Chapter 4 :Implementation of Decontamination Projects

4.1. Overview of Decontamination

(1) Targets of Decontamination and Flow

The areas to be decontaminated are areas that are necessary from the viewpoint of protection of human health, and living areas such as residential areas, schools, parks, large Facility, roads, agricultural lands and the like, as well as forests and areas within forests where people frequently enter.

In the decontamination process, MOE first determined the owners of the land and buildings to be decontaminated, got consent for entry, conducted preliminary radiation monitoring, and investigated the condition of buildings, etc. Based on the results, a decontamination plan for each property and building was prepared, the method of decontamination was confirmed with the owner, etc., consent for decontamination was obtained, and decontamination work was conducted.

After the decontamination work was implemented, radiation monitoring was carried out to confirm the effectiveness of decontamination, and reporting was made to owners of land and buildings.

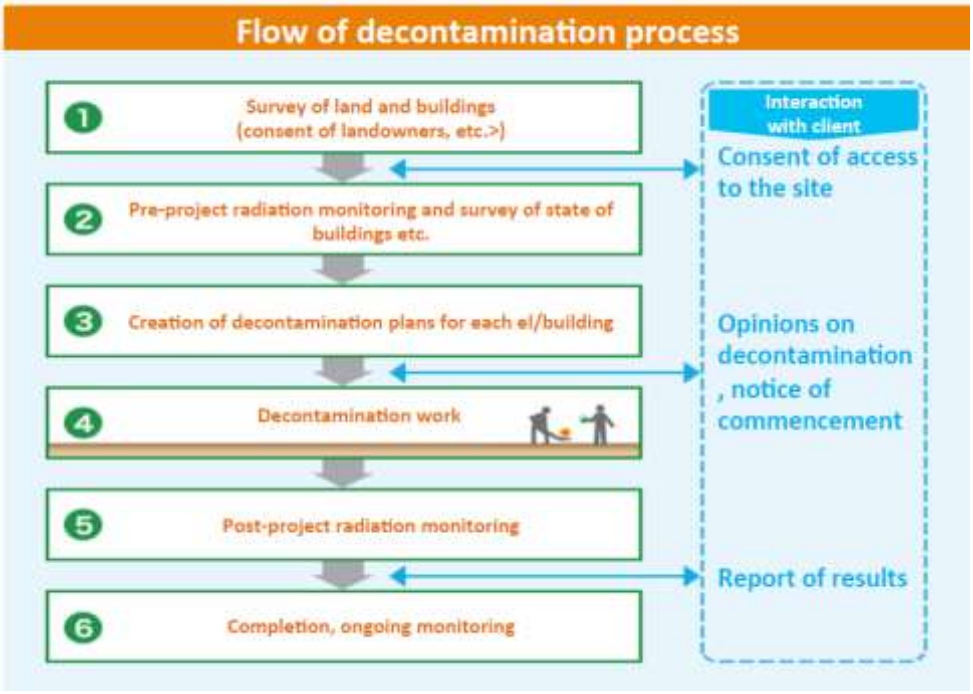


Figure 4-1 Flow of decontamination process

(2) Role of Decontamination Contractors, etc., in Projects

In implementing the decontamination projects, work was handled by construction contractors with know-how based on extensive local work on large-scale projects, plus experience in securing and managing workers. Investigative and design consultants were in charge of investigation of land and buildings, radiation monitoring, supervision support and other matters.

For explaining to and obtaining consent from the land and building owners, etc., MOE was mainly responsible for Special Decontamination Areas (SDA), while municipalities were mainly responsible for Intensive Contamination Survey Areas (ICSA), and decontamination contractors who worked on site also responded to residents in various ways.

4.2. Preliminary Surveys and Obtaining Consent in Special Decontamination Areas

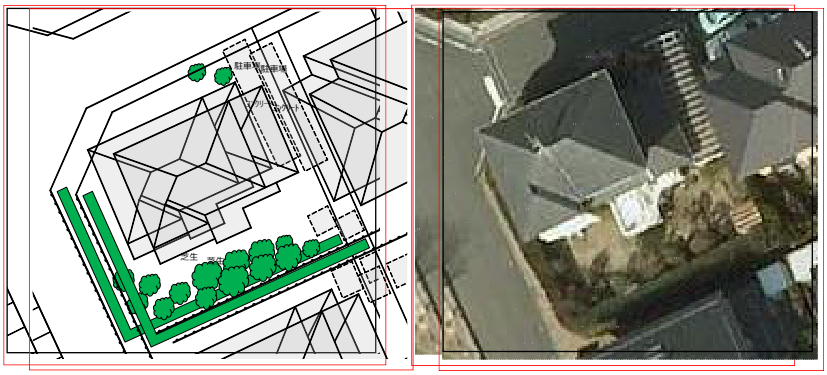
4.2.1. Preliminary Surveys and Formulation of Decontamination Plans

(1) Surveys of Land and Buildings (identifying persons concerned)

In order to prepare decontamination plans and obtain consent, first, research was done to identify the persons concerned, such as land and building owners (persons who have the right to block the implementation of measures such as decontamination on the property where measures such as decontamination of soil, etc., are to be performed, or other fixed items such as trees). Residents in Special Decontamination Areas had been evacuated under evacuation orders, and they were in various evacuation destinations. In addition, there were many kinds of cases of ownership, and in many cases the landowners were not clearly known. For example, there were cases in which one person concerned owned many pieces of land and buildings, cases in which one piece of land had a different name registered and separate owner due to inheritance, etc., cases in which the owner was deceased but the registration information was not up to date, and cases in which a person other than the farm land owner was actually doing the farming activities, etc.

For these reasons, to compile information on land and houses, the persons concerned were identified with information from various sources, such as property registries, land and house records, and housing and property maps, etc., while also obtaining cooperation from municipal authorities, heads of administrative districts, and land readjustment associations , etc.

In order to clarify details about properties for which consent was sought and to determine the magnitude of decontamination required, the Ministry also compiled information on land and housing by indicating the property boundaries of residential land (by land owner) and buildings on maps and aerial photographs. In doing so, some cases were observed in which databases of land and housing based on geographic information system (GIS) technology helped boost efficiency at subsequent stages when conducting field surveys and preparing and distributing consent forms. There were also cases in which existing laser surveys and GIS information intended for residents' asset management were also utilized for the decontamination work.



Credit: Shimizu Corporation

Figure 4-2 Example of plotting of land and buildings using GIS

(2) Preliminary Radiation Monitoring and Survey of Building Condition

In order to clarify the details of places to be decontaminated in draft consent forms through photographs and drawings, etc., radiation monitoring surveys and damage surveys of buildings, etc., were conducted to

serve as preliminary property surveys (field surveys) prior to decontamination work.

Since the decontamination method would differ depending on the target of decontamination as well as the material and condition of the target surface, those factors were confirmed, and in radiation monitoring surveys, measurements were done after representative measurement points were selected for each target of decontamination in the survey areas.

In some cases buildings had been damaged by the earthquake disaster, etc. If the damage was significant, it could be difficult to conduct the decontamination work, so in order to determine (after decontamination) whether a building's damage had been caused by the earthquake or by decontamination, it was necessary to create a record of the situation before the decontamination work, and to confirm that with the persons concerned as well.

For this reason, architects and emergency risk appraisers conducted visual inspections of damage from the exterior of buildings and created sets of photographs for each building, etc., to be decontaminated.

For preliminary radiation monitoring and surveys of building condition, since it was necessary to enter private property and other premises, consent for entry was obtained from the landowners, residents, or other persons concerned, and the surveys were conducted within the scope of consent obtained.

There were cases in which mapping information was loaded in advance into a portable digital assistant (PDA) equipped with GPS, and the information acquired at the site was then loaded into the PDA in real time, in order to efficiently conduct the field surveys..

(3) Preparation of Decontamination Plans for Each Property and Building

Based on the above, in terms of explanatory materials used when obtaining consent, for each person concerned, work contractors prepared a "Diagram of the Current State of Buildings, etc." describing the external appearance and status of damage of buildings, etc., and a "Decontamination Plan" document indicating the buildings to be decontaminated plus the extent of land as well as the decontamination methods.

4.2.2. Acquiring Consent

In implementing decontamination and other measures, actions were taken to obtain prior consent from the persons concerned, such as landowners, concerning the details of decontamination or other measures to be implemented, based on Article 38 of the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials.

(1) Procedures for Acquiring Consent

1) Preparation of Draft Consent Form

In acquiring consent from persons concerned, it is necessary to indicate in writing the target and methods of decontamination, plus other conditions, etc., and keep a record of consent. For this purpose, the following documents were prepared: "Decontamination Plan" (Figure 4-3), "Present Condition Confirmation Form," (Figure 4-4) and "Decontamination Implementation Consent Form" (Figure 4-5).

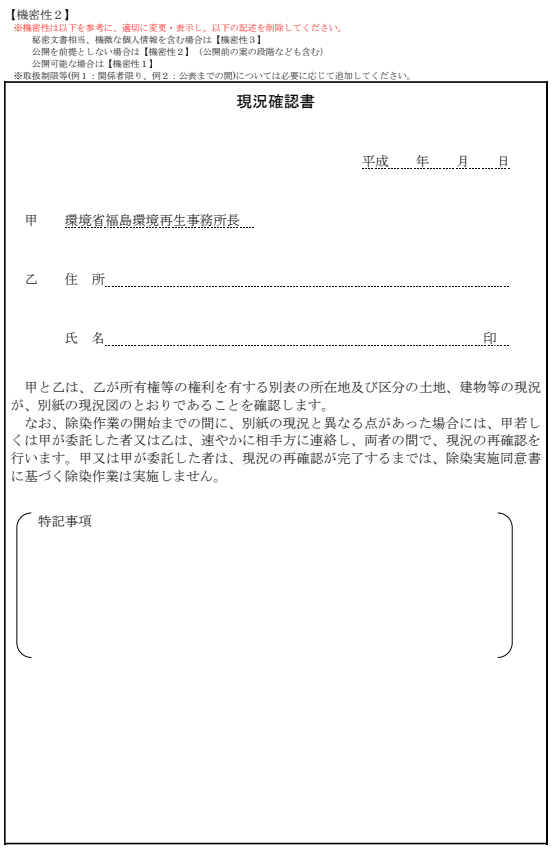
2) Acquiring consent

In principle, the method of obtaining consent was to mail questionnaires on consent for decontamination to the persons concerned, confirming the date of a site visit, etc., confirming the target of decontamination on-site, and explaining the decontamination method, etc. However, if the person concerned was residing outside the prefecture and would find it difficult to attend on-site, a visit was made to the home or place of evacuation, or to provide an explanation by telephone.

The draft consent form was explained on-site and the content of the decontamination work was finalized. In addition there was discussion and confirmation with the person concerned regarding detailed conditions for doing the decontamination, such as things the person concerned wanted decontaminated in the living areas (such as water courses, and access routes to ancestral shrines in hills near their homes), and things they did not want decontaminated (such as significant yard trees and moss).

If as a result consent was obtained regarding the current situation of buildings and the Decontamination Plan, the "Present Condition Confirmation Form" and "Decontamination Implementation Consent Form" were completed, then sealed (endorsed).

Figure 4-3 Example of Decontamination Plan



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秘密文書相当、機微な個人情報を含む場合は【機密性３】
公開を前提としない場合は【機密性２】（公開前の案の段階なども含む）
公開可能な場合は【機密性１】
※取扱制限等(例１：関係者限り、例２：公表までの間)については必要に応じて追加してください。

現況確認書

平成　年　月　日

甲　環境省福島環境再生事務所長

乙　住　所

氏　名　印

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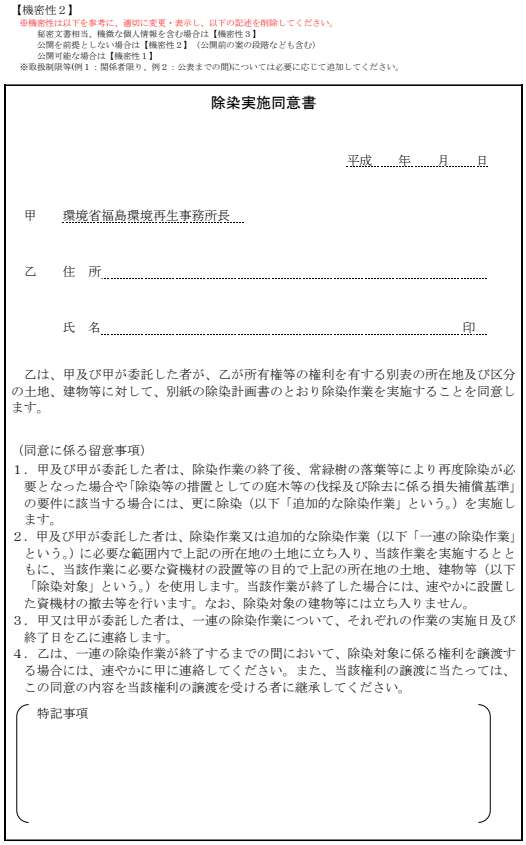
特記事項

Figure 4-4 Example of Present Condition Confirmation Form



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公開可能な場合は【機密性１】
※取扱制限等(例１：関係者限り、例２：公表までの間)については必要に応じて追加してください。

除染実施同意書

平成　年　月　日

甲　環境省福島環境再生事務所長

乙　住　所

氏　名　印

乙は、甲及び甲が委託した者が、乙が所有権等の権利を有する別表の所在地及び区分の土地、建物等に対して、別紙の除染計画書のとおり除染作業を実施することを同意します。

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特記事項

Figure 4-5 Example of Decontamination Implementation Consent Form

3) Posting in official gazette

In the Special Decontamination Areas, when the location of the persons concerned was unknown and the consent could be obtained in the Special Decontamination Areas, in accordance with Article 38 of the Act on Special Measures concerning the Handling of Environment Pollution by Radioactive Materials, the location of land to be decontaminated and decontamination methods, etc. are posted in the official gazette, and in case there was no objection, etc., within three months from the date of publication, consent was deemed to have been obtained.

If the current landowner was unknown, there were cases in which the land in question was posted in the official gazette and confirmed for a certain period of time, but after a certain period of time, when three parties (the landowner, MOE, and the contractor) were supposed to witness the site, the municipality would attend in place of the landowner, and decontamination was implemented even with the landowner unknown.

In the case where a large number of persons concerned were involved, there were cases in which by cooperation of the government, a government witness replaced the landowner witnesses.

(2) Efforts and Initiatives for Acquiring Consent

In order to obtain consent, it was necessary to identify and obtain consent from persons concerned who have rights to the target of decontamination, regardless of whether they were in residence or in evacuation, but there were potentially tens of thousands to hundreds of thousands of targets of decontamination, even

counting residential areas alone, and there were many cases of complex ownership and where the landowners were unknown. In Special Decontamination Areas everyone was in evacuation.

Under such circumstances, it was necessary to obtain consent by investigating the registries, etc., identifying the persons concerned, determining the place of evacuation, explaining the current situation, and explaining the decontamination method.

When obtaining consent, detailed drawings were prepared in advance, as well as materials about decontamination methods for each subject of decontamination, and careful explanations were provided to obtain consent. In explanation and consultation with residents, efforts were made to listen to the opinions and requests of the residents, to discuss the work methods, etc., to answer questions and concerns, etc., until both sides were satisfied.

For cases in which residents had evacuated, such as Special Decontamination Areas, efforts were made so that they themselves could confirm the decontamination work, such as obtaining the consent on site and allowing them to witness the decontamination work. Guidance and training were provided to contractors and decontamination workers involved in obtaining consent, so that they could respond sincerely and establish trusting relationships with the persons concerned.

There were also cases in which local workers who were themselves engaged in decontamination work cooperated to facilitate an earlier start of construction work. For example, they helped to get consent by obtaining information to reach evacuees through acquaintances.

Meanwhile, especially at the initial stage, decontamination methods and policies had not been decided in some cases, so questions or requests from residents could not be answered quickly. Also, the process of obtaining consent did not proceed smoothly in some cases, so it was not possible to start decontamination work in those areas, resulting in complaints from persons concerned who had been early to provide their consent.

Regarding the decontamination of individual houses, it was important that the persons responsible for obtaining consent had a consistent understanding of things. Otherwise, exceptions could disrupt the consistency of decontamination compared to other houses in the area.

(3) Status of Consent Obtained

1) Statistics on consent obtained

The trend for consent obtained in Special Decontamination Areas is shown in Figure 4-6, the number of persons concerned is shown in Table 4-1. Consent was obtained from 31,085 people out of 31,326 persons concerned, while consent was not obtained from about 241 persons concerned (as of the end of September 2017).

Table 4-1 Persons concerned
(Special Decontamination Areas)

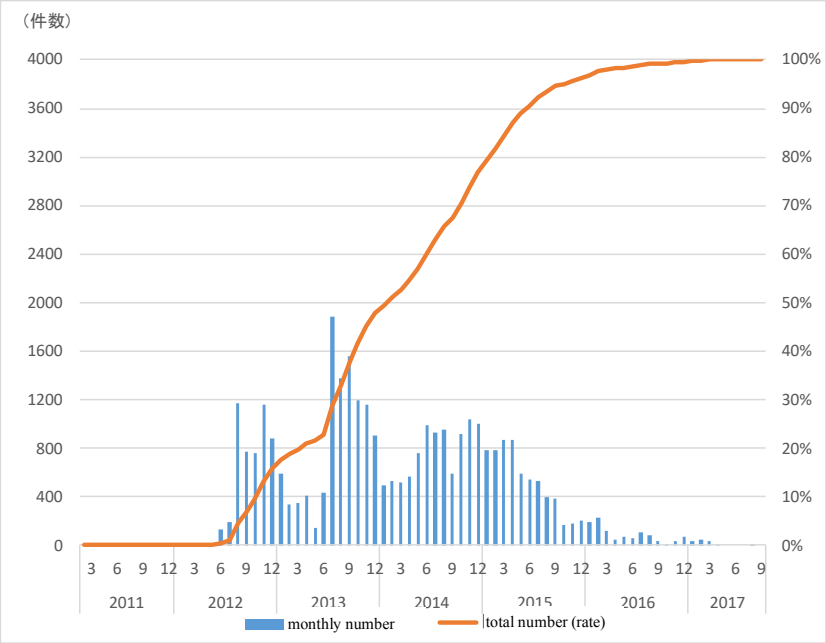


Figure 4-6 Trend of consent acquisition
(Special Decontamination Areas)

Municipality	Persons concerned (persons)
Tamura City	316
Naraha Town	4,095
Kawauchi Village	365
Okuma Town	464
Katsurao Village	827
Kawamata Town	822
Futaba Town	250
Iitate Village	2,599
Tomioka Town	4,643
Namie Town	7,573
Minamisoma City	9,372
Total	31,326

2) Categories of reasons to withhold consent

An effort was made to obtain consent for decontamination from persons concerned in Special Decontamination Areas, but consent was not obtained from some persons concerned. As a background to this, knowledge on the influence and risk of radiation was not widely known at the time of the accident, coupled with the repeated unclear explanations such as “no immediate impacts on the human body” about the influence of radiation, so it is conceivable that people were anxious and harbored distrust of the national government.

Table 4-2 Major reasons for withholding consent (Special Decontamination Areas)

Category	Major reasons for withholding consent
General	· Dissatisfaction and distrust in decontamination and government policy.
	· Cannot understand the purpose of decontamination.
	· Decontamination is meaningless unless the dose drops to zero.
	· The dose will be high adjacent to Areas where Returning is Difficult, so decontamination is a waste of effort.
	· Have no intention to return, so decontamination is a waste of effort.
Residential land	· Unable to manage own home after decontamination, so cannot give consent to decontaminate.
	· Do not want decontamination for the time being because damage to the house is significant (no roof) and the property adjacent to the residential land is extensive in area.
	·Belief that there is no meaning in decontaminating only the area around the main

	building.
Farmland, forest	- There is no point in only decontaminating 20 m radius around the target of decontamination. If the entire forest will not be decontaminated, I will not give consent.
	· I question whether inversion tillage will make the dose drop. It does not make sense, so I cannot give consent.
Temporary Storage Sites	· Since no Temporary Storage Site has been decided, I cannot give consent.
Compensation	· Will not give consent for decontamination unless compensation issues with TEPCO are resolved.

Note) Typical reasons to withhold consent in Special Decontamination Areas are indicated, including cases where consent was eventually obtained.

Column	"Acquiring consent for decontamination projects" Fukushima Regional Environmental Office

Decontamination was implemented under the assumption that consent would be obtained from landowners or other persons concerned. However, it was extremely difficult to obtain consent, especially at the beginning, in the context of anger toward the TEPCO Fukushima Daiichi nuclear power station accident and the lack of knowledge about decontamination.

Acquisition of consent in Special Decontamination Areas (SDA) was carried out sequentially with Tamura City first, then Kawauchi Village and Naraha Town. In Tamura City, personnel from the Fukushima Office for Environmental Restoration (now Fukushima Regional Environmental Office) obtained consent directly between June and August 2016 from about 300 landowners and other persons concerned. In Kawauchi Village, officials of the Fukushima Office for Environmental Restoration obtained consent from half of the persons concerned. To accelerate the obtaining of consent, once the method was established the remaining work to obtain consent in Kawauchi Village was contracted out. The work was also contracted out for Naraha Town and other municipalities.

At the start of decontamination, etc., MOE explained at briefings for residents that it would be seeking consent. Initially, residents were very angry and anxious, and it was not an atmosphere conducive to explaining matters, so we held many briefing sessions.

To obtain consent the Fukushima Office for Environmental Restoration set up a system of having teams of two persons, having one experienced active or retired municipal employee paired with one individual from the private sector, going to meet with each person concerned and speak about decontamination. They obtained consent by explaining the decontamination method based on each location. If the person concerned was elderly, an attempt was made to be as straightforward as possible with the language used to explain.

When work was contracted out to obtain consent, until around 2013, personnel from the Fukushima

Office for Environmental Restoration also accompanied the persons tasked with obtaining consent, and besides obtaining consent, they also presented briefings and training sessions using guidebooks, question and answer compilations, and decontamination consent forms, all in an effort to encourage conscientious and suitable efforts.

In one municipality, no progress was made at all immediately after efforts to obtain consent began, but at last, after repeated explanations, consent was obtained for just two administrative districts, and decontamination of houses was performed. Because the administrative districts happened to be along a main road, people from other districts were able to observe decontamination being performed, which promoted an understanding of decontamination, and then progress obtaining consent was made in other administrative districts as well.

Also, when difficulties were encountered in obtaining consent, personnel from the local municipality accompanied personnel from the Fukushima Office for Environmental Restoration, and that helped immensely.

In the future, decontamination will continue even in Areas where Returning is Difficult, so we will continue with efforts to carefully and sincerely obtain consent.

4.2.3. Monitoring Surveys

(1) Methods for Measuring Radiation Dose

The air dose rate and surface dose rate of gamma rays were measured mainly using a scintillation type survey meter, at heights of 1 cm, 50 cm, and 1 m. To measure the degree of contamination of the target of decontamination, the surface contamination density by beta rays from the surface was measured using a GM survey meter.

In order to confirm the degree of contamination of the target of decontamination and the effects after decontamination, measurements were made using a collimator (having cylindrical shielding material with lead, etc.) so as not to be affected by surrounding radiation.

When measuring the air dose rate, a radiation survey meter that satisfies the performance and requirements specified in JIS Z 4333 is used. When measuring the surface contamination density, the measured count rate (cpm) is recorded using a radioactive surface contamination survey meter that meets the performance and other requirements prescribed in JIS Z 4329.

Measurement of radiation dose is to be done in dry state in principle, in order to suppress the shielding effect by moisture.

Scintillation type survey meter

GM survey meter

Collimator

Measurement of air dose rate

Measurement of surface contamination density

Figure 4-7 Measurement instruments and methods

Source: "Decontamination Guidelines, May 2013, second edition (supplemented in September 2016)" (MOE)

(2) Development of Monitoring Techniques

In measuring air dose rates and surface dose rates, there were cases of utilizing an air dose rate measurement system with wearable GNSS (Global Navigation Satellite System). This enabled equipment to be reduced to one-fifth the original weight, and the radio transmission of measurement data made it possible to have just one person serve as both guide and recorder. Thanks to GIS, it increased work efficiency by a factor of ten with high speed guidance with car navigation sensing, and enabled the visualization of measurement results and progress of decontamination work.

In addition, a gamma camera was developed that makes it possible to visualize radiation by color-coding high or low radiation levels in a captured image. This made it possible to visualize radiation, which is otherwise invisible, and contributed to the confirmation of the effectiveness of decontamination and the safety of Temporary Storage Sites.

Credit: Kazima Corporation

Figure 4-8 Example of an air dose rate measurement system with a wearable Global Navigation Satellite System

Figure 4-9 Example of a gamma camera

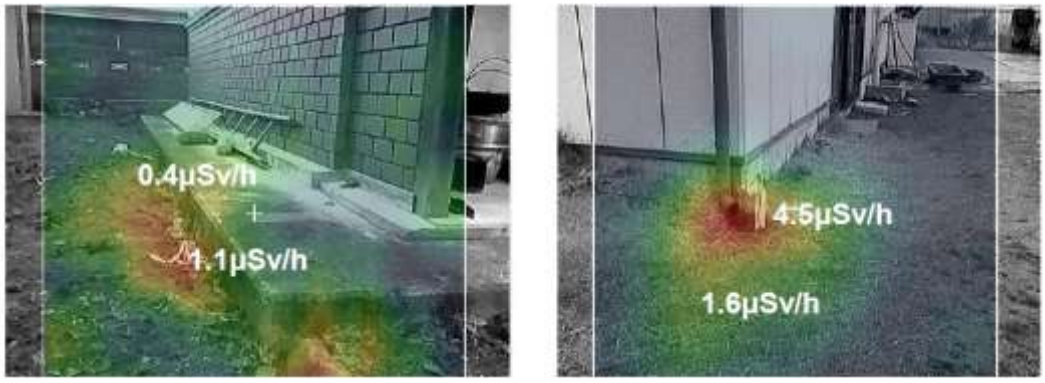


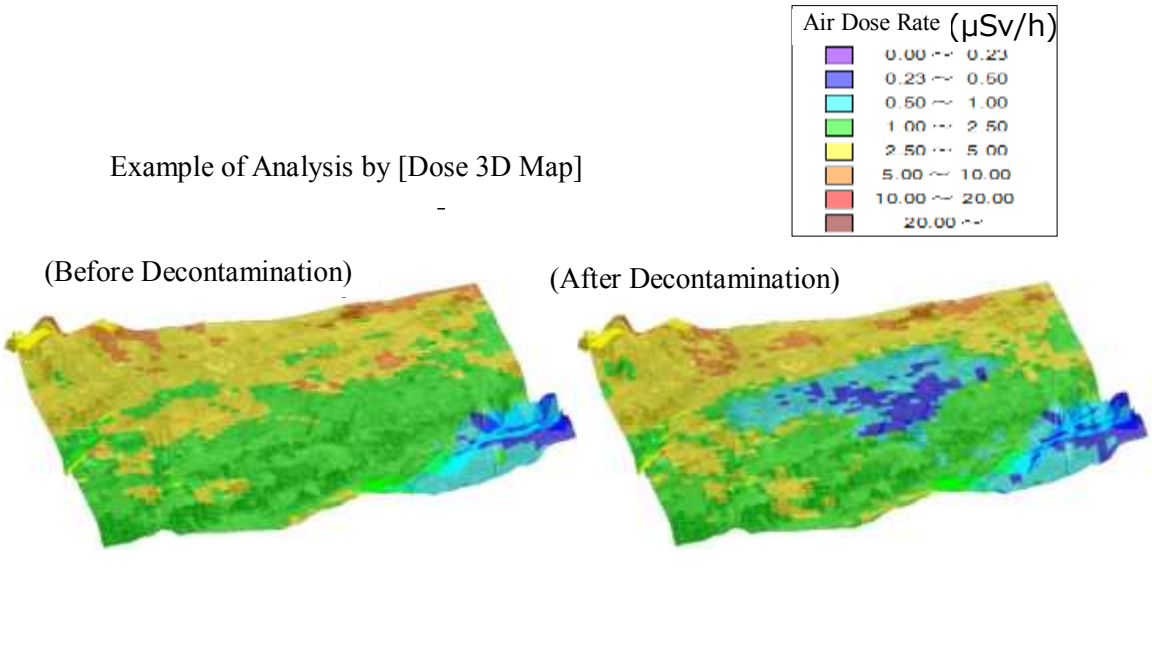
Figure 4-10 Example of image taken by gamma camera

Source: Reconstruction Agency, MOE, Fukushima City, Koriyama City, Soma City, Date City "Exchange of opinions with experts on decontamination: Thinking from past experience by the national government and four cities - Fact Book "(August 1, 2014)

(3) Support System for Decontamination Activities

JAEA has developed a "Calculation System for Decontamination Effect (CDE)" as a system to predict the air dose rate after decontamination and evaluate the decontamination effects. This system was developed as a system to estimate and evaluate the air dose rate before and after decontamination and to evaluate the effect of decreasing the dose rate by decontamination, and by using the general purpose software Excel it has become a system that many people can utilize. In addition to developing a "Restoration Support System for Environment" (RESET) that allows predictive evaluation of decontamination effects on a simple operation screen on the Internet, for use in municipalities in Special Decontamination Areas and Intensive Contamination Survey Areas, JAEA also makes predictions for the national government, municipalities, etc., and the findings are used to provide advice and technical guidance concerning decontamination implementation.

There is also a 3D decontamination effect prediction system developed by TEPCO and major construction companies. They use analytical technologies that read quantitative decontamination results from examples of decontamination work and predict decontamination effects based on realistic conditions (consideration of terrain and sky shine, etc.). They made it possible to predict the effects of decontamination work and explain the actual results, and helped to facilitate efforts to obtain consent from residents.



Credit: Shimizu Corporation

Figure 4-11 Example of 3D decontamination effect prediction system

4.3. Methods of Decontamination Work

4.3.1. Basic Principles of Decontamination and Overview of Decontamination Work

(1) Basic Principles of Decontamination

The decontamination work is mainly to remove soil and sediments containing radioactive materials. It also includes washing with water. For this reason, it is necessary to prevent contamination from removed soil, sediment, waste water after washing, etc., in places where decontamination work has been completed. Basically it should be working from top to bottom, to the extent possible. In residential areas, work is done in order, from removing branches of trees that are higher than the roof of a house, then working on roofs, upper floors, lower floors, and yards. In sloping forests, this meaning working from the top to the bottom of the slope. Likewise, for roads the work goes down from the top of the slope, and finally decontaminates the roadside gutters. If removed soil, etc., is to be transported, the road is cleaned and the roadside gutters are decontaminated after the transporting is done. Work plans were formulated based on these principles.

In terms of regional units as well, it is desirable to work in order, from areas at higher elevations to lower elevations, but in reality, in order to quickly proceed with decontamination, it was decided to implement decontamination starting with those areas where consent had been obtained and Temporary Storage Sites were secured.

In the Decontamination Guidelines “Guidelines for Decontamination and Other Measures, Second Edition” (MOE), important points for decontamination and other measures are indicated as follows.

① Take the necessary steps to protect the health of the surrounding residents and conservation of the living environment by taking measures such as prevention of scattering and discharge, prevention of offensive odors, noise, and vibration, etc., and record the amount of soil removed.

② In order to effectively reduce the radiation dose by decontamination, it is necessary to identify contaminated locations at a relatively high concentrations that contribute to the radiation dose, and to decontaminate in an appropriate manner depending on the characteristics of contamination. In addition, it is necessary to verify the effects by taking measurements before and after decontamination, and effectively reduce the radiation dose in the people's living environment.

③ In order to prevent the removed soil, etc., from mixing with other materials, it is necessary to keep removed soil and decontamination waste separate to the extent possible.

④ It is important to try to reduce the amount of removed soil generated by decontamination work and it is also important to prevent the spread of contamination that might arise by doing decontamination work. For example, washing with water produces waste water containing radioactive substances. Thus, to the extent possible and as appropriate, contractors are expected to remove radioactive substances by methods other than washing with water, in order to avoid impacts where the water would flow. Furthermore, when it is deemed necessary in consideration of the actual circumstances of the area, regular monitoring will be carried out after such measures.

In addition, the following remarks are indicated in "Common Specifications for Decontamination and Other Work" (MOE) and "Technical Guidelines on Decontamination Operations" (Fukushima Prefecture).

· For decontamination, the sequence for efficient work is "from top to bottom" and "from upstream to downstream."

· Decontaminate in sequence of yard trees, roofs, rain gutters, yard areas, etc., in consideration of the spread of contamination from decontamination work.

· To prevent re-contamination, perform work in order from high to low positions.

· Work should be conducted from upstream to downstream in the water gradient, to avoid scattering water around.

(2) Overview of Decontamination Work

The decontamination methods in Special Decontamination Areas are stipulated in "Common Specifications for Decontamination and Other Work" for each land classification and target of decontamination. The main decontamination methods are shown in Table 4-3.

Table 4-3 Main decontamination methods

Classification	Subject to decontamination		Main decontamination method (choose the appropriate method)
Residential area etc., school, park, large facilities	Roof · rooftop		Removal of sediment / wiping / brush wash / high pressure water wash
	Exterior wall · moat		Wiping / brush wash / high pressure water wash
	Rain gutter		Removal of sediment / wiping / high-pressure water washing
	Yards, ·grounds	Unpaved surfaces	Removal of sediment / weeding / lawn mowing / deep cutting of grass / stripping of grass / laying of new turf Gravel and crushed stones cleaning by high pressure water / removal and covering of gravels and crushed stones removal of topsoil at drainage points under eaves / removal of topsoil near the root of trees / scraping of surface soil / coating / inversion tillage Trimming of yard trees - planting / logging and stumping of obstacle trees / restoration of yard soil
		Paved surfaces	Removal of sediment / brush washing / high pressure water washing / scraping / blasting / extra high pressure water washing
	Playground equipment		Wiping / cleaning / scraping
Road / Slope	Paved roads		Removal of sediment / high pressure water washing / scraping / blasting / extra high pressure water washing / cleaning with a road surface cleaning vehicle
	Unpaved roads		Weeding / removal of sediment / scraping of topsoil / covering / inversion tillage / high pressure wash of gravel and crushed stone / gravel · crushed stone removal · coating
	Guardrails		Brush cleaning / high pressure water cleaning / wiping
	Roadside gutters, etc.		Removal of bottom sediment
	Footbridges		Removal of sediment / high pressure water cleaning / wiping / brush cleaning
	Roadside trees		Removal of sediment / weeding / removal of topsoil near the root / delimbing
	Slopes		Removal of grass · fallen leaves · sediment
Farmland	Paddy fields / fields		Weeding / scraping of topsoil / mixing with water and removal of soil / inversion tillage / deep plowing/ deep tillage / willow tree cutting down, chipping,· root removal, pulling out / clear cutting of bamboo / logging of obstacle trees · root cutting / additional soil / cutting and removal of shrubs / soil restoration, fertilization
	Pastures		Weeding / scraping of topsoil / deep plowing / deep tillage
	Waterways		Removal of bottom sediment, etc.
	Levees		Removal of sediment / weeding / scraping of topsoil
Grassland · strips			Cutting of shrubs / thinning of bamboo

Orchards	Removal of sediment / weeding / peeling of rough bark / high pressure water washing of bark / pruning of fruit trees / cutting down, root cutting / scraping of topsoil · excavation
Forest	Removal of organic residue /sorting of cuttings/ pruning of coniferous trees / cutting and removal of undergrowth and shrubs / removal of organic residue sediment

1) Decontamination of residential areas and large facilities

In buildings such as houses and large facilities, in order to prevent the spread of contamination such as through scattering and discharge due to decontamination, decontamination was carried out in order, from top to bottom, from roofs, to rain gutters, exterior wall, fences and playground equipment, and yards, to roadside gutters, etc.

