2011.11.26 Science Council of Japan
Role and Responsibility of Scientists in the response to TEPCO Fukushima Nuclear Power Plant Accident

Contributions from Civil Engineering

Minoru Yoneda
Department of Environmental Engineering
Kyoto University
(Japan Society of Civil Engineers)

"Civil Engineering is the engineering to contribute the establishment of a beautiful rich country and sustainable society with understanding and reverence of nature" (JSCE HP)

What's the role of civil engineers to recover the beautiful and rich country and sustainable society in Fukushima?

Of course, we have to endeavor to recover various infrastructures, but, here, limiting our contribution relating to the recontamination of radioactivity.

Committees of JSCE and their contribution to the restoration of Fukushima

Category I (structural eng.): Verification of the influence of the earthquake, and the measure for avoiding future damage.

Category II (hydraulic eng.): Verification of the influence of the Tsunami, and the measure for avoiding future damage. Research on the contamination of river, river-bed and ground water.

Category III (geotechnical eng.): Feasibility study of seashore landfill as final disposal site.

Category IV(planning and management): Landscape and functions of restored cities. Setback planning.

Category V (Concrete eng.): Development of stable concrete for final disposal.

Category VI (construction management): Management of decontamination and environmental restoration enterprise.

Category VII (Environment and energy eng.): Treatment and risk analysis of waste and soil contaminated with radioactivity. Energy planning.

Treatment policy of contaminated waste and soil:

Excerpt from “Present treatment policy of water and sewage processing byproducts containing radioactivity, Nuclear disaster task force, 16, Jun, 2011

Total concentration of ^{134}Cs and ^{137}Cs is less than 8,000Bq/kg:

Landfill disposal is available if the disposal sites must have appropriate structure such as water shield and waterproof and not used for residence in future. ---> controlled landfill type

Total concentration of ^{134}Cs and ^{137}Cs is more than 8,000Bq/kg and less than 100,000Bq/kg:

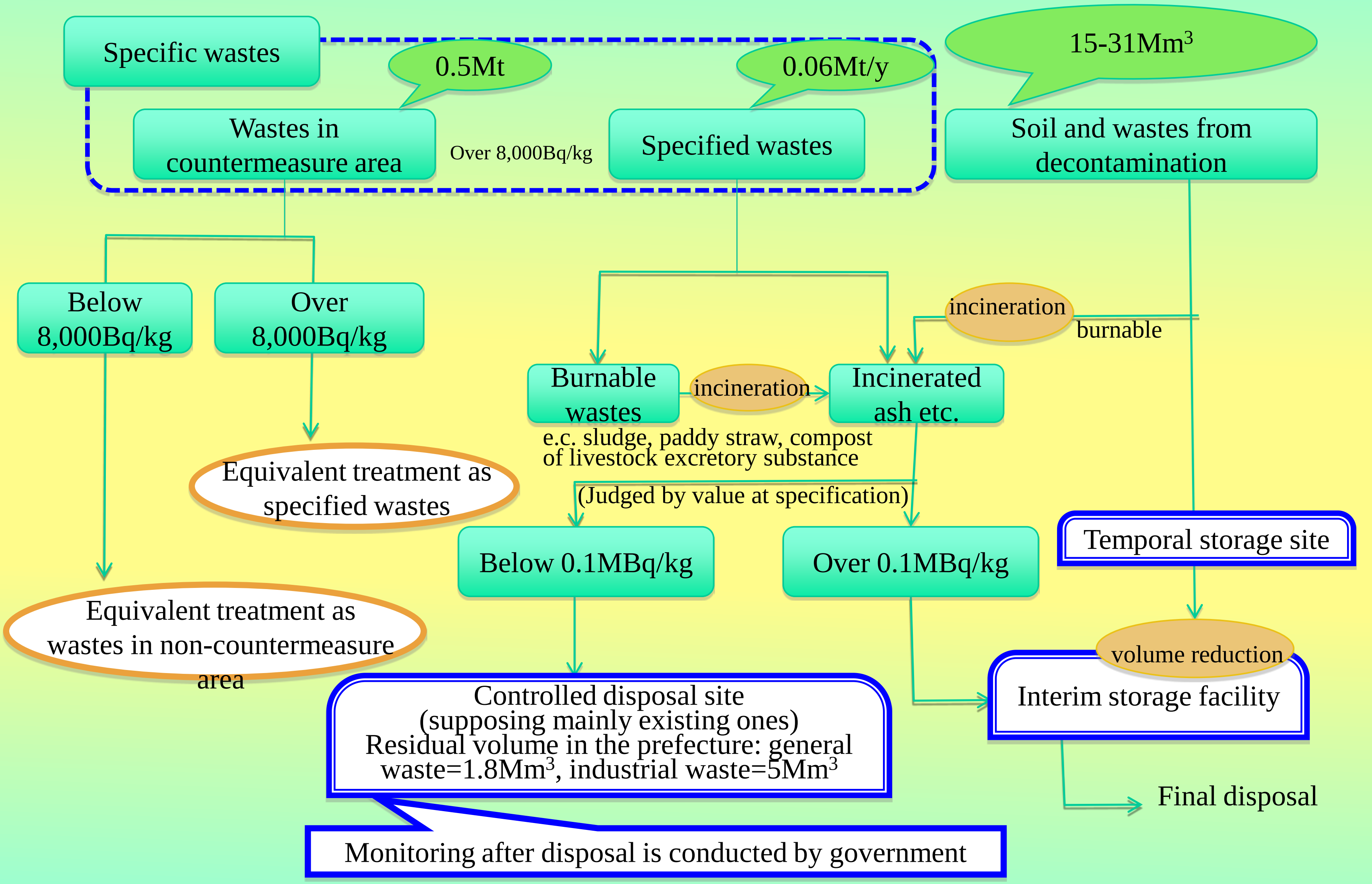
Radioactivity concentration with which exposure to general public living in the vicinity is less than 10μSv/year, when the disposal site is not used for residence. Landfill disposal is available after evaluation of the safety of each site and consideration of the method of long term conservation. ---> controlled landfill type with firm water shielding

Total concentration of ^{134}Cs and ^{137}Cs is more than 100,000Bq/kg:

Wastes and sludge should be conserved in the facility with appropriate radiation shielding in their occurring prefecture at all possible. ---> isolated landfill type with radiation shielding.

Establishment of interim storage facility and final disposal site must be the bottleneck.

Treatment flow of specific wastes and decontamination wastes in Fukushima



MOE: countermeasures for radioactive substances from atomic power plant accident
http://www.env.go.jp/jishin/rmp.html

Structure of each facility (constructed with know-how of usual waste disposal site)

Start of full-scale decontamination

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Storage at temporal site (around 3 years)

