Preventative and Multilayered Measures for Contaminated Water Treatment at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company - Through completeness of comprehensive risk management -

December 10, 2013
The Committee on countermeasures for contaminated water treatment
<Overview>


- For prevention of unintended effluence of contaminated water into the ocean and significant impacts on the environment, it is important to completely perform comprehensive management of the overall risks; establish a system of overall function, which will work even if any of the facilities or its operation, or part of measures malfunctions; be trusted from Japan and overseas countries; and retain safety and security.

- The Subgroup for understanding and visualization of groundwater and rainwater behavior and the Subgroup for risk assessment were established under the Committee to enhance technical reviews with regard to behaviors of groundwater and rainwater and analyses/evaluation of risks of contaminated water leakage, with experts in those fields attended for intensive reviews.

- To perform reviews from the on-site viewpoint, the Committee carried out on-site inspection and at the same time made efforts to cooperate with the Intergovernmental Council for Fostering Mutual Understanding on the Contaminated Water Issue.

- Further, as the issues included those against which it was difficult to take measures only by use of the existent, general knowledge, we requested information to gather intellects from inside and outside of Japan in the following six fields: (1) Contaminated water storage, (2) Contaminated water treatment, (3) Purification of seawater within the plant port, (4) Contaminated water management within buildings, (5) Premise management to restrict affluence of groundwater, and (6) Understanding of behavior of groundwater, etc.
As a result of these reviews, we extracted measures and technologies as preventative and multilayered measures to be additionally taken including those “to remove” contaminated water, those “to keep out” water from the sources of pollution, and those “not to leak” contaminated water, and indicated the overall image of the measures, taking into consideration their priorities, etc.

(Concrete examples of measures)

Multilayered measures: “Wide-area facing (surface water shut-off)” or “Additional water shut-off and facing inside thereof”,
- Heightening and duplicating tank embankments,
- Using underdrain for drainage ditch and changing route to the plant port,
- Scavenging strontium in soil,
- Accelerating installation of welded-joint tanks and using highly-reliable large tanks such as double-shell steel tanks,
- Detection of minute leakage from tanks,
- Purification of seawater inside of the plant port by such means as deposition, absorption and separation,
- Utilizing such devices as contamination preventing membranes, which can remove radioactive materials,
- Covering marine soil inside of the plant port, etc.

Preventative measures: Measures against large-scale tsunami (taking measures to increase water proofness of buildings and review of additional measures such as tide embankments)
- Water stopping of buildings (through holes in exterior walls of buildings, gaps between buildings and peripheries of buildings)
- Reduction of contaminated water transfer loops, etc.

We indicated perspective about how the current risks will be reduced by taking these measures.

It is required to firmly take these measures arranged here, including reviews by task forces, to communicate information to Japan and overseas countries, and to reconsider our plan when necessary. In addition, we have a problem of handling of a large amount of tritiated water, which we cannot solve only by the above-listed measures. To this end, we decided to establish task forces under the Committee to foster reviews for comprehensive evaluation.
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Note: The figures, tables, etc. appearing in the text and the attachments were current at the time
of our review for arrangements and therefore, note that they include those that need minute
investigations and improvement in accuracy, those that change from time to time, etc.
1. Basic Idea of Preventative and Multilayered Contaminated Water Treatment

Since holding the first committee meeting on April 26, 2013, the Committee on countermeasures for contaminated water treatment (hereinafter referred to as the “Committee”) has inspected the measures for contaminated water treatment taken after the accident for units 1 to 4 at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company (hereinafter referred to as the “Fukushima Daiichi Nuclear Power Station”) and proceeded with reviews with regard to the measures in an attempt to radically solve the contaminated water problems. At the third committee meeting held on May 30, 2013, we arranged the “Measures to restrict groundwater affluence”. Each of these measures, including reduction of concentrations of radioactive materials in the trenches and seaside impermeable walls, has made firm progress.

On the other hand, insufficiency of the measures so far taken by Tokyo Electric Power Company (TEPCO) has been made clear including clarification of effluence of contaminated groundwater to the plant port and leakage from the contaminated water tanks (approximately 300 tons).

Under the circumstances, on September 3, 2013, the Nuclear Emergency Response Headquarters prepared the “Basic Policy with Regard to Contaminated Water Issues at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company”, indicating basic ideas including, “From now on, not leaving the issues to TEPCO, the Government should lead to take necessary measures. At this point, we should not take conventional, successive, ex post facto measures but broadly find conceivable risks and take radical measures in a preventative and multilayered manner”. In addition, at the first meeting (September 10) of the Inter-Ministerial Council for Contaminated Water and Decommissioning Issues founded under the Nuclear Emergency Response Headquarter, the following items were decided and confirmed as the efforts to be made for the time being by the Committee in the “Response Policy and Concrete Action Plan towards Decommissioning and Contaminated Water Issues”: 
1) Efforts to utilize domestic and overseas intellects
   - For potential risks having technical difficulties to clear, we will form a team to gather domestic and overseas intellects and broadly collect measures. (The received measures will be examined mainly by the Committee on countermeasures for contaminated water treatment.) [Examination will be carried out intensively from this month and arrangements will be made within two months. Examination will also be carried out thereafter when necessary.]

