sandbags that comply with the Public Works Research Center’s Design and Construction Manual for Laminating Techniques for Weather Resistant Large Sandbags have been confirmed as maintaining tensile strength of 240 N/cm or greater after 900-hour weatherability tests, for instance, and they are designed to withstand being collected and transferred by heavy machinery even after being stored for about three years.

Water shielding sheet

- The principal factor behind the performance degradation of water shielding sheets is believed to be degradation resulting from UV light, but thus far they have been confirmed as having durability of at least 15 years. What is more, if they are used under the soil then there is no degradation due to UV light, and so they have a track record of being used for more than 30 years from the time they are first put in landfills at the final disposal sites for waste landfill (Source: Japan Geosynthetics Technologies Association).
- The sheet has a degradation risk due to UV light, damage from heavy machinery during installation, or damage caused by birds.
- Care must be taken with the joints during installation.

*10: See information about the patrolling and inspection of waste disposal facilities under the “Rules for the Category 2 Waste Disposal Activity of Nuclear Fuel Materials or Materials Contaminated with Nuclear Fuel Material.”

*11: According to the “Guideline for Environmental Radiation Monitoring (partially revised in April 2010)” issued by the Nuclear Safety Commission,

(1) If many significant measured values are acquired under well controlled conditions as in cases where they have been obtained from a single monitoring post over time, statistical processing of the data shall be conducted, and an average of the past measured values ± (3 × standard

deviation) shall be the variation range under normal condition.

(2) If it is difficult to find the value under the method (1), the range from the minimum to the maximum values among the past measured values can be defined as the variation range under normal condition.

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Terminology

環境省
Ministry of the Environment