On roofs, work included removal of sediment, wiping, and brush washing, and on concrete roofs, high pressure water washing was also done. Rain gutters were cleaned with high pressure water, etc., while exterior walls were wiped off, brushed and washed with high pressure water.

After wiping off fencing and playground equipment, etc., in the yard, work included removing sediment in the yard, weed removal, and topsoil scraping, etc. were implemented. When topsoil scraping was done, new soil was applied.

In the Intensive Contamination Survey Areas, partial decontamination of places with high air dose rate was carried out based on the results of preliminary radiation monitoring.

When decontamination was carried out, an effort was made not to damage buildings, and if it was a location with extensive damage due to the earthquake disaster could not be decontaminated due to being a thatched roof, etc., the target and method of decontamination was determined after discussion with the owner.

Also, as time passes after decontamination, radioactive substances that had adhered to roofs and exterior walls, etc., tend to flow out due to rain, etc., and tend to accumulate in rain puddles and below vegetation, etc., so decontamination was conducted accordingly.

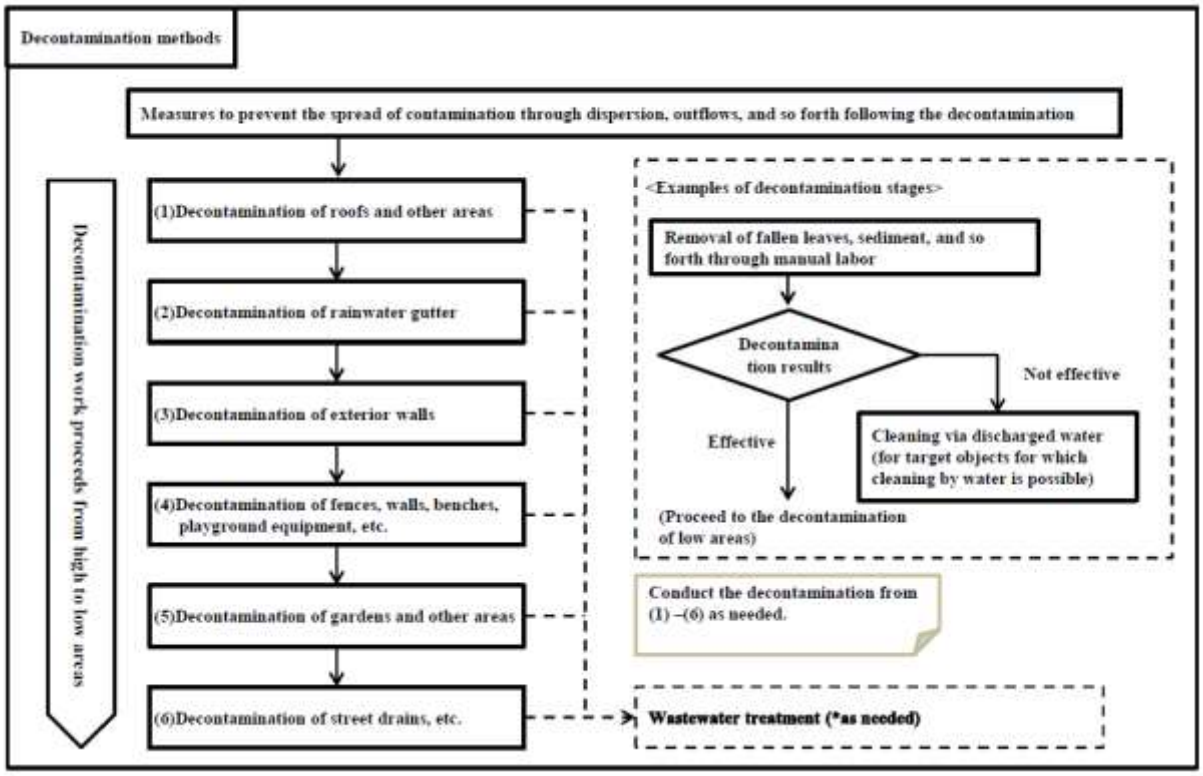


Figure 4-12 Basic flow for the decontamination of buildings and other structures

Source: MOE "Decontamination Guidelines, Second Edition" (supplemented September 2016)

Credit: Kajima Corporation
Removal of sediments

Credit: Taisei Corporation
Wiping off

Credit: Maeda Corporation
Brush cleaning

Credit: Maeda Corporation
Removal of gravel and crushed stones

Credit: Maeda Corporation
Removal of gravel and crushed stones

Credit: Obayashi Corporation
Scraping of topsoil

Credit: Taisei Corporation
Covering with topsoil

Credit: Okumura Corporation
Covering

Figure 4-13 Status of decontamination of residential areas and large-scale facilities

2) Decontamination of roads, etc.

On roads, work was implemented in order, from road surface to roadside gutter, etc. to prevent the spread of contamination such as scattering and runoff due to decontamination and the generated wastewater was subjected to wastewater treatment.

After sediments were removed, the pavement surface was decontaminated by high-pressure water washing, extra-high pressure water washing, blasting or the like, depending on the state of the surface and the contamination situation. Due to the large area of pavement surfaces such as roads and parking lots, various technologies were developed to efficiently decontaminate, such as high pressure washing trucks for road surfaces that were upgraded from high pressure washing trucks.

On unpaved surfaces, work performed included sediment removal, weeding, scraping of the topsoil, high-pressure water washing of gravel and crushed stone, etc.

In addition, road structures such as guardrails were wiped and high pressure washed with water, and for surfaces, sediment removal and weeding were carried out. After this decontamination was completed, work performed included cleaning of road surfaces and removal of bottom sediment of roadside gutters, etc.

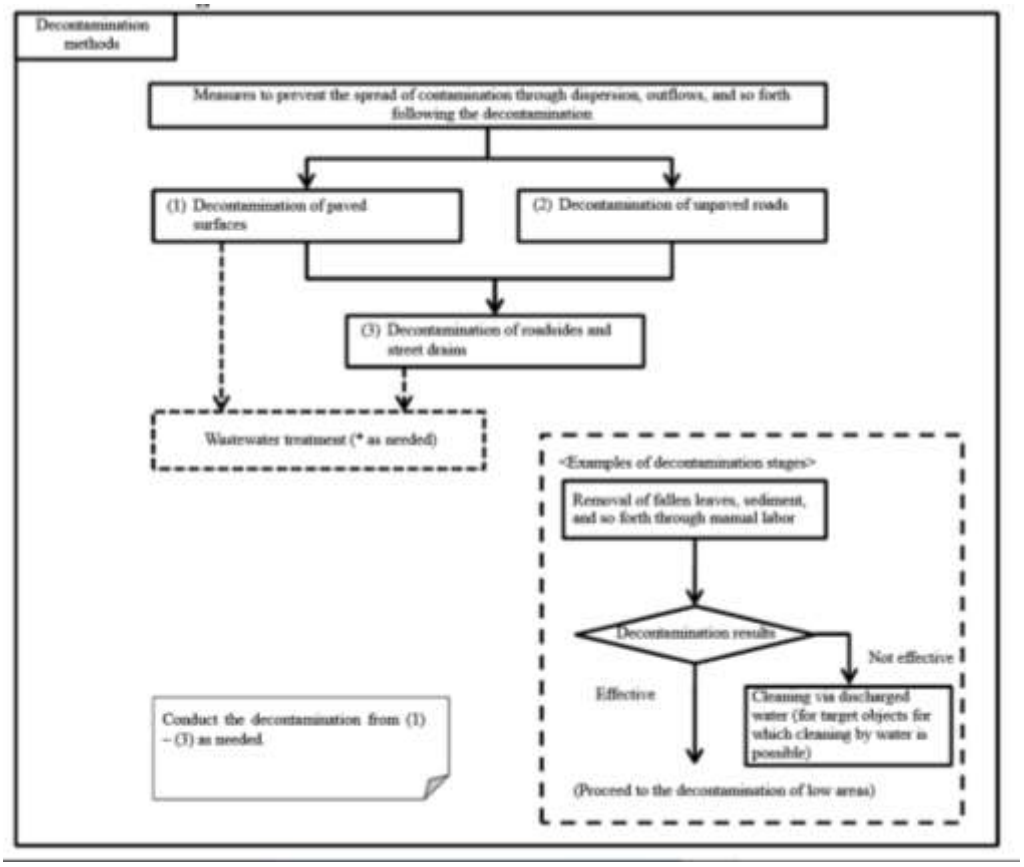


Figure 4-14 Basic flow of road decontamination

Source: MOE "Decontamination Guidelines, Second Edition" (supplemented September 2016).

Credit: Taisei Corporation
Wiping off

Credit: Taisei Corporation
Brush cleaning

Credit: Taisei Corporation

Credit: Taisei Corporation
High-pressure water washing

Credit: Maeda Corporation
Blasting

Credit: Maeda Corporation
Extra high-pressure washing

Figure 4-15 Status of decontamination of roads

3) Decontamination of agricultural land

On agricultural land, once it has been cultivated after a disaster, it is not practical to scrape off the topsoil, as cesium that had been deposited on the surface becomes diluted and dispersed in the soil of the cultivated field.

For this reason, farmland use was included in the Intensive Contamination Survey Areas, etc., and in plowed farmland, inversion tillage and deep tillage were performed. In these agricultural lands, steps were taken such as fertilization with potassium in order to address issues of absorption into crops.

On agricultural land that was not cultivated, such as in evacuated areas, after removal of sediments, topsoil was scraped off. Even in evacuated areas, where the doses were low, decontamination was done by

inversion tillage and deep tillage, which do not require soil removal. Technical document of the Ministry of Agriculture, Forestry and Fisheries about agricultural land decontamination measures shows for inversion tillage if radioactive cesium concentrations in the soil are lower than 5,000 Bq/kg, and for topsoil scraping if above that. However, for relatively low concentrations in agricultural land in Special Decontamination Areas, MOE suggests deep plowing and deep tillage, and in other areas, topsoil stripping.

In agricultural lands where some time had passed since the accident, the land became overgrown with shrubs and brush, making it necessary to have root removal, and additional soil was needed as an alternative to topsoil scraping.

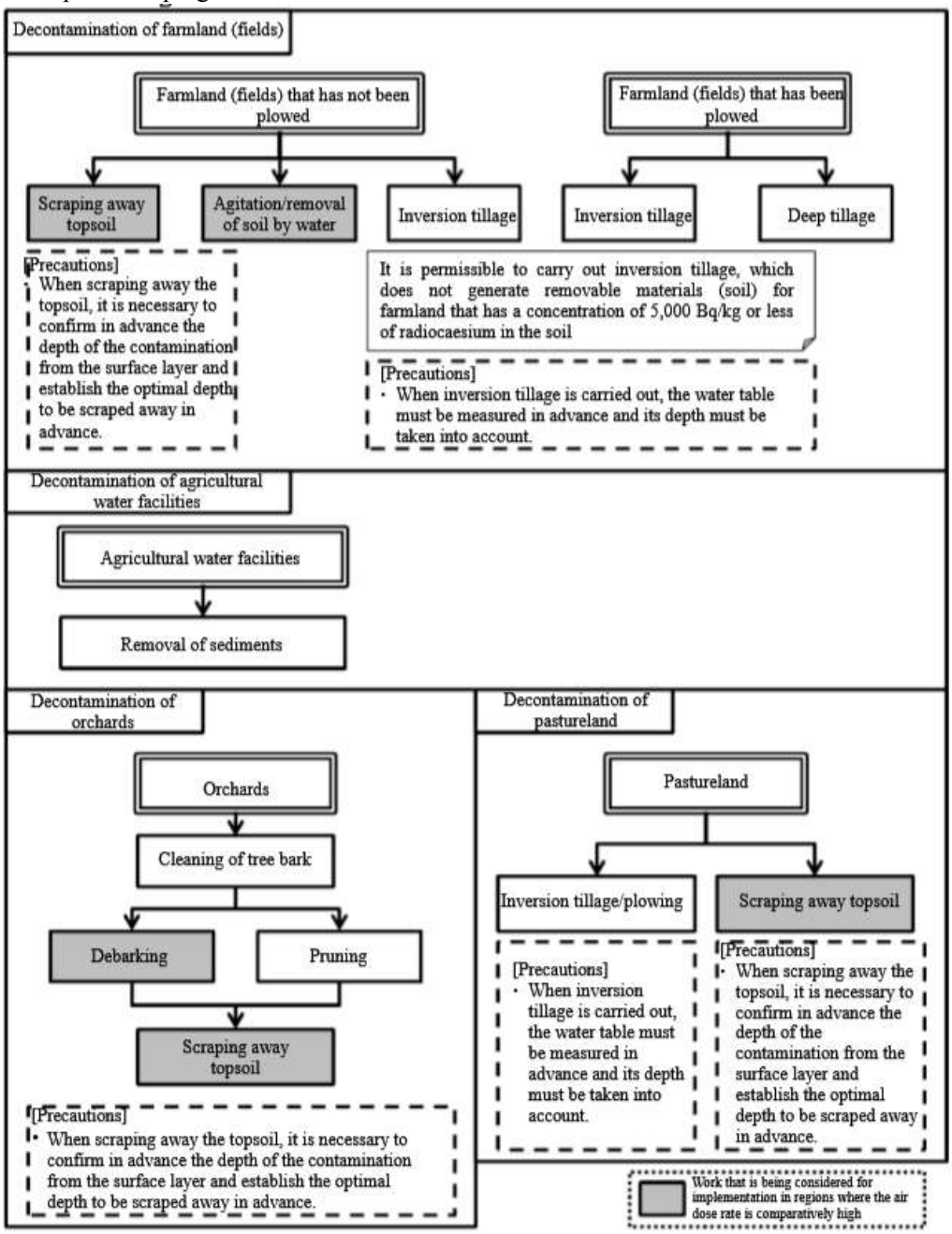


Figure 4-16 Basic flow of decontamination of Farmland

Source: MOE "Decontamination Guidelines, Second Edition" (supplemented September 2016).

Credit: Maeda Corporation

Credit: Shimizu Corporation

Manual weeding, mechanical weeding, mechanical bundling etc.

Credit: Shimizu Corporation

Topsoil scraping

Credit: Okumura Corporation

Additional soil

Credit: Hazama Ando Corporation

Credit: Shimizu Corporation

Topsoil scraping and collecting using specialized equipment

Credit: Okumura Corporation

Deep tillage

Credit: Obayashi Corporation

Inversion tillage

Figure 4-17 Status of decontamination of agricultural land

4) Decontamination of forests

① Measures including decontamination of neighboring forests of residences

Regarding forests in the vicinity of residences, etc., from the viewpoint of reducing the radiation dose in the living environment of residents, measures were conducted within about 20 m from the edge of the forest edge near residences.

In forests, after removing undergrowth and brush, fallen leaves and other organic residue was removed. In forests where some time had elapsed after the accident, radioactive cesium had migrated under fallen leaves and other residue, so in some cases simply removing organic residue would not be effective enough for decontamination. In such cases, where trials have been proven effective, residue (humus soil directly beneath fallen leaves and organic residue) was removed using tools such as bamboo brooms to a distance of 5 m from the edge of the forest. In the process, care was taken not to overly expose the roots of plants, from the viewpoint of preventing soil runoff.

In evergreen coniferous forests such as cryptomeria and Japanese cypress, radioactive cesium could still be attached to some branches and leaves because the needles usually fall over the course of about three or four years and large differences arise depending on the forest condition. In such cases, branches and leaves were removed from standing trees at the forest edge, as necessary.

In addition, when re-contamination has been confirmed as a result of soil runoff over time from forests that have a low ratio of soil coverage by organic residue and forest floor vegetation and have a steep gradient and high degree of contamination, the necessary countermeasures are carried out (e.g., installing wooden fences, etc.).

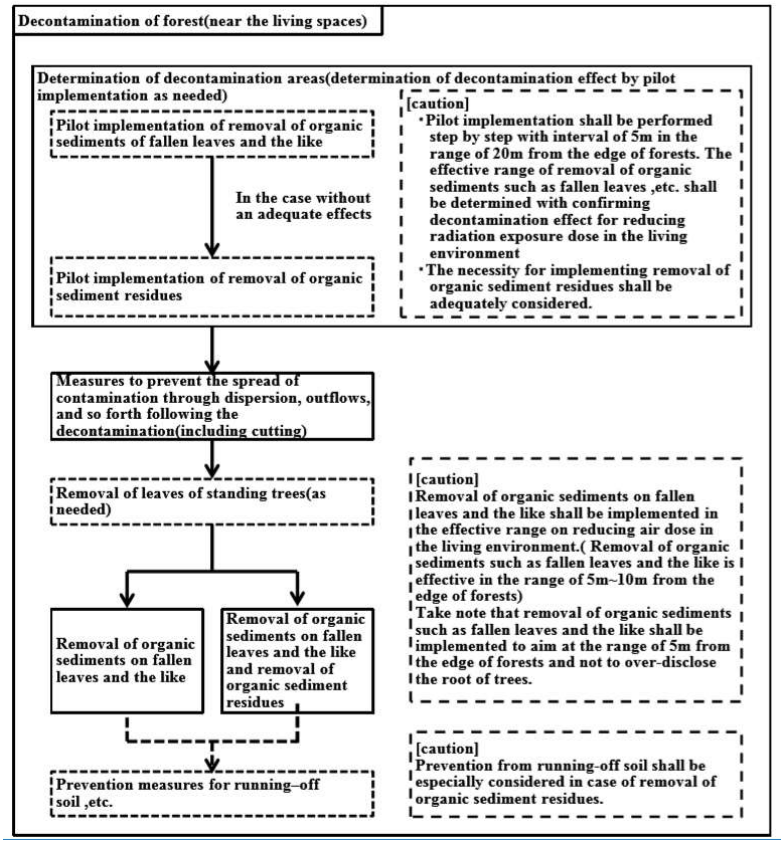


Figure 4-18 Basic flow of forest decontamination

Source: MOE "Decontamination Guidelines, Second Edition" (supplemented September 2016)

Credit: Okumura Corporation
Removal of residue

Credit: Okumura Corporation
Conifer tree pruning

Figure 4-19 Status of Forest Decontamination

Removal of organic residue by metal rake

Ground surface after removal of organic residue

Figure 4-20 Example of removal of organic residue such as fallen leaves

Removal of residue by bamboo broom* after removal of organic residue
* Cut to about 20 to cm to ensure flexibility of tip.

Ground surface after removal of organic residue (roots start to be exposed).

Figure 4-21 Removal of organic residue and residue

Credit: Kawauchi Village

Fig. 4-22 Example of measures including decontamination of forests (measures to prevent soil runoff)

② Decontamination measures for forests where people frequently enter

Regarding locations where people routinely enter forests such as satoyama near residences, considering the specific needs of the local people and from the viewpoint of reducing the additional radiation dose taking into consideration the site conditions, decontamination is implemented after considering the scope and method of implementation. Specifically, decontamination is to be implemented properly after considering factors such as the frequency of access and time typically spent, and the risk of soil runoff, etc., especially in recreational areas and where there are many opportunities for people to enter the forest, such as mushroom farm, charcoal making, campgrounds, walking paths, hiking path, forest roads, rest areas, open areas, and parking lots, etc.

Regarding forest areas where people frequently enter, as necessary, remove organic residue such as fallen leaves, remove organic residue, remove branches and leaves of standing trees, and implement measures to prevent soil runoff. This is done taking into consideration air dose rates, frequency of access and time usually spent at each facility (or for each section of the facility, as necessary), in accordance with decontamination measures in forests near residential areas, and after deciding on the effective range of forest decontamination based on test work.

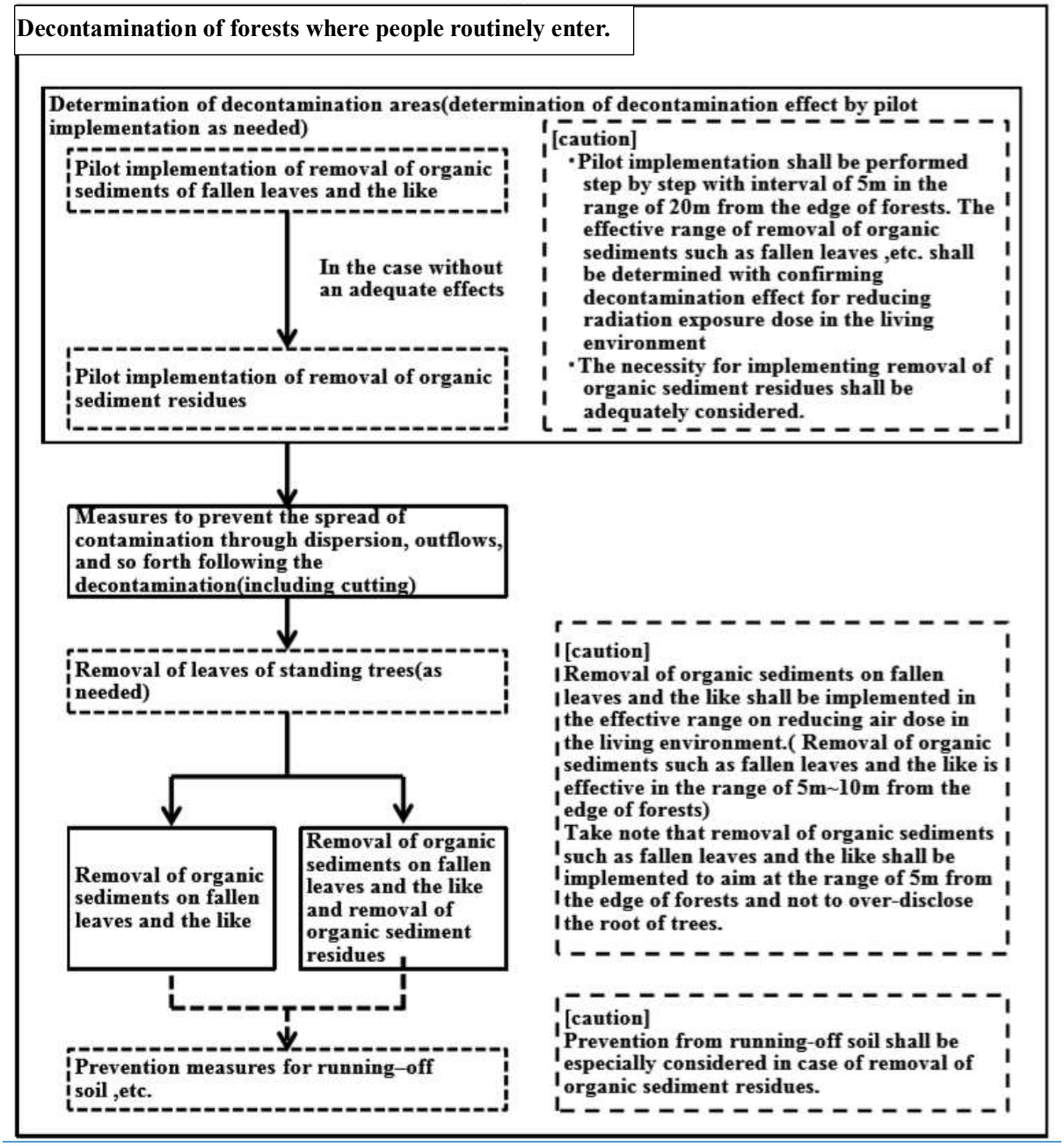


Figure 4-23 Basic flow of decontamination and other measures in places where people frequently enter the forest

Source: MOE "Decontamination Guidelines, Second Edition" (supplemented September 2016).

5) **Decontamination of reservoir**

For decontamination by scraping bottom sediment from reservoir, considering the possibility that more radioactive cesium may be present below the surface layer, efforts were made to avoid producing an excessive amount of removed soil, etc. To do so, the thickness to remove was determined by scraping off several centimeters at a time at the appropriate places in the pond while measuring the surface contamination density.

In addition, sediment had to be scraped to the extent that decontamination would be effective in reducing the air dose rate in the surrounding living environment. However, if there was a possibility that the air dose rate in the surrounding living environment could be affected in the future by the flow of water into or out of the pond after decontamination, as necessary, decontamination of the bottom sediment was conducted on an scale that was appropriate considering the possibility of sediment transport within the pond. This included locations where there was no current impact on the air dose rate in the surrounding living environment.

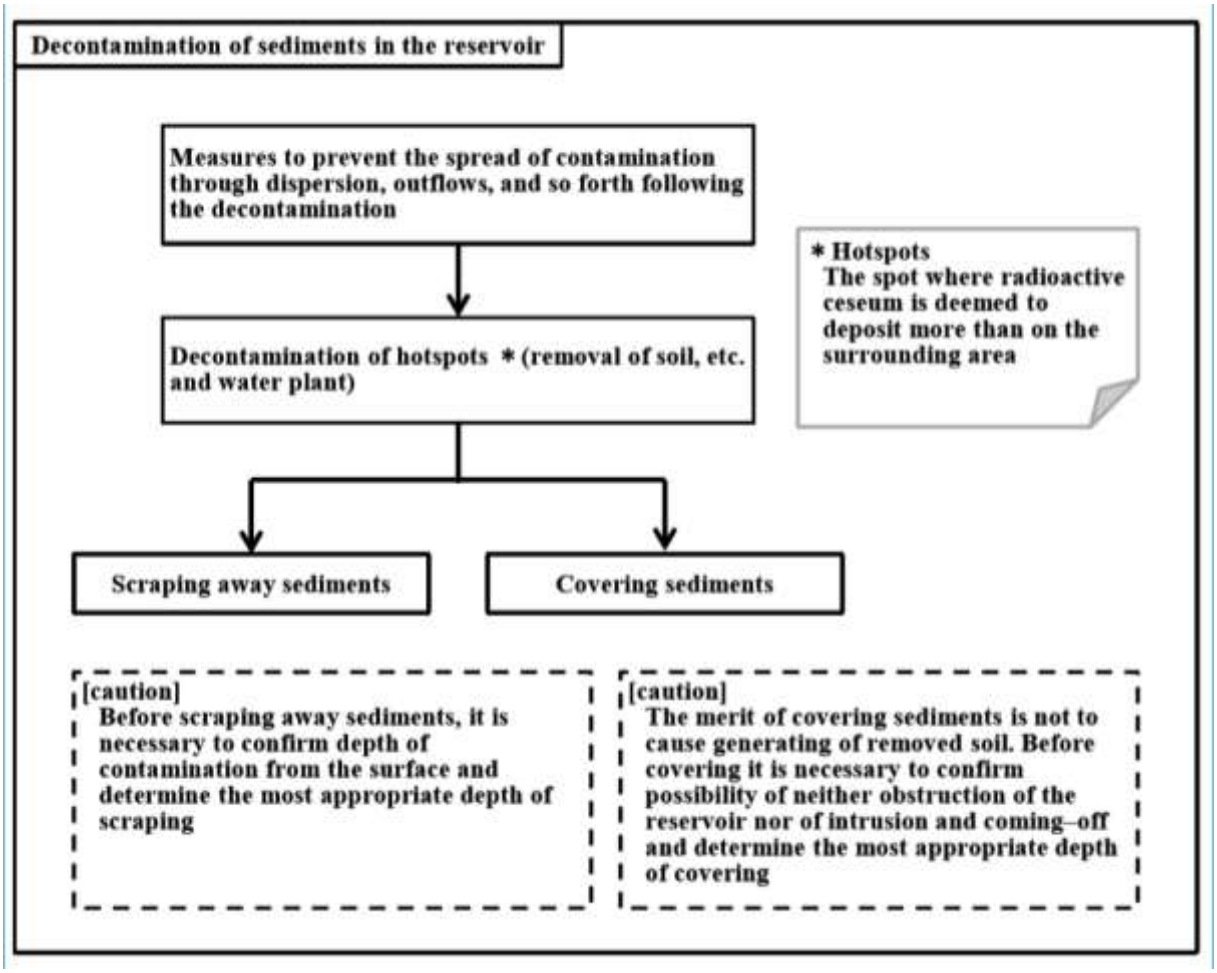


Figure 4-24 Basic flow for the decontamination of sediment in reservoir

Source: MOE "Decontamination Guidelines, Second Edition" (supplemented September 2016).

(3) Decontamination Work in Special Decontamination Areas

1) Preparation of work plans

The Common Specifications for Decontamination and Other Work indicate decontamination methods and other matters for each target. Prior to commencing work, decontamination contractors prepared overall work plans that cover all procedures and methods required to complete their work, and submitted them to supervisory.

2) Test work

The work methods for decontamination depend on the situation on-site as well as the material and surface condition of the target of decontamination, so it is impossible to uniformly design an optimum work method and work conditions. For this purpose, test work was conducted in advance in order to decide the most effective decontamination procedures.

For example, test work was conducted in actual site conditions and decontamination methods were decided based on reviews by supervisory personnel at MOE. Examples include the number of wipes needed in wiping operations, the depth and speed of deep tillage, and the rate of advancing of high-pressure road surface washers, etc.

3) Implementation of decontamination work

Decontamination work was implemented based on work plans. After implementation, reports were prepared to summarize the work results, and the persons responsible for the work verified that it was done properly based on the report and submitted the results to supervisory personnel at MOE.

4) Attendance by residents

Regarding Special Decontamination Areas, since the residents had evacuated and were therefore absent, when decontamination work was to be done the schedule was provided in advance to persons concerned so that they could attend and observe if they wished to do so. This approach encouraged persons concerned to understand the work situation of decontamination, and confirmed on site the matters that required confirmation.

5) Confirmation surveys

Confirmation surveys were carried out after decontamination work to confirm whether work had been performed properly. For example, proper wiping and washing are difficult to determine only by visual inspection after decontamination work, so supervisory personnel from MOE would randomly select a sample section of a surface and have the workers repeat work there using the same method. It could then be confirmed whether or not a reduction in the surface dose rate could be observed comparing before and after the decontamination work.

Measurement of the radiation dose in confirmation surveys was carried out before and after decontamination by using a collimator (using lead as a tubular shielding material) to calculate the air dose rate, etc., at a height of 1 cm, measured using the same measuring equipment before and after.

6) Work process and progress management

From the start of work to completion, decontamination contractors are required to complete a daily work report, making note of the weather, work location, work description, number of workers, work progress quantities, work equipment, and radiation doses in the work area, as well as instructions, approvals, and

consultation items, etc. The reports include photographs to record the work, and checklists on the results of decontamination measures.

It was decided to use photographs of work as a means of work management. Based on photograph management standards, photographs are taken at each stage of work and after work completion, showing work conditions in locations that cannot be visually inspected, work progress measurements, quality control status, and disaster photographs of work in progress, etc. The photographs are to be stored properly and submitted when work is completed.

In addition, for work categories with numerical specifications listed in documentation on Common Specifications for Decontamination and Other Work, measurements are taken based on the items and standards for measurements specified in work progress control standards. The design values and actual measurements are compared and recorded, and compiled in work progress control charts and tables.

(4) Development of New Technology

At the beginning of the full-scale decontamination work, there were decontamination methods that used various existing techniques and proposals for new materials. Test work was conducted using many work methods, equipment and materials, and after evaluation and repeated refinements, they were adopted as new techniques for use at decontaminations sites. Many of these work methods were incorporated sequentially during revisions of documentation on the Provisional Quantification Standards for Decontamination Work.

(5) Issues in Decontamination Work

1) Changes in work methods over time

The decontamination techniques used for decontamination work in Special Decontamination Areas changed as time elapsed after the accident. For paved road surfaces, a certain degree of decontamination was achieved initially, but as time passed, cesium migrated deeper, so the effective method was no longer to clean the surface but to use blasting to cut the pavement surface.

Also, as time passage after the accident, weeds grew in the soil of yards of homes and other properties and on unpaved roads, and brush and shrubs grew in fields, resulting in an increase in work for the weeding and cutting of brush and shrubs, compared with the initial decontamination work, etc.

2) Processing after topsoil scraping

Topsoil scraping is effective for dose reduction, but it takes a certain amount of time for the bare ground to recover. Particularly, when this is combined with heavy rainfall, the result could be the runoff of surface soil or slope collapse, so until the vegetation is restored, in some cases blue sheets were used to cover and protect the ground as a short term response measure.

For decontamination in residential areas, when the heavy rain fell on sloped land there was some runoff of additional soil material (mountain sand) whose original shape was restored after being scraped, so work had to be repeated in some cases. To prevent recurrence, it was decided to use crushed stone for about 2 m downstream to prevent the discharge of mountain sand from residential land.

3) Soil amendment of removed soil

For decontamination of agricultural land in Special Decontamination Areas, when scraped soil was put into a large container bags and transported to Temporary Storage Sites, the contents liquefied (turned to

mud) by vibration, so the bags could not stand alone at Temporary Storage Site, and could not be stacked in some cases. As a countermeasure, soil amendment was considered, and attempts were made to stabilize the stacks at Temporary Storage Sites by using gypsum as a hardening material, with no impact on agricultural land.

4) **Supplemental decontamination**

Although the air dose declined due to wide area decontamination, supplemental decontamination was done in cases where localized high-dose locations were found, such as rain puddles, rainwater drain outlets, roadside gutters, surface edges of paved and unpaved roads, under vegetation, on slopes and on flat surfaces, etc.