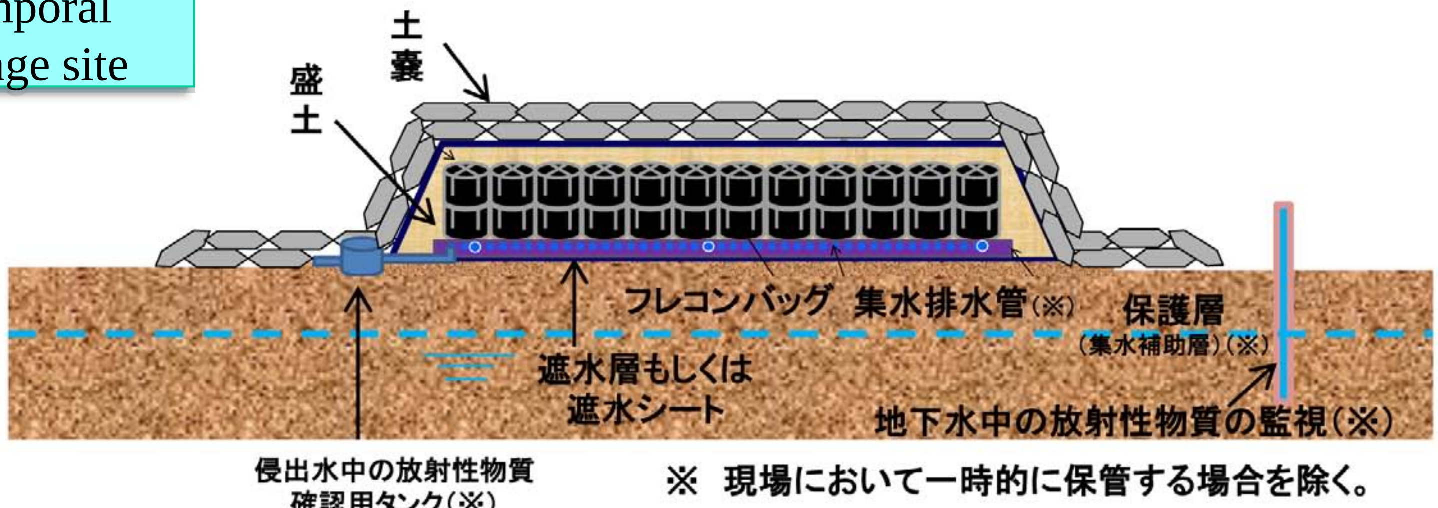
↓

Storage st interim storage facility (within 30 years)

↓

Final disposal

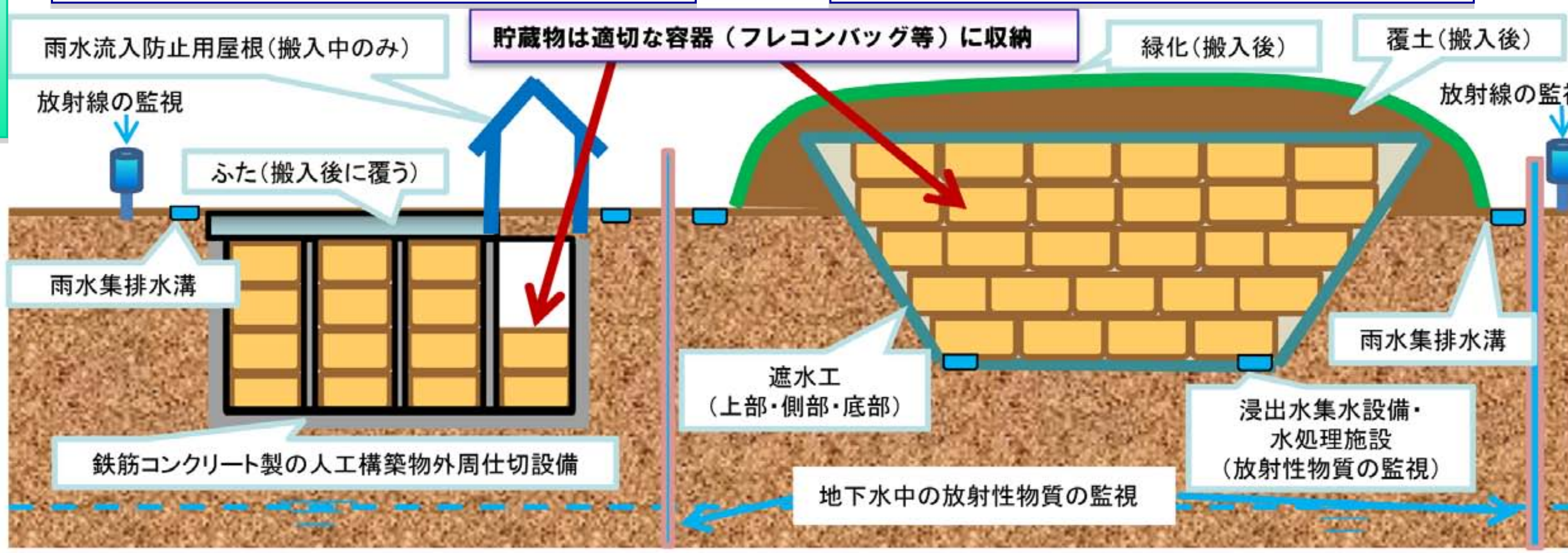
Temporal storage site



Storage facility in the interim storage site

Example of the facility dealing with the high concentration and soluble waste

Example of the facility dealing with the low concentration and insoluble waste



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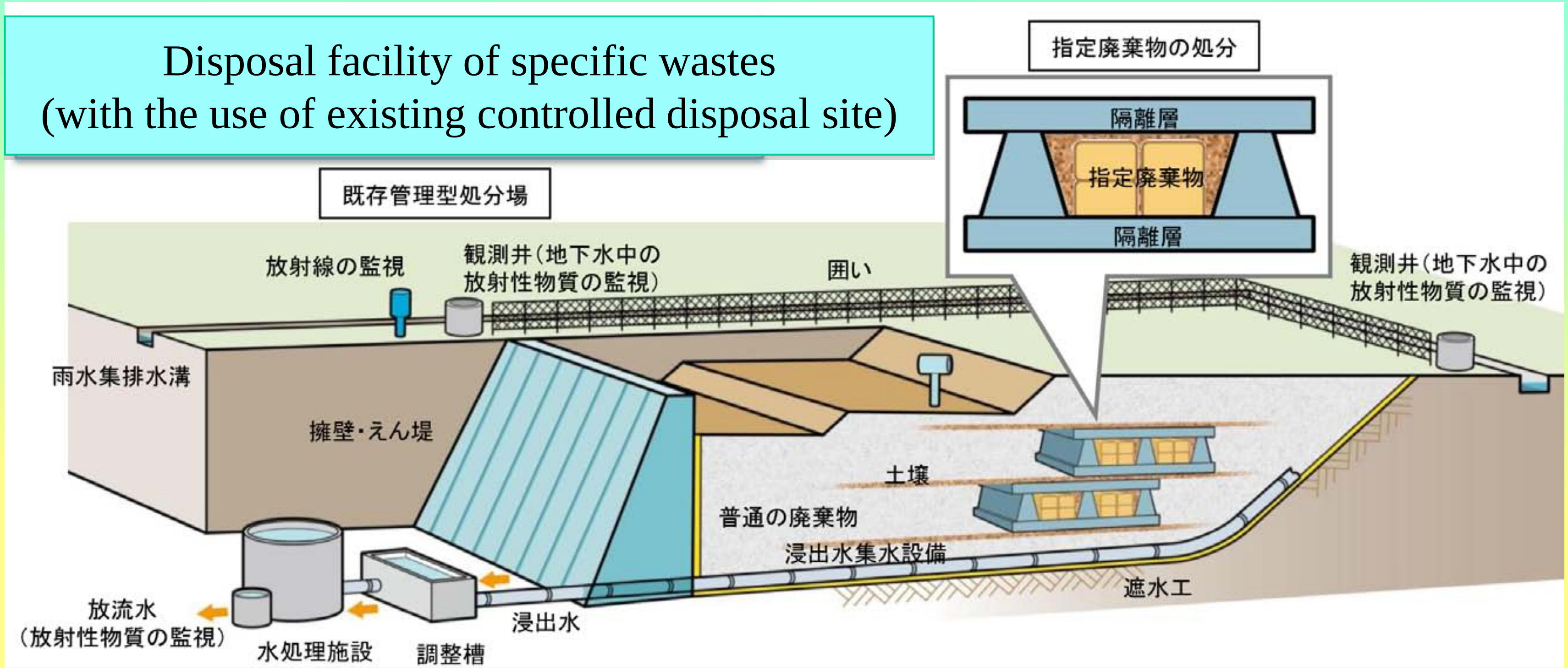
Structure of each facility (constructed with know-how of usual waste disposal site) continued



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Policy of interim storage facility and final disposal facility:
・ivory-towered installation?
・possibility of consistent management as near-at-hand parks?
・consideration of sea area solid waste disposal?
(250Mm^3 soil and sand was used in the second period construction of Kansai airport)

Volume of contaminated wastes and soil?