As an example in a Special Decontamination Area, if a filter drain or the drain itself had deteriorated, the drain was removed, the bottom material excavated and removed, and the components reinstalled or replaced with new ones. Because more space was required for the reinstallation, the diameter of excavation was expanded. If there was a source of contamination in connecting pipes, the pipe was removed starting from the level of the connecting pipes in a downward direction and horizontally until the dose decreased.

5) **Responding to persons concerned**

Decontamination contractors adjusted their responses for persons concerned when deciding methods and targets of decontamination. There were various inquiries and requests from persons concerned. In response, while reporting to and consulting with MOE and other clients, the consultants strove to build positive relationships and respond, to the extent possible and within the scope of the decontamination work.

On the other hand, certain problems also arose. In the case of decontamination of houses, work was performed after checking with the persons concerned regarding the work method and what to leave behind, but in the decontamination of planted trees, for example, in some cases problems arose when the contractor cut down plants and trees that the owner had felt were important, because contractors could not distinguish between them.

In agricultural land decontamination, in some cases persons concerned requested that paddies be converted to crop fields or that improvements be made to access roads. In such cases, the contractors responded while consulting with MOE and local governments.

Column	"Challenges and solutions in decontamination work" Mr. Shigemi Kumagai, Kahoku Kensetsu, Inc. (subcontracted by Hazama Ando Corporation)

The decontamination work requires steps be taken prior to the start of work, such as radiation dose monitoring and confirmation of decontamination details with landowners. Even after starting the work, there could be changes in the details and methods while work is under way. It was stressful at times, as an effort was needed for problem solving. In Namie Town in particular, all of the landowners had been evacuated, so it took a long time to contact them and confirm things.

In the work of stripping contaminated soil on residential land, after the decontamination work, the dose was measured and if there were still spots with a high dose the work had to be redone, but first we would have to wait for a decision on the depth and extent of work.

In the decontamination of the residential land, it was important to be considerate of landowners. We could not handle items on the property without the landowner' permission, and some items were full of memories for them even if covered with dust. There were also fragile items, and we had to handle them carefully. Also, there was manual work scraping off soil in confined spaces, so persistence was required.

However, there were times when landowners returned to check on the decontamination work and showed their appreciation when they saw their homes looking clean. That gave us the strength to keep on going.

For decontamination of agricultural land, we would restore levees (between fields), and there were times when local farmers would work together with us using their own specialized farm equipment. The sense of unity was improved through working together, making it easier for people to understand each other.

For some workers this was the first time doing construction-related work. Some did not take the decontamination work seriously and only lasted a few days on the job. Also, some did not have expertise in civil engineering terminology, equipment types and functions, and did not understand things that I thought should have been obvious. Initially I couldn't see why they could not understand. For work that required certification, there were operators who despite being certified lacked operating experience, so work did not proceed as well as I expected, or something occurred that made me fear for an accident. There was also guidance from joint ventures and they also assigned personnel and provided training based on each person's ability, so I think that things improved considerably.

In Namie Town, some places returned to looking like abandoned land, as some property was neglected when it took one to five years after decontamination for the evacuation orders to be lifted. Evacuation orders were only recently lifted, but it seems that many of the returnees are elderly. I really hope that farming will resume, young people will return, and that this once again becomes a vibrant town.

Column	"Challenges and solutions in decontamination work" Mr. Yusuke Suzuki, Soso-Retec KK (subcontracted by Shimizu Corporation)

The most difficult thing when I first started doing decontamination work was the gap between my own pride and sense of value for this work versus the evaluation from the public.

Also, many workers came from various places and there were age differences. It was hard to build team spirit, but I felt that it was the most important to facilitate the decontamination work. I also learned the importance of working with an appreciation of the feelings of landowners.

I am from another prefecture, but I got married in Fukushima and we are now living here with children.

For the children, I want to make an effort to do decontamination work for the reconstruction and restoration of this place, Fukushima.

Column	"Challenges and solutions in decontamination work" Mr. Yoshinari Itagaki, Kajimaroad Co, Ltd. (subcontracted by Kajima Corporation)

After October 2013 I was in Tamura City engaged in decontamination work under the direct supervision of MOE, and I was currently performing decontamination work in Tomioka Town.

A difficult point was at the beginning when due to the rapid recruitment of workers, a large number of them were nearly amateurs so we had to begin by telling them how to hold and use a shovel. To reduce radiation doses it was sometimes necessary to decontaminate the same spot two, three, or more times. However, since the work itself did not require high technical skills, within about a month they had learned enough to perform satisfactory decontamination work and output.

In terms of dose reduction, we tried to raise their sense of accomplishment by measuring the dose in real time after decontamination was done, and letting workers know how much the dose had been reduced.

Regarding work output, we worked to achieve quality and volume of output by having teams of the same number of people doing similar work at the same time in several locations. We would announce their output on a daily basis in an effort to create some competition.

In the future, I think that there will be fewer large-scale decontamination projects, but even in smaller-scale decontamination work, we want to do our best for the reconstruction of the Hamadori District, using the techniques we developed and not forgetting what we worked so hard to learn.

Column	"Challenges and solutions in decontamination work" Mr. Hajime Fujishima, Kishimoto-Kensetsu (subcontracted by Obayashi Corporation)

It has been around six years since I came to Fukushima Prefecture on my assignment. In that time, we have engaged in decontamination demonstration projects in Hirono Town and full decontamination work in Kawauchi Village and Tomioka Town. But no one had previous experience in the work of decontamination, so initially it was like trying to grasp a cloud as we searched for a way to proceed. Many of the workers were inexperienced due to unemployment and career changes, so we tried to avoid using technical language and were careful not to proceed with work until they were able to understand what was required. When inspecting work sites, I tried to interact with as many workers as possible, and to make it a lively workplace where anyone could speak out about any concerns. As a result, although workers differed in terms of where they came from, in age, and in company affiliation, there was no conflict between workers and the workplaces were lively and cheerful, with good team spirit. We interviewed anyone who sought work here, being sure to check their health status, medical history, and comprehension of decontamination work. Anyone found to be inappropriate was not allowed in. By doing so, we were able to prevent inconsistencies in decontamination work and prevent serious accidents. Seeing nurseries and elementary schools returning to the calm that existed before decontamination and seeing the children running around healthily, the workers were rewarded with the feeling that their work had served the community. Going forward, I am committed to keep focusing on the restoration work, and I feel a strong sense of determination and responsibility to continue doing work that is safe and secure.。

Column	"Thoughts on being engaged in decontamination work" Mr. Sho Kawamura, Nikki Construction Co., Ltd. (subcontracted by Taisei Corporation)

I first started working on decontamination in the Kusano administrative district of Iitate Village on the last day of June 2012, and already nearly six years have passed. I think back to the victims of the Great East Japan Earthquake that struck on March 11, 2011. The villagers had to "evacuate from an evacuation," and had no time to settle comfortably back at home due to the huge problem of radioactive contamination. It has pained me to think about that.

Decontamination work done in the absence of residents was something I had never experienced before. When I went under the eaves or entered the gardens of a landowner's homes, or entered their forests and or farmland, I always had the mindset of acting with the care I would have if this was my own home. I express my condolences from the bottom of my heart.

In the spring of 2013, our company started working on decontamination mainly on the residential land Usuishi district where we had been assigned. It was a very challenging time for our company. Among other things, with the magnitude of the task of hiring 400 workers, our company struggled to recruit workers, and nearly half of the people we hired were inexperienced in the construction industry, making me feel my limitations. We had to continually repeat explanations of things like safety measures, technical terms, and work procedures. I always encouraged the workers to commit themselves to decontaminate carefully and conscientiously, as though this was their own town or field, forest or home.

Thinking back, due to small oversights, I am sure I inconvenienced the workers, with troubles in lodgings and accidents occurring on-site due to lack of checking.

However, as the years passed, once-inexperienced workers also learned and became capable of doing what was required, and in 2017 more than 80 participating members were active as a powerful work force. Of course, everyone including myself will not forget our original intentions, and we are working with our commitment to learn every day.

We are collecting and packing grass, trees, branches and soil contaminated with an invisible radioactive substance into large container bags and transporting them to Temporary Storage Sites. But actually, I think there will be no complete solution during my lifetime. So I feel it is our duty to pass on to the next generation the knowledge and know-how that we gained in the past six years. In the hopes that all of the more than 6,000 residents who lived in Iitate Village before the disaster can return as soon as possible, I would like to continue doing the remaining work safely and quickly.

Column	"Receiving incombustible and combustible materials at Temporary Storage Sites" Mr. Tetsuo Ito, Ito Komuten Co., Ltd. (subcontracted by Maeda Corporation)

Contaminated materials removed from farmland, houses and forests as a result of decontamination work are placed in large container bags and stored for a while at Temporary Storage Sites. When storing them at Temporary Storage Sites, the container bags of removed soil are stacked up and surrounded by shielding container bags so as to shield the radioactive materials generated by decontamination work. The height of the stacks is basically five layers for incombustibles and three layers for combustibles.

The piles that still remain at Temporary Storage Sites in each municipality may appear to be nothing special at first glance, but in practice, many refined techniques are necessary.

The first thing is that even though the container bags of removed soil transported in from each site are uneven in shape and firmness while the shielding container bags are uniform. But the bags have to be lined up horizontally and maintain their balance. The second thing is the speed at which removed soil container bags must be handled. The receiving process will not work properly unless it is able to match the speed with which the bags arrive by transport.

At the beginning of the work, since the removed soil container bags brought in were being placed somewhat randomly, it became increasingly difficult to maintain consistency in the height of the shielding container bags as the stacks at the Temporary Storage Sites grew higher. This dramatically reduced the speed of placing each container bag, so we decided to develop some countermeasures to address the situation.

As a first measure, we performed rough sorting of the container bags at the site of decontamination work, based on the size and characteristics of the bags. The aim of the rough sorting was to make the container bags somewhat more uniform.

As a second measure, we boosted the communication between the Temporary Storage Site teams and the transportation teams. Prior to that, the only communication was to coordinate the timing of the hauling trucks, but we changed this to respond to the needs of the Temporary Storage Site teams in terms of the size and firmness of the bags.

As a result, it was possible to build the stacks more smoothly than at the beginning, which resulted in better work processes.

Over the past two years, through repeated trial and error, we have been able to establish standard work methods for the stacking of the removed soil container bags, and this includes safety aspects.

Finally, in the context of ongoing efforts for the recovery from the earthquake disaster, our company will do its part and make its utmost effort to assist with the post-earthquake reconstruction.

Column	"Aiming for the peace of mind of village residents" Mr. Yoshiyuki Hagiwara, Murasaki kensetsu Co., Ltd. (subcontracted by Okumura-Nishimatsu-Daiden Specified Construction Joint Venture Corporation)

Since 2012 I have been engaged in decontamination work in Katsurao Village, a type of work that I had never experienced before. The work was often done on mountain slopes and in forests that is not accessible by heavy equipment, so workers often had to carry the removed material by hand, and that limited the amount of work that could be done in a day. When we thought about the amount of decontamination work to be done it seemed like a daunting task, but we worked steadily, step by step, while ensuring safety and looking for ways to make improvements.

We worked with a strong commitment to restore the village to a condition in which all the villagers could live with peace of mind. Especially in our work of decontaminating farmland, I hope that in the future the crops cultivated here will be safe for consumption. This is why we always carry a radiation dosimeter to verify the decontamination effectiveness as we work with steady determination. Initially, the decontamination workers tended not to make a good impression and not be liked in the community, but now they work with pride and a high sense of motivation.

We will continue to do safe and reliable work until the completion of the decontamination project of Katsurao Village, and am sincerely hoping for smooth progress in the reconstruction of Fukushima Prefecture.

4.3.2. Details of Decontamination Techniques (methods of use and conditions in Special Decontamination Areas)

Details (methods of use and conditions) of the main decontamination techniques used in Special Decontamination Areas are indicated below.

(1) Residential Areas, Schools, Parks, Large-scale Facilities, Roads

1) Ground / building surface etc.

① Removal of sediments

Overview	For leaves, moss, mud, etc., for residential areas, schools, parks, roofs of large facilities, roofs, roof gutters, gutters and grounds, road paved, unpaved, bridge pedestrians, and other sediments are removed.
How to implement decontamination	· Remove sediments such as fallen leaves, moss, mud and so on with hands, scoops, brushes or brushes with rubber gloves, rakes, etc., and pack them in a large container bag.
Required Equipment, Machine, etc.	· If the material of the roof is liable to be damaged, do not get on the roof directly, remove sediments from a high place work vehicle etc. using mop etc.
Prerequisites Constraints Application conditions	· In consideration of diffusion of contamination by decontamination work, for example in the case of residential area etc., decontaminate in the order of roof, gutter, yard, etc. · For the place to decontaminate for the first time after the accident, work well by checking whether it is a sediment at the time of the accident or whether the sediment is fallen leaves, etc., after the accident. · Removal of sediment is particularly effective at high dose levels. · Decontaminate from a place with a high dose level.
Workability Development technology Devices Points to remember	· Since mechanization is difficult, manual work is the main. · In the work on the roof, measures against crash disasters (parents, safety belt) are necessary.

② Wipe off

Overview	Wipe off on residential areas, schools, parks, roofs of large facilities, rooftops, exterior walls / fences, rain gutters, road guardrails, pedestrian bridges, etc.
How to implement decontamination	· Wipe carefully with waste cloths moistened with water etc. (including neutral detergent and acetic acid), using each folded surface carefully until the condition that the surface contamination density does not decrease substantially even by additional implementation . - To prevent redeposition of contamination, wipe off with a new surface every wipe. · Remove deposits such as moss and mud which are difficult to remove, and carefully remove brittle parts that do not hurt the material of the object, for areas where dirt that can be confirmed visually and so on is severe. · Exterior wall · fence and guardrail carefully remove in dry condition using a brush (including car wash brush, deck brush etc.) that does not hurt the material of the object, instead of waste etc.
Required Equipment, Machine, etc.	· Waste etc. Brush (including car wash brush, deck brush)
Prerequisites Constraints Application conditions	· To prevent recontamination, wipe in order from the high position to the low position. · If rust is present, rust itself is removed by wiping or the like. · Application to rain gutters is effective in areas with high dose levels.

	· It is difficult to obtain dose reduction effect for wiping roofs, etc., in low dose areas.
Workability Development technology Devices · Points to remember	· As radioactive cesium may be attached to the waste cloth etc. used for wiping, do not touch it with direct hands directly. · At high altitudes, scaffolding and aerial platform work are required. · Wiping work is a lot of fragile objects, and work by manual work is the subject. · In the work on the roof, measures against crash disasters (parents, safety belt) are necessary. · Regarding the roof, it is also effective to wash with a dry brush as to the rough surface.

③ Brushing

Overview	Perform cleaning such as residential areas, schools, parks, roofs of large facilities, pavement surfaces such as exterior walls, fences, yards and grounds, concrete, asphalt, road guardrails, pedestrian bridges and so on, using brushes and the like.
How to implement decontamination	· Clean carefully until decompression density does not decrease as a result of additional implementation by deck brush or scrub brush. · Apply water at 4 L/m^2 before brushing, and after brushing rinse with about 4 L/m^2 of water as well. · Clean the drainage path of wash water beforehand so that smooth drainage can be performed and recover waste water with a rainwater cell. The recovered wastewater is transported to a wastewater treatment facility in or near the site.
Required Equipment, Machine, etc.	· Deck brush, sewage, etc. · Sprinkler car (tank capacity 3,800 L), water · Temporary installation etc. for wastewater collection
Prerequisites Constraints Application conditions	· To prevent recontamination, perform brush cleaning in order from high position to low position. · When targeting the roof of the roof or roof tile, the rotating brush is not suitable and is not used.
Workability Development technology Devices · Points to remember	· It is applied to a narrowed part where high pressure water cleaning cannot be applied, a fragile roof and the like. · Concrete retaining wall etc. · It is effective for structures such as garden stone · In the work on the roof, measures against crash disasters (parents, safety belt) are necessary.

2) Pavement surface etc.

① High pressure water cleaning

Overview	For high-pressure water washing, such as residential areas, schools, parks, roofs of large facilities, roofs, roofs, roofs, pavement surfaces such as exterior walls, fences, rain gutters, yard and grounds, concrete, asphalt, road pavement surfaces, guardrails, Clean with high pressure water machine.
How to implement decontamination	· If sediments are present, remove them beforehand. · In order to prevent the gutter from being broken, use a high-pressure washer, in principle, rinse with high pressure water of about 5 MPa or less, about 2 L/m^2. · Clean roof and rooftop with high pressure washer, in principle about 15 MPa, with high pressure water of about 20 L/m^2. · The pavement surface is cleaned with high pressure water of about 20 MPa and 20 L/m^2 in principle, using a suction type high pressure washer. · In order to obtain cleaning effect, bring the injection port close to the object to be

	cleaned (about 20 cm) and wash at an appropriate moving speed. · Clean the drainage path of wash water beforehand so that smooth drainage can be performed and recover waste water with a rainwater cell. · The recovered wastewater is transported to the wastewater treatment facility inside or near the site.
Required Equipment, Machine, etc.	· Sprinkler (tank capacity 3,800 L), water, water supply tank (1 m^3 made of polyethylene) · High pressure washer (Motor driven, output 18kw 3.7kw) · Suction type high pressure washer (discharge pressure 20.5 MPa, vacuum pump) · Roadside gutter cleaning vehicle (blower type, hopper capacity 3.1 m^3, air flow rate 20 m^3 / min) · Motor generator (rated capacity 17 / 20kvA, exhaust type (primary)) · Temporary installation etc. for wastewater collection · Submersible motor pump for work (50 mm in diameter, 20 m in total) Rotary suction remover (φ 300, φ 450) · Track with crane (2 ton stacking, 2.9 t hanging) Sewage filter (200 L), sewage tank (1 m^3 made of polyethylene)
Prerequisites Constraints Application conditions	· Do not splash water around the periphery, inside from the edge, from the upstream towards the downstream of the water gradient. · Care with sheets etc. so that water does not splash around. Waterproof paint, wash with care not to break the waterproof sheet. · Confirm beforehand that there is no possibility of breakage etc. of objects etc. by high pressure water washing. · Be aware that there is a possibility of damaging property such as peeling of the surface. · In order to prevent scattering of soil, etc., due to water pressure, first wash at low pressure, wash gradually by raising the pressure gradually while checking the flow of washing water and scattering situation. · Clean the parts where many sediments are adhering, such as roof overlapping parts, parts corroded with metals, roof drains around, etc. · When targeting a pavement surface etc., a suction type high pressure washer is used, but in the case of other objects, the waste water is collected with a rainwater vessel or the like. · Pavement surface freezing, work is not possible during snow covering. · There were cases in which the high pressure water washing of the roof was not carried out when the roof was damaged when the roof of the general house was washed with high pressure water.

Workability Development technology Devices · Points to remember	· It is not applicable to fragile roof, etc. · It is incompatible with steep slope roof. · In the work on the roof, measures to prevent crashes and accidents (parent routes, safety belt) are necessary. · In order to reduce labor saving and efficiency by machine construction, we developed a vehicle capable of efficiently and safely performing road decontamination by improving the vehicle to recover the function of drainage pavement. (The same applies to extra-high pressure water cleaning)  Credit: Kajima Corporation    汚泥タンクと洗浄水タンク Credit: Maeda Corporation

② Ultra high pressure water cleaning

Overview	Scraping the surface using an ultra-high pressure water washer for pavement surfaces such as schools, parks, large-scale facilities grounds, concrete, asphalt, road pavement surfaces, etc.
How to implement decontamination	· Use a super high pressure washer (cleaning water recovery type) of 150 MPa or more to scrape off the pavement surface (about 5 mm). · Collect scraps generated by a powerful suction vehicle. · Recovered decontamination waste water is divided into scrap (sludge) and water by performing coagulation sedimentation treatment and the like.
Required Equipment, Machine, etc.	· Scoop, borax etc. · Extra high pressure water washer (Maximum pressure 240 MPa (including strong suction)) · Roadside gutter cleaning vehicle (capacity 5.1 m^3) · Motor generator (output 3 kVA, low noise type) · Air compressor (portable exhaust type (primary), 3.5 to 3.7 m^3 / min) · Sprinkler (tank capacity 3,800 L)
Provision conditions Constraint conditions Application conditions	· Pavement surface freezing, work is not possible during snow covering. · If cutting in the vicinity of the curb is impossible with the ultra-high pressure water washer, perform a handy type · end compatible type or high pressure water washing. · For types that are not of wash water recovery type, scatter curing is performed, and washing water is collected by suction car etc. using roadside gutters etc. · Measure the surface dose rate after decontamination after the road surface dries.
Workability Development	· The introduction of the technology which automatically performs waste water collection, the work speed has greatly improved. It is particularly effective in a

technology Devices · Points to remember	wide range of decontamination. · In wide area decontamination, it is necessary to decontaminate roads in order to use roads for transportation of removed materials and so on.

③ Blast

Overview	Scrap the surface using shot blasting machines, such as residential areas, schools, parks, pavement surfaces of large facilities such as yards and grounds, concrete, asphalt, paved surfaces of roads, and the like.
How to implement decontamination	· Shatter blasting machines to scratch the surface uniformly by knocking abrasive material such as iron ball particles on the surface. · Cut asphalt scraps etc. are collected by a dust collector connected to the blasting machine and packed in a large container bag. · Since dust is generated, curing and other measures are taken to prevent scattering to the surroundings, and dust is recovered. · Collect abrasive material remaining on the road with hand-pushed magnet car and collect it.
Required Equipment, Machine, etc.	· Shot Blasting Machine (Cleaning Width 700 mm, 1,000 mm) · Motor generator (rated capacity 100/125 kvA, 125/150 kvA, exhaust type (primary)) · Dust collector (For cleaning width 700 · 1,000 mm, wind speed 75 m) · Track with crane (4 t product, 2.9 t hanging / 8 t product, 2.9 t hanging) · Track (4t product, 8t product)  Credit: Maeda Corporation.
Prerequisites Constraints Application conditions	· Apply on a relatively large area paved surfaces. · Pavement surface freezing, work is not possible during snow covering. · When rain or when the road surface is wet, it is difficult to collect work and cutting material and stop working. · Removal rate decreases in places with rut or cracks and pavement compared to flat surface. · If the road is uneven or the crack width is 5 mm or more, the same construction method cannot be adopted. · At the cutting edge, to eliminate unevenness, a lap of about 5 to 10 cm is necessary. · Because the end of the pavement surface such as the building and adjacent to the structure cannot be constructed 15 to 30 cm, decontaminate by high-pressure water washing or the like. · It is effective only with high-pressure water washing (including super high pressure)for high dose level areas where dose cannot be reduced.
Workability Development technology Devices · Points to remember	· It is necessary to remove accumulated sediments such as side parts in advance. · It is not applicable to places with many cracks. · It is not applicable to wet parts. · Construction property drops greatly in a narrow area where the pavement area is about 10 m^2 in a residential area.

④ Cleaning by road cleaning vehicle

Overview	Clean up with a road cleaning vehicle for pavement surfaces of roads.
How to implement decontamination	· Clean with a road cleaning vehicle for preparation work or maintenance before decontamination work. · Collect the removed items in flexible container bags.
Required Equipment, Machine, etc.	· Scoop, borax, brush, etc. · Road surface cleaning vehicle (brush type, hopper capacity 3.1 m^3 four wheel type)
Prerequisites Constraints Application conditions	· Frozen road surface, it is impossible to work when snowing. · When collecting the decontamination collected in a flexible container bag, curing and other measures are carried out to prevent the dust from scattering.
Workability Development technology Devices · Points to remember	· Preliminary decontamination of sediments of road shoes was carried out with a road cleaning car. · In wide area decontamination, it is necessary to decontaminate roads in order to use roads for transportation of removed materials and so on.  Credit: Maeda Construction Co., Ltd

3) Unpaved surface etc.

① Weeding, lawn mowing

Overview	Weed and grass clippings using grass cutters etc. are carried out for unpaved surfaces such as yard such as residential areas, grasses such as schools, parks, large-scale facilities grounds, street trees of roads, etc.
How to implement decontamination	· Before removal of sediments and top soil, weeds that interfere with work are weeded, weeded, and cut down by shawl mowers or human power. · Package removed grass and turf in bag of large soil.
Required Equipment, Machine, etc.	· Mower (shawl type, cutter diameter 255 mm) · Dump truck (loading mass 2 t product), truck (loading mass 4 t product, 2.9 t hanging)
Prerequisites Constraints Application conditions	· It is not possible to work when the object is frozen or snowy.
Workability Development technology Devices · Points to remember	- The workability of the weeding work on the steeply sloping site is greatly reduced, and the economic efficiency is also lowered. - In some cases steep sloping grounds are included, there are cases where it is inevitable that it is a harvesting work using a safety belt or manual work, and work efficiency and opportunities to be implemented are limited.

② Deep cutting of turf

Overview	Deep cutting of turf with a sod cutter or a large lawn mower is targeted on unpaved surfaces such as yard such as residential area, grass such as school, park, large ground facility ground, lawn etc.
How to implement decontamination	· After grass cutting and grinding, use the hand guided lawn mower (Sod cutter etc.) to cut the lawn grass deep (about 3 cm thin recoverable stripping). · When large-scale lawn mowers are put in, use heavy-duty lawn mowers to cut deep (about 3 cm). Leave the root mat layer. · Package the removed turf in a large container bag. · Cover the stepped part and cover soil (about 3 to 6 mm).
Required Equipment, Machine, etc.	· Hand guided lawn mower (reaping width 55 ~ 65 cm) · Backhoe (crawler type, exhaust type (secondary), standard bucket volume pile 0.28 m^3 (flat pile 0.2 m^3)) · Dump truck (loading mass 2 t product) · Clay material (grassy soil)
Prerequisites Constraints Application conditions	· It is not possible to work when the object is frozen or snowy. · Large lawn mowers are limited to flat working sites and loose sloping surfaces.
Workability Development technology Devices · Points to remember	· The application of a large lawn mower is high in economic efficiency and work feasibility, but application conditions such as a vast and flat terrain are limited. · Cutting with a large lawn mower is efficient, but it is premised on application in a flat place.

③ Scraping the topsoil

Overview	Scrap off topsoil on unpaved surfaces such as yard such as residential area, soil such as school, park, large-sized facility grounds, unpaved side of road, etc.
How to implement decontamination	· Scrape out the topsoil uniformly (about 5 cm) by scooping, screeching, backhoe, etc. and pack it in a large container bag.
Required Equipment, Machine, etc.	· Scoop, shade etc. · Backhoe (crawler type, exhaust type (secondary), mountain 0.45 m^3 (flat area 0.35 m^3), mountain 0.28 m^3 (flat area 0.20 m^3), mountain 0.13 m^3 (flat area 0.10 m^3))
Prerequisites Constraints Application conditions	· Confirm the scraping thickness in advance by consultation. At the work stage, we will promote reliable compliance with the scraped thickness and try to reduce the dose reliably. · To prevent differences in scraping thickness from being caused by workers, standardize work content to workers before work.
Workability Development technology Devices · Points to remember	· Particularly through work is essential for work around houses. Human power is the main work for work, depending on the situation, small heavy machinery can be used but the workability is not high. · For decontamination around houses it is assumed that human power or mini backhoe, etc., is applied. · Since the lead-in wires (electricity, telephone, internet wiring, etc.) are hindered around the house, careful remedial measures such as alerting and protecting measures must be thoroughly taken carefully.

④ Covering the land surface

Overview	We will perform leveling of the clay material for unpaved surfaces such as yard such as residential area, soil such as school, park, large-sized facility ground etc., unpaved side of road etc.
How to implement decontamination	· When topsoil is removed, cover it with the same type of soil as before, by the scoop etc. to the original thickness. · Leveling the topsoil and leveling, restoring the topsoil before the scraping of the topsoil, with the same compaction degree as before.
Required Equipment, Machine, etc.	· Scoop etc. · Backhoe (crawler type, exhaust type (secondary), mountain 0.28 m^3 (flat area 0.20 m^3)) · Vibration roller (discharge pair type (primary) combined type 3 to 4 t) Vibration roller (hand guide type, 0.5 to 0.6 t, 0.8 to 1.1 t) · Dump truck (loading mass 2 t product) · Clay material
Prerequisites Constraints Application conditions	· It may be difficult to secure the same kind of soil as before.
Workability Development technology Devices · Points to remember	· Application of versatile backhoe, etc., is superior in terms of workability and economy. · Clay material according to planting plant, etc., may be necessary in some cases.

⑤ Deep plowing

Overview	Drill the surface soil and lower soil for unpaved surfaces such as yard of houses etc., soil such as schools, parks, grounds such as large facilities etc., unpaved side of roads, etc.
How to implement decontamination	- Surface soil is peeled off homogeneously by about 10 cm with human power or backhoe, and temporarily placed on vinyl sheet, etc. · Remove the lower soil by about 20 cm, uniformly, and temporarily place it in a place different from the surface soil. · After leveling the surface soil with a scoop or backhoe, leveling the lower soil, leveling it, restoring it to the same degree of compaction as before, up to the present condition level.
Required Equipment, Machine, etc.	· Scoop etc. · Backhoe (crawler type, exhaust type (secondary), standard bucket capacity 0.28 m^3 (flat area 0.2 m^3) mountain 0.45 m^3 (flat area 0.35 m^3)) · Vibration roller (discharge pair type (primary) combined type 3 to 4 t) · Compaction machine (tamper)
Prerequisites Constraints Application conditions	· Because it is a work method that does not remove contaminated soil, there are cases where it is not acceptable especially in residential areas.
Workability Development technology Devices · Points to remember	· It is important to temporarily place soil so that the upper layer peeled soil does not get mixed in the peeled soil of the lower layer (securing decontamination effect by preventing recontamination).

⑥ Removal of topsoil such as roots of trees, drains, near eaves

Overview	Removal of topsoil for roads such as residential areas, schools, parks, yard of large facilities, grounds of trees such as ground, drainage outlets, near eaves etc., for example.
How to implement decontamination	· Take scoops, rakes, etc. to scoop accumulated deciduous leaves and soil, and pack it in a large container bag.
Required Equipment, Machine, etc.	· Shovel, rake, etc.
Prerequisites Constraints Application conditions	· Depending on the situation of rainfall flowing out, the work site may be a hot spot. It is necessary to consult with supervisory personnel beforehand and decide work flow etc. to be certified as a hot spot.
Workability Development technology Devices · Points to remember	· Particularly polite tasks are essential for work around houses. Human power is the main work for work, depending on the situation, small heavy machinery can be used but the workability is not high. · There are cases where it is possible to introduce large heavy machinery for drainage outlets and planting of large facilities, but consideration according to the application place is required.

⑦ Removal of gravel and crushed stone

Overview	Gravel and crushed stone are removed for unpaved surfaces such as yard such as residential areas, gravel such as schools, parks, large-scale facilities grounds, crushed stones, unpaved surfaces of roads, etc.
How to implement decontamination	· Gravel and crushed stone are homogeneously removed (about 5 cm) by bags, scoops, backhoes, etc., and bagged in a large container bag. · If the thickness of gravel, crushed stone in the current situation is less than 5 cm, gravel, crushed stone and topsoil of about 5 cm in total are removed homogeneously, including the soil underneath.
Required Equipment, Machine, etc.	· Scoop etc. · Backhoe (crawler type, exhaust pair (secondary), mountain 0.45 m^3 (flat area 0.35 m^3), mountain 0.28 m^3 (flat area 0.20 m^3), mountain 0.13 m^3 (flat area 0.10 m^3)) · Vibration roller (Combined type, mass 3.0 ~ 4.0 t) · From the viewpoint of work efficiency, it is desirable to implement heavy equipment (small backhoe etc.) as much as possible.
Prerequisites Constraints Application conditions	· From the viewpoint of work efficiency, it is desirable to implement heavy equipment (small backhoe etc.) as much as possible.
Workability Development technology Devices · Points to remember	· It is necessary to adopt a stripping method considering the size and narrowness of the target site, and apply large backhoe and compact or mini backhoe, etc., to the target area. · In many situations, lead-in wires (e.g., electricity, telephone, Internet wiring, etc.) to houses etc. are obstructed, so work requiring attention and measures such as protective measures is essential. · When peeling off with heavy machinery, safety measures such as loudspeaker horn etc. that can attract attention to operators in case of emergency and placement of observers for the surrounding safety are important.

⑧ Cover of gravel, crushed stone

Overview	Cover gravel and crushed stone for unpaved surfaces such as yard such as residential area, gravel such as school, park and large facility grounds, crushed stone, unpaved side of road, etc.
How to implement decontamination	· When gravel or crushed stone is removed, cover the gravel and crushed stone with the backhoe, etc., with the same type of gravel and crushed stone as before, cover the same current condition height as before, at the same compaction degree as before.
Required Equipment, Machine, etc.	· Backhoe (crawler type, exhaust pair (secondary), piled high 0.45 m^3 (flat area 0.35 m^3), piled high 0.28 m^3 (flat area 0.20 m^3), piled high 0.13 m^3 (flat area 0.10 m)) · Vibration roller (Combined type, mass 3.0 ~ 4.0 t)
Prerequisites Constraints Application conditions	· It may be difficult to secure the same type of stone as before.
Workability Development technology Devices · Points to remember	· Since the scraping thickness and covering thickness are 50 mm and the standard value is ± 10 mm, if the size of purchased crushed stone is 40 mm, it takes time to finish with this accuracy.

4) Yard tree, planting

① Branch removal from yard trees

Overview	We plant branches of yard trees, hedges, planting, street trees etc., for yard trees such as residential areas such as yard trees, schools, parks, grounds for large facilities etc., street trees on roads, etc.
How to implement decontamination	· Depending on the type of trees and the timing of branch removal, branches and pruners such as yard trees, hedges and planting are done by pruning machines and branch cutting shears within a range that does not significantly affect the growth of trees. · Pack pruned branches and bags in large container bags. Those of a length not stuffed in a large container bag are cut so that they can be packed.
Required Equipment, Machine, etc.	· Revival · Aerial Working Vehicle (Truck Equipment Lift Boom Type Work Floor Height 9.7 m) · Chainsaw (saw length 350 mm, displacement 34 cc) · Truck (with crane device) (loading mass 4 t product, 2.9 t hanging)
Prerequisites Constraints Application conditions	· Depending on the height of the trees, planting, street trees on the standing trees, branch removal is equivalent to pruning of coniferous trees.
Workability Development technology Devices · Points to remember	· Depending on the species of trees, there is a possibility of branch removal and aptitude, so it is necessary for landscaping professionals to confirm. · Since hedging is the purpose of hedge, if it cuts too much, it will not be able to demonstrate its function. Do not pay attention to each one, pay branch within the range that blindfold as a whole.

② Logging and harvesting of troubled trees

Overview	We will cut down yard trees and hedges, targeting planting such as yard trees in residential areas etc., schools, parks, large facilities etc.
How to implement decontamination	· Forest trees with a breast height of 6 cm or more are cut from the root using a chainsaw or the like. Cut the root pot and cut it out. · Put the removed items such as leaves, branches, stems, roots, etc., into the large cotainer bag. Those of a length not stuffed in a large container bag are cut so that they can be packed.
Required Equipment, Machine, etc.	· Chainsaw (saw length 350 mm, displacement 34 cc)
Prerequisites Constraints Application conditions	- Logging is not carried out as a standard. It is carried out when it is indispensable to carry out other decontamination work or when the dose can be effectively lowered by logging at high doses. · It is necessary to confirm the trees to be harvested by having the persons concerned witness and mark them.
Workability Development technology Devices · Points to remember	· As the trunk diameter increases, the work efficiency drops dramatically. · Applying preservatives, etc., according to tree species is required. · Hedge follows the branch removal.

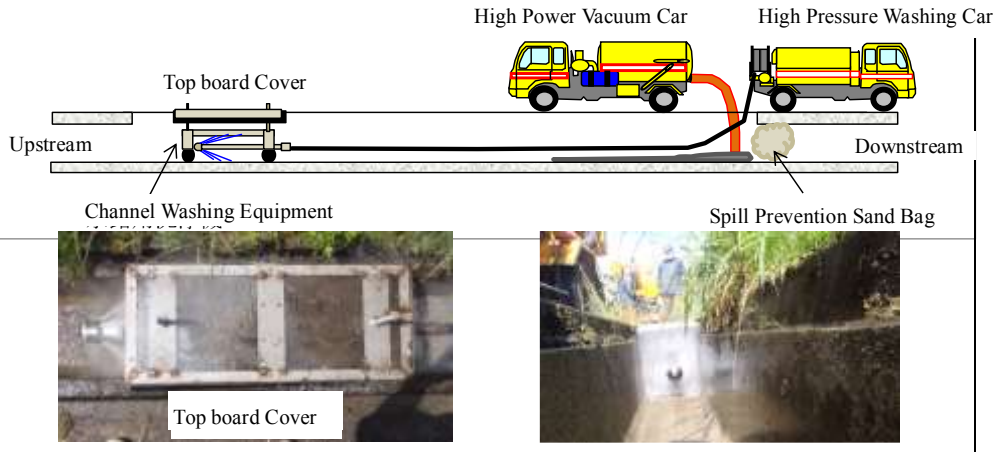
5) Others

① Wiping, cleaning, scraping of playground equipment

Overview	Wipe, wash, and scrape for school, park, playground equipment of large facilities, etc.
How to implement decontamination	· Wash the surface of playground equipment with brush or cloth. If necessary, use neutral detergent, acetic acid or the like. · High pressure water washing is performed on the joint portion of the metal playground equipment. Rust of metal playground equipment is scraped off with sandpaper, grinder, etc., then gently wipe off. · Wooden playground equipment wipe or polish wood surface with waste, brush, sandpaper, electric power tool. · Wipe off with care such as waste moistened with water, etc., (including detergent and acetic acid), use each folded surface and carefully polish until the surface contamination density does not decrease much even by additional implementation wipe it off.
Required Equipment, Machine, etc.	· Brush, waste etc. · High pressure water washing machine · Brushes, sandpaper, grinders, electric tools etc.
Prerequisites Constraints Application conditions	· If the surface is smooth with the painted playground equipment (steel bar, jungle gym, etc.), wipe with a paper towel, etc., However, if there is irregularities on the surface of school monuments etc., brushing is done in a dry state. · When decontaminating playground equipment, etc., at school facilities, explain beforehand that the paint on the surface may be peeled off by wiping or brushing work, and discuss with school officials.
Workability Development technology Devices · Points to remember	· Different workability is different depending on the type of playground equipment · standard. · Decontamination of playground equipment was carried out, but since infants and children use it, replacement is often done at the time of business restart. It is necessary to confirm the intention of school officials, etc., in advance. · In areas where rust is generated, the dose may not decrease unless rust is removed.

②Removal of bottom sediment such as roadside gutter of road

Overview	For the roadside gutters, etc., of the road, wash the sediment with high pressure water and suction the sediment.
How to implement decontamination	· Remove sediments such as fallen leaves, mud, etc., which are easy to remove using a scoop or the like in advance. · If concrete joints in the roadside gutters are deep, remove sediments of the joints using a spatula or the like. · Use a drainage cleaning car or the like at about 14 MPa, wash with about 20 L/m^2 of water, and collect wastewater. · Package the removed sediment in a large container bag. The recovered wastewater is transported to a wastewater treatment facility in or near the site.
Required Equipment, Machine, etc.	· Scoops, brooms etc. · Roadside gutter cleaning vehicle (blower type hopper capacity 10.3 m^3, 3.1 m^3, air flow rate 40 m^3 / min) · Drain pipe cleaning car (tank capacity 2 m^3, pressure 14 MPa)
Prerequisites Constraints Application conditions	· To prevent scattering, if the building is adjacent, do curing. · In case of washing the roadside gutter with lid with high pressure water, in order to clean the bottom surface, the side surface and the top portion (bottom surface of the lid) in the roadside gutter, using an injection tool in which the high pressure water diffuses in the circumferential direction, Take the method to move. · In the roadside gutter with the lid, when soil flowing from the mountain or

	embankments accumulates more in the roadside gutter and injection equipment does not enter and high pressure water cleaning cannot be performed, remove the lid of the section once and remove manually I do. · When removing manually operated roadside gutters with no lids, the road is flat, so use a unicycle when transporting the removed sediments to the piling location. · When washing roadside gutters or the like with high pressure water, check the drainage route in advance, lay down small container bags in the downstream roadside gutters, provide weirs, and collect collected drainage with roadside gutter cleaning cars. As a precautionary measure, if necessary, spread a small container bag containing zeolite on the downstream side of the work site.
Workability Development technology Devices · Points to remember	· In washing using injection equipment, drainage amount increases because bottom quality is recovered by flowing to the downstream. Therefore, the waste water treatment amount also increases. · For sludge containing a lot of water, fill it in a small container bag and drain it, then refill it into a large container bag. Also, a pressurized dehydrator was used to shorten working time. · A side stream decontamination system has been developed and applied to remove sediments in a water channel at once with application of mud removal technology such as a lidding with high pressure water and suction recovery. Even for a waterway without a lid, it was possible to effectively decontaminate a waterway without attaching a top cover and scattering washing water around the waterway.  Credit: Shimizu Corporation · In the method of sucking and collecting contaminated soil together with washing water, a solid-liquid separation step (step of separating contaminated soil and washing water) and a water treatment step are required. · Because work clothes are contaminated due to handling of bottom sediments and rebounding of high pressure washing water, in high dose section, we have used disposable Tyvek suits, etc. · Bottom quality of roadside gutters is often higher than surrounding decontamination. It is necessary to pay sufficient attention to diffusion of contamination by high pressure water, etc. Also, it is necessary to pay attention to workers' radiation exposure measures.

③Removal of grass, deciduous leaves, sediments on embankments

Overview	Removal of shrubs, weeds, etc., grasses, fallen leaves, and sediments are carried out for the embankments.
How to implement decontamination	· Prior to the removal of sediments, weeds that interfere with work are weeded, and cut down by shawl type mower or human power. · Remove deposits such as deciduous leaves, moss, mud and the like with a rake etc., and pack in a large container bag.
Required Equipment, Machine, etc.	· Mower (shawl type cutter diameter 255 mm) · Truck (with crane device) (loading mass 4 t product, 2.9 t hanging)
Prerequisites Constraints Application conditions	· Removal amount (thickness) is determined after test work. · When decontaminating the cut surface, check the condition of the lath net and make it. · In the case of slope developed by earth cutting, taking into consideration the circumstances of the surroundings and the like, the work range will be about 20 m from the living area. · The vegetation engineer selects an appropriate work method by Road Earthmoving Surface Planning and Slope Stabilization Engineering Guidelines (June 2009 (Japan Road Association)).
Workability Development technology Devices · Points to remember	· When the inclination angle of the slope becomes steep, the work efficiency decreases. · When collecting decontamination on a declaration, pay attention to the method of transportation of large decomposed bags of decontamination (especially transportation method above the surface of the legs) · Decontamination of declining surfaces from living areas cannot be expected, decontamination of rising surfaces is effective. · The effect of decontamination may be low only by removing deposits.

(2) Farmland

1) Grass, support tree, etc.

① Paddy field, field manure weed

Overview	Paddy fields and field grasses will be subjected to weed control by manpower.
How to implement decontamination	· Use a shawl-riding grass mower to weed rice fields and fields.
Required Equipment, Machine, etc.	· Shawl-type grass mower (Shoulder hanging cutter diameter: 255mm)
Prerequisites Constraints Application conditions	· Weeding in a narrow place and a embankments where mechanical weeding cannot be introduced. · Pay attention to the working time under high dose. · Wear protective clothing, masks, gloves and safety boots.
Workability Development	· Injuries by cutting the foot due to jumping of the blade. · When using mowers, safety education (practical training) is required.

technology Devices · Points to remember	

② Mechanical weeding of paddies and fields

Overview	Weeding grasses by machine in paddy field and field.
How to implement decontamination	· Weed rice fields, fields, and pastures using agricultural tractors.
Required Equipment, Machine, etc.	· Agricultural tractor (110ps, wheel type) · Offset transmitter (working width 200cm) · Agricultural tractor (110ps, wheel type) + Offset transmitter (working width 200cm) · Some rollers are used.   Example of using an off-set sender Example of using rollers Credit: Kajima Corporation.
Prerequisites Constraints Application conditions	· The area to be decontaminated to a certain extent (more than 1,000m^2), and the area where there is no danger such as falling down of the machine. · Stop work in muddy conditions after rainfall. · Wear protective clothing, masks, gloves and safety boots.
Workability Development technology Devices · Points to remember	· Agricultural machinery can be used.

③ Collection of cut grass

Overview	Collect cut grass from paddies and fields.
How to implement decontamination	· Collect cut grass using a grass collector, a grass mower/packer, etc.
Required Equipment, Machine, etc.	· Grass collector (hand guided type, 120cm) · Mowing packing machine (hand guided type, φ500 × 700) · Mowed grass packing machine (Hand guide type, φ500 × 700)
Prerequisites Constraints Application conditions	· Contiguous areas to be decontaminated, over a certain size (more than 1,000 m^2) and where there is no tipping danger for the equipment. · For outdoor work wear protective clothing, masks, gloves and safety boots.
Workability Development technology Devices · Points to remember	• Stop work if conditions are muddy after rainfall. · In some cases, roll bailers and other machines that separate the tasks of grass cutting and collecting are used.

④ Weeding of meadow

Overview	Weed grasses for pasture.
How to implement decontamination	· Weed grass pasture by tracer. · The grass removed will be collected and packed in a roll-barrel, and then transported and collected after it has been made into a roll-bar. · Spray herbicide with a boom sprayer.
Required Equipment, Machine, etc.	· Agricultural tractor (passenger · wheel type four wheel drive 52 to 59 grade (70 to 80ps)) · Flail mower (direct installation) (width 1.5 m) · Roll baler (width 1.0 m, height 1.0 m) · Rake (width 3.6 m) · Boom sprayer (600 L, width 12.3 m) · Truck (loading weight 4.0 to 4.5 t) · Herbicide  Flail mower  Boom Sprayer  Rake Credit: Taisei Corporation
Prerequisites Constraints Application conditions	· Carry out in the area subject to decontamination to a certain extent (1,000 m^2 or more) and in places where there is no danger such as falling of the machine. · Wear safety glasses, masks, gloves and safety boots for outdoor work.
Workability Development technology Devices · Points to remember	· Agricultural machinery can be diverted. · Roll balers can do grass cutting and packing at the same time. · Store every soil in large container bags.

⑤ Brush cut (shrub)

Overview	Grass shrubs are cut for grassland and shrub bushes.
How to implement decontamination	· Weeds, shrubs, etc., are cut by chain saw, etc., transported and bundled, bagged in large container bags. · For items that cannot be transported / accumulated as it is, shredded shrubs etc., cannot be bagged, cut and bagged in a large container bag.
Required Equipment, Machine, etc.	· Mowers (Chainsaw saw length 600 mm (80 cc)) · Mowing machine (shawl type cutter diameter 255 mm, 1.3 kW class)
Prerequisites Constraints Application conditions	· Because the shape of the grassland and turf is various, first check the size of the local flatland etc., select the place to pack in the large container bags, transportation route, loading place, etc., Particularly, in places where bagging or temporary placement is carried out, safety of operation is secured by selecting a flat place. · Establish safe work paths and haul roads prior to mowing and paying work to ensure safety of feet. · In a dense area of shrubs, basically use a chain saw to do brush cutter. · In the coarse area of shrubs, basically a shoulder-type grass cutter is used to cut brush. In a mowing machine, when there is a thick shrub which is difficult to cut and cut, use a chain saw. - Cut the shrub shoots to the size that can cut off the branches and carry it, transport it, accumulate. · When cut down high-height bamboo, since bamboo that was cut is hindered and sometimes workability gets bad, carry it out in a long state every time you cut and cut it. · When packing bags, because branches, etc., may damage large container bags, so that the cut ends are not sharp, and prevent damage to large container bags. · When filling bags, removable goods do not fit well and the large container bag will collapse, so by fixing the large container bag to the exclusive stand, it is easier to insert and advance bag filling work with less mold breakage .
Workability Development technology Devices · Points to remember	· There is a limit to the filling performance with bagging by human power, so economic efficiency / workability is inferior. · If packing is bad, it may be compressed by load when stacked in a Temporary Storage Site, and the temporary storage stability may be impaired. These combustibles may rot and cause generation of flammable gas and settling / deformation. · From the viewpoint of volume reduction, it was made into chips by a self-propelled wood crusher and the like to enhance packing properties. · Compressing and shaping carved trees and branches and leaves etc. into a roll shape and packing by wrapping Further volume reduction and corruption control technology Eco roll is introduced to reduce volume of combustible materials · suppress corruption, We have made effective use of the site and secured soundness during the storage period. · When exiting the workplace, confirm that it is not contaminated with screening exceeding 1,300 cpm, which is stricter than the contamination limit (13,000 cpm).

⑥ Logging of bamboos

Overview	Cut the whole bamboos to paddy field and soil of field.
How to implement decontamination	· Cut the bamboos by chain saw, cut brush and slice off. · Load removed materials (leaves, branches, trunks) into the unladed haulers, transport and accumulate them. · Digging up the rhizome of bamboo and do root soil separation. · Load sifted substances (roots) in a non-land transporter, transport and accumulate. · Fill back, flatten the ground, and roll back the excavated area.
Required Equipment, Machine, etc.	· Backhoe (with skeleton bucket) Piled high 0.45 m^3 · Crawler dump truck 1 t · Chainsaw · Wear safety glasses, masks, gloves, safety boots
Prerequisites Constraints Application conditions	· Treating thoroughly bamboo grown after the earthquake. · Collect branches, trunks and roots.
Workability Development technology Devices · Points to remember	· Be careful not to bounce the chain saw during ball cutting. · In case of lower mowing, pay attention to bouncing of the mower.  Backhoe (with skeleton bucket) Credit: Taisei Corporation

2) Soil

① Land conditioning

Overview	Paddy and field soil, subject to inelastic adjustment.
How to implement decontamination	· Use vibrating rollers, etc., to correct the unevenness of the topsoil.
Required Equipment, Machine, etc.	Vibration roller (boarding type combined roller 3 t exhaust type primary)
Prerequisites Constraints Application conditions	In super wet fields such as self-jetted paddy fields, the combined rollers sink and cannot move, so work is impossible. · Beforehand whether the combined roller can run or check the trouble capability. · As rainfall and puddle parts will rebuild the surface part of the cultivated soil, in principle work is not done.  Credit: Obayashi Corporation
Workability Development technology Devices · Points to remember	· If heavy machinery, etc., cannot enter, create an approach route. Therefore, economic efficiency and workability of the sloping land deteriorates from the flat ground.

② Surface hardening material spray

Overview	Paddy fields and field soils are sprayed with surface hardening material.
How to implement decontamination	· Spray the solution mixed with solidified material using a seed spray machine and confirm that the surface soil has solidified sufficiently. · The amount of solidifying material in the solution is 15 t / ha, the solidified thickness is 2 to 3 cm, and the curing period is assumed to be 7 days (continuous no precipitation days). · Confirm that radioactive substances are not detected beforehand in water used for solution.
Required Equipment, Machine, etc.	· Seed spraying machine (vehicle type (seed only) 1.0 m^3) · Air compressor (25ps, 0.7 MPa, 2.5 m^3 / min) · Truck with crane equipment (4 ton stacking, 2.9 t hanging) · Sprinkler (tank capacity 3,800 L) · Surface hardening material (neutral solidification material)
Prerequisites Constraints Application conditions	· In the winter season, work is impossible because the solidified material does not solidify. · Because it requires a curing period, it is restricted by weather condition. - Spraying to places where water is pooled is impossible. · When scraping over the topsoil of 25,000 Bq / kg or more, it is done as measures to prevent high dose of dust scattering.
Workability Development technology Devices · Points to remember	· If heavy machinery, etc., cannot enter, create an approach route. Therefore, economic efficiency and workability of the sloping land deteriorates from the flat ground.

③ Scraping the topsoil

Overview	Scrap off topsoil on paddy field, field, pasture soil.
How to implement decontamination	· Using backhoe, belt conveyor built-in type scraper, tow type scraper, etc., scrape off the topsoil. (About 5 cm).
Required Equipment, Machine, etc.	· Backhoe (exhaust type (primary), crawler type stacking 0.45 m^3 (flat stacking 0.35 m^3)) · Light oil
Prerequisites Constraints Application conditions	· It is impossible to work in super wet fields such as self-jetting paddy fields. · Determining the scraping thickness according to the dose level (depth distribution of radioactivity concentration). · When rice straw and shrub rhizomes (willow, etc.) are under the surface layer, remove them with heavy equipment etc. · If necessary, add fertilizer, organic material and soil improvement material. Peel off the mixed soil and strip it homogeneously with backhoe, etc., according to the thickness.
Workability Development technology Devices · Points to remember	· The work method which showed its effect by a method different from the standard includes a skimmer method and a turf stripper. Together with agricultural machine manufacturers, these agricultural machinery manufacturers have been working on development and improvement. · Skimmer method is a technique to efficiently scrape and recover agricultural surface layers using compact and lightweight dedicated equipment with automatic topography response system by electronic control (thickness control sensor). There is a scraper on the machine front part, a belt conveyor for scraping the top soil is provided by horizontal rotation of the special resin board, and it is possible to load the earth and sand scraped off in a parallel or tracking transport car directly. · Work speed of skimmer method is about 3 times that of backhoe, economic efficiency is higher than backhoe. Since the dose reduction rate of the skimmer method is higher than the backhoe higher than the backhoe, the accuracy is higher than that of the backhoe. · If heavy machinery, etc., cannot enter, create an approach route. Therefore, economic efficiency and workability of the sloping land deteriorates from the flat ground. · For this reason, if the cutting thickness can be made thinner and the work range is wide, if the dry soil is large, the amount of scraped off soil is greatly reduced, and the work cost is reduced, but there are restrictions on the flatness of the surface There is a need for joint use with another work method for the range where work is impossible. Also, the number of machines themselves is small. · Because there are overhead lines in farm roads and agricultural land beside agricultural land, clearly indicate the position of the overhead line with flags and flags, etc. When passing, prevent overhead line damage accident by deploying traffic controller.  Skimmer method  Turf stripper Credit: Shimizu Corporation

④ Reverse cultivation / Deep Plowing

Overview	Reverse cultivation or deep cultivation is carried out for paddy field, field, pasture soil.
How to implement decontamination	· Overturning is carried out once at a plowing depth of 30 cm or 45 cm with a plowed tractor. · Using a rotary tiller for deep plowing, cultivate and stir with a target of about 30 cm in plowing depth and plow the field deeply.  Rotary tiller Credit: Obayashi Corporation
Required Equipment, Machine, etc.	· Tractor for agriculture (passenger · wheel type four wheel drive 52 to 59 kW class (70 to 80ps), 22 kw class (30ps))
Prerequisites Constraints Application conditions	· On agricultural land where work soil was agitated by plowing after the accident, carry out overturning or deep plowing. · Fruit trees, tea ceremonies, etc. If deep plowing is carried out where perennial crops are cultivated, there is a risk of damaging the roots. · If the worker layer is gravely, gravel appears in the working layer due to deep plowing, so measures such as graveling are required. · If necessary, measure the groundwater level and take great care to deeply cultivate it. · When the temperature is low and the topsoil is frozen, the function of the small tractor may not be sufficient. · For land not cultivated after the accident, deep tillage is applied when the soil concentration is lower than 5,000 Bq / kg. · It is important to check the depth distribution of soil radioactivity concentration and the depth of the tiller and to determine the inversion depth.
Workability Development technology Devices · Points to remember	· Unlike scraping, contaminated soil does not occur, so it is superior to scraping off the top soil and covering soil in economic efficiency and work fee . · If heavy machinery, etc., cannot enter, create an approach route. Therefore, economic efficiency and workability of the sloping land deteriorates from the flat ground. · Determine the optimum depth of work by confirming the depth of the cultivation layer and foundation gravel layer. · Because there is a risk of breaking the tiller, it is necessary for the tiller to be located at a depth of 30 cm or more. · It is necessary to have the ground tolerance that the backhoe can operate.

⑤ Excavation

Overview	We will carry in the soil of paddy fields and fields etc., delivery of covering soil, spread and compact.
How to implement decontamination	· After scraping off the soil, use the heavy machine to do the land clay, flatten the level, level up, recover to the height of the present condition. · The quality of the covering soil is decided in consultation with the supervisory personnel. · Submit the soil covering material to the supervisory personnel prior to use so that the soil test table and radioactive materials concentration measurement result are obtained before use.
Required Equipment,	· Scoop etc. · Backhoe (crawler type, exhaust type (secondary) piled high 0.28 m^3 (flat stacking

Machine, etc.	0.20 m^3)) · Vibration roller (discharge pair type (primary) combined type 3 to 4 t) · Vibration roller (discharge versus hand guide type 0.5 to 0.6 t) · Dump truck (loading mass 2 t product), earth and sand
Prerequisites Constraints Application conditions	· For agricultural land that was not plowed after the accident and agricultural land in which the working layer was stirred by plowing after the accident, the former, where the topsoil remains unchanged, even if the radioactive cesium concentration is the same, has a high value as the air dose rate which should be noted. · It is necessary to analyze and diagnose soil after decontamination, and then make necessary amount of soil covering and so on.
Workability Development technology Devices · Points to remember	· If heavy machinery, etc., cannot enter, create an approach route. Therefore, economic efficiency and workability of the sloping land deteriorates from the flat ground.

⑥ Ground recovery

Overview	Ground will be restored by soil conditioner or zeolite spraying for paddy field, field, pasture ground soil.
How to implement decontamination	· Sprinkle the soil conditioner while pulling the spraying device with the tractor. · Tillage was reported to the Governor of Fukushima Prefecture as a special fertilizer under the provisions of the Fertilizer Control Act (Act No. 127 of 1954), which comprehensively improves the physicochemical and biological properties of the soil and produces soil it has a function to enhance the power. · Submit soil remediation material to supervisory personnel prior to use to obtain consent. · There is also a method of spraying zeolite instead of soil conditioner.
Required Equipment, Machine, etc.	· Construction tractor (usually 9t), agricultural tractor (crawler type, 40ps) · Spraying equipment (tow type capacity 800 L working width 3 m class), (working width 1.8 m class) · Soil conditioners (calcium carbonate, potassium silicate), zeolite
Prerequisites Constraints Application conditions	· After soil analysis and diagnosis after decontamination, it is necessary to consider the necessary amount of soil conditioner or zeolite.
Workability Development technology Devices · Points to remember	· If heavy machinery, etc., cannot enter, create an approach route. Therefore, economic efficiency and workability of the sloping land deteriorates from the flat ground. · The MOE decides and instructs the spray menu of the restoration material. · Soil conditioners promote the growth of weeds, and there is also material delivery.

⑦ Double plowing

Overview	Plowing is carried out twice on paddy field, field, pasture soil.
How to implement decontamination	· Till and agitate using rotary etc. after spraying ground recovery material, etc. Tilling and stirring are standardized twice.
Required Equipment, Machine, etc.	· Agricultural tractor (passenger wheel type 4 wheel drive 22kw class (30ps))
Prerequisites Constraints Application	· Work is impossible in super wetlands such as self-jetting paddy fields where there is a possibility that the tractor may sink and not run. · Check the trafficability whether the wheel type tractor can run.

conditions	
Workability Development technology Devices · Points to remember	· If heavy machinery, etc., cannot enter, create an approach route. Therefore, economic efficiency and workability of the sloping land deteriorates from the flat ground. · Determine the optimum depth of work by confirming the depth of the cultivation layer and foundation gravel layer.

3) Waterways

① Removal of bottom sediment (raising earth and sand)

Overview	Remove sediment and so on (raising earth and sand) for waterway of agricultural land.
How to implement decontamination	· Remove deposits such as fallen leaves, moss, mud and the like that are easy to remove using a scoop or the like.
Required Equipment, Machine, etc.	· Scoop etc.
Prerequisites Constraints Application conditions	· Removal of waterways on agricultural land is almost done by manual labor because of narrow working environment. · In the work, put the removed sediment in the pouch at once in the vicinity, and carry out small transportation by human power. As a container suitable for carrying, use a bag with a hand belt. · When water is flowing through the waterway, remove the upstream and downstream sides of the work range, use a submersible pump that can be installed by human-powered conveyance, remove work without running water. · In the catchment basin and the like of a waterway where radioactive materials are accumulated and hot spot is high concentration, it is necessary to pay attention to cumulative exposure management of workers and to shorten the operation time as much as possible.
Workability Development technology Devices · Points to remember	· The waterway has a long working range, so that raising the earth and sand in man powering work is inferior in economic efficiency and constructability. - In the lidded waterway, sediment containing radioactive materials is deposited not only on the bottom of the waterway but also on the lid hook, and it is necessary to remove them together. - It is necessary to pay attention not to leave earth and sand.

② Removal of bottom sediment (bag stuffing)

Overview	Remove sediment (bagging), etc., for waterway of agricultural land.
How to implement decontamination	· Package the removed bottom sediment in bags of large container bag by manpower.
Required Equipment, Machine, etc.	· Large container bags
Prerequisites Constraints Application conditions	· Removal materials do not fit well during bag filling work, so large container bags may collapse in some cases. Therefore, by fixing the large container bag to the exclusive stand, it is easy to introduce, advance the bag filling work with less mold breakage. · Because the water content of the bottom sediment is large, add inner bags to large container bags or use flexible waterproof containers to prevent leakage of sewage.
Workability Development	· The length of the work is long, the bagging in manual labor is carried, bags packed in small pieces with small container bags are packed in large container bags, so it

technology Devices · Points to remember	is inferior in economic efficiency and constructability. · In the side trench decontamination system which removes sediment in the water channel at once by applying high-pressure water by applying mud removal technology such as lidding, suction collects sediment accumulating in the waterway together with high-pressure water washing water into the vacuum car. · In the method of sucking and collecting contaminated soil together with washing water, a solid-liquid separation step (step of separating contaminated soil and washing water) and a water treatment step are required.

4) Others

① Bag filling (standard transport method)

Overview	Put paddy soil for paddy field, field, pasture soil.
How to implement decontamination	· Collect elimination soils using backhoes and so on and pack them in large container bags.
Required Equipment, Machine, etc.	· Backhoe (exhaust versus (primary) · Crawler type stacking capacity 0.45 m^3 (flat stacking 0.35 m^3)) · Large container bags
Prerequisites Constraints Application conditions	· A jig such as a production frame for packing in a large container bag is necessary. · Align the height of large container bags after packing.
Workability Development technology Devices · Points to remember	· In a wide range of agricultural land decontamination, the plowed removed soils are accumulated, and the large container bag filling work is carried out in a state of being assembled to some extent. Human power work such as attachment of bags to large container bag production frames and binding of bag mouth after filling is also necessary, which is inferior to economic efficiency. · A method of stuffing the removed soil into large container bags behind the machine with a screw conveyor type scraper with a special bucket with a hammer knife has also been developed. · Skimmer method and Turf stripper method are also effective in packing bags.

(3) Forest

① Removal of organic residue and residue

Overview	Evergreen coniferous forests, deciduous broad-leaved forests, etc., are subjected to removal of organic residue and accumulated organic residue.
How to implement decontamination	· Gather rags, fallen branches etc. with rakes etc., about 5 cm from the surface (about 10 cm in unmanaged areas), carry, collect and bag in a large container bag. · After removal of organic residue, at the place where accumulated organic residue is left, accumulate them again with rakes, etc., and pack it in a large container bag. · Remove to the extent that the mineral soil layer is not exposed.
Required Equipment, Machine, etc.	· Glove, rake, dustpan, · Blue sheet, carrying bag.     Credit: Taisei Corporation
Prerequisites Constraints Application conditions	· If it is difficult to secure work safety with general safety measures due to the steep slope, strengthen safety measures at the time of work according to the situation of the land. · In areas where safety measures cannot be taken due to steep slopes or the like, decontamination work was carried out by negotiating with the supervisor, separately setting the scope of work (e.g., upper slope, decontamination up to 2 m from the slope bottom, etc.). · When exposing the roots of the trees, it becomes a cause of deterioration of the forest function, so in removing it, consult with the forest managers and supervisory personnel sufficiently so as not to expose the roots of the trees, decide the applicable scope.
Workability Development technology Devices · Points to remember	· In sharp mountainous areas, it is necessary to transport with a small manpower up to the slope and the efficiency drops, so the workability and economic efficiency may be inferior. · Considering the small transportation of the removed materials, carrying small sandbags to workers and carrying out collection work. · There were many illegal dumps in the forest, sorting of decontamination and remaining waste was occasionally added.

② Undergrowth · shrub brush

Overview	Evergreen coniferous forests, deciduous broad-leaved forests, etc., are subject to cutting and removal of undergrowth and shrubs.
How to implement decontamination	· Mow cuttings of undergrowth, shrubs, etc., are carried out by shawl-type grass mowers, etc., When there is a cutting branch, a falling branch etc., collect them on the edge of the forest and pack them in a large container bag. · For items that cannot be packed in a large container bag, cut it so that it can be stuffed, or bind it with a cord or the like so that it becomes a coarse loaf of about 30 cm in diameter with a length of 2 m or less and accumulate in the edge of the forest.
Required Equipment, Machine, etc.	· Shawl type grass cutter, rake, rake, hand knitting, carrying bag, chain saw.
Prerequisites Constraints Application conditions	· It is carried out in order to improve the prospect of the root of forest trees.
Workability Development technology Devices · Points to remember	· Removal products that have been transported to the slope for a small amount may be subjected to a volume reduction process (compression by a suction bag or crushing of branch trees) on the spot, but efficiency can be improved by reducing the volume collectively. By using the arm roll car and the container, it is possible to transport the removed material without waste.  Aggregate volume reduction location  Loading of remover to container  Arm roll car · Since it is a narrow range of work between forest trees, it is necessary to clearly indicate the work range (especially grass cutting work) with tape or the like, and prevent other workers from entering the work area, to prevent accidents caused by grass cutters.  Credit: Taisei Corporation

③ Pruning of conifers, collecting of cutting branches

Overview	For evergreen coniferous forests, pruning of coniferous forests and collection of branches are carried out.
How to implement decontamination	· For evergreen coniferous forests (Cryptomeria japonica, Cypress and other cedar) of Ⅲ grade or higher class, branches up to about 4 m above the ground are cut off by saws, etc., for standing trees in the range of about 5 m (1 to 2 rows) from the edge of the forest. · Make sure that the length of the crown does not fall below the original half. · For similar types of standing trees covering buildings with branches and leaves considerably, they are cut off with a saw or the like. · Cut off branches within 2 m in length. Bundle them with cords, etc., so that they become fascine of about 30 cm in diameter, pack them in large container bags, and carry them to the edge of the forest. · For those that cannot be packed in large container bags, cut them so that they can be packed and bag them.
Required Equipment, Machine, etc.	· Saw, hatchet, etc., high branch cutters, blue sheet · Electric chain saw for high branch, carrying bag.
Prerequisites Constraints Application conditions	· It may be applied to the wind protection forest around the residential area.
Workability Development technology Devices · Points to remember	· Removal substances that have been transported to the slope for a small amount may be subjected to volume reduction treatment (crushing of branch trees) on the spot, but efficiency can be improved by reducing the volume by concentration. By using the arm roll car and the container, it is possible to transport the removed material without waste. (See ② Undergrowth and shrub brush) · From the viewpoint of safety work, use a high branch scissors, high branch electric chain saw, without using a ladder, up to 4 m above the ground. · Try to prevent injuries to be used only by experienced people.

(4) Necessary Work Period and Number of Workers

The metrics for full decontamination in the Special Decontamination Areas are indicated in the table, including work period, total area, and monthly area. The difference is large for each municipality due to differences in the number of workers assigned, etc., and the monthly amounts range from 10 to 200 cases on residential land (1 to 30 ha), 11 to 50 ha of farmland , 2 to 10 ha of roads, and 1 to 30 ha of forests.

The period of time and the number of workers required for decontamination depended on many factors, such as the size and area of the roof and land, the roof and wall material, the size and condition of the yard (presence of yard trees, etc.), the availability of the lift trucks, the need to install temporary scaffolding, the need to replace gravel, the need to decontaminate nearby forests, and the transport of removed soil, etc., to Temporary Storage Sites, etc. As a result, it is difficult to generalize, but typically the work per household would require 5 to 10 workers and about two weeks. Also, according to Provisional Quantification Standards for Decontamination Work, for example, to remove sediments on a roof (other than concrete) in residential area, the standard per 1,300 m2 was 0.50 supervisors, and 3.20 regular decontamination workers.