Estimated volume of wreckage in Fukushima: 2.28 Mton
Sewage sludge: 0.07 Mton/year (dehydration sludge)

Volume of removed soil etc. by decontamination: estimation of MOE

Little amount case:

Higher dose area:
Removal of ground soil in residential and productive areas,
Cleaning of side ditch of road etc.,
Artificial pruning and removal of fallen leaves in forests
Lower dose area:
Decontamination of hot-spot,
Removal of ground soil at children's living environment

Fukushima…15 Mm^3 after incineration
(15 Mm^3 before incineration)
Other prefectures…1.4 Mm^3 after incineration
(1.4 Mm^3 before incineration)

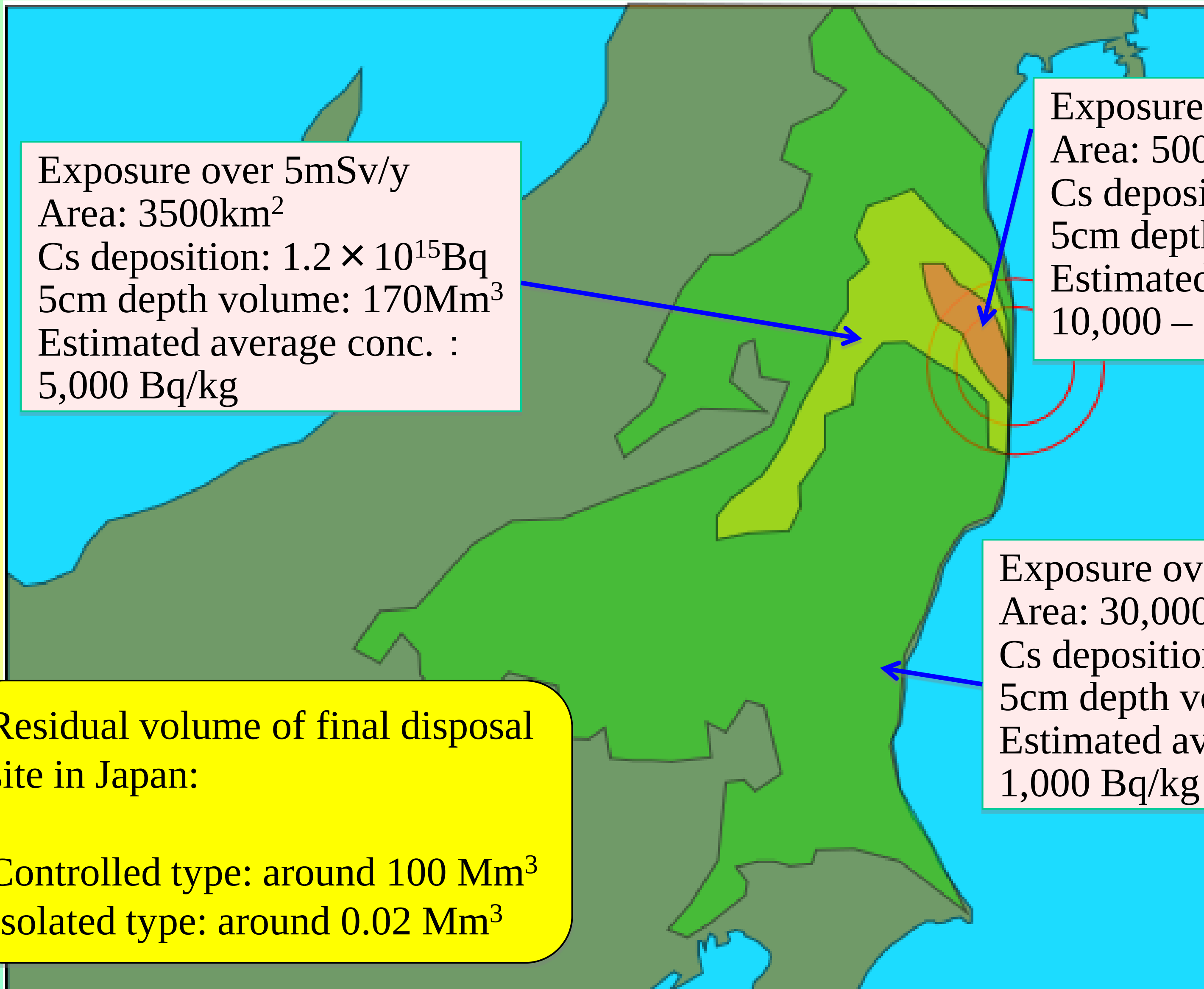
Much amount case:

Adding to the case of little amount,
Area over 20 mSv/year:
Artificial pruning and removal of fallen leaves in forests of non-living area.
(except conservation area)
Lower dose area:
certain level removal of ground soil as additional decontamination

Fukushima…28 Mm^3 after incineration
(31 Mm^3 before incineration)
Other prefectures…13 Mm^3 after incineration
(13 Mm^3 before incineration)

The above is enough or necessary?

More than 70% of the intended area is forest.
Volume of contaminated soil is orders of magnitude more than that for estimated removal.
e.g. What is the cost and effect of 1cm depth removal of ground soil in forest?



Residual volume of final disposal site in Japan:

Controlled type: around 100 Mm^3
Isolated type: around 0.02 Mm^3

Road map of the construction of interim storage facility.　Quite simply, role of civil engineering…

schedule related to construction of interim storage facility

番号	項目	内容	23年度 4	7	10	1	24年度 4	7	10	1	25年度 4	7	10	1	26年度 4	7	10	1
1	基本構想検討	●廃棄物・土壌の種類・性状・量、放射性物質の濃度等の調査 ●概略の施設構造・規模・工事費等の算定、候補地の検討(複数案)			構想検討													
2	中間貯蔵施設の場所選定	●中間貯蔵施設の場所選定の都道府県・市町村・地元との調整				県・市町村・地元調整												
3	基本設計・実施設計	●中間貯蔵施設の施設構造・規模・工事費等の概略算定　※基本設計(各種予備協議ができる概略のもの)、実施設計(工事発注・用地買収ができるレベル)						基本設計		実施設計								
4	環境影響調査・放射性物質の環境への影響調査	●環境影響項目に関する調査、評価、対策の検討等 ●放射性物質の環境への影響の調査、評価、対策の検討等						文献調査		現地調査								

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How far do we execute? Or, how far should we execute?

"The Japanese authorities involved in the remediation strategy are encouraged to cautiously balance the different factors that influence the net benefit of the remediation measures to ensure dose reduction. They are encouraged to avoid over-conservatism which could not effectively contribute to the reduction of exposure doses.": Summary Report of the Preliminary Findings of the IAEA Mission on remediation of large contaminated areas off-site the Fukushima Dai-ichi NPP, 7 – 15 October 2011, Japan

It is also necessary to evaluate the loss or adverse effects by decontamination.

Dynamic model of Cs in the environment is essential for determining decontamination level, especially, of forest.

What happen if we leave it as it is?

Effluence amount in future? Rate of infiltration to groundwater?

Resuspension amount radionuclide from forest?

Effect of decontamination?

Decontamination effect in case of bottom weed removal?

Ecological effect of A_0 layer removal?

Effedt to Soil erosion rate, water retentivity, and flood occurence?

Cost-benefit analysis including evaluation of adverse effect is essential for appropriate planning of decontamination.

But, very little information for time variation of future exposure level so far.

Data collection for environmental simulation is one of prominent roles for civil engineer. (experience in runoff analysis of soil or agrichemicals and investigation of runoff coefficient from forest, etc.)