Table 4-4 Full decontamination metrics (work period, total area, monthly area)

Municipality	Residential land			Farmland		Roads		Forests	
	Properties	Area (ha)	Work period (months)	Properties	Area (ha)	Work period (months)	Properties	Area (ha)	Work period (months)
Tamura City	140	23	6	140	6	29	6	190	6
Naraha Town	2,600	420	13	830	16	170	16	470	16
Kawachi Village	160	17	10	130	10	38	16	200	16
Okuma Town	180	37	16	170	16	31	16	160	16
Katsurao Village	460	150	31	570	31	95	31	660	31
Kawamata Town	360	99	37	600	39	71	34	510	39
Futaba Town	97	9.0	10	100	8	8.4	5	6.2	8
Iitate Village	2,000	440	43	2,100	49	330	43	1,500	49
Tomioka Town	6,000	590	35	750	40	170	39	510	38
Namie Town	5,600	600	36	1,400	35	210	35	390	37
Minamisoma City	4,500	690	33	1,700	38	270	36	1,300	37

＜Quantity per month＞

Municipality	Residential land (properties/month)	Residential land (ha/month)	Agricultural land (ha/ month)	Roads (ha/month)	Forests (ha/month)
Tamura　City	23	4	23	5	32
Naraha Town	200	32	52	11	29
Kawauchi Village	16	2	13	2	13
Okuma Town	11	2	11	2	10
Katsurao Village	15	5	18	3	21
Kawamata Town	10	3	15	2	13
Futaba Town	10	1	13	2	1
Iitate Village	47	10	43	8	31
Tomioka Town	171	17	19	4	13
Namie Town	156	17	40	6	11
Minamisoma City	136	21	45	8	35
Average	72	10	26	5	19

Note: Work period is the period during which work on the corresponding land category was performed in each municipality, including waiting periods during the work

The area per month is calculated from the total number of cases or area and the total work period, and may differ significantly depending on actual work conditions, etc.

4.3.3. Decontamination Effects in Each Targeted Area

A document entitled “On the effect of the decontamination method in the decontamination projects implemented by the national government and local governments so far” (January 2013, Decontamination Team, Ministry of the Environment) brought together and organized information on the results of initial decontamination work (mainly during 2011) conducted by the national and local governments mainly in areas with relatively high radiation levels in Fukushima Prefecture, and summarized information on the extent to which the amount of radioactive substances could be reduced by decontamination.

Among the data on decontamination work implemented initially, the report focused on data on the vicinity of residential areas, such as buildings and other structures and roads. (Fields and forests are not subject to analyze because of a lack of data for analysis.)

Since the aim was to compile information on the effects of each decontamination method, it was decided to use the ratio of reduction of surface contamination density by each decontamination method as the decontamination effect analyzed.

In order to reduce variations due to factors other than the target of decontamination, the target of analysis was data for surface contamination density before decontamination of 2,000 cpm or more.

(1) Buildings and Other Structures

1) Rain gutters and roadside gutters, etc.

① Rain gutters

· The reduction rate of the surface contamination density is about 60 to 80% by wiping after removal of sediments, and it is about 40 to 80% by washing with high pressure water after removal of sediments. Wiping after removal of sediments has a higher reduction rate than high pressure water washing.

· Because a significant amount of radioactive substances accumulates in sediments in rain gutters, it is important to note that removing those sediments is an effective means of implementing decontamination.

② Rainwater drains

· The reduction rate of the surface contamination density is about 60 to 90% by washing with high pressure water after removal of sediments.

· Sediment removal is being done, and its effectiveness is believed to be significant.

· In terms of data interpretation, it is important to note that the reduction rate will be lower due to high concentrations of radioactive substances penetrating seams and cracks due with initial rainfall.

· In terms of decontamination implementation, it is important to note that if the rainwater drain is damaged, care should be taken because of the possibility that the surrounding soil may be contaminated.

③ Roadside gutters

· The reduction rate of the surface contamination density is 70 to 90% with removal of sediment, and it is about 60 to 90% with high pressure water washing after removal of sediment.

· In terms of decontamination implementation it is important to note that since a large amount of radioactive substances were accumulated in sediments in roadside gutters, it was sufficiently effective only to remove sediments, and that where roadside gutters are damaged, the surrounding soil could be contaminated and require extra care.

2) Roofs, etc.

· The reduction rate of the surface contamination density in the case of roofs is about 0 to 20% (*) by wiping, about 20 to 60% by washing, and about 40 to 80% by washing with high pressure water. (* For the wiping off of the roof of a private house conducted in the autumn of 2012, a reduction rate of about 20 to 50% was achieved by improving the wiping method.)

· In case of a rooftop, the reduction rate is about 60 to 90% in high pressure water washing. It is considered that the shape of the rooftop is not very complexed, so the effect by high pressure water washing is significant.

· In the case of a veranda, etc., the reduction rate is about 20 to 50% by high pressure water washing. However, the dataset is small. It is about 60 to 90% by washing with high pressure water after removal of sediments.

· Below are some points to keep in mind for data interpretation.

- Variations will arise depending on the material and shape of the surface of the roof.
- In high pressure water washing, the results varies how much contaminated water remains.
- For roof cleaning and wiping, even for data with high surface contamination density, small reduction rates can be observed in some cases. These cases are believed to be affected by factors such as rust and materials, such as cement roof tiles, unglazed clay roof tiles, and coated iron plates.

· The following are points to keep in mind when implementing decontamination.

- When decontaminating work using water, it is important to take measures to prevent the scattering of washing water.
- Where rust is present, the benefits of washing with high pressure water may be low, so it is necessary to remove the actual rust by wiping or other means.
- In the case of high-pressure water washing, it is necessary to be careful because property may be damaged such as by peeling of surfaces.

3) Exterior walls

① Concrete

· The reduction rate of the surface contamination density is about 10 to 30% by wiping and about 20 to 80% by washing with high pressure water. However, the dataset for wiping is small.

· Radioactive materials may have already been washed away to some extent due to rain, as there was much data showing low surface contamination density (less than 2,000 cpm) and the adhesion of radioactive substances was small.

· In case of high-pressure water washing, it is necessary to be careful because property may be damaged such as peeling of walls.

② Metal, windows, doors, shutters, etc.

· For metal, windows, doors, shutters, etc., of exterior walls, the datasets are small for all methods.
· In the case of metal, the reduction rate is 40 to 70% for washing and about 40 to 90% for washing with high-pressure water.
· In the case of windows, doors, shutters, etc., the reduction rate is 70 to 80% by wiping, 20 to 70% by washing and 50 to 90% by high-pressure water washing.
· There is a possibility that radioactive materials were already washed away to some extent due to rain, as there was much data showing low surface contamination density (less than 2,000 cpm) or the adhesion of radioactive substances was small.

③ Tile sidings

· The reduction rate of the surface contamination density is about 60 to 70% by high-pressure water washing. However, dataset is small.
· Tile siding high-pressure water washing has a higher reduction rate compared with high-pressure water washing of concrete walls.
· There is a possibility that radioactive materials were already washed away to some extent due to rain, as there was much data showing low surface contamination density (less than 2,000 cpm) or the adhesion of radioactive substances was small.

4) Yards, etc., site

① Dirt and grass areas

· The reduction rate of the surface contamination density is about 0 to 60% by mowing, 40 to 80% by topsoil removal, and about 70 to 100% by soil replacement.
· Soil replacement is carried out when the surface contamination density is relatively high.
· Below are some points to keep in mind for data interpretation.
  - For topsoil removal in yards, there is a possibility that the reliability of decontamination work may be lowered due to the presence of vegetation and the fact that yards may be uneven compared with sports grounds.
  - For mowing, there is a possibility that the effectiveness of decontamination may vary due to variations over time in the conditions of adhesion of radioactive materials to the grass itself, and may be affected by the growing conditions of the grass.
  - Mowing reduces the shielding effect of grass on beta rays and may reduce the reduction rate.

② Grass

· The reduction rate of the surface contamination density is 70 to 90% in the case of grass stripping, and as high as about 90% for replacement (stones laid after grass removal).
· From the viewpoint of limiting the amount of removed soil generated and restoring the grass, in terms of decontamination implementation this is important to note that it is also necessary to consider removal by "deep pruning," which has been confirmed to have a certain effect in reducing the radiation dose.

5) Paved surfaces such as parking lots

① Paved asphalt surfaces

· The reduction rate of the surface contamination density is about 50 to 70% for washing, 30 to 70% for high-pressure water washing, and about 70 to 90% for scraping.

· In high-pressure water washing, variations in reduction rate are large regardless of the surface contamination density.

· In terms of decontamination implementation with high-pressure water washing, it is important to note that there may be greater variations in the reduction rate if the decontamination area is large, such as a parking lot, due to variations in effectiveness depending on the operation method at each point (nozzle height above ground, working time per unit of area, etc.) and the surface conditions (water permeability and drainage, etc.).

· Below are some points to keep in mind for data interpretation.

- For decontamination work using water, measures are needed to prevent the scattering and spread of washing water.
- If cracks or other such features are present, caution is necessary because of the possibility of penetration into the damaged portion.

② Paved concrete surfaces

· The reduction rate for the surface contamination density is about 40 to 70% for high-pressure water washing and about 60 to 90% for scraping.

For scraping, differences could appear in the reduction rate depending on the work method.

· In terms of decontamination implementation with high-pressure water washing, it is important to note that there may be greater variations in the reduction rate if the decontamination area is large, such as a parking lot, due to variations in effectiveness depending on the operation method at each point (nozzle height above ground, working time per unit of area, etc.) and the surface conditions (water permeability and drainage, etc.).

· Below are some points to keep in mind for implementing decontamination.

- Concrete is less uneven and the decontamination efficiency is relatively high, but contamination tends to concentrate where moss is attached.
- For decontamination work using water, measures are needed to prevent the scattering and spread of washing water.

③ Interlocking

· The reduction rate of the surface contamination density is about 50 to 80% by high pressure water washing and about 40 to 70% by scraping.

· Below are some points to keep in mind for data interpretation..

- When scraping off, the reduction rate may be lowered by cutting scraps and radioactive materials remaining in the gaps of the block.
- The reduction rate of interlocking scraping (shot blasting, concrete plane) is smaller than scraping of paved asphalt surfaces or paved concrete surfaces. It is conceivable that cutting residue remained in the interlocking gap.

6) Sports grounds, etc. (dirt surfaces)

· The rate of reduction of the surface contamination density is relatively high at about 80 to 90% for the removal of surface soil.

· It is believed that the lower level of unevenness of grounds enables a consistent reduction rate.

· In terms of decontamination implementation, it is important to note that it is necessary to check the depth of contamination from the surface layer in advance, and to set the optimum thickness of stripping.

(2) Roads (paved asphalt surfaces)

· With most of the data being for washing, the reduction rate of the surface contamination density is about 0 to 50%. Most of that data is for drainage pavement functional recovering vehicles and the variation in the reduction rate is large.

· The reduction rate of high pressure water washing is about 10 to 50%. However, the dataset is small.

· The reduction rate of scraping is about 10 to 70%. (*Improvement of the reduction rate is currently being attempted by improving the recovery of cutting waste)

For washing, high-pressure water washing and scraping, in many cases the reduction rate is lower than for paved asphalt surfaces such as parking lots of buildings and other structures.

· Below are some points to keep in mind for data interpretation.

- When the decontamination range is large like a road, the high pressure water washing may vary depending on the operation method of the location (the ground height of the nozzle, working time per area, etc.), variation in the reduction rate may become large due to the conditions of the surface (water permeability and drainage).
- In the case of using drainage pavement functional recovery vehicles with low water pressure and circulating wash water, the reduction rate tends to be lower. In addition, the road washing and recovery of wastewater is lower on road surfaces that are worn or are distorted by earthquakes or other factors.

· In terms of decontamination implementation, it is important to note that for decontamination work using water, measures are needed to prevent the scattering and spread of washing water.

Table 4-5 Decontamination effect for each decontamination target

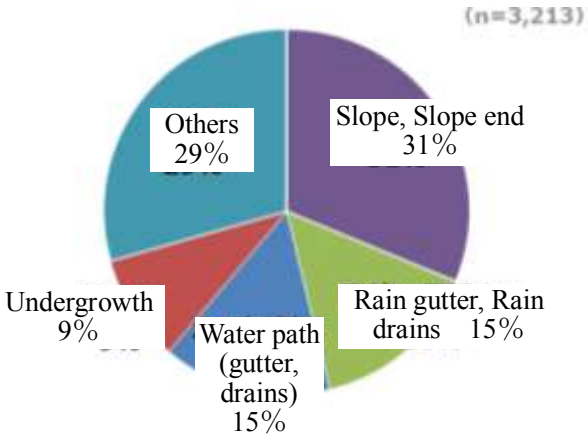
Part		Details	Decontamination method	Average reduction rate	25% - 50% - 75% value	Remarks
House, facility, etc.	Rain gutter Roadside gutter	Rain gutter	After deposit removal Wiping off	67% [n=212]	59－74－84%	Rain gutters mainly in private houses.
			After deposit removal High-pressure water washing	56% [n=131]	40－68－81%	Rain gutters mainly in private houses. Partly, combined with wiping.
		Rainwater drains	After deposit removal Wiping off	67% [n=212]	59－74－84%	Rain gutters in public facilities and private houses. Clean with brushing as well.
		Roadside gutter	Sediment removal	56% [n=131]	40－68－81%	Only remove earth and sand.
			After deposit removal High-pressure water washing	67% [n=212]	59－74－84%	Rain gutters mainly in public facilities. Clean with brushing as well.
	Roof etc.	Roofs, etc.	Wiping off	15% [n=56]	2－9－22%	Mainly roof of private house. Wiping with cloth, etc., Partly wiping with a paper towel.
			Washing	40% [n=235]	16－45－64%	Mainly roof of private house. Deck brush wash. Some, wire brushes and hand polisher.
			High-pressure water washing	55% [n=76]	37－64－81%	Public facilities, private houses, factory roofs. There are many combinations with brushing.
		Rooftops	High-pressure water washing	75% [n=87]	63－78－90%	Roof of public facilities. There are many combinations with brushing.
		Verandas, etc.	High-pressure water washing	41% [n=10]	24－46－53%	Veranda etc in public facilities, etc., Partly, combined with brushing and wiping.
	exterior wall	Concrete	Wiping off	22% [n=6]	10－19－33%	public facility.
			High-pressure water washing	47% [n=19]	19－45－76%	There are many public facilities, some private houses. Some use brushing and wiping together.
		Metal (tinplate, titanium, iron plate, etc.)	Washing	51% [n=5]	37－65－69%	Private house. Brush cleaning.
			High-pressure water washing	43% [n=9]	44－83－92%	Factory, private house, school. Partly, wiping is used in combination.
		Window · door · shutter etc.	Wiping off	74% [n=8]	65－69－84%	There are many private houses and public facilities.
			Washing	46% [n=6]	24－62－65%	Private house. Brush cleaning. Partly, wiping is used in combination.
			High-pressure water washing	64% [n=7]	53－70－85%	The private house is mostly. Partly, brushing is used in combination.
		Tile siding board	High-pressure water washing	61% [n=4]	58－71－74%	Private house. There are many combinations with

Part		Details	Decontamination method	Average reduction rate	25% - 50% - 75% value	Remarks
						brushing.
	Yard, etc., site	Earth / Grassland	Mowing	19% [n=144]	-3－29－55%	Public facilities, warehouses, premises of private houses.
			Topsoil removal	58% [n=232]	42－68－81%	Public facilities, factories, parks, premises of private houses. Top soil removal of 3 to 5 cm or more (before being covered).
			Replacement	73% [n=23]	65－79－95%	Public facilities, premises of private houses. Only data with a relatively high surface contamination density. The backfill material is gravel, crushed stone, soil.
		lawn	Grass stripping	72% [n=32]	72－80－86%	Public facilities only.
			Replacement	86% [n=15]	85－87－88%	Public facilities only. Laying the crushed stone after removing the lawn.
	Parking lot etc. Pavement surface	Paved asphalt surfaces	Washing	52% [n=60]	47－59－65%	Mainly public facilities site. Road cleaning truck. Partly, metal brush sweeper, watering car + sweeper.
			High-pressure water washing	46% [n=329]	30－50－67%	Mainly public facilities site. There are many combinations with brushing.
			Scraping	78% [n=20]	70－82－87%	Mainly public facilities site. Shot blast.
		Paved concrete surfaces	High-pressure water washing	52% [n=73]	35－56－68%	Public facilities, warehouses, premises of private houses. There are many combinations with brushing.
			Scraping	73% [n=63]	62－81－90%	Private house premises. Shot blasting, vacuum blasting, dust collecting sander, grinding machine.
		Interlocking	High-pressure water washing	62% [n=45]	50－69－76%	Premises of public facilities and private houses.
			Scraping	54% [n=11]	38－57－65%	Public facilities site. Shot blasting, concrete sander.
	Ground etc.	soil	Topsoil	85% [n=271]	83－88－93%	Parks and schoolyards (before being lodged).
Road		Paved asphalt surfaces	Washing	20% [n=369]	2－28－49%	Mainly dense paving section. Partly drainable pavement. Drainage pavement function recovery car (mostly washing water pressure about 5 MPa). Some, sweepers + watering cars, metal brush sweeper.
			High-pressure water washing	28% [n=12]	13－24－54%	Used in conjunction with sand discharging and brushing.
			Scraping	31% [n=125]	7－39－72%	Mainly dense paving section. Shot blast.

4.3.4. Supplemental Decontamination

(1) Situation regarding Implementation of Supplemental Decontamination and Effects

Supplemental decontamination was carried out at about 10,000 homes so far based on the results of supplemental monitoring, etc. Embankments, rain puddles, roadside gutters and other water spots were the main target or this work, and the reduction effect was confirmed at approximately 50%.



Others : concrete surface, asphalt surface, bare field

Analyzed Data(about 10,000 houses decontamination : about 1,000 houses were partially decontamination, about 9,000 houses were hot spot decontamination)

Figure 4-25 Supplemental decontamination locations

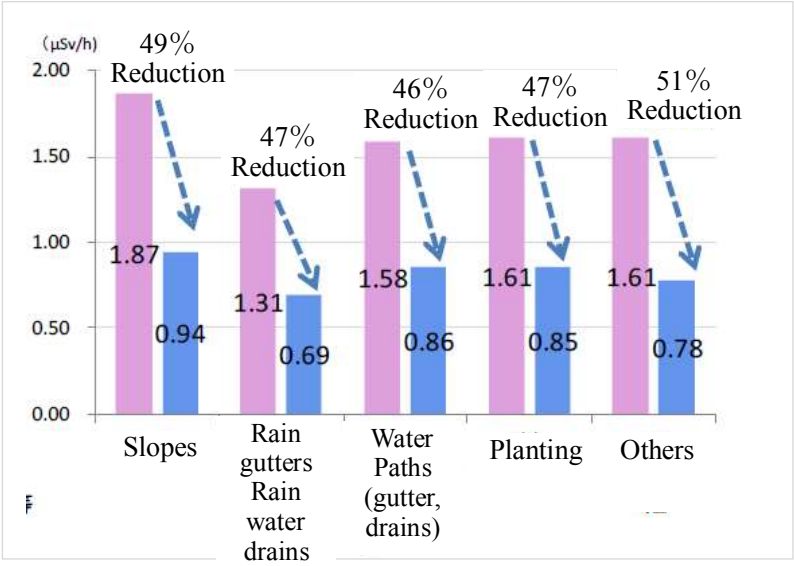


Figure 4-26 Dose reduction effect by supplemental decontamination (air dose rate 1 m above ground)

Source: MOE, documents from "The 18th Investigative Committee on Remediation" (December 27, 2017).

4.4. Temporary Storage Sites

4.4.1. Securing Temporary Storage Sites

(1) Challenges with Securing Temporary Storage Sites

In promoting decontamination, it was essential to have places to temporarily store the removed soil, etc., arising from decontamination. To secure Temporary Storage Sites it was necessary to have the understanding of landowners and local residents, but since it was not initially possible to offer adequate, residents voiced safety concerns such as the possibility of higher air dose rates near Temporary Storage Sites, and the possibility that removed soils, etc., accumulated there might leak and spread. There were also worries that the temporary storage period might be extended and the sites end up being used as disposal sites, and concerns that the removed soil, etc., from other areas might end up stored here.

In terms of securing Temporary Storage Sites, it was necessary to have sufficient area for placing the removed soil, collected and to have access roads. In cases where the area could not be secured enough in one Temporary Storage Site, multiple sites should be secured, and where the land was not flat, levelling work was sometimes required.

Also, with regard to the necessary area, as the amount of removed soil, etc., would vary depending on the decontamination method used, it was difficult to accurately predict the amount of soil to be removed. Temporary Storage Sites were gradually added as the decontamination work progressed, but in some cases the progress of work was affected when temporary storage sites were not ready.

In Intensive Contamination Survey Areas, it was necessary to secure Temporary Storage Sites but this became very difficult to do while residents lived in the area and much of the land was in use, such as agricultural land. If a Temporary Storage Site could not be secured, it was decided to use on-site storage. In case of on-site storage in residential yards, if the period of storage was prolonged, in some cases it was necessary to relocate the removed soil, etc., in the event of expansion or renovation work on buildings, or sale of the property, etc.

(2) Initiatives for the Securing of Temporary Storage Sites

In addition to carefully explaining the necessity of Temporary Storage Sites, MOE sought local understanding to secure Temporary Storage Sites, in cooperation with administrative district managers, community group chairpersons and others. Efforts were made to find realistic solutions with the local communities, and candidate sites were selected by administrative district unit.

In addition, MOE explained Temporary Storage Site designs as well as shielding soil and management methods, tried to resolve and relieve anxiety about their safety.

Temporary Storage Sites have lower air dose rates than the surrounding area because decontamination and leveling are done when preparing the sites, and increases in air doses are prevented by installing shield soil. There was greater understanding of their safety thanks to these measures, plus the measuring of air dose rates at the site boundaries, sharing of information with the local community, conducting site tours, and by having residents themselves measuring and confirming air dose rates. Some municipalities also made efforts to help residents feel safer by creating systems with the residents themselves monitoring the sites.

Also, understanding about Temporary Storage Sites was advanced thanks to some areas where the decontamination work started, sites were secured and decontamination work advanced quickly, and there were almost no concerns about the safety and contamination.

When it was difficult to set up a Temporary Storage Site, MOE was flexible in response to local circumstances, for example, using on-site storage rather than making it an absolute requirement to have a Temporary Storage. Particularly in areas outside of Fukushima Prefecture and urban areas in Fukushima Prefecture, it was difficult to secure large Temporary Storage Sites, even though it was necessary to start decontamination promptly. In such cases, many local governments carried out decontamination using on-site storage in residential yards and public parks, etc. by carefully explaining the safety and plans for subsequent removal, etc., and asking for understanding.

Also, in order to reduce the amount of soil removed, etc., to be delivered to Temporary Storage Sites, the decontamination waste generated was subjected to volume reduction such as shredding, crushing, compression and incineration as much as possible so as to reduce the volume.

(3) Securing Land for Temporary Storage Sites

Temporary Storage Sites are basically secured by lease contracts with landowners. There are many contract periods of three years, but also one year contracts and also contracts that last until removal. If extension of a contract is necessary, this is done based in consultation with landowners.

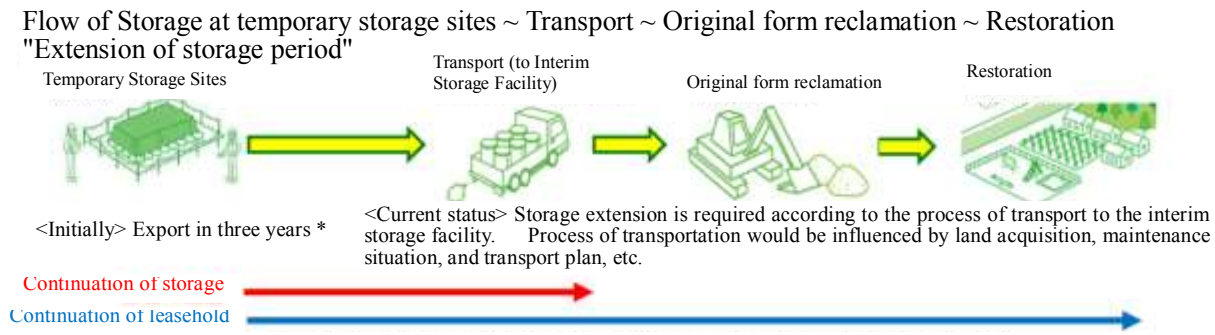


Figure 4-27 Flow from storage to land restoration at Temporary Storage Sites and prolongation of storage period

Column	"Securing Temporary Storage Sites" Fukushima Regional Environmental Office

Temporary Storage Sites had to be secured before starting decontamination which was a precondition for obtaining consent and starting decontamination. It was important from the viewpoint of work, management, and transportation of removed soil, etc., to have Temporary Storage Sites located on flat land, with at least a certain amount of land area, and with good access. On the other hand, when securing Temporary Storage Sites, it was necessary to first obtain consent from the local residents in the neighborhood as well as consent from the landowner of the land at the Temporary Storage Site.

Regarding the location of Temporary Storage Sites, the original intention was to efficiently transport material to Interim Storage Facility , and it was the policy to concentrate Temporary Storage Sites within municipalities, but in many local governments, in the process of seeking cooperative relationship with local residents, the number of cases of Temporary Storage Sites in each administrative district increased. For securing Temporary Storage Sites, the approach was not to just search for a suitable place on the map. Staff members of the Fukushima Office for Environmental Restoration (present: Fukushima Regional Environmental Office) also went to locations in person to find suitable sites for temporary storage and discussed matters with landowners and others. Some municipalities tried to set up Temporary Storage Sites in forests, but it was difficult to secure land that was flat and sufficient in size, so the policy was to coordinate with landowners to set up Temporary Storage Sites temporarily on farmland in each administrative district.

At briefing sessions, the residents were angry and anxious and it was not an atmosphere conducive to explaining, but we continued to hold briefing sessions a number of times.

There was anxiety about leasing the paddy fields that had been handed down for generations, to be used as Temporary Storage Sites, and a variety of other anxieties and concerns about their safety and possible extensions.

These concerns were understandable, so personnel from the Fukushima Office for Environmental Restoration explained each matter carefully. Initially, as there were no Temporary Storage Sites, it was difficult to imagine what they would be like. Therefore, we created a model of the Temporary Storage Site, and used it to make clear explanations to land landowners and others. In addition, about concerns about the spread of radioactive materials, we used pamphlets to explain that there was no risk of radioactive materials leaking out, and explained that we would conduct monitoring which helped people understand. Furthermore, in coordination with landowners, we were greatly helped by the cooperation of municipal officials and administrative district managers. Through these efforts we made progress in having people understand securing Temporary Storage Sites.

We will strive to promptly return the land to landowners by carefully managing the Temporary Storage Site currently being leased, transporting the removed soils away, and restoring the sites to their original condition.

Source: "Decontamination Information Plaza Exhibit Lending Catalog (Model)"

4.4.2. Establishing Temporary Storage Sites

(1) Basic Design

Facility requirements and management requirements of Temporary Storage Site for rapid decontamination are described in the Decontamination Guidelines section "Fourth Edition: Guidelines on Storage of Removed Soil."

① Storing combustible materials

If removed leaves, fallen branches, logged trees and leaves or other combustibles are left in a pile, gas will be generated due to decomposition and potentially cause a fire, so the material should be covered with a breathable water resistant sheet, etc., and degassing pipes and temperature sensors installed (Special Decontamination Areas). Also, the storage condition of the waste should be checked regularly, and if white smoke or water vapor, etc., is confirmed, the internal temperature should be measured and managed appropriately.

② Storing incombustible materials such as soil

Since incombustible materials such as removed soil will not generate gas even if stored, they can be covered and stored with an impermeable sheet that does not pass water.

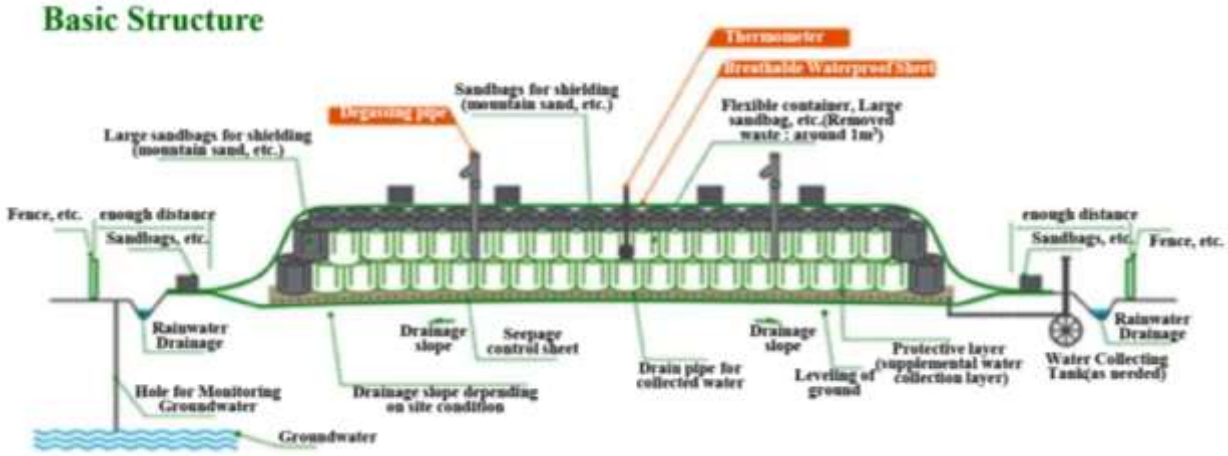


Figure 4-28 Basic design of Temporary Storage Sites for above-ground storage of combustible materials removed by decontamination

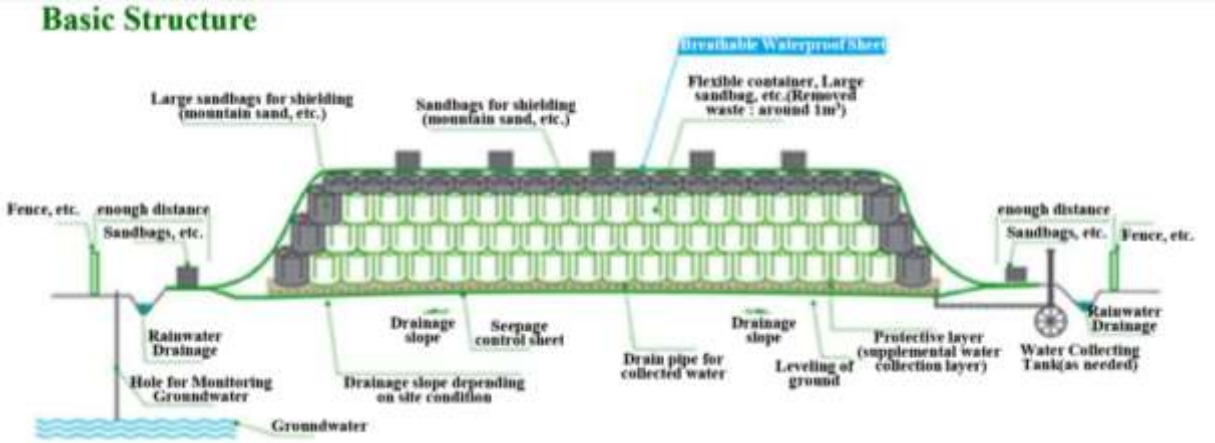


Figure 4-29 Basic design of Temporary Storage Sites for above-ground storage of incombustible materials removed by decontamination Source: MOE "Decontamination Information Site"

③ Ensuring safety

At Temporary Storage Sites, a fence or the like should be installed after sufficiently securing the distance from residential areas to prevent persons from accidentally approaching the sites.

To prevent scattering and runoff, and to prevent the infiltration of rainwater, etc., and the pollution of groundwater, etc., the removed soil, etc., is placed in flexible containers or large container bags, placed on a water-impermeable layer (waterproof sheets or other impermeable sheets), and covered with waterproof sheets.

Radiation from flexible containers and large container bags is shielded by surrounding them with shielding container bags containing uncontaminated mountain sand, etc., to reduce the radiation dose at the site boundary to the same level as the surrounding area. Soil with a thickness of 30 cm can reduce the radiation dose by 98%. Shielding soil at Temporary Storage Sites in Special Decontamination Areas uses non-polluted soil at 400 Bq/kg or less, procured by purchasing soil or obtaining from nearby soil collection sites. Also, the policy is to reuse the soil after the stored materials have been removed.

For organic materials such as plants and the like, in order to limit any temperature increase from fermentation to a certain level, the size of each storage pile is kept small and the surface area per unit of volume is kept large, in order to boost heat dissipation. However, in the event of a temperature rise above a certain limit, it is important to be prepared with access routes for heavy equipment, etc., and with fire extinguishing equipment.

<Function and structure required for Temporary Storage Sites>

Temporary Storage Sites for removed soil, etc., are expected to provide the functions of "prevention of scattering of removed soils," "prevention of infiltration of rainwater, etc.," "prevention of discharge of radioactive material," and "shielding of radiation, and limiting of additional radiation doses." Therefore, they are constituted the structure of equipment and materials to satisfy these functions.

① Prevention of scattering of removed soil, etc.

Removed soil, etc., is placed in bags that can have their openings closed or containers that can be closed with a lid (highly weather resistant large container bags, flexible containers, etc.) before being delivered to Temporary Storage Sites.

Containers delivered to Temporary Storage Sites are covered with soil or other materials to prevent the scattering of removed soil, etc.

② Prevention of infiltration of rainwater, etc.

Containers delivered to Temporary Storage Sites are covered with impermeable sheets such as waterproof sheets so as to prevent rain from falling on them to the extent possible (or use containers with a waterproof function).

③ Prevention of discharge of radioactive material

To prevent contamination of soil, surface water, and groundwater with leachate from removed soil, etc., the containers are placed on top of an impermeable sheet, etc., placed on the bottom surface (or use a containers with a waterproof function).

④ Shielding and isolation of radiation

Radiation is shielded by covering the removed soil, etc., with shielding container bags, etc.

Fencing, etc., is installed around the Temporary Storage Site to ensure that people do not get in, thereby ensuring isolation.

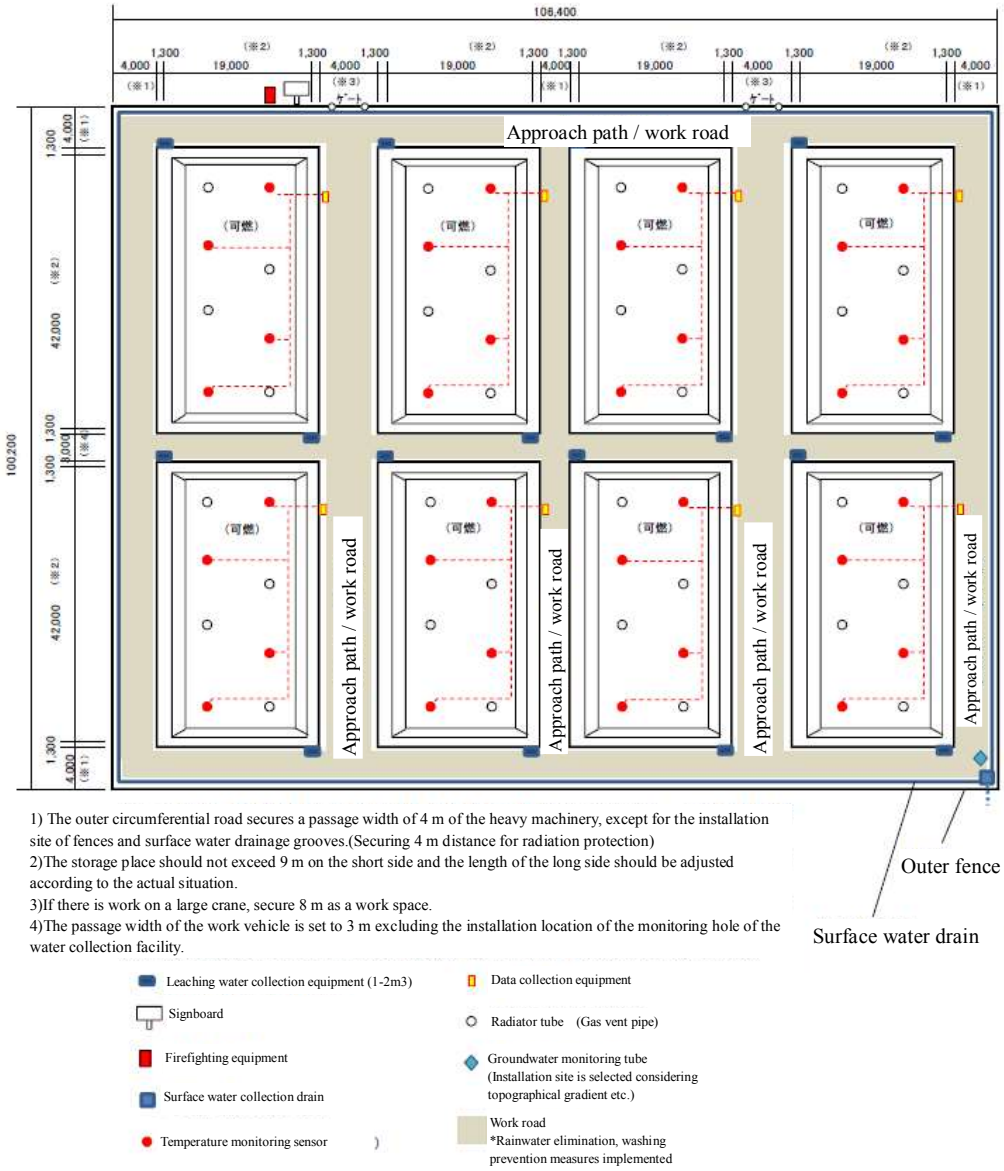


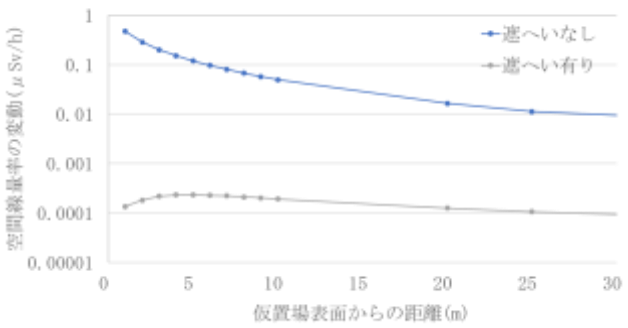
Figure 4-30 Example of Temporary Storage Site layout (location for combustible materials)

Explanation	Evaluation of radiation impacts from Temporary Storage Sites

It is also clear from evaluation by calculation that the impacts of radiation from removed soil, etc., stored at Temporary Storage Sites in Fukushima Prefecture were sufficiently reduced by taking measures such as shielding by soil and ensuring the necessary isolation distance.

Preliminary condition of provisional place

Size	Vertical 20m×width 20m×height 2 m
Radioactive cesium concentration in removed soil	10,000 Bq/kg
Storage method	Ground type
Shielding material	soil
Condition for shielding	Side shielding 1 m and upper shielding 30 cm



Evaluation results of impacts of radiation from Temporary Storage Sites based on differences in shielding and isolation distance Source: Fukushima Prefectural Centre for Environmental Creation

Temporary Storage Site (Katsurao Village)

Temporary Storage Site (Namie Town)

Management facility (Naraha Town)

Temporary Storage Site under construction (Iitate Village)

Figure 4-31 Scenes at Temporary Storage Sites

Column	"Design concepts for Temporary Storage Sites" Mr. Kazuto Endo, National Institute for Environmental Studies

Decontamination is being implemented as a basic approach for "removing," "isolating," and "shielding" radioactive substances. A Temporary Storage Site is a place where contaminated materials that have been removed from the living environment are packed into flexible containers, etc., and brought to Temporary Storage Sites away from the living environment, to be stored there for a period of time until being processed in the future. If they cannot be isolated from the living environment, measures are taken to block the radiation with shielding soil, etc., to ensure there is no impact on the living environment.

Contaminated materials include removed soil and decontamination waste. The former is treated as incombustible, and the latter as combustible. In the case of incombustible material, the stacking height at Temporary Storage Sites is set at five layers to ensure the stability of the pile and prevent the collected material from re-scattering, and to prevent the flexible containers and the large container bags from being damaged by the load. In the case of combustible materials, heat may be generated by the decomposition of organic substances, so the stacking heights are set at two or three layers from the perspective of preventing spontaneous ignition due to heat buildup.

At Temporary Storage Sites, a large amount of radioactive cesium will be present because contaminated materials will be collected in one location. Therefore, from the perspective of preventing the leakage of radioactive cesium, an impermeable sheet is laid on the bottom. Since radioactive cesium is extremely low in elution due to its strong adsorption to soil, it would not typically be necessary to use a water impermeable sheet, but that is being done as precaution. In addition, on the water impermeable sheet, a collection drain pipe is installed and connected to a water collection tank outside the storage pile, so radioactive cesium can be monitored if it happens to leak out. The top of the Temporary Storage Site is covered with an impermeable sheet, etc., so that excess rain water does not intrude. Since incombustible materials do not generate heat, an impermeable sheet is used, but since combustible materials can generate heat, they are covered with a breathable water resistant sheet (blocks water but allows gases to pass through) to promote heat dissipation, and heat radiation pipes are installed to prevent heat buildup.

Temporary Storage Sites are covered with the sheets after delivery of removed soil, etc., is completed, and monitored until the stored materials are carried out again. Efforts are made to ensure the soundness of Temporary Storage Sites, including regular observation to ensure the air dose rate has not risen suddenly, to notice if any leachate water contaminated by radioactive cesium has entered the catchment tanks, and to notice whether the protective sheets have moved or become damaged, etc.

Initially, the Temporary Storage Sites were presumed to be used for a storage period of three years, but the expected three-year period for removal has now been exceeded, and

maintaining them as temporary structures has become more difficult. To manage the overall Temporary Storage Sites by water impermeability, as rainwater enters due to deformation of the pile and partial damage of impermeable sheets by birds and other animals, the management load increases because it is necessary to regularly pump water out. Therefore, a new construction method to reduce the management load was adopted by placing the removed soil, etc., collected from decontamination into waterproof flexible containers or large container bags and then transporting them to Temporary Storage Sites, eliminating the need for the impermeable sheets as well as collection and drainage pipes. Since each storage container is water impermeable, it is no longer necessary to have waterproofing or water collecting tanks at the bottom and not necessary to cover the upper part with waterproof sheets. To prevent deterioration of the storage containers from ultraviolet light, the entire Temporary Storage Site is covered with a light-shielding mat.

In the absence of any previous experience or structure standards for the long-term storage of not only incombustible but also combustible materials contaminated with radioactive cesium, various techniques other than those mentioned above have also been introduced in the maintenance of the Temporary Storage Sites. We have arrived at today after having made various improvements.

(2) Standard Specifications Relevant to Temporary Storage Sites

For Temporary Storage Sites in Special Decontamination Areas, MOE has prepared the "Standard Construction Methods for Temporary Storage Sites in Special Decontamination Areas" in order to specify the standards for building the sites, including basic concepts; preliminary studies, surveys and designs; site leveling plans; ground preparation; foundation work; delivery and stacking of removed soil etc.; coverings; end treatments; and associated facilities, etc. This document is loaned to contractors who do work relating to the set-up of Temporary Storage Sites and, etc., and they do the work according to these Standard Construction Methods.

The Standard Construction Methods have been revised and now are comprised of two editions, "Filling Removed Soil, etc., into Containers that Are Not Water-Resistant or Waterproof" and "Filling Removed Soil, etc., into Containers that Are Waterproof." The revisions are based on the actual installation situations at Temporary Storage Sites and issues that occur on site, and allow for options such as using a light-blocking sheet that is not waterproof as the covering sheet when containers filled with removed soil, etc., are water resistant or water proof.

(3) Creating Temporary Storage Sites

The design of Temporary Storage Sites involves many factors that are site-specific. Initially, no detailed design guidelines existed, and even after the newly-created design books were presented, it took time to be recognized by supervisory personnel. Over time, these guidelines and reference diagrams were compiled and improved.

The decisions for the location of each Temporary Storage Site were made under various constraints, and

the work conditions were also unique in some cases. Most of the Temporary Storage Sites for direct decontamination work under MOE were originally on agricultural land, so the ground loading strength was weak, leading to concerns about ground subsidence, and the land became muddy when the rain fell. In the future it is impossible to improve the ground to restore the original state to the landowners, secure the aisle passages for heavy machineries and work yards with the ironing boards, arrange the removed soil, etc., delivered order from the back side of the Temporary Storage Site, It piled up and it was work to retreat to the entrance side.

Also, since the sites to be decontaminated were in an area with layers of decomposed granite, there were cases in which decomposed granite layers were also scooped up in the preparation of the Temporary Storage Sites, and it was difficult to prevent scouring in installing drainage gutters in such places.

Since there were overhead lines and the like at some of the Temporary Storage Sites, there were cases in which it was necessary to modify the shape of the storage pile in order to ensure a minimum distance between the boom and the overhead lines during crane operation.

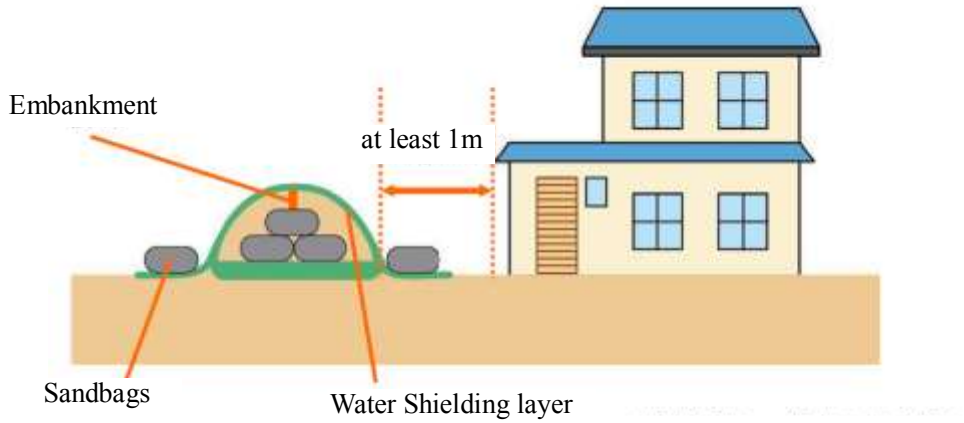
(4) On-site Storage

In the Intensive Contamination Survey Areas, there are municipalities that decontaminate by on-site storage rather than setting up a Temporary Storage Sites, due to the need to quickly start decontamination work. For on-site storage, the two methods are above-ground storage and underground storage.

For above-ground storage, a waterproof sheet is spread out and containers containing removed soil, etc., placed on top, and then a waterproof sheet is placed on top to prevent rainwater infiltration, and the edges or the sheet are secured to prevent them from blowing in the wind. For underground storage, the on-site storage location is excavated, a waterproof sheet is spread out, the containers containing removed soil, etc., are placed, and then covered with soil.

According to the “Guidelines on Storage of Removed Soil,” in order to ensure safety, when storing 2 m × 2 m × 1 m removed soil, etc., it should be covered with a covering soil layer at least 30 cm thick, or it should be at least 1 m away from any building where persons live. If it is not possible to have this distance of at least 1 meter, the response was to taking shielding measures.

① Above-ground storage



② Underground storage

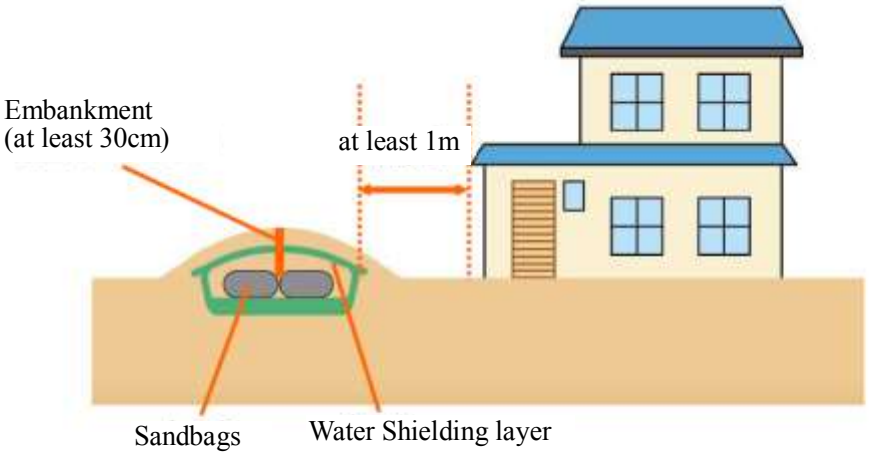


Figure 4-32 Examples of storage of removed soil

Source: MOE "Guidelines on Storage of Removed Soil"

(5) Storage Containers for Removed Soil

In the decontamination, etc., work ordered by MOE in Special Decontamination Areas, storage containers being used are mainly flexible containers of about 1 m 3 capacity (size: φ about 1.1 m × H about 1.1 m) and large container bags. Considering the characteristics and weight of the removed soil, etc., to be stored, as well as the storage period and other factors, if the storage was to last over a certain period of time (multiple years) or where the removed soil contained high levels of moisture, weather-resistant inner bag were used, such as cross-shape flexible containers, running-type flexible containers, and heavy weather resistant large container bags with inner bags, etc.

In the initial plans, since it was estimated that storage at the Temporary Storage Sites would be about three years, products with weathering resistance of three years were often used for large container bags, but even if storage is to continue for three years or more, by being covered with an impermeable sheet or a shielding container bag, etc., no serious problem due to deterioration or the like has occurred. The service life of the water impermeable sheets is assumed to be 15 years, and with proper inspection and repair it is considered that there is no major functional impairment.

Table 4-6 Examples of flexible containers and large container bags

Type	Image	Characteristics
Flexible container (cross shape)		· Assumed to be used once for full life. · Inferior in weather resistance and waterproofness compared to running type. · Some types have improved weather resistance with UV treatment, some with inner bags, some with improved waterproofness by inner coating, etc.
Flexible container (running type)		· Assumed to be filled and emptied repeatedly. · Excellent weather resistance and waterproof qualities.
Large container bag		· Water permeable. · Some types have improved in weather resistance with UV treatment, some made more waterproof with inner bags, etc.

When storing removed soils, etc., generated by decontamination in theSpecial Decontamination Area, the material is to be classified ① to ⑨ as follows based on the Common Specifications for Decontamination and Other Work..

Table 4-7 Storage classification of removed soil etc.

Combustible material	①Plants (pruned branches, deciduous leaves, grass, moss, weeds, litter layers, harvested trees, roots etc. Remove any attached soil, to the extent possible). ②Other combustible waste (Tyvek suits, cloths, masks, filters, rubber gloves, paper, etc.)
Incombustible materials, · Mixtures	③Soil, etc. (soil, pebbles, gravel, etc. Remove plants, to the extent possible.) ④Concrete pieces, etc. (tile, brick, blocks, rock, etc.) ⑤Asphalt mixture

	⑥Other incombustible materials and mixtures (excluding dangerous goods, hazardous substances)
Dangerous goods / harmful substances	⑦Building materials containing asbestos ⑧Gypsum board ⑨Other dangerous goods, harmful substances

Explanation	Strength testing of materials used in Temporary Storage Sites

Studies and research are also being conducted on whether sufficient strength is ensured during the storage period, with materials (in containers, etc.) used to store the removed soil, etc., at the Temporary Storage Sites

Tensile strength test of storage container belt

Lifting and suspending test of storage

Drop test of container bag

Source: Fukushima Prefectural Centre for Environmental Creation

(6) Volume Reduction

An enormous quantity of removed soil, etc., is generated by decontamination, so it is essential to reduce the overall volume so as to reduce the volume that needs treatment and disposal, and for securing land for storage. Methods of volume reduction include physical volume reduction such as compression and crushing, incineration and melting, and “separation” (bunkum) in which fine particles such as clay with radioactive cesium attached are sorted and reduced. On location where decontamination is carried out to aim volume reduction by crushing, chipping, and compression, etc. Examples are provided below.

① Crushing

Branches cut down in the process of decontamination of forests are generated in large quantities, will have a large ratio of air space, and will be a waste of space even if an attempt is made pack them up. Therefore, the branches are crushed using a crusher and packed in bags to reducing the air space.

Credit: Okumura Corporation

Figure 4-33 Cut branches (left) and cr
dec

on

Figure 4-34 Inside the crushing facility: Bun **rs**
(right)

② Chipping

Decontamination waste generated by decontamination, such as branches and leaves, is reduced by crushing to the size of chips. There are examples of self-propelled wood crushers being used in residential areas, etc.

Figure 4-35 Before chipping (left) and after chipping (right)

Source: MOE, Fukushima Office for Environmental Restoration "Compilation of Good Examples of Decontamination" (May 2013)

Fig. 4-36 Chip forming device

Source: Ministry of the Environment Fukushima Office for Environmental Restoration " Compilation of Good Examples of Decontamination" (May 2013))

③ Compression, packing

Crushing and chipping are examples of decreasing the air spaces and reducing the volume by crushing the waste. The crushed material is further reduced in volume by vacuum compression. This volume reduction technique uses vacuum compression and a compression bag. One common problem is clogging by leaves, etc., and puncturing of the compression bag by branches and leaves which can be solved using special nozzles and special compression bags. This technique can reduce combustibles such as fallen leaves, branches, and grasses to one-half to one-third of their original volume.

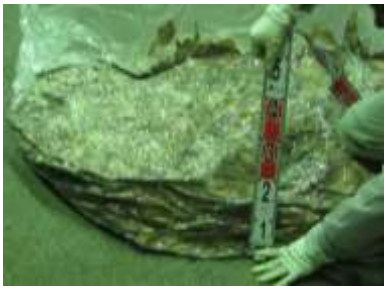
There are also examples in which combustible materials such as plants and branches are compressed, shaped into a roll, and packed with wrapping so as to reduce volume and decomposition, in order to ensure the effective utilization of Temporary Storage Sites and keep the material manageable during the storage period.

Credit: Maeda Corporation

Fig. 4-37 Compression packing device

Credit: Shimizu Corporation

Fig. 4-38 Combustible material reduction / anti-corruption device



Credit: Taisei Corporation

Figure 4-39 Before Compression (Left) and After Compression (Right)

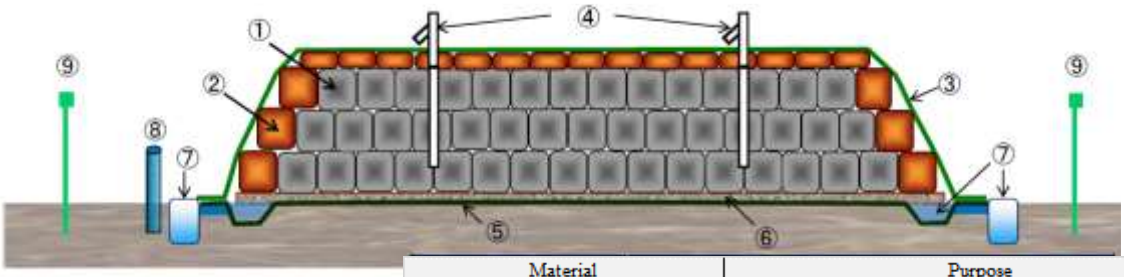
4.4.3. Management of Temporary Storage Sites (Special Decontamination Areas)

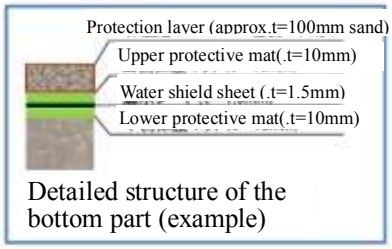
(1) Managing Temporary Storage Sites

After the delivery of removed soil, etc., is completed and the work of shielding the top surface is done, the decontamination contractor will manage until the handover of responsibility is completed, and contractors designated by MOE will take over the site management.

For the management of Temporary Storage Sites, MOE prepared the “Temporary Storage Site Management Manual” to prescribe site management systems, inspection and management items,

management techniques, and monitoring items, etc. In addition, a "Maintenance and Repair Manual (provisional operation)" has been created. Both manuals are lent to management companies contracted for maintenance and repair work at Temporary Storage Sites, etc., and their work is carried out according to these manuals.





Detailed structure of the bottom part (example)

Material	Purpose
① Container of removed soil, etc.	Prevention of scattering removed soil, etc.
② Shielding sandbags	Radiation shielding
③ Upper sheet	Prevention of scattering removed soil, etc., rainwater intrusion. Internal gas release.
④ Heat sink pipe	Internal heat release
⑤ Lower sheet	Prevention of scattering removed soil, spill of radioactive
⑥ Protection Sheet	Protection of lower sheet
⑦ Leachate collection/drainage	Prevention of spill of radioactive materials
⑧ Ground water monitoring pipe	Prevention of spill of radioactive materials (monitoring of no
⑨ Intrusion prevention fence	Dsecure distance from radioactive materials, Prevention of invasion of outsiders and wild animals, Blindfold

Daily inspection once a week	・Visual inspection ・Measurement of air dose rate
Daily inspection once a month	・Measurement of groundwater
When necessary	・Measurement and treatment of leachate in the catchment tank
Emergency inspection at the time of extreme weather and earthquake	・Visual inspection ・Measurement of air dose rate

Figure 4-40 Basic design of Temporary Storage Sites plus daily management and inspection (site in a Special Decontamination Area, example for combustible material)

At Temporary Storage Sites in Special Decontamination Areas, it is necessary to periodically check for the presence of stored water in the discharge water collection tanks, check the radioactive cesium concentration if a certain amount of water accumulates in the tank, and discharge it only after ensuring it is below the control value (Cs-134 concentration [Bq/ℓ] / 60 + Cs - 137 concentration [Bq/ℓ] / 90 ≤ 1). If the control value is exceeded due to soil and material entering in the tank, the water is transported to a water treatment facility, subjected to coagulation sedimentation or other treatment, and then discharged only after confirming that it is below the control value.

In addition, visual and other inspections are conducted once a week, and if any trouble is noted, repairs or other actions are promptly carried out, and steps are taken so as not to let the trouble worsen. Up to now, the main repairs have been as follows.

· Water pooling occurred on the upper sections of impermeable sheets above the stored material, so pumps were used or drainage was created on the top.

· Weeds were growing on shielding container bags and retaining mounds, so the weeds were removed.

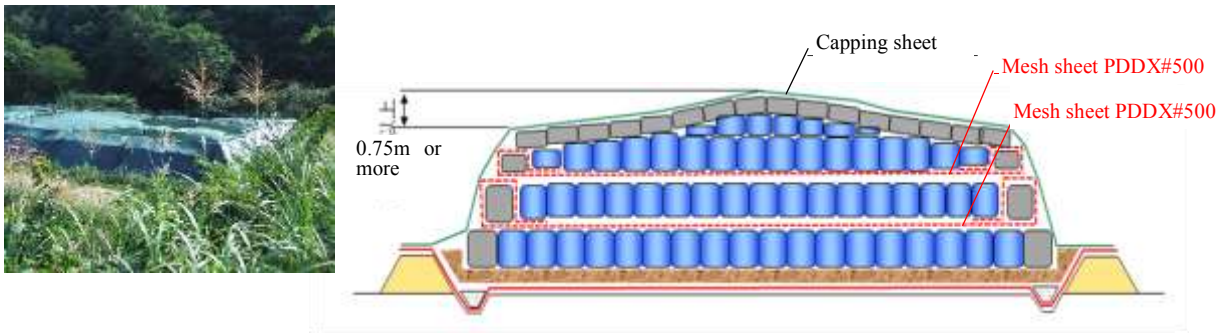
· The covering sheet was damaged, so it was repaired with repair tape.

Municipalities conduct inspections of Temporary Storage Sites in the Intensive Contamination Survey Areas, and the prefecture and MOE also conduct patrol surveys and confirm the storage condition of removed soil, etc. As a result of the patrol surveys, cases such as partial damage of storage containers were confirmed, but no discharge of removed soil, etc., was confirmed.。

(2) Improving Temporary Storage Sites

1) Cratering on the top end

On storage piles of decomposable decontamination waste, examples of rainwater accumulation were observed in depressions on top due to uneven settling from compression of the stored materials, as a result of decomposition of organic matter. For this reason, measures were taken to eliminate rainwater by creating low parts of the shielding container bags, to eliminate rainwater by holding the top end in an arch shape by using urethane foam or a settling prevention plate. There is an example in which a mesh sheet is laid in a layer of the stored material to prevent uneven settling.



Credit: Taisei Corporation

Fig.4-41 Example of preventing cratering on top

2) Leachate treatment

Since the bottom sheet should block water coming up from the ground, and the top sheet should block rainwater, any leachate at Temporary Storage Sites should normally only be water that accumulates in the leachate tank coming from the stored materials, and it should gradually decrease. However, in some cases, water came in via seam joints in sheets and the infiltration of rainwater from the breathable sheet, etc., the generation of the leachate water did not converge in some cases. For this reason, in addition to repairing seams of the sheets, measures were taken such as covering entire storage piles with impermeable sheets.

(3) Managing Stored Materials

In MOE document on Common Specifications for Decontamination and Other Work it is specified that the tags attached to containers such as flexible containers should have information readable for at least three years under a series of conditions, including decontamination measures, delivery to a Temporary Storage Space, and storage, and be made of materials and have a surface treatment (only for non-hazardous items) to make them corrosion resistant, weather resistant, and durable, and have tag colors to identify the contents.

As the decontamination work progressed, some decontamination contractors developed and utilized QR code printing systems, selecting and typing in necessary information with a handheld input device.

When full-scale decontamination began there were no unified specifications for the management of these large container bags, so in some cases workers simply hand-wrote information on the bags using marker pens, but after receiving suggestions from decontamination contractors about using tags, MOE included the concepts in Common Specifications for Decontamination and Other Work.

Table 4-8 Correspondence between content and tag color in Special Decontamination Areas

	Color	Contents
A	White	Soil, etc., (soil, pebbles, gravel etc.)
B	Green	Decomposable combustibles (pruned branches, deciduous leaves, grass, moss, weeds, litter layers, harvested trees, roots, etc.)
C	Yellow	Combustible materials (Tyvek suits, cloths, masks, filters, rubber gloves, paper, etc.)
D	Blue	Incombustible materials (concrete pieces, etc. [brick, blocks, rock etc.], asphalt mixture, sludge etc.)
E	Black	Incineration ash
F	Red	Dangerous goods (asbestos-containing materials, soil contaminated with harmful substances, etc.)

Development of "QR code issuing system"
- Handy-type input machine which can select necessary items and dose
- Transfer of data and issuing QR code
- Data are able to be assembled into personal computer with product-format to decontamination information system

Credit: Kajima Corporation

Figure 4-42 Example of QR Code Issuing System in Special Decontamination Areas

(4) Transferring Removed Soil, etc., and Clearance of Temporary Storage Sites

Documents entitled "Outbound Transport Consideration Items (Provisional Operation)" and "Methods to Restore Original Conditions (Provisional Operation)" were prepared by MOE concerning how to transport the removed soil, etc. away from the Temporary Storage Sites and how to restore the original site conditions when returning the land.

4.4.4. Quantities of Removed Soil, etc.

(1) Special Decontamination Areas

In Special Decontamination Areas, as of the end of December 2017, about nine million bags of removed soil, etc. had been generated and stored at 242 Temporary Storage Sites.

Table 4-9 Statistics on quantities generated

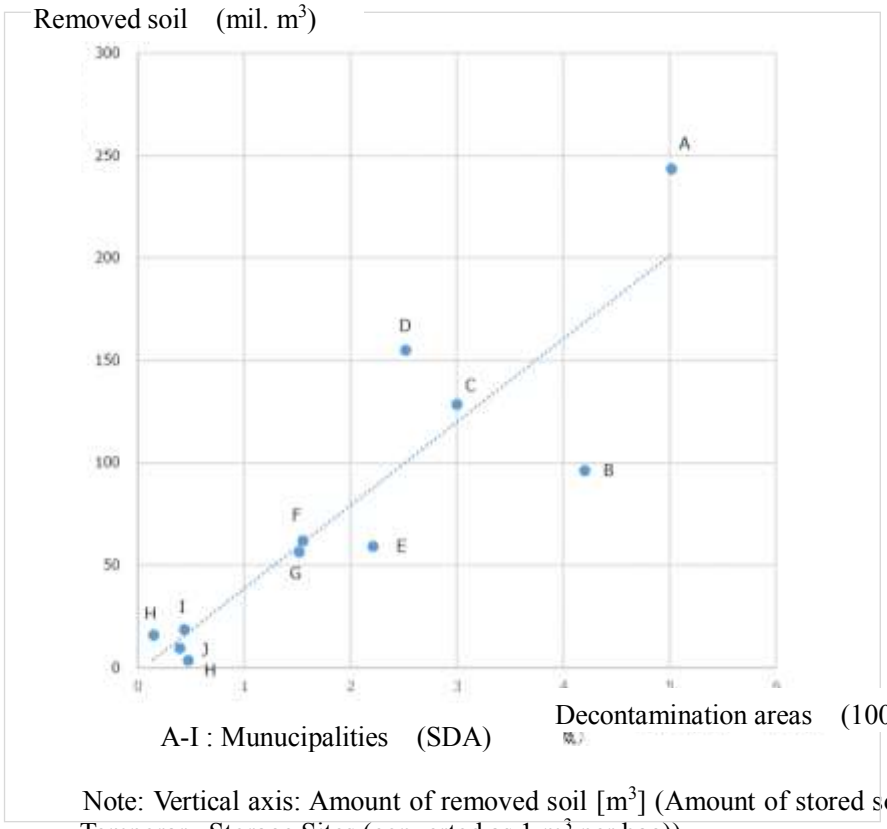
As of December 31, 2017

Municipality	Temporary Storage Sites (number)	Quantity generated (number of bags)
Tamura City	5	38,962
Naraha Town	21	597,241
Kawauchi Village	2	95,444
Okuma Town	15	467,229
Katsurao Village	25	565,289
Kawamata Town	43	629,467
Futaba Town	4	202,359
Iitate Village	84	2,502,019
Tomioka Town	8	1,593,069
Namie Town	22	1,336,311
Minamisoma City	13	1000,478
Total	242	9,027,868

注 Notes: 1. The number of Temporary Storage Sites includes Temporary Storage Sites, and short-term storage space.

2. The volume of stored material per bag is about 1 m^3 (although one bag may become smaller than 1 m^3 due to the volume reduction of stored material). In the future, quantities of stored material may increase due to supplemental decontamination, etc.

With decontamination in Special Decontamination Areas, looking by municipality at the relationship between the size of the area where decontamination was implemented and generated amount of decontaminated soil, etc., the amount of removed soil increased in correlation with the size of decontamination area



Note: Vertical axis: Amount of removed soil [m^3] (Amount of stored soil, etc., in Temporary Storage Sites (converted as 1 m^3 per bag))
Horizontal axis: Decontamination implementation area [ha] (total for residential land, agricultural land, forests, roads)

Figure 4-43 Decontamination Area and amount of removed soil, etc.

Source: MOE (editor), TEPCO Holdings

(2) Intensive Contamination Survey Areas

Regarding decontamination in the Intensive Contamination Survey Areas, as of September 2017, about 6.47 million m^3 of removed soil, etc., was stored at about 170,000 on-site storage sites, and 887 Temporary Storage Sites.

Table 4-10 Statistics on quantities generated of removed soil, etc.

Municipality	On-site storage		Temporary Storage Sites		Total	
	Quantity stored	Locations	Quantity stored	Locations	Quantity stored	Locations
Fukushima Prefecture	1,850,890	137,266	4,144,330	843	5,995,220	12,128,549
Iwate Prefecture	26,484	312	0	0	26,484	312
Miyagi Prefecture	16,676	674	80,063	29	96,738	703
Ibaraki Prefecture	55,139	1,045	2,657	2	57,796	1,047
Tochigi Prefecture	175,442	25,162	6,119	2	181,561	25,164
Gunma Prefecture	3,338	781	1,836	7	5,174	788
Saitama Prefecture	6,634	46	650	2	7,284	48
Chiba Prefecture	101,085	1,729	70	2	101,155	1,731
total	2,235,688	167,015	4,235,725	887	6,471,412	167,902

Note: For Fukushima Prefecture the numbers are as of the end of September 2017.

4.5. Organization and Management of Decontamination Work in Special Decontamination Areas

4.5.1. Securing the Necessary Resources through Decontamination Contractors

(1) Securing Workers

The decontamination work needs to be performed according to the state of the radiation dose and the state of the decontamination target, etc., and since the work that can be mechanized is limited, a large number of decontamination workers are necessary. In order to secure these decontamination workers, workers had to be hired not only locally but also from outside the prefecture.