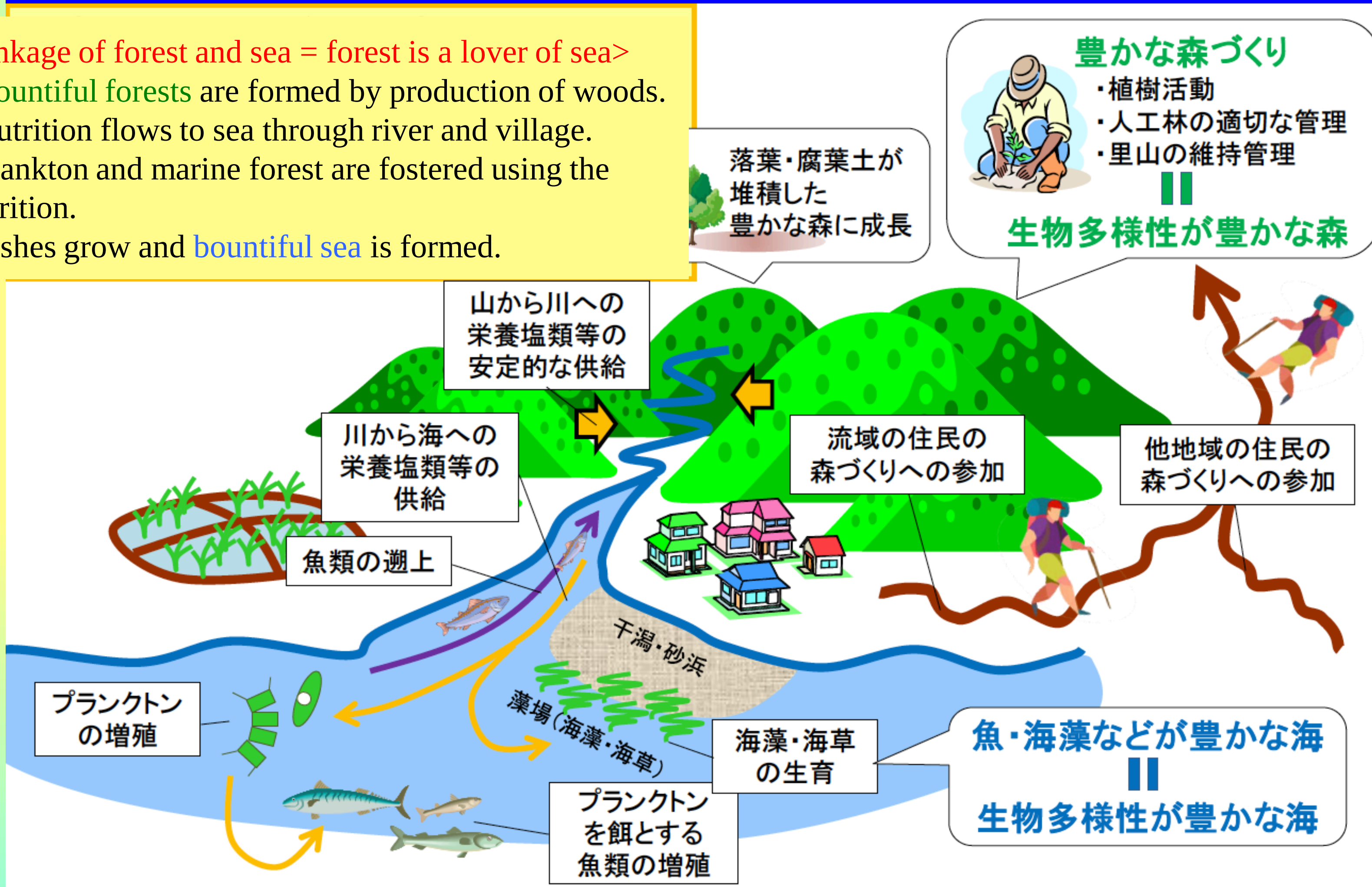
Incineration and melting must be the key process as pretreatment before final disposal. Dynamic behavior analysis of Cs in the incineration and melt treatment must be of immediate importance.

Decotamination plan must consider dynamism of radionuclide and exposure analysis in the linkage of forest, village, and sea.

Biodiversity and the linkage of forest, village, and sea.
- Activity of ‘forest is the lover of sea’ as a model. -

<linkage of forest and sea = forest is a lover of sea>

・Bountiful forests are formed by production of woods.
・Nutrition flows to sea through river and village.
・Plankton and marine forest are fostered using the nutrition.
・Fishes grow and bountiful sea is formed.



“Concept of Sanriku restoration national park (tentative name)”, Central Environment Council, July, 11th 2011, MOE
http://www.env.go.jp/jishin/park-sanriku/index.html

Decontamination cost

View of on site treatment. (offered by Takenaka Corp. and Takenaka Civil Eng.& Const. Co., Ltd.)

Excavation removal cost: 30,000-50,000 yen/m3
(Possibly more expensive because of radioactivity)
Only disposal to site can cost about the same.

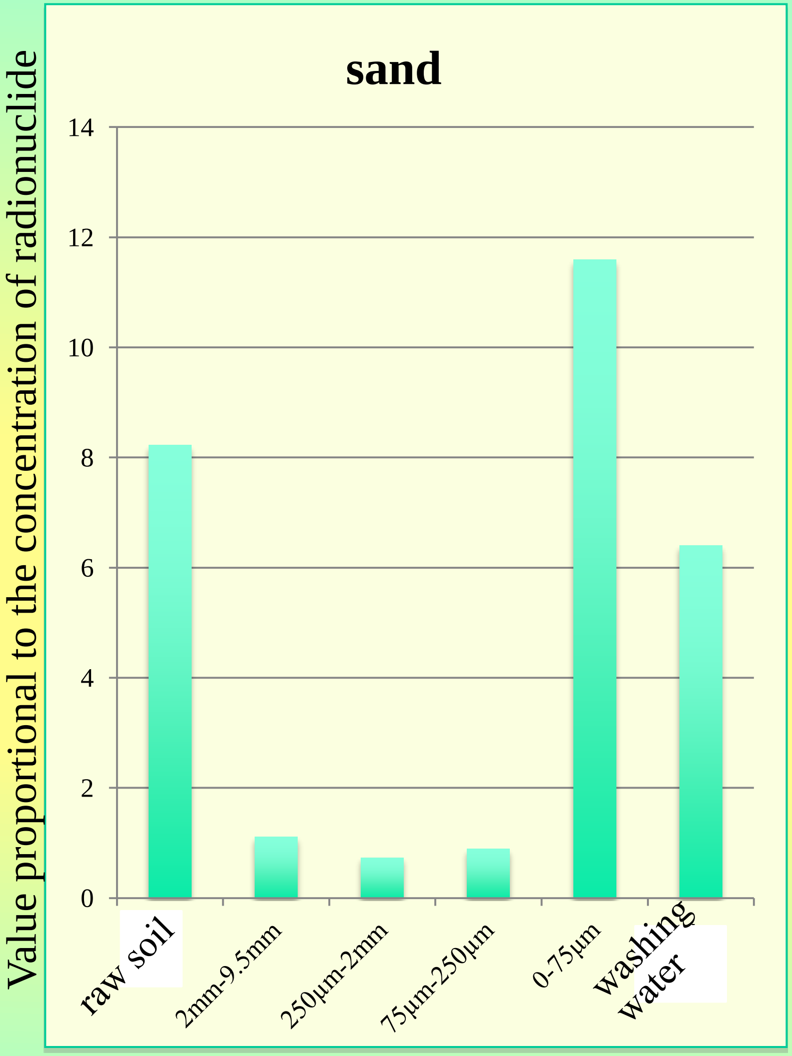
Washing and classification treatment on site:
20,000-40,000 yen/m^3
Countermeasure cost for high concentration sludge is also necessary.

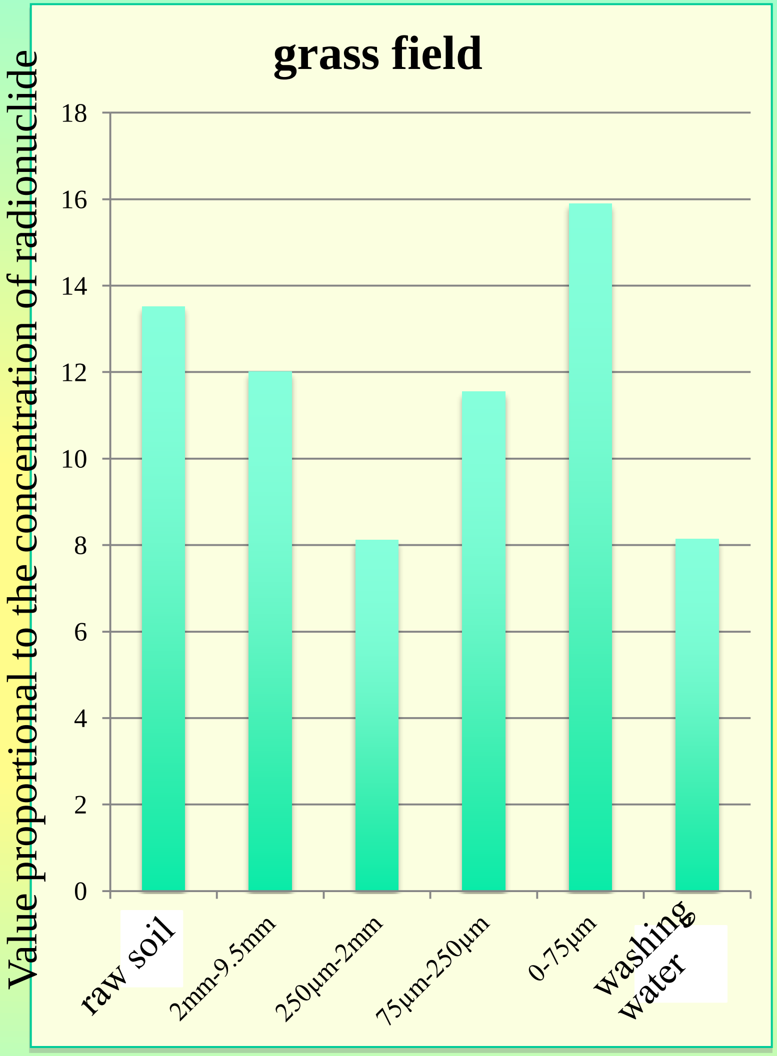
Therefore, assuming 50,000 yen/m^3 for decontamination, it cost about 3 billion yen/1 km^2
Assuming 30 Mm^3 soil is decontaminated, it costs over 1000 billion yen.

Construction cost of controlled type disposal site: 10-20 billion yen/Mm^3
Construction cost of sea area solid waste disposal site: 450 billion yen/120 Mm^3 (for bank protection, e.g. Tokyo bay area)
Construction cost of isolated type disposal site: severalfold more of controlled type

It may be more expensive because of the cost of countermeasure against radioactivity.

Effective washing method must be developed.





Example of the results of soil washing and classification by water in a park of Koriyama. It is not so simple to wash soil when it contains much organic substances.

There are various countermeasure methods for contaminated site. ---> Soil removal is not necessarily the best method. It is important to select the best method.

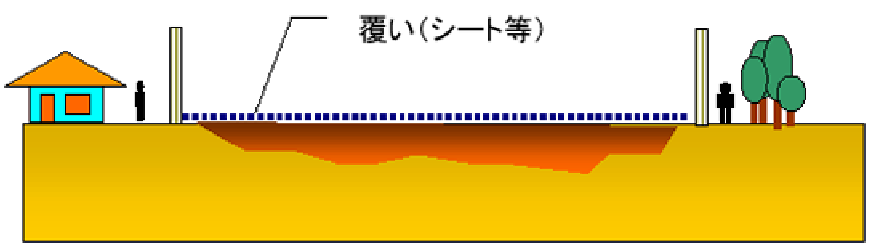
Technical standard for implementation of countermeasures such as contamination removal, MOE, 2002.
www.env.go.jp/info/iken/h140903a/a-2-3.pdf

Countermeasures considering risk of direct ingestion:

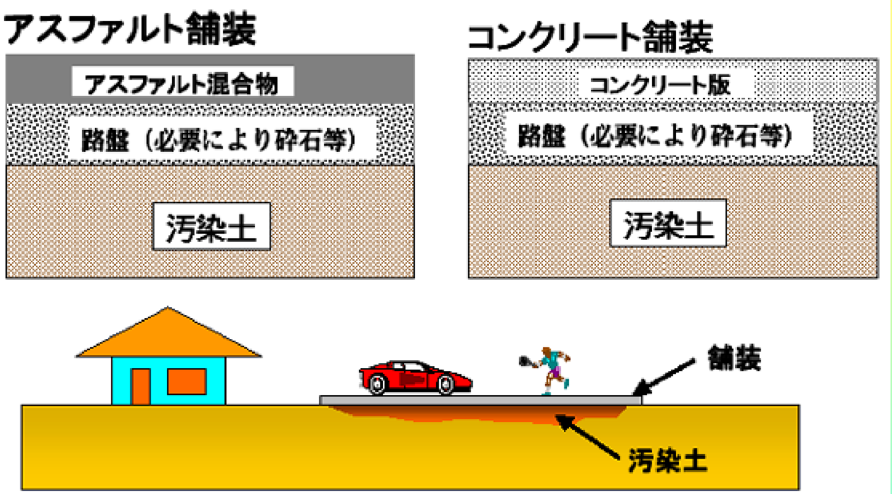
1) no admittance
2) pavement
3) soil cover (mound)
4) cover with other material
5) replacement with soil of unspecified area
6) replacement with soil in specified area
7) in-situ containment
8) containment with water shield
9) containment with isolation
10) excavation for removal

There are also some countermeasure methods considering risk of groundwater ingestion.