However, the Earthquake off the Pacific coast of Tohoku that caused the TEPCO Fukushima Daiichi Nuclear Power Station accident caused serious damage mainly in Miyagi, Iwate and Fukushima Prefectures. In Miyagi Prefecture and Iwate Prefecture, etc., large-scale restoration and reconstruction projects have been progressing since the earthquake disaster, and the demand for civil engineering workers for decontamination work, etc., was also large outside Fukushima Prefecture. Therefore, securing decontamination workers was extremely difficult.

Therefore, in MOE, local governments, etc., explained efforts to reduce concerns about becoming decontamination workers by introducing decontamination work in an easy-to-understand manner, and in Special Decontamination Areas also worked on securing decontamination workers by implementing measures such as paying special work allowances.

(2) Educating Workers

Decontamination work requires a certain level of knowledge of radiation and decontamination methods. However, decontamination work was the first experience in Japan, and not only workers but also contractors of decontamination works had little knowledge and experience concerning decontamination and radiation protection. In addition, there were many workers who had no experience of construction work, and there were many cases where knowledge was insufficient for safety management, which is otherwise common knowledge at typical work sites. For this reason, efforts were made to educate a large number of workers about various matters, such as decontamination work, radiation, safety and health.

For example, before each worker enters the decontamination site for the first time, in addition to conducting new entry visitor education by special education based on the Ordinance on Prevention of Ionizing Radiation Hazards or a separate program, each contractor promotes full knowledge by repeatedly conducting continuous education, safety measures, etc. In addition, because Fukushima Prefecture and MOE held workshops for workers and field supervisors, decontamination contractors were able to develop educational activities more smoothly and easily.

Various accidents and troubles occurred along with the progress of work, and the content of education expanded in response, and in addition to improvement of the initial content on radiation protection measures and work safety, efforts were also made to raise awareness through explanations about the necessity and significance of decontamination work, and also education was also conducted concerning consideration for the local community and regulatory compliance.

(3) Materials and Equipment Used in Decontamination Work

In parallel with the decontamination work, in the disaster area, restoration and rebuilding work from the disaster caused by the earthquake and tsunami was being done, making it a challenge to secure the necessary quantity of specialized equipment among the equipment and materials used for decontamination work. In general, specialized equipment is expensive, so it is necessary to consider the efficiency improvements to be gained and cost-effectiveness of introducing the equipment. Also, particularly at the early stage of the decontamination operations, the equipment leasing companies were concerned about their equipment being contaminated by radioactive substances, making it difficult to conclude lease contracts.

Therefore, in addition to effective use of equipment used for general civil engineering work, in some instances decontamination contractors also used agricultural equipment for decontamination work (in the case of decontamination contractors, there were cases of employing local farmers and utilizing the agricultural machinery they already owned for decontamination work).

For most of the equipment could be decontaminated, such as by wiping it off after use, in order to meet criteria for contamination inspections, and then be returned to owners.

Regarding protective clothing and protective equipment, etc., by following the Ordinance on Prevention of Ionizing Radiation Hazards as well as the guidelines for that Ordinance, workers what was required, and avoided increasing waste that would have been generated by using excessive protective clothing and protective equipment, etc.

(4) Securing the Work Environment

At the peak of decontamination work, each site in the Special Decontamination Areas would have a workforce of a few thousands up to 10,000 people, and accommodations were needed for these workers. However, as Special Decontamination Areas were evacuation areas, existing accommodation facilities were not operating, and accommodation facilities were limited in the surrounding municipalities, so there were also challenges with securing traffic routes and dealing with traffic congestion for daily commuting.

For this reason, although in principle, accommodation is prohibited in Preparation Areas for Lifting of Evacuation Orders, because accommodation is specially approved in cases where it was necessary for reconstruction, there were some examples of workers' dormitories being established with the cooperation of municipalities and the understanding of the local people. On such occasions, efforts were made such as starting by decontaminating schools and public facilities on land owned by municipalities, then setting up the workers' lodgings, and carrying out security patrols of lodgings.

In addition to increasing the number of workers within commuting distance within the prefecture, efforts were also made to secure lodgings in various places, such as reducing the number of vehicles on the road by using commuter buses, staggering commuting times by setting different work start times, and dispatching traffic guides, etc.

Credit: Okumura Corporation

Figure 4-44 Example of a workers' dormitory(capacity about 350 people)

(5) Cooperation with Local Communities

In decontamination work it was necessary to earn the trust of landowners and it was important to gain local cooperation. Efforts were made to promote employment of local companies and local residents, and according to a survey by the Japan Construction Federation (February 2017), about 40% of all workers lived within the prefecture.

Many workers with no experience of engaging in construction work were hired, so a greater effort than usual was made to promote safety education, etc. Also, because of the unfamiliar working environment, quite a few workers quit after a short period of time, but local workers had a high degree of attachment to the area and this led to careful work.

In order to facilitate decontamination of agricultural land, it is important to communicate to gain understanding of owners and cultivators of agricultural land. For that reason, farmers were hired directly as workers of cooperating companies, they brought in their tractors for the work, and various efforts were done to utilize their agricultural expertise and experience in decontamination work. By having farmers decontaminating their own farmlands, the speed of agricultural land decontamination was accelerated. An effort was made to secure trust by having farmers working to decontaminate agricultural land.

Equipment and foods, living supplies were procured at local shops as much as possible.

4.5.2. Project Management by Decontamination Contractors (Special Decontamination Areas)

(1) Decontamination Work Plans and Work Scheduling based on Weather Conditions

Some areas such as the Aizu area in Fukushima Prefecture have high snowfall and snow accumulation in winter. In decontamination work, errors can arise in the measurement of air dose rates and surface dose rates due to snow accumulation, quality can deteriorate when confirmation of decontamination work becomes more difficult due to snowfall and snowfall accumulation, and workability and safety can decline. It was therefore decided not to perform decontamination work during the snowy season and the snowfall period.

In the case of rainy weather as well, errors can arise in the measurement of the air dose rates and the like, materials being removed can be washed away and increased moisture levels can increase the weight, leachate from removed materials can accumulate at Temporary Storage Sites, and rainwater can accumulate when the temporary covers are lifted for delivery at Temporary Storage Sites. It was therefore decided to stop the decontamination work when there is more than a certain amount of rainfall, and work plans were formulated and work was scheduled based on weather conditions.

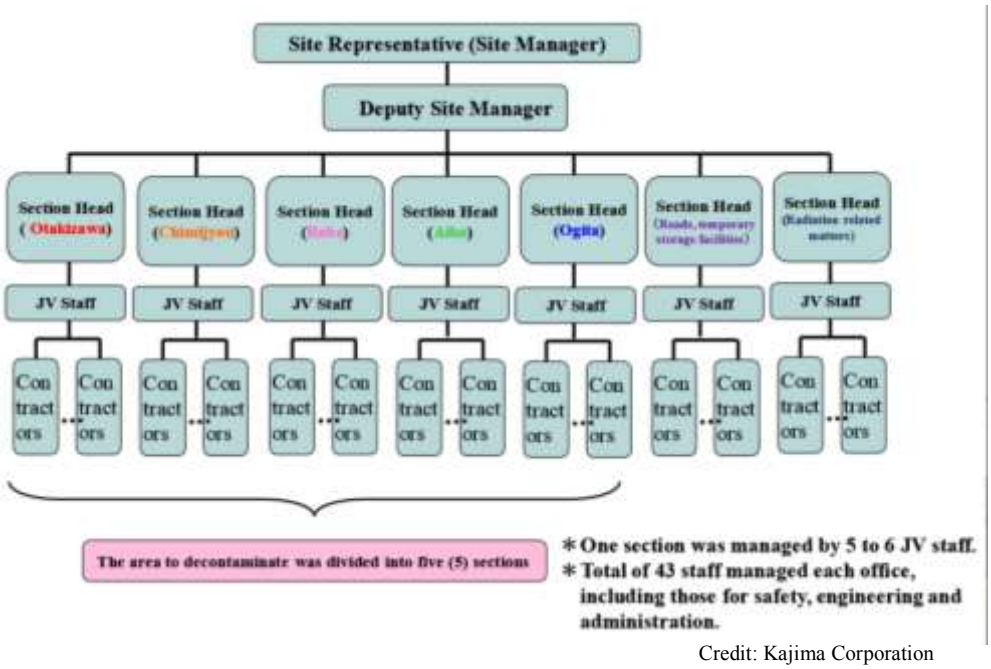
(2) Management of Implementation System

The designation of persons (work leaders) who lead the work for each work unit (work team), persons responsible for radiation control (radiation control managers) were designated to supervise the radiation control of workers doing decontamination and other work.

Lists were prepared of workers working on decontamination and other work. Decontamination workers were registered on the list before starting work and their registration was removed when they ceased to be engaged in the work. It was confirmed that they possessed an individual dose record book at the time of being registered as decontamination workers, and if they did not have one, they were required to obtain one before cancellation of registration.

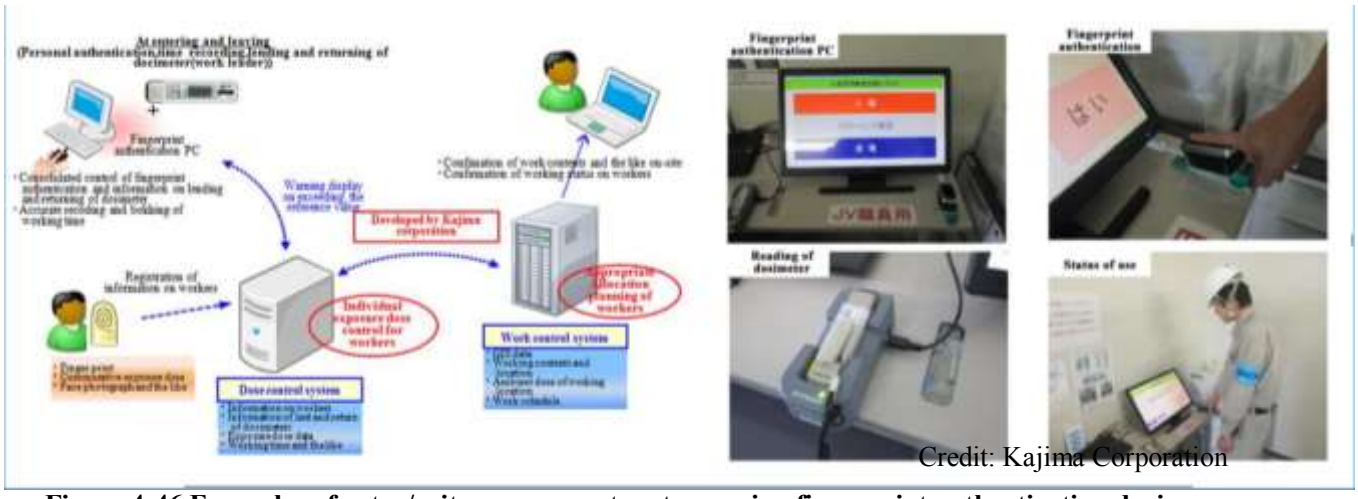
Applications for decontamination worker identification cards were submitted to supervisory personnel at MOE, the identification cards were issued, and decontamination workers were required to carry them at all times when working.

Since a large number of workers would enter and exit the work areas, in order to smoothly conduct the recording of worker name, work hours, and exposure doses, etc., in some cases facial recognition and fingerprint authentication devices were used.



Credit: Kajima Corporation

Figure 4-45 Example of implementation system of decontamination work



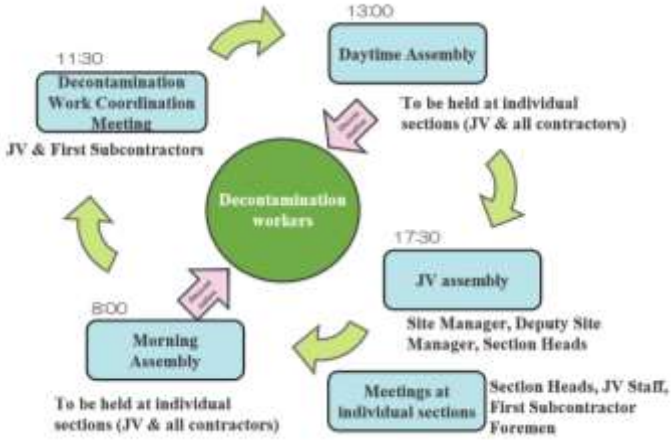
Credit: Kajima Corporation

Figure 4-46 Examples of entry/exit management systems using fingerprint authentication devices

(3) Communicating Notifications and Safety Precautions

Besides the primary contractors, implementation work required the involvement of large numbers of cooperating companies and workers, so it was a challenge to have adequate communication of notifications and safety precautions, etc.

For this reason, there were also many examples of communicating notifications and safety precautions. These included coordination meetings to confirm progress and exchange information concerning decontamination work, held regularly between the Fukushima Office for Environmental Restoration (MOE), municipalities, labor standards supervision departments, police, fire departments, and primary contractors (joint ventures), as well as meetings and updates, morning and lunchtime briefings, held at various levels of authority among joint ventures, cooperating companies, and work zones.



Credit: Kajima Corporation

Fig. 4-47 Example of communicating notifications

Credit: Maeda Corporation

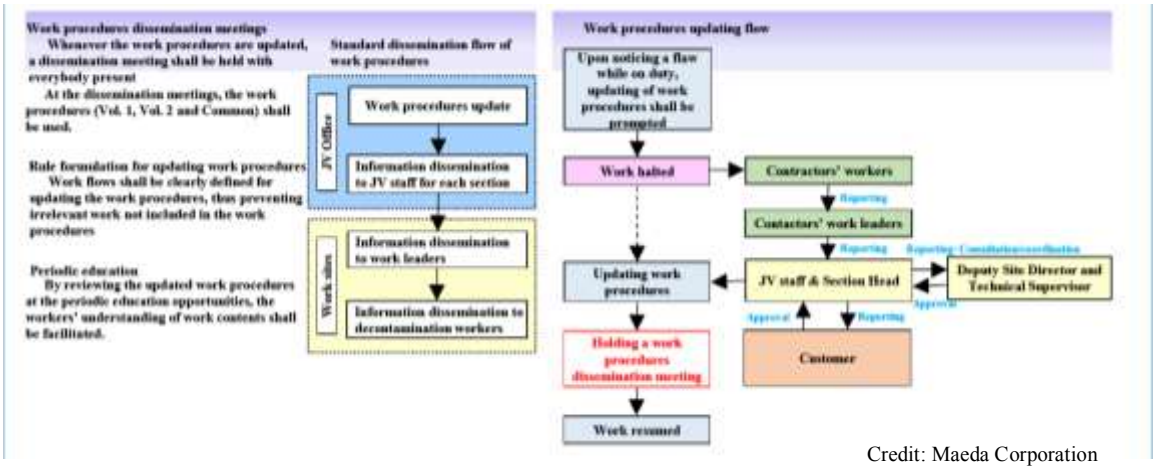
Fig. 4-48 Example of a work coordination meeting and safety precautions

(4) Consistent Quality Control and Work Procedures

The management of work quality is crucial, because decontamination involves work to reduce radiation, which is invisible to the eye, and it is also difficult to establish target values for radiation doses after decontamination.

Therefore, with each decontamination method, in order to demonstrate the expected decontamination effects, procedures manuals were prepared indicating specific procedures for decontamination methods indicated in Decontamination Guidelines and specifications, workers were educated, and extensive efforts were made to apply the established work procedures. In addition to the decontamination techniques, the procedures manual also describes the supervisory role of decontamination contractors, methods of using materials and equipment for decontamination work, methods of confirming and ensuring work safety, and responses during extreme weather and emergencies.

These procedures and quality control methods were revised based on trial and error and knowledge in the actual decontamination work. In the case of revision of work procedures, etc., measures were taken to inform workers about the changes, such as holding meetings to fully communicate the information.



Credit: Maeda Corporation

Figure 4-49 Example of extensive notification system for work procedures

(5) Radiation Management for Workers

1) Medical examinations for ionizing radiation from decontamination, etc., and testing of internal exposure doses

Workers regularly undergo medical examinations for ionizing radiation from decontamination, including when they are hired or leaving employment, and are measured using whole body counters for radiation doses by internal exposure.

To secure the decontamination contractors ensure that workers receive dosimetry for internal exposure, MOE on behalf of the national government established one whole body counter clinic at one location in Naraha Town (later moved to Tomioka Town) and one in Minamisoma City, and persons engaged in decontamination work were able to use them free of charge.

2) Measures at work

From the viewpoint of radiation protection, decontamination contractors conducted various efforts to reduce the exposure doses received by workers. For example, rest stations were set up near the decontamination work sites, and there was a thorough effort to ensure that when the workers would eat and drink, etc., they would be doing so at rest stations, not outdoors at the decontamination sites. Where it was difficult to set up or use a resting place, a thorough effort was made to ensure workers would consume food and drink inside a vehicle.

3) Exposure management of workers

Decontamination contractors had their workers wear personal dosimeters to measure the external exposure dose before starting and after finishing work every day, and managed the external exposure doses.

In decontamination work, based on the Ordinance on Prevention of Ionizing Radiation Hazards, it was also mandatory to conduct surface contamination inspections (screening) so workers would not bring out radioactive materials pollution sources from the workplaces.

At the actual decontamination sites, it was a challenge to screen a large number of workers, and to have the screening of workers concentrated at a specific time of the day (at lunch, end of work, etc.). Therefore, some decontamination contractors achieved efficiency improvements and labor saving by automating the screenings during breaks, lunch and upon exiting from decontamination work.

Credit: Kajima Corporation

Figure 4-50 Example of mechanization and automation of screening

4) Unified management of exposure dose

Although the exposure dose of workers was managed by each decontamination contractor based on the Ordinance on Prevention of Ionizing Radiation Hazards, since workers often moved between the contractors, there was a need to centrally manage the data on exposure doses recorded by each contractor. For this reason, in November 2013, it was decided to establish the System of Registration and Management of Radiation Exposure Doses for Decontamination and Related Work and to centrally manage the exposure dose information of decontamination workers through the Radiation Workers Registration Center of the Radiation Effects Association.

Each decontamination contractor regularly submits the exposure dose of the workers to the Registration Center, and the exposure doses of the worker are centrally tracked based on central registration numbers in their individual dose record book.

According to the records of the Registration Center, the number of workers engaged in decontamination and other operations was 76,951 over the five years from 2012 to 2016, and the exposure associated with decontamination work averaged 1.0 mSv. Even among the workers with the highest radiation doses, the dose was less than 20 mSv over the period of five years.

Table 4-11 Exposure doses of workers engaged in decontamination work over five years (2012-2016)

Dose (mSv)	Workers (%)
1 or less	51,354 (66.7)
More than 1 and less than 5	23,998 (31.2)
More than 5 and less than 10	1,465 (1.9)
More than 10 and less than 15	123 (0.2)
More than 15 and less than 20	11 (0.0)
More than 20 and less than 25	0 (0.0)
More than 25 and less than 30	0 (0.0)
More than 30 and less than 40	0 (0.0)
More than 40 and less than 50	0 (0.0)
More than 50 and less than 60	0 (0.0)
More than 60 and less than 70	0 (0.0)
More than 70 and less than 80	0 (0.0)
More than 80 and less than 90	0 (0.0)
More than 90 and less than 100	0 (0.0)
More than 100	0 (0.0)
Total no. of workers (%)	76,951（100.0）
Average dose (mSv)	1.0

Source: “Dose Statistical Data Based on the Information Registered with the System of Registration and Management of Radiation Exposure Doses for Decontamination and Related Work ” (Registration Center of the Radiation Effects Association, 2016), compiled by MOE.

Note: This is the dose distribution for workers engaged in decontamination operations over the five years from January 1, 2012 to December 31, 2016. The dose for 2011 is added to the dose for 2012.

(6) Management of Worker Health

High temperatures and sun exposure in the summer are factors creating a harsh working environment and greatly affect the health of decontamination workers. To cope with such a situation, in workplaces with a large number of workers, in addition to cautionary warnings, various measures were taken to prevent and deal with heat stroke in consideration of weather conditions, including wearing protective clothing fitted with ice packs, and avoiding work during the hottest hours.

(7) Treatment of Domestic Waste

In the Areas under Evacuation Orders, water supply and sewerage systems, and waste disposal facilities, etc., had stopped functioning due to damage and evacuation caused by the earthquake disaster, so processing was performed by neighboring processing facilities and in some cases their buffer capacity was lost. Thus, processing was initially left to the responsibility of the decontamination contractors, but eventually the national government exchanged information with processing facilities in other municipalities, etc., confirmed the decontamination work plans and the extra processing capacity in the area, and took measures to avoid negative impacts.

(8) Countermeasures for Wildlife

Damage was caused by wild boars in many areas from where local residents had evacuated, due to the lack of a human presence as their natural enemy, and due to the corresponding increase in breeding. Damage was frequently caused by wild boars digging for worms as food, after cloth sandbags had been placed to prevent runoff after excavation for decontamination, and the only option was extermination. In addition, any cattle and other livestock discovered were promptly reported to the municipal offices and actions requested.

4.5.3. Education for Decontamination Workers (Special Decontamination Areas)

(1) Education for Worker Entering a Site for the First Time

When workers enter a decontamination site for the first time, they received a training covering the outline of work, safety policies at the workplace, basic safety and health rules, safety and health events, workplace safety rules, and considerations for residents.

In addition, safety and work education included workplace policies showing workplace safety priority items and concrete implementation guidelines, and past case examples and patrolling results were compiled and classified according to case examples in “Essential Workplace Safety Rules.”

Employees are informed of work procedures by a publicity brief based on work procedures manuals for individual work, local education for improving the understanding of workers, and decontamination optimization education.

Regarding decontamination special education, which is legally mandated and separate from the training provided when workers first enter a worksite, training is implemented based on the “Textbook for Special Education on Decontamination Operations” (Japan Industrial Safety and Health Association). Traditionally, this education would be offered by a worker’s direct employer, but in this case the primary contractors

themselves are providing the trainings to all workers, rather than treating it as the responsibility of the subcontractors.

Credit: Kajima Corporation

Figure 4-51 Example of education and training flow for decontamination workers

Table 4-12 Example program of safety education for newly employed workers.

	Program	Key contents
1	Confirmation of employment agreement	Confirmation of the company to belong to, minimum wages, special duty allowance, medical checks
2	Work outline	Explanation of an outline of jobs to do
3	Safety policies at the working place	Explanation of safety policies at the working place Prevention of falling down Prevention of minor collision between men and heavy machinery Prevention of minor collision between men and mowers Radiation and health care, other related topics
4	Basic rules of safety and sanitation	Explanation of basic rules of safety and sanitation Consideration to give to local residents Dose measurements and contamination inspections Safety equipment Practice to carry Identification Card and armband Information on work plans and work procedures Smoking, eating and drinking Responses to take when injured Traffic rules
5	Activities relevant to safety and sanitation	Explanation of activities relevant to safety and sanitation
6	Tidiness and order	Explanation of the rules to keep working places tidy and in order
7	Risk potential prediction "KY"	Explanation of the process to predict risk potential for sharing KY: an acronym of "Risk potential prediction" in Japanese
8	Harmonization with the community	Explanation of consideration to give to local residents
9	Safety rules on duty	Explanation of "22 musts in safety rules" which assembled the cases experienced and the results found during patrol for each of selected cases
10	Instruction to receive WBC checks	Description of WBC reception and cautionary points

Credits: Maeda Corporation

(2) Ongoing Education and Training

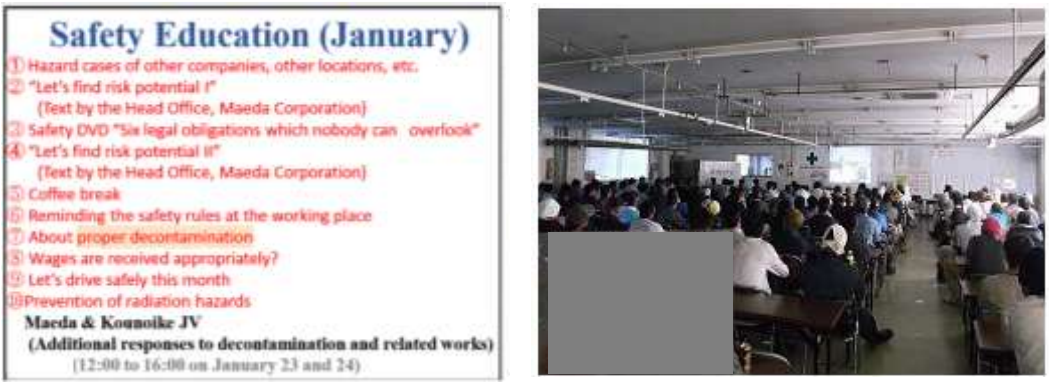
In addition to the training provided to workers upon first entering a site, regular education was also provided, including regular weekly and monthly education, periodic events such as work procedure trainings, and one-off trainings to inform workers about major problems, etc. In order to educate many workers, in some cases training sessions with over 100 workers were held daily.

The various seminars did not rely on one-way teaching, but rather, an effort was made to keep them relevant and dynamic, with discussions and sharing of personal experience, introduction of positive examples, the use of visual and easy-to-understand teaching materials with diagrams and video, and guided inspections by model group leaders, etc.

Adjustments were made to provide different levels of learning content, for example, by offering different material for workers, managers (group leaders) and primary contractor officials. Inexperienced new workers wear a novice sticker on the helmet so they can be identified, and an effort is always made to have novices assigned to working groups to be together with experienced workers.

In addition, special education was provided on-site for local construction company officials and workers, etc., and support was also provided to obtain certifications.

Regarding consideration of local communities and regulatory compliance, in addition to education on promises that had been made to local communities, workers received education on behavior outside of work, from daily life attitudes to prevention of drunk driving.



Credits: Maeda Corporation

Figure 4-52 Example of regular safety education

Credit: Shimizu Corporation

Figure 4-53 Examples of education using videos and images

Credit: Maeda Corporation

Figure 4-54 Examples of safety activities

Figure 4-55 Example of on-site training

Credit: Maeda Corporation

Figure 4-56 Example of making things clearly visible for new workers

法令遵守(コンプライアンス)教育(1)

平成 25 年度 飯舘村除染等工事(その 2)
大成・熊谷・東急・りんかい日産・村本 特定建設工事共同企業体

1 「法令遵守」とは

近年、法令に違反したり、社会的規範や企業倫理(モラル)に反したりすることで、社会的な信用を失墜し、企業における事業の推進が困難となったり、事業の存続に大きな影響を与える事例が見られます。

ある乳業メーカーが、本来廃棄すべき乳材料を製品に再利用し、その結果、食中毒を発生させてしまい、社会的信用を失って、廃業に追い込まれる事案がありました。

企業が社会的な責任を果たし、健全に事業を推進する上で、**法令遵守**(ほうれいじゅんしゅ、英語では「**コンプライアンス**」と呼びます)や社会的規範や企業倫理を守ることは大変重要です。

2 「万引き」は犯罪で法令遵守違反!

スーパーなどで代金を支払わずに、商品を持ち去る行為「**万引き**」は犯罪であり、明らかな法令遵守違反行為です。

「万引き」して警備員などに見つかれば、当然、**警察に逮捕**され、拘留されることも珍しくありません。

除染のお宅の物を勝手に持ち出すことも「**窃盗**」に値します。窃盗も犯罪であり、明確な法令遵守違反です。

万引きや窃盗行為を起こした場合、その作業員やJV職員は作業所から**退場処分**になります。

3 「酒場などでの暴力行為」は絶対ダメ!

「**暴力行為**」はあってはならない犯罪であり、明らかな法令遵守違反です。

暴力行為があった場合、その作業員やJV職員は作業所から**退場処分**になります。

4 「痴漢行為や性犯罪」は絶対ダメ!

痴漢行為や**性犯罪**は明らかな法令遵守違反です。痴漢行為などがあった場合、その作業員やJV職員は作業所から**退場処分**になります。

5 「酒気帯び・飲酒運転」は絶対ダメ!

酒気帯び運転や**飲酒運転**は犯罪です。酒気帯び運転などで交通事故を起こし、死傷者を出せば、「危険運転致死傷害罪」に問われ、厳しい罰則を受けることになります。酒気帯び運転を知りながら、助手席に乗っていても、「酒気帯び運転ほう助」として共犯扱いとなります。

タクシーや代行運転を利用し、**酒気帯び運転**や**飲酒運転**は絶対にしないようお願いします。

酒気帯び・飲酒運転をした場合、その作業員やJV職員は作業所から**退場処分**になります。

6 「寝たばこ等による火事」も絶対ダメ!

火事は社会的な影響が極めて大きく、人命にも関わる重大事件です。火事を起こすことは、絶対に許されません。

宿舎や自宅での「**寝たばこ**」や「**灰皿の火の不始末**」はあってはならない事です。

除染作業での火気使用上のルールも徹底して守っていただき、絶対に火事を起こさないようお願いします。

刈払機ガソリン給油時における近くでのタバコなどの火気厳禁、冬季におけるストーブの消火確認の徹底、遮水シートの溶着作業上の火災防止ルールの厳守もお願いします。

Credit: Taisei Corporation

Figure 4-57 Example of education for regulatory compliance

(3) Worker Morale and Awareness

Since decontamination differs from work such as civil engineering and construction to build structures and the results are harder to see, the feeling of accomplishment can be low and work can feel monotonous, with negative impacts on worker morale and alertness, resulting in a decline in the quality of decontamination work.

In order to improve and maintain the motivation of workers, guides like the "Eight Rules of Decontamination" and "Ten Commandments of Decontamination" were devised as codes of conduct for decontamination worker. Efforts were made to raise awareness and have workers internalize them by reciting them together in daily morning briefings and the larger safety gatherings, etc.

Also, at seminars and other opportunities, efforts were made to raise worker awareness and improve the quality of decontamination by repeatedly mentioning that the purpose of decontamination is to reduce the radiation dose and prepare an environment for disaster victims to return home. In addition, activities to heighten the motivation of workers were also developed by awarding excellent workers and employees.

Credit: Shimizu Corporation

Figure 4-58 Example of large group at daily morning gathering reciting mottos for decontamination

Figure 4-59 Example of code of conduct for decontamination workers

Credit: Maeda Construction Co., Ltd.

Column	"Work management systems and safety management" Mr. Takashi Mizutani, Hazama Ando Corporation

In decontamination work in Namie Town, 26 administrative districts were decontaminated, and an enormous number of workers, up to 4,000 per day, were engaged in the work. The decontamination ranged from areas with relatively low air doses such as Preparation Areas for Lifting of Evacuation Orders, to broad areas such as Areas where Returning is Difficult along National Road No. 114. It was necessary to do daily counts, checks and controls of the daily cumulative exposure data for all workers. Actually, from the result, some work exceeded the voluntary control values, so we imposed limits on the working hours.

We used a "Decontamination Integrated Management System" for this management. It is a cloud-based database system that can handle an enormous amount that would be impossible manually, and it centrally manages data that can be shared among users, including worker exposure data, monitoring results before and after decontamination for each landowner, information on flexible containers at Temporary Storage Sites, and more.

Utilizing this system, we conducted a wide range of tasks, including work progress and process control, the creation of decontamination reports, and safety documentation management, etc., to perform safe and reliable daily decontamination work.

For safety management, we assigned personnel in charge of safety in each administrative district. In cooperation with JV officials and the heads of cooperating companies, the safety personnel work perform daily patrols to ensure that qualified personnel are assigned according to work plans, that work procedures are being followed as planned, that there are no unsafe facilities, and that no unsafe activities are happening. In addition, one full-time spotter was assigned to every machine for work with heavy machinery. Originally there was some confusion, but everyone is now trained so everyone understands that the spotter's duties are indispensable for preventing heavy equipment accidents, and it is now a habit not to work in the absence of a spotter. In addition, we set up six separate locations for morning assemblies of workers, where we gave appropriate safety instructions according to the situation in the district of responsibility, and we also handled worker health management in a way that we could actually see the individual workers.

We conducted safety education every month to raise the safety awareness of personnel and workers and boost safety activities. As presenters, we actively invited outside speakers from various organizations in an effort to avoid taking safety for granted and to provide the latest information. Speakers came from the Japan Construction Occupational Safety and Health Association, Futaba and Minamisoma Police Stations, Namie Fire Department, Tomioka Labor Standards Office, the National Health Insurance Society, JAF, and our own headquarters and branch offices, etc. For site managers and key personnel of cooperating companies, as a part of our monthly CSR education, we also explained accidents and labor troubles that had occurred in other work, as we aimed to work together with JV and cooperating companies to prevent various problems.

Regarding traffic measures, before evacuation orders were lifted, all workers were commuting from out of town. Moreover, most of the personnel and workers were commuting from afar, and the only roads available for commuting were National Roads No. 6 and No. 114. For this reason, from the viewpoint of prevention of traffic accidents and traffic congestion, we set up six decentralized locations for the morning assembly of workers and monitoring facilities, and this helped to prevent the concentration of vehicles on the road.

Column	Improving radiation dose management systems” Mr. Takeshi Nishikawa, Kajima Corporation

In decontamination work, the first step in organizational management is to manage the worksite entry and exit of more than 2,000 workers (data about when, who, where, until when, exposure doses, screening implementation).

In the initial emergency decontamination work, we used barcode cards for individual workers, but for the full-scale decontamination work in Tomioka Town three years after the earthquake, we developed and operated an individual identification system using fingerprint authentication. By doing this we can prevent entry by false substitutes and prevent inflated hour claims, while having reliable entry and exit control. In addition, since it is an endless (open ended) database, we can conduct instant searches and data compilations of the whole database or by company or individual, and this connects to reliable radiation management.

Column	“Conscientious decontamination work” Mr. Yoshio Shimizu, Taisei Corporation

Challenges faced in decontamination work

1. The area of work is extremely large and created challenges for management operations (about 230 square kilometers)
2. Maximum number of workers is on a scales we had never before experienced (about 6,000 workers/day)
3. Many workers had no previous experience in construction industry (civil engineering, construction, etc.)

(About 4,800 (80%) of approx. 6,000 workers are inexperienced.)

November 2017 marks the start of our sixth year engaged in decontamination work.