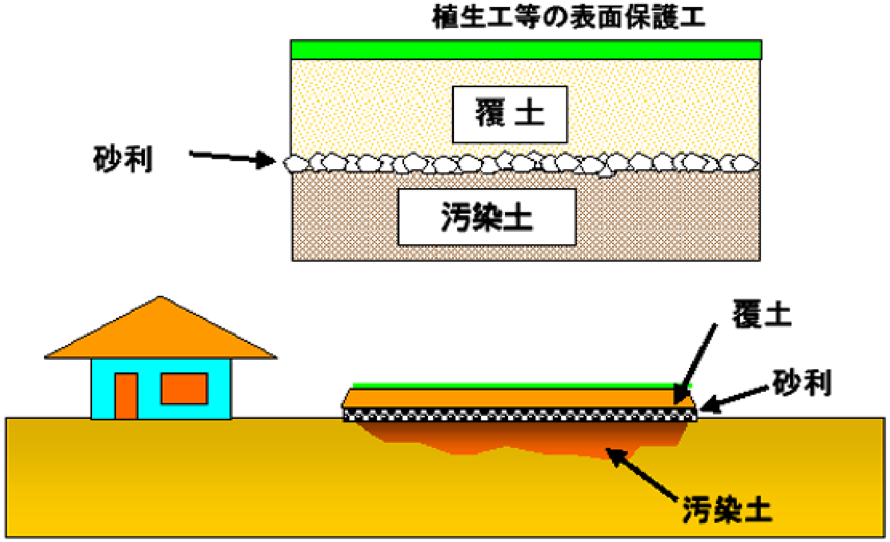
1) no admittance measure



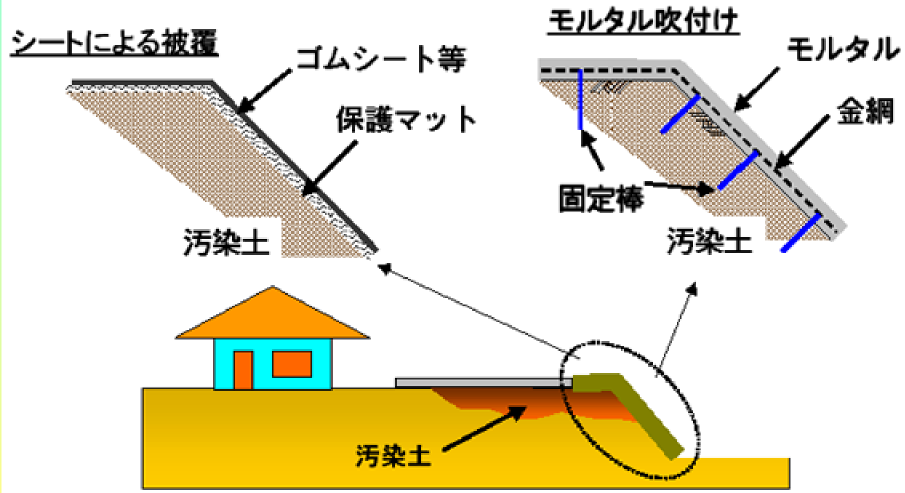
2) Pavement measure



3) soil cover (mound) measure

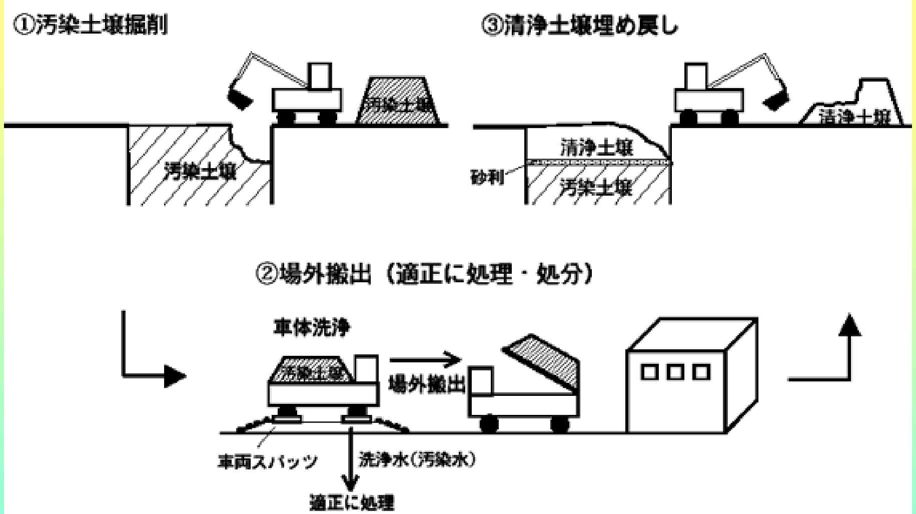


4) cover with other material measure



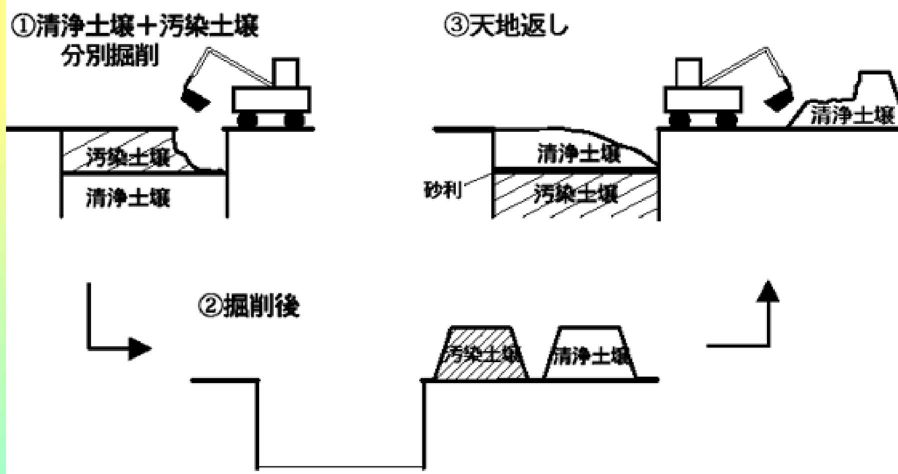
5) replacement with soil of unspecified area

汚染土壌掘削→場外搬出→清浄土壌埋め戻し

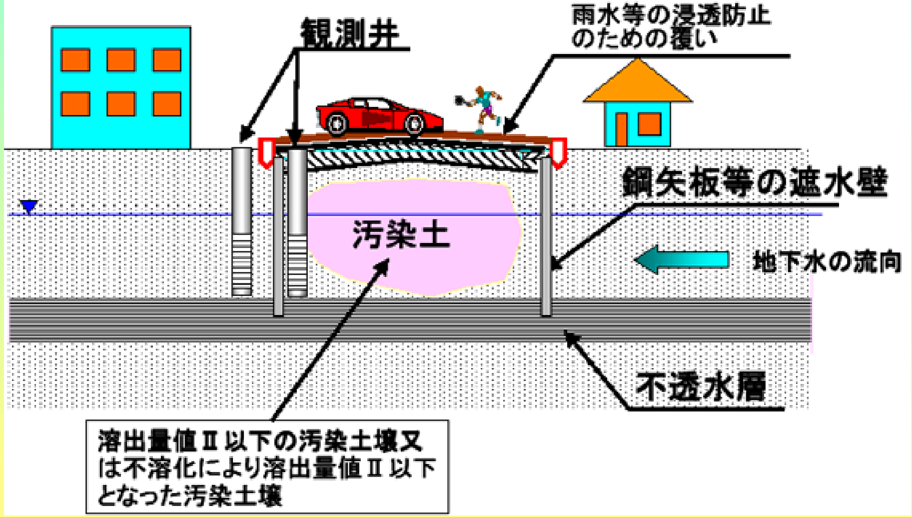


6) replacement with soil in specified area

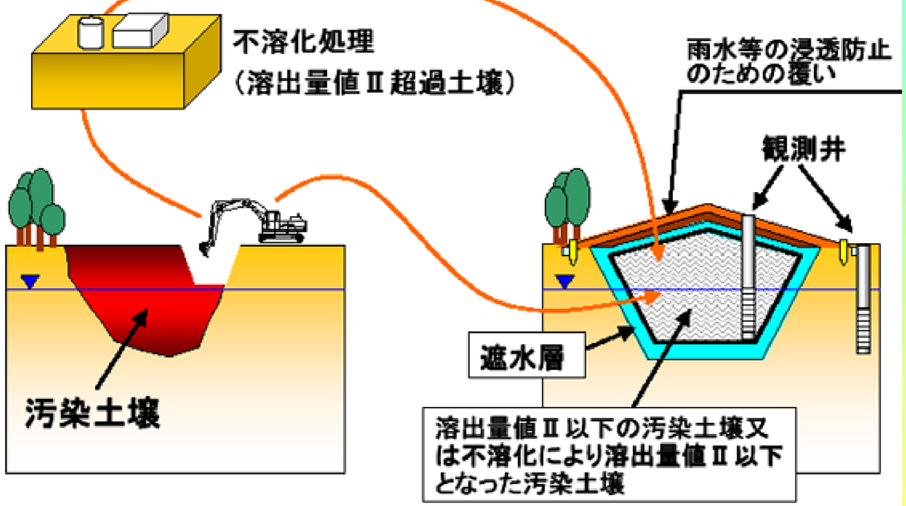
清浄土壌+汚染土壌の掘削→天地返し



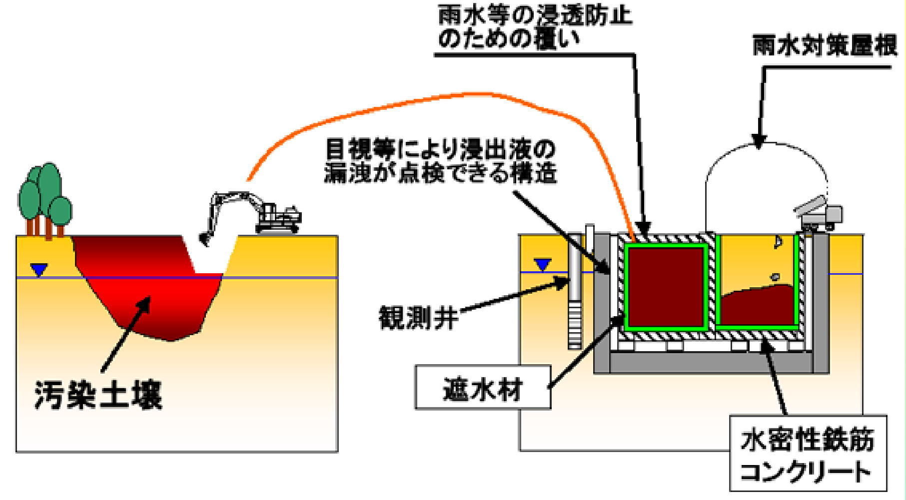
7) in-situ containment



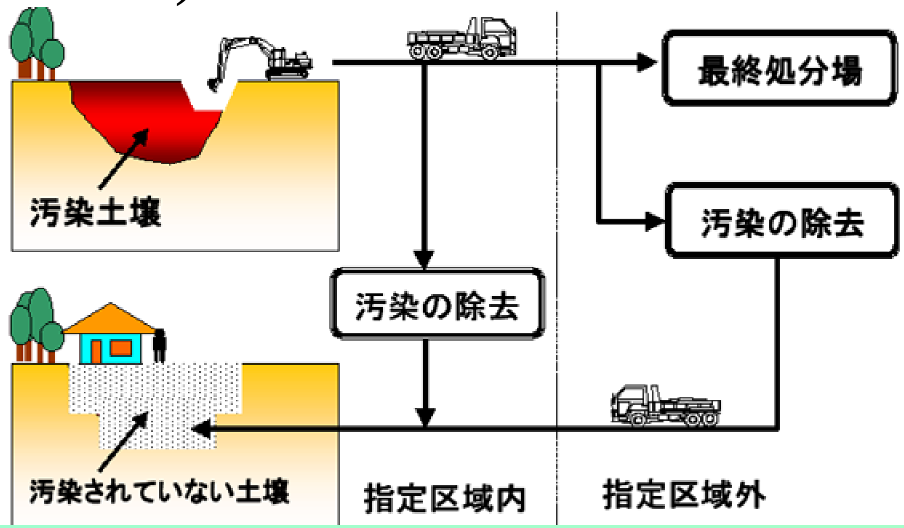
8) containment with water shield



9) containment with isolation



10) excavation for removal



For carry-in to each disposal site and construction of interim storage facilities and final disposal facilities:

Should we decrease the volume of final disposal by separation enrichment?
Or, should we treat the waste and soil as usual waste, or even with dilution?

Half life of ^{137}Cs is 30 years:

- 1/10 after 100 years isolation
- 1/100 after 200 years isolation
- 1/1000 after 300 years isolation

Shield of radiation from ^{137}Cs with concrete (about twice thickness is necessary with soil):

- 1/2 with 4cm thickness
- 1/10 with 13cm thickness
- 1/100 with 26cm thickness
- 1/1000 with 39cm thickness

The risk of Cs will disappear after some hundreds years isolation with 40cm thickness concrete or twice thickness soil.
Many Structures stand for more than hundreds years so far.
Meanwhile, how many years are necessary for the recovery, if forest is broken down?

First, risk communication with neighbors and local government is necessary. It is important to give a fix for better or equal situation in the worst case.

Can The facility be not only for disposal, but also for effective use for neighbors and local government?

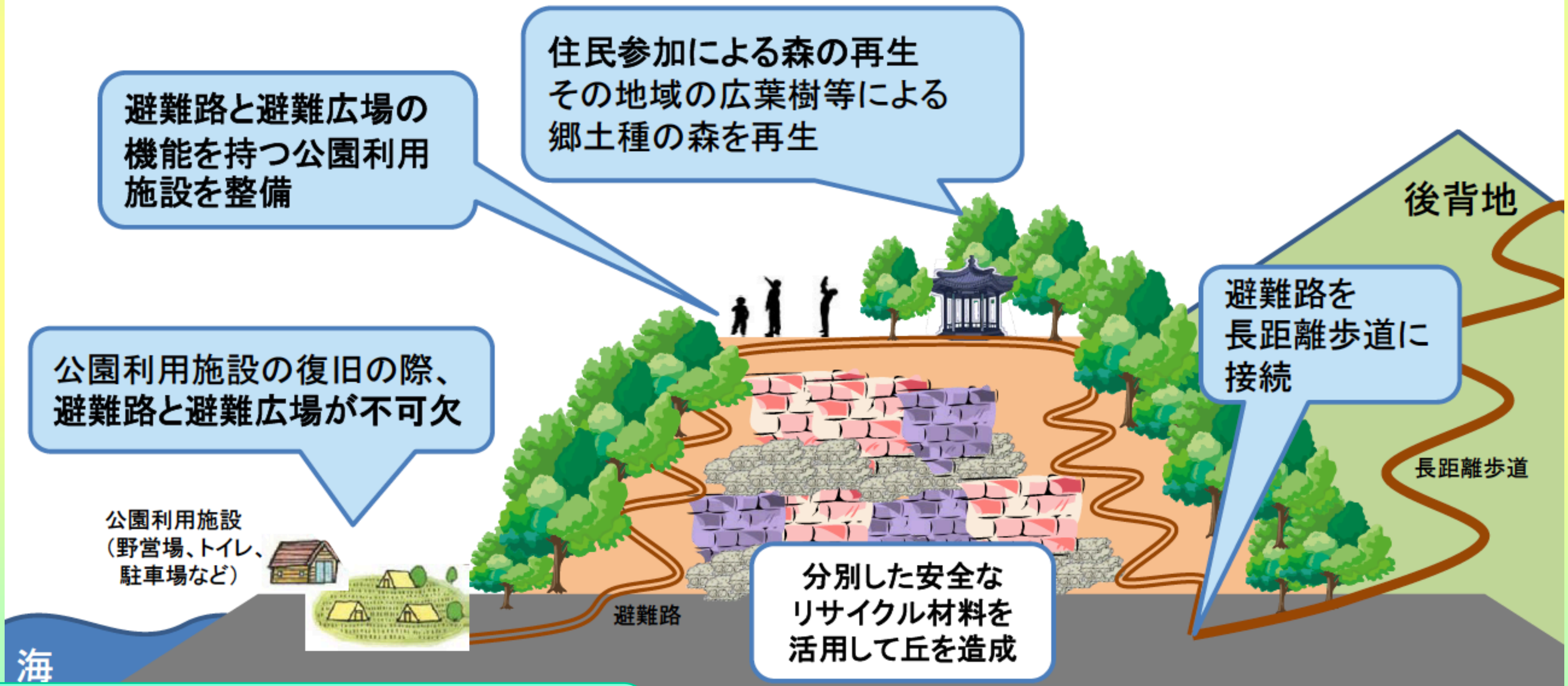
Constuction of sight view hill which can be evacuation area of users

Construction of ‘sight view hill’

・It is developed for a park which can be used as lookout, a place for contact with nature, and a place for studying tsunami experience.
・It is used for emergency evacuation area for residents and tourists.
・Forest and nature at seaside area will be restored with the participation of residents.
・It can be a symbol of restoration.