In this work, we have been engaged in decontamination of a vast area that includes residential areas, forests, farmland, and roads (approx. 230 square kilometers, greater than the area inside the circular Yamanote rail line in Tokyo). Decontamination work is something no one had experienced before, so all the company personnel and the workers engaged in this work were inexperienced. Above all, the most important thing for us as a primary contractor was to raise the awareness of everyone involved, by having company personnel acquire solid knowledge and then be able to explain to workers that knowledge in detail, of course, but also the purpose, the importance of the work, and the work methods, etc.

About 6,000 workers are engaged in the decontamination work per day at peak times in Iitate Village. One of our responses to these challenges was to compile "workplace rules" onto one paper to be learned by workers when they first enter a worksite (attention to safety management, local conditions to be noted, etc.) and also video training (decontaminate methods), and these materials are being used by the group leaders in charge of each area to raise awareness of all workers.

Morning Briefing

Going forward, we will continue to conduct the day-to-day decontamination work safely with careful attention (slowly and carefully) by conducting on-site to ensure the contents of the education are being carried out.

Column	"Restoring Katsurao Village to pre-disaster conditions" Mr. Hirotoshi Inoue, Okumura Corporation

The decontamination work was started on a scale that never before experienced. In order to tackle this huge national project with courage and pride, with the decontamination work in Katsurao Village as well, we used a variety of expertise and performed the operations while making innovations and improvements.

① Establishment of work management systems

The area to be decontaminated was huge at 1,500 ha, and this was an enormous project with 3,000 workers per day during the peak period, so we set up a supervising organization for the entire project, and with that at the top, we divided the village into three work zones. All instructions, orders and essential information were transmitted top-down from this supervising organization to each work zone and to each work team within each work zone, all at the same time. Also, extensive reporting went from each work zone to the supervising organization, the information from the reports was fed back to all work zones, and this strengthened the vertical and horizontal organizational collaboration.

② Safety management, labor management

For some of the workers this was the first experience in civil engineering work, and because their awareness about safety and labor varied widely, we created a unified manual for all work and distributed it to all the work zones. The manual included topics like a "Site Entry Manual" covering procedures from new worksite entry to actual work, documents to submit, key points to note, a "Safety Bible (Katsurao Rules)" with details from planning to execution of each type of work, and so on. We also launched a team focused on safety within the supervising organization, strengthened cooperation with a work team for each work zone, and actively carried out safety activities. In particular, we made "calling out" the basis of safety, with a campaign to encourage workers to communicate vocally with each on the job, loud and clear.

③ Quality control

In order to ensure the quality of decontamination (dose reduction, etc.) and to eliminate variability among workers, we created a manual detailing the procedure and method of work and measurement, and distributed it in all the work zones. In addition, we implemented quality patrols by the work teams located within the supervising organization to maintain and improve quality.

④ Gaining the trust of residents

It was a major precondition that we had to have the understanding and trust of residents and surrounding local governments that had been forced to evacuate. We made sure everyone involved in the work was aware that they were responsible for a major national effort, and strove to maintain compliance, discipline, and appropriate behavior not only during work but also in daily life. We gave special attention to traffic accident prevention, such as awareness-raising for traffic safety compliance when commuting, and traffic safety campaigns linked with the efforts of police and surrounding local governments. In addition to sharing information through discussion meetings (with the village and village council) on the progress of decontamination and on requests from the village, for the residents of the neighborhoods, we also had a public relations team that included a local leader who joined us as a staff member. As a result of the establishment of the "Katsurao Reconstruction Project Cooperative Association," in which we cooperated, we helped promote local village businesses' involvement in the decontamination work, we were able to secure a valuable workforce from the village and neighboring municipalities and to gain their understanding and cooperation for decontamination.
Four and a half years have passed since we got involved, and though has been gradual, villagers are beginning to return and the center of the village is coming back to life. I sincerely hope that Katsurao Village will regain the natural and human vibrancy it had before the earthquake disaster.

Column	"Work management systems and safety management" Mr. Hideyuki Matsutani, Obayashi Corporation

I served as the site representative and supervising engineer in operations including the Kawauchi Village Decontamination Project, Tomioka Town Decontamination Project, Kawauchi Village Decontamination Soil Removal Preparation Project, Futaba Town Interim Soil Storage Site Construction Project, and the Interim Soil Storage Facility (Okuma Work Zone 3) Construction Project.

The following can be cited as challenges we faced.

1. Managing work over an extensive area (382 ha) and with a large number of workers (maximum 1,300 people)
2. Educating workers to acquire knowledge on decontamination methods and radiation
3. Maintaining workers' motivation to do the decontamination work

Particularly, for the work management system and safety management in Tomioka Town, we created a system to divide the extensive work area into three zones based on the local administrative districts and managed each as a separate decontamination site. In order to manage a large number of workers, we made the decision to create small work groups with just 10 to 15 workers each, and created a command system with one task leader at the top of each group. Also, since there were many inexperienced workers in the big work force, we put novice stickers on helmets to help them be identified, and paired them with veteran workers.

We held small seminars every week to provide knowledge on decontamination methods and radiation and to improve safety levels, and made sure that senior management from primary contractors also attended.

Task leaders and workers with exceptional performance received awards of excellence at safety assemblies which helped us maintain and improve the motivation for decontamination and safety work.

Column	"Work management systems and safety management" Mr. Masahiko Kashima, Shimizu Corporation

Many types of the work in decontamination depend on human power, which means that a significant number of workers are needed. Many were forced to evacuate due to the nuclear plant accident and were unable to return to the jobs they had before the disaster. So an effort was made to encourage the hiring of local people for the decontamination work, and I was keenly aware of the difficulties of managing such a large number of workers who had never before been involved in construction work.

What happens if the backhoe bucket comes into direct contact with a person? What if a person gets caught under the carrier of the transport machine ? We held safety seminars with the participation of all workers, using actual construction equipment and mannequins to show occupational accidents that people would not usually have the occasion to see for real. The shocking scenes and dramatic sounds are beyond what people can imagine. The reactions were big, with people making various comments, like "We cannot accept any injuries from heavy equipment. It's like murder!" "We need to be always alert and be risk-aware ." "Now I realize how unaware I used to be." With these activities we have had big results in improving overall awareness about work risks and work safety.

We will continue with our efforts to improve the work environment and safety management for workers, and from these experiences we will strive for safety management that can trigger awareness within the workers themselves.

Column	"Work management systems and safety management" Mr. Kenichiro Osawa, Maeda Corporation

One major characteristic of decontamination work is that a huge number of workers will work on a whole town and the work will be continuous on a yearly basis.

The decontamination work itself was unprecedented for us in the construction industry. We had to manage it on a scale and sense of magnitude never yet experienced, and that was a major challenge.

On the other hand, from the owners' perspective the houses and fields requiring decontaminating were "irreplaceable" and "one of a kind." In other words, we had to manage a huge number of cases, but at the same time, handle each one very carefully.

In order to address these challenges, Maeda Corporation utilized a "pyramid-type management system" and promoted "quality assurance by emulating good work methods."

This "pyramid-type management system" is a way to make clear the policies and the command and control system, give each section its responsibilities and manage them. If we tried to give instructions to every single worker on the frontlines, the time available for communication with each worker would be relatively small, and as a result, detailed instructions might not reach everyone. For that reason, we created a system in which staff direct the task leaders and the task leaders direct the workers, and each staff gave detailed instructions to the task leaders. As a result, detailed instructions reached all the workers, and I think that this helped to eliminate loss and waste in the decontamination work, increase productivity, and ensure a solid process.

With respect to promoting "quality assurance by copying good work methods," we recorded videos of exemplary work and by using the videos to promote those procedures all across the organization, we could get our workers to accept them very quickly, and could ensure consistent quality in decontamination work. I think that there were also side benefits, because once the workers properly understood the basics, they would come out with suggestions on how to further improve our methods. By thoroughly instructing workers to emulate model work, we were able to encourage workers to be quality conscious, and to eliminate each work group's inconsistencies in decontamination quality, and I think that we succeeded in providing consistent quality of decontamination work for the land owners.

Finally, about safety management, the key thing here was having thorough education for the task leaders. What I felt from doing all of this is that a work team that has excellent safety management will also be excellent in terms of work output and quality, and it will be a model of good performance for all aspects of work. For safety management, we used a booklet entitled "Workplace Rules" to educate workers. Because it was not only experienced construction industry workers doing this decontamination work, if we imposed rules that were too difficult, they would not be followed. I am confident that the reason we were able to complete the work safely was because we created the "Workplace rules" based on easy-to-understand safety points that we developed in the course of doing the work, were able to have the workers be aware of them directly in the workplace, and could make safe work habits reach each and every worker.

4.5.4. Initiatives relating to Cooperation with Local Communities (Special Decontamination Areas)

(1) Exchanging Ideas with Local Governments

Information exchange meetings were held generally on a monthly basis among three parties (local governments, MOE, and decontamination contractors) to create a forum for discussing the current situation and future plans, plus items to note and confirm, etc., and the opportunities for communication were beneficial for the progress of the decontamination work. Although 100% of municipal requests and so on could not be taken up at the meetings, they were an opportunity to understand the needs of the local governments and for the contractors to outline their concerns, and it is believed that they helped strengthen the relationships with local governments.

(2) Provision of Information on Decontamination Sites

1) Field visits

Initially at the beginning of the decontamination work, even with explanations of the details of decontamination work and the safety of Temporary Storage Sites, etc., residents did not have the experience of seeing the actual work or conditions, and so they ended up with concerns about safety and a general sense of anxiety. For this reason, on-site tours were conducted to show the decontamination work and Temporary Storage Sites.

It seems that the general sense of anxiety could be removed by holding organized tours of the decontamination work for town councilors, administrative district heads, and residents of the target administrative districts, as well as allowing voluntary tours, to let people visually observe the details of decontamination and its results. Regarding the Temporary Storage Sites, it seems that the sense of resistance to their placement decreased because people could see that actual measurements of the air dose rate near the sites were lower than before the Temporary Storage Sites were built. In addition, being able to use a gamma camera or other equipment to visualize and explain the doses before and after decontamination work on houses helped people understand the effects of decontamination which promoted a better understanding of the work.

2) Provision of information on decontamination implementation status, etc.

Each decontamination contractor explained the content of the decontamination work and the status of progress, etc., in an easy-to-understand manner by means of illustrations and photographs by their websites and publications, etc., and worked to raise the understanding of decontamination work.

Credit: Maeda Corporation

Figure 4-60 Information sharing with web-pages and hand-outs

3) **Establishment of information provision facilities**

Facilities such as “Decontamination Counseling Rooms” and a “Hotto Station” in Tomioka Town were opened in order to increase understanding about decontamination work by providing information on the present status of decontamination and dialogue with landowners and residents.

Besides providing decontamination information, they also provided space for residents to rest when they temporarily returned home to observe decontamination work. Also, local residents worked here as advisors, so the venues were a space for residents to interact. Also, the spaces were used for exhibitions of photographic works.

(3) Good Community Relations

1) Improving the behavior of workers

There were instances of staff from decontamination contractors taking turns once a week to stand at major intersections or in front of convenience stores to monitor workers’ in-store and road manners. For example, they would politely remind workers not to dispose of gloves and masks used for decontamination work in the store trash bins, or not to enter stores wearing muddy boots, or to avoid speaking loudly inside the store.

Workers were also encouraged to have good manners in the community, being polite and greeting local residents.

2) Measures to prevent traffic congestion

In Special Decontamination Areas, there are few lodgings near the work sites, so many workers commuted from the surrounding region. Also, due to the earthquake disaster and evacuation orders, traffic congestion sometimes occurred due to the limited choices in passable roads. For this reason, efforts were made by arranging for commuting buses, offsetting the morning assembly times and locations, and making starting times and working hours earlier, etc.

Also, since the main roads for work commuting were the same roads used to bring children to elementary schools during rush hours, various actions were taken to avoid accidents involving children, such as

dispatching traffic guides, and in some cases having decontamination contractor staff monitoring roads for excessive speed of commuting vehicles during the hours children go to or return from school, etc.

Credit: Taisei Corporation
Outreach activities at convenience stores

Credit: Taisei Corporation
Traffic guides and reminders

Figure 4-61 Examples of activities for good community relations

4.5.5. Accidents and Problems

(1) Accident Statistics

There were 1,786 cases of accidents over five years of decontamination work in Special Decontamination Areas, and the highest year was 2015 (727 cases). Three fatal accidents occurred. In the fall of 2016, a series of heavy machinery accidents occurred, including fatalities, so on November 4, 2016, the Fukushima Office for Environmental Restoration issued a warning to the contractor s, and on November 21 urgently summoned representatives of the contractors and ordered more thorough safety measures and on-site management. On November 30, the Japan Construction Federation (Special Committee for Electric Power Countermeasures) also made similar requests. After that, the contractors carried out urgent patrols.

Also, there were many cases of insect bites and heat stroke.

Table 4-13 Types of incidents (Special Decontamination Areas) As of March, 2017

Year	Crash, fall	Fall, trip	Pinned, caught	Flying object	Structure collapse	Traffic	Animal bite	Cut, scrape	Insect bite	Heat stroke	property loss	Fire	Other	Total
2012	1	12	2(1)	0	0	9	0	5	7	3	0	0	3	42(1)
2013	8	29	12(1)	3	1	34	1	22	38	29	6	0	16	199(1)
2014	6	66	24	12	0	83	0	36	42	44	80	1	30	424
2015	7	54	33	14	1	95	4	52	151	179	63	3	71	727
2016	2	24	19(1)	12	2	112	7	20	77	54	34	1	30	394(1)
Total	24	185	90(3)	41	4	333	12	135	315	309	183	5	150	1,786 (3)

( ) are fatal accidents.

(2) Improper Decontamination and Efforts to Improve

1) Response to improper decontamination

On January 4, 2013, media reported that there had been substandard decontamination work at some sites, so MOE established the "Headquarters for Promoting Proper Decontamination ," and conducted a survey of the cases cited. It concluded that many cases could not be determined to be improper decontamination, but in order to eliminate doubts about decontamination work, on January 18, 2013, MOE announced a Program for Proper Decontamination with three components to "strengthen the structures of MOE": "thorough enforcement of contractor responsibilities," "creation of a wide range of management mechanisms" including effective independent monitoring, and the establishment of a 110 hotline (call center) to report improper decontamination, etc., in an effort to eradicate improper decontamination and restore the confidence of residents.

Thereafter, the expert Committee to Promote Proper Decontamination met on March 18, 2013, and confirmed four cases of improper decontamination so far in Special Decontamination Areas and two cases in Intensive Contamination Survey Areas, for a total of six cases reported, and response actions were taken.

Table 4-14 Implementation status of Committee to Promote Proper Decontamination

Meeting No.	Date	Venue	Main agenda items
1	3/18/2013	Koku Kaikan, Room B101	1. Establishment of Committee to Promote Proper Decontamination 2. Efforts to promote proper decontamination so far 3. Other
2	7/8/1013	Koku Kaikan, Room 201	1. Establishment of Committee to Promote Proper Decontamination 2. Efforts to promote proper decontamination so far 3. Other
3	11/18/2013	MOE Meeting Room 1	1. Recent decontamination trends 2. Efforts to promote proper decontamination so far 3. Other
4	4/22/2015	Central Gov't Bldg. No. 4 Building, 12F, Special Meeting Room 1214	1. Status of progress of decontamination 2. Status of Implementation of Program for Proper Decontamination 3. Recent cases and efforts 4. Other
5	5/24/2016	Koku Kaikan, Room 123	1. Status of implementation of Program for Proper Decontamination 2. Efforts to improve the reliability of decontamination work and plans for this fiscal year 3. Other
6	6/28/2017	Koku Kaikan, Room 201	1. Status of progress of decontamination 2. Status of implementation of Program for Proper Decontamination 3. Recent cases and efforts 4. Improving trust in decontamination · Status of implementation of community contribution action plan

<Members of Committee for Proper Decontamination> (Titles omitted)

Name	Affiliation
Masaaki Hosomi	Professor, Graduate School, Tokyo University of Agriculture and Technology
Masashi Kamon	President, National Institute of Technology, Kagawa College, Professor Emeritus, Kyoto University
Hiroshi Suzuki	Professor Emeritus, Fukushima University
Yukimi Sekiguchi	Certified Public Accountant, Tax Accountant
Tetsuya Hasegawa	Manager, Social Affairs and Environment Department, Fukushima Prefecture (1st - 4th meetings)
Junichi Ogata	Manager, Social Affairs and Environment Department, Fukushima Prefecture (5th meeting onward)

Table 4-15 Case list of improper decontamination (Special Decontamination Areas)

When discovered	Summary	Response by MOE, etc.	Measures to prevent recurrence
Dec 2012	Water from high pressure washing scattered during decontamination of a veranda of a private house in Shimokobana work area of Naraha Town	· Vice Minister of the Environment, Parliamentary Secretary of the Environment, Director of the Fukushima Office for Environmental Restoration and supervisory personnel confirm the site · Instructed workers to prioritize decontamination and investigate locations where water scattered, routes of wastewater flows, and presence of well contamination	· Confirmed no difference in radiation dose before and after drainage flow, confirming that radioactive substances containing cesium are below the detection limit in well water
Dec 2012	Water from high pressure wash flowed into roadside gutter during decontamination in parking lot in front of the Nimaibashi post office, Iitate Village	· Received newspaper coverage and checked the situation with the contractor (joint venture) · Instruct decontamination of affected locations	· Decontamination of public roadside gutters from which pressure wash water spread out was done according to specifications
Feb 2015	Decontamination waste was illegally buried in forest in Minamisoma City	· Contractor was instructed to take action to prevent recurrence · Strengthened oversight system by increasing number of supervisors	· Further education to improve handling of waste · Ensure that primary contractor supervisor checks before work is done, gives instructions, and confirms work in progress on site · Strengthening patrols to prevent improper decontamination

Mar 2015	Soil, etc., generated by decontamination of Minamisoma City and general waste mixed into flexible container	· Inspection of contents of large soil · Instruct the contractor to thoroughly separate the contents	· Thorough separation of contents of large soils

Table 4-16 Case list of improper decontamination (Intensive Contamination Survey Areas)

When discovered	Summary	Response by MOE, etc.	Measures to prevent recurrence
May 2014	Removed soil from decontamination work at one private home illegally buried on property near another private home in Tamura City	○ MOE · In the name of Director's office for decontamination, guidance documents were issued to relevant local governments to ensure "thorough management of removed soil from decontamination and other measures" · In the name of the director of the Fukushima Office for Environmental Restoration documents were sent to the mayor of Tamura City instructing the city "thoroughly manage removed soil from measures such as decontamination," and to report how it happened this time and specific recurrence prevention measures, etc.	· Instructed to collect buried container bags · In the name of the mayor, issued guidance documents to primary contractor to take measures to prevent recurrence, implemented patrols by city staff etc., and strengthened guidance on inspections, etc. · Notified of suspension (3 months)
Dec 2015	Illegal dumping of removed soil from Koriyama City found on streets of Iwaki City	○ MOE · Requested report of improved management and recurrence prevention measures in Koriyama City · Written request made to each municipality to improve proper management of removed soil etc.	○ Koriyama City · Sent written instruction to each decontamination contractor to prevent improper decontamination work · Implemented training on proper handling of removed soil, etc., for each primary contractor

2) Regulatory compliance and proper decontamination

Other than “improper decontamination,” “incidents of legal compliance at with regard to project implementation,” and “cases that seemed to be inadequate regarding securing local sense of safety and building trust” were reported to the Committee to Promote Proper Decontamination and dealt with.

In March 2017, an official working at the Fukushima Office for Environmental Restoration was arrested (and later prosecuted) on bribery charges for the illegal act of accepting bribes, after it was discovered that the official had received funds for accommodation expenses totaling an equivalent of hundreds of thousands of yen in 2015 and 2016 from a specific business that expected to be recommended as a subcontractor for decontamination work in Namie Town. In response, the following actions were taken: (1) giving personnel instruction, (2) strengthening of ethics training as public servants for all personnel at the Fukushima Office for Environmental Restoration, (3) thorough efforts to ensure civil servant ethics among supervisory personnel, (4) prohibition at the Fukushima Office for Environmental Restoration on actions including wining and dining with contractors, (5) launch of a “contractor direct dial” phone line to receive problem reports from hired contractors, (6) notifications to contractors, etc.

In May 2017, it was discovered that some subcontractors had overcharged in their invoicing for decontamination work ordered by Fukushima City, having falsely represented regular forest decontamination work as bamboo forest decontamination at a higher unit price. Fukushima City as the contract issuer ordered the primary contractor to return the funds that had been paid excessively, and imposed administrative sanctions.

In June, 2017, it was discovered (later prosecuted) that an employee of a primary contractor that was engaged in decontamination work for Tamura City had altered receipts for accommodation expenses, and improperly received reimbursements based on the receipts. In response, MOE (1) imposed administrative sanctions on the primary contractor, (2) investigated the decontamination work that had been ordered by MOE and found that there had been no fraud such as inflated charges due to tampering of receipts, but discovered accounting errors and announced the findings, and (3) repeated its requests that the construction industry reinforce its corporate governance and bolster efforts to ensure compliance with laws and regulations.

In addition to these cases, other instances of improprieties have occurred, such as murder by decontamination workers, the involvement of antisocial elements, and traffic accidents, etc. Such incidents diminish trust in the decontamination work, so MOE has been working to ensure that there are systems in place among work issuers and contractors for the proper execution of work.

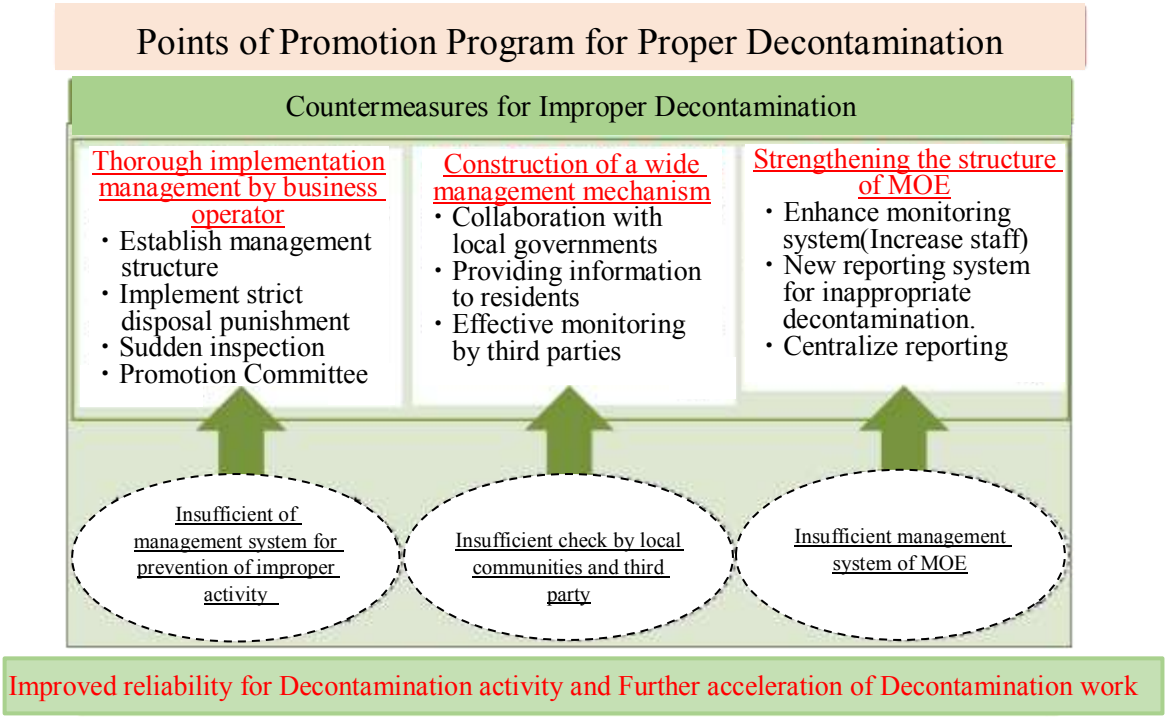
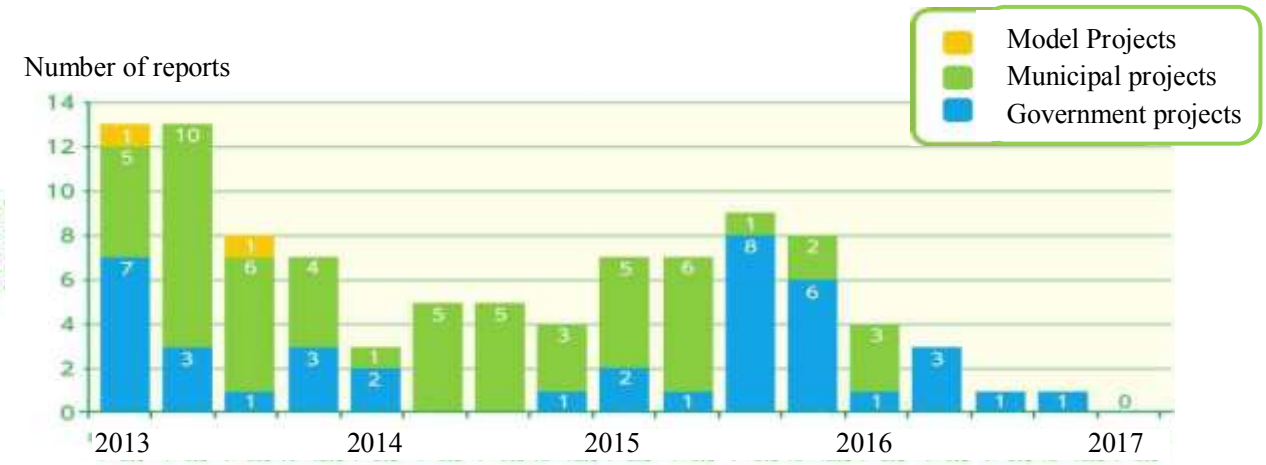


Figure 4-62 Main points of Program for Proper Decontamination



* Numbers include reports received by the 110 hotline (call center and website) for reporting of improper decontamination, as well as the Fukushima Office for Environmental Restoration and the Decontamination Information Plaza.

Figure 4-63 Number of reports on improper decontamination

Source: Documents from “Committee to Promote Proper Decontamination” (sixth meeting)

(3) Recommendations for Corrective Actions from Labor Standards Inspection Offices

Full-scale decontamination began in July 2012, and on October 4 the Koriyama Labor Standards Inspection Office issued its first recommendation for corrective actions to contractors who had implemented decontamination work in Tamura City.

The recommendations covered cases of failure to survey legally required parameters at work sites before decontamination work (average air dose rates, values of radioactive concentrations such as contaminated soil, etc., to be decontaminated), and failure to use effective respiratory protection such as dust masks.

In response to the recommendations for corrective actions, there was consultation among the Fukushima Office for Environmental Restoration, the Koriyama Labor Standards Inspection Office, and the decontamination contractors. Regarding the measurement of doses, if a survey of dose, etc., is conducted in accordance with the Ionizing Radiation Ordinance for Decontamination, time and costs are incurred, so it was deemed that the minimum dose requiring protection (2.5 μSv/h) was exceeded, so the use of the minimum protective equipment (surgical mask) was required. Regarding protective equipment, in the case of working in dust under high doses, high-performance protective equipment (dust masks), etc., are to be used.

Regarding special work allowances, wage payments are specified in the Common Specifications for Decontamination and Other Work ordered by MOE, and primary contractors are obliged to provide payments of the full amounts to target workers, and to verify the status of payment. Also, in order to confirm the status of payment of special work allowances to workers, primary contractors are required to present to MOE ledgers of wages paid. In addition, MOE is requesting the Japan Construction Federation and the Associated General Constructors of Japan to circulate information to raise awareness that any increase in the unit price for design work is expected to increase the wages for skilled workers, in order to encourage young people to enter the decontamination business through improved treatment.

Table 4-17 Statistics for supervisory guidance from the Fukushima Labor Bureau (2013-2016)

Item \ Year		2013	2014	2015	2016
Number of companies subjected to supervision		1,047	1,152	1,299	1,020
Number of violating companies		709	774	839	586
Violation rate (%)		67.7%	67.2%	64.6%	57.5%
Number of violations, of which:		1,784	1,697	1,586	982
	Working conditions	1,210	898	691	485
	Safety and health matters	574	799	895	497

Source: Supervisory guidance results for decontamination contractors, Fukushima Labor Bureau, MHLW (Ministry of Health, Labor and Welfare)

Table 4-18 Main violation details (2013-2016)

Violations of Industrial Safety and Health Act and Ionizing Radiation Ordinance for Decontamination

The Act	Ionizing Radiation Ordinance for Decontamination	Contents	2013	2014	2015	2016
Article 22	Article 5	Dose measurement	31	97	92	44
	Article 7	Preliminary survey	64	145	122	101
	Article 9	Work captain	8	3	24	13
	Article 14	Contamination inspection of workers exiting work sites	22	18	18	4
	Article 15	Contamination inspection of items carried out of work sites	5	12	15	0
	Article 16	Use of protective gear	44	38	47	17
Article 59	Article 19	Implementation of special education	35	5	6	1
Article 66	Article 20	Implementation of special health checkup	23	26	18	4
Article 100	Article 24	Reporting on decontamination ionization health check results	—	75	87	107
Others		Prohibition of smoking etc.	—	45	41	11

Violations of Industrial Safety and Health Act and Others

The Act	Ordinance	Contents	2013	2014	2015	2016
Article 20	Article 155	Work plan for vehicles, construction equipment	—	8	11	8
	Article 158, 164 others	Work safety of vehicles, construction equipment	—	28	29	13
	Article 519, 563 other	Measures to prevent falls from high places, scaffolds	—	22	19	6
Article 31	Articles 653, 655		—	7	13	5
Article 29	-	Guidance from primary contractors to subcontractors	—	146	182	108
Article 45	Article 167, 169 2	Regular voluntary inspections of vehicles, construction equipment	—	9	12	8
Article 23	Article 540	Safety routes	—	4	4	4
Others		Duties, etc., of persons responsible for safety and health	—	111	155	43

Violations of Labor Standards Act

Labor Act	Contents		2013	2014	2015	2016
Article 15	Explanation of working conditions		201	121	102	46
Article 24	Payment of regular wages ※		133	88	56	36
	(Major categories)	Deduction from wages of fees (memberships, accommodations, food, etc.) without conclusion of labor-management agreement	68	54	33	24
		Wage non-payment for time required for special medical examination and internal radiation measurement	35	25	16	6
Article 26	Payment of leave allowance		8	31	4	1
Article 32	Working hours		174	145	93	77
Article 37	Payment of bonus wages		266	238	219	159
Article 89	Formulation and notification of employment rules		—	61	52	23
Article 107	Creation of worker register		121	56	36	29
Section 108	Creation of wage ledger		213	111	90	86
Other	Notification of dormitory rules, notification of installation of dormitory, etc.		—	47	39	28

Source: Supervisory guidance results for decontamination contractors, Fukushima Labor Bureau, MHLW

(4) Large Container Bags Washed Away in Heavy Rain

In the case of torrential rains in the Kanto-Tohoku region in September 2015, heavy rain fell especially on the Nakadori region in Special Decontamination Areas, and Iitate Village also received 382 mm over the course of three days from September 9 to 11 September (nearly twice the average September rainfall of 205 mm).

Due to this heavy rain, the major rivers in the village flooded, 448 large container bags that had been temporarily placed at decontamination sites on agricultural land along the river flowed out to the river, but 443 bags were collected. The remaining five bags were inaccessible in ravines that were difficult to reach, so after a review of possible methods to collect them safely, they were all retrieved on May 16, 2016. Bottom sediments of rivers and lakes were monitored in the area downstream of the spill, and it was found that concentrations of radioactive cesium were within or below the range of concentrations found in monitoring before the heavy rainfall.

To prevent reoccurrence, as a rule it is important not to place container bags in any flood hazard area, to minimize the length of temporary placement, to strengthen communication systems, and to continuously have a tally of container bags at decontamination work sites. In the event of heavy rain or flooding, it was decided to carry out emergency measures such as using rope to tie together any container bags temporarily placed at a decontamination site and secure them to heavy equipment, etc.

Also, the Fukushima Office for Environmental Restoration was informed that five workers did not come back on the evening of September 17 when they were in a steep ravine trying to retrieve container bags that had been washed away. The fire brigade that had received a call from the contractor abandoned its search at 8:27 p.m. on September 17. With cooperation from Fukushima Prefecture, Fukushima Prefecture Police Headquarters, Soma Fire Department Headquarters, and the Ground Self Defense Force, the search was resumed from 6:00 a.m. the following morning, and it was confirmed that all members were safe by 9:44 a.m. MOE issued guidance stating that in the event of a disaster, it is crucial to recognize that the priority should be given to ensuring the safety of human lives, including those of third parties and decontamination workers, and that contractors should have disaster prevention systems in place.

(5) Decontamination Contractors' Initiatives

Accidents, improper decontamination, etc., occurred in the context of education being provided for workers who numbered up to 20,000 persons a day at one site. As mentioned above, decontamination contractors conduct education and management in various ways starting with the beginning of a project, but in order to prevent accidents and improper decontamination, they continue with thorough efforts to improve management systems and provide education, etc.

① Development of work management systems

· The system was developed based on the assignment of one decontaminating contractor staff member and one primary cooperating company staff member to each 30 decontamination workers.

· To confirm that work was being performed properly, they would conduct day-to-day visits to the sites to observe groups based on type of work, and also conduct group-by-group quality patrols (quality checks of work standards, ensuring there was no illegal dumping, etc.) and safety patrols (safety checks of work standards and confirmation of compliance with related laws and regulations).

② Education of staff and workers (activation of communication)

· For decontamination contractor personnel as well as the workers in cooperating companies, efforts were made for educated and awareness raising about the following points in order to ensure thorough quality control.

<Decontamination contractors>

· Instruct cooperating companies to ensure that workers do not engage in any work that is not in compliance with work standards, or work that can lead to misunderstandings

· By rereading the work standards reconfirm the understanding of not only workers but also the staff themselves, and work to make improvements to work standards.

· Make efforts to better communicate with cooperating companies and workers in order to identify problems in a timely manner.

<Cooperating companies and workers>

· Educate workers so that they do not engage in work that does not meet standards or conduct work that can lead to misunderstandings.

· If in doubt, consult with the joint venture at any time.

· Establish a quality control "refuge" (consultation system) for workers to report to the joint venture (primary contractor) cases in which they observe or are being forced to do substandard work, and display posters announcing the system in rest areas and offices, etc.