Damaged facility of national park ---> restoration (including relocation and land reclamation)

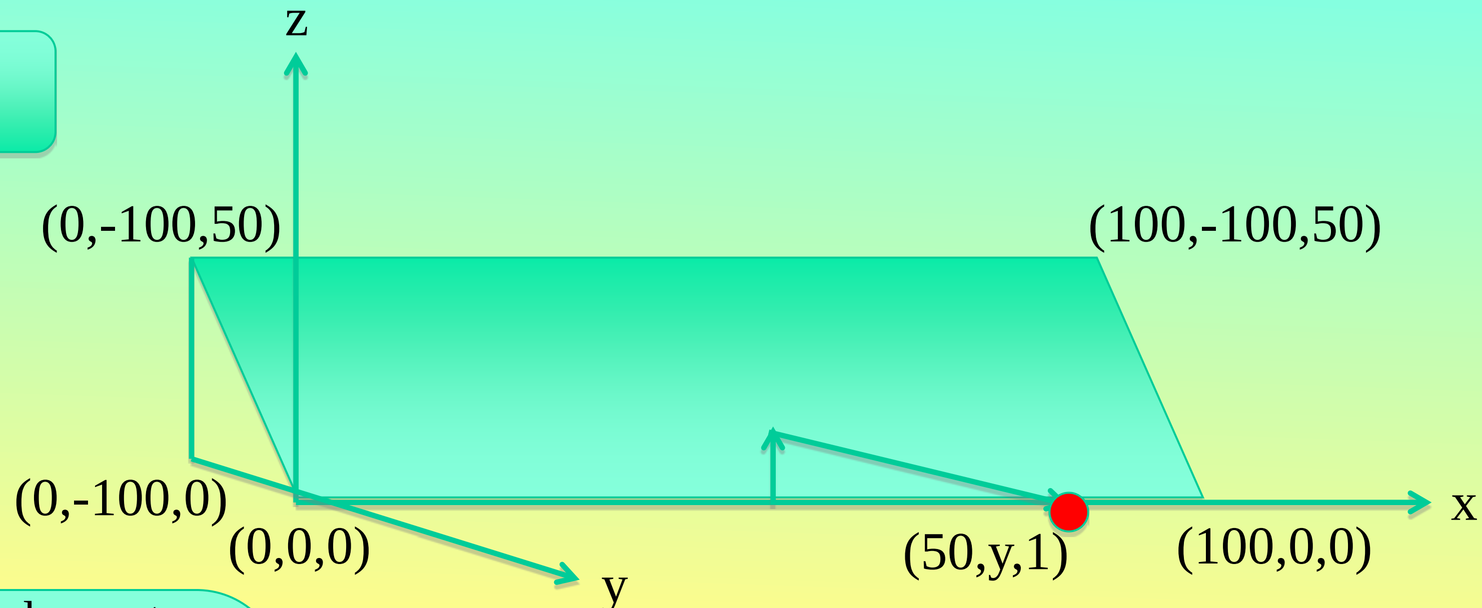
Segregation and use of waste as safe recycling material



Contaminated waste and melting slug may be used for breakwater etc.

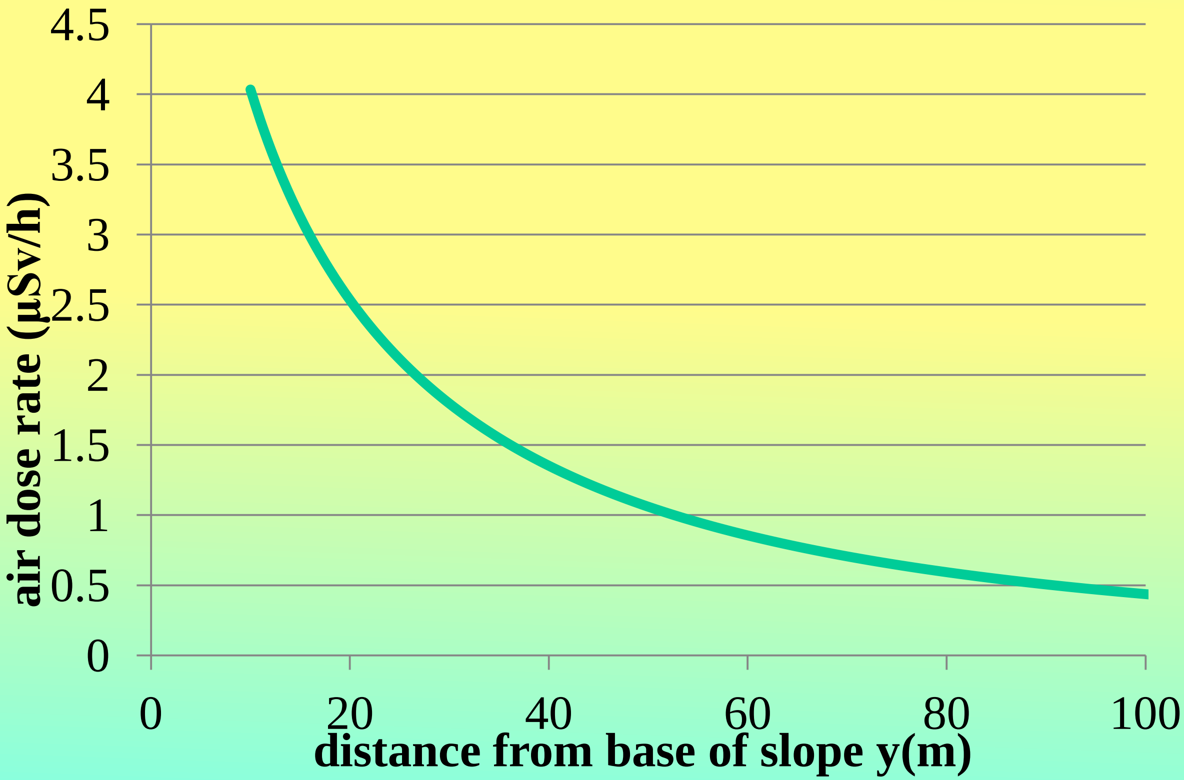
“Concept of Sanriku restoration national park (tentative name)”, Central Environment Council, July, 11th 2011, MOE
http://www.env.go.jp/jishin/park-sanriku/index.html

Exposure dose from forest



Estimation of air dose rate from the slope with ^{137}Cs horizontal deposit of $10 MBq/m^2$

Exposure dose reduction might be small even after decontamination around residence.



Decontamination of forest, or setback of residence?

Use of forest or setback area? Parks?

Role and contribution of civil engineering to the restoration of Fukushima especially looking at decontamination:

Waste treatment: establishment of the techniques of incineration and melting, etc.

Contaminated soil treatment: establishment of the techniques of removal work and washing

Disposal of soil and waste: establishment of the techniques for interim storage facility and final disposal site, and their construction. (Is sea area disposal site most feasible as a final disposal site considering the volume to be treated?)

Optimal restoration planning: temporal-spatial dynamism analysis of radiation and exposure in future. The restoration city planning should be considered along with setback planning and disposal site construction.

Management is essential for the planning with consideration of various effect, risk, cost and benefit in a comprehensive manner for minimizing exposure dose of people.

The most important role of Civil Engineering must be "management" to synthesize wisdom in various area.

Supplement: Advice from IAEA, excerption from 'Summary Report of the, Preliminary Findings of the, IAEA Mission on remediation of large contaminated areas off-site the , Fukushima Dai-ichi , 7 – 15 October 2011, Japan'

Advice 1. The Japanese authorities involved in the remediation strategy are encouraged to cautiously balance the different factors that influence the net benefit of the remediation measures to ensure dose reduction. They are encouraged to avoid over-conservatism which could not effectively contribute to the reduction of exposure doses. This goal could be achieved through the practical implementation of the Justification and Optimization principles1 under the prevailing circumstances. Involving more radiation protection experts (and the Regulatory Body) in the organizational structures that assist the decision makers might be beneficial in the fulfillment of this objective.

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

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

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

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

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

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