2) Preventative and multilayered efforts
   - Partially based on the on-site reviews, the Committee on countermeasures for contaminated water treatment will find further potential risks and add measures when necessary. [Review will be carried out intensively from this month and arrangements will be made within this year. Review will also be carried out thereafter when necessary.]
   - (Not leaving the issues to TEPCO) the Committee on countermeasures for contaminated water treatment should carry out necessary on-site inspection. [Carried out when necessary]

Based on the following basic ideas, the Committee found risks and reviewed the preventative and multilayered measures for contaminated water treatment:

[Basic ideas of contaminated water treatment]

Since occurrence of the accident, each time an event of contaminated water leakage occurred, additional measures to respond to it was reviewed and appropriately taken. As a result, risks have been reduced accordingly but as a matter of fact, events of contaminated water leakage still occur. The information on each leakage event has been disclosed each time. However, in many cases the information was disclosed before we could fully explain the cause analyses, the assessment of impacts of leakage, and the measures to be taken for the events, and therefore anxiety in and outside of Japan became greater than the actual severity of the event. In addition, successive and ex post facto measures have been taken and the situation has been kept where each time an event of leakage, etc. occurred, we forcibly had to respond to it. Under the circumstances, it is required to completely find risks and enhance the multilayered measures to be taken in case where the existent measures does not fully function or the preventative measures against those risks that do not still become apparent but can be assumed in advance.
As the foundation to take these measures, in order to prevent unintended effluence of contaminated water to the ocean and significant impacts on the environment, it is important to completely perform comprehensive management over the overall risks; consider various combinations of measures and optimize the timing of taking those measures; establish a system of overall function that will work even if one of the facilities or its operation, or part of measures malfunctions; to be trustworthy domestically and overseas; and retain safety and security.

To this end:

1) To continuously grasp the amount of contaminated water, the concentrations of radioactive materials and their locations, and sort and accumulate the data as the basic information on contaminated water.

2) To minutely examine the basic information such as topography, geography and hydrology, grasp behaviors of groundwater and rainwater based on the above information, and carry out technical reviews based the principles and characteristics of water behavior when verifying the events that have occurred and the effects of the measures taken.

3) To find potential risks by broadly assuming scenarios of contaminated water leakage, and extract necessary measures from the viewpoints of “removing” the sources of pollution, “keeping out” water from the sources of pollution, and “not leaking” contaminated water.

4) Based also on the relationship with the measures for decommissioning, to comprehensively foster the measures by considering effects and characteristics of each measure, side effects, mutual effects between measures and risks of malfunctioning of measures; by clarifying the priorities of measures from the viewpoints of minimizing risks, making measures multilayered and fail-safing; and at the same time by optimizing to the combinations of measures.

5) On the various time scales, from short term to long term, to examine and set scenarios of taking measures and getting effects and appropriately perform time management for process of risks and measures.

6) Even after commencement of measures, to keep monitoring, comprehensively evaluate the risks based on the basic information and the technical reviews, reconsider the plan when necessary, and improve the methods of taking measures.

We decided to arrange the measures based on these six ideas. In the future, too, it is important to completely manage the progress of the measures based on these ideas.
2. Flow of Review of Contaminated Water Treatment

Based on the basic ideas as described in Chapter 1, the Committee sorted what has occurred to date and found out the conceivable risks. <Figure 2-1>
In addition to the measures so far taken by TEPCO, it was already decided to mount landside impermeable walls of frozen soil type and introduce a more efficient multi-nuclide removing facility, both at the government expense, and now designing was going on. Here, in addition to these measures already decided, we extracted preventative and multilayered measures that would be necessary as the measures for contaminated water treatment in accordance with the risks we found out.
In addition, in order to indicate the overall image of the measures including the concrete contents, priority and performance schedule of each measure, we systematically sorted the condition of presence of the sources of pollution and then evaluated the degree of the risks of each source of pollution and the progress, effects, etc. of existent measures. As described in detail in chapters 3 and 4, in concrete, we verified the effects of the measures by grasping and visualizing the behaviors of groundwater, rainwater, etc. and intensively reviewed the risk assessment to grasp the risk reduction effects of taking each measure. In the process of this review, the Committee performed on-site inspection.
Because the measures here described included those that would be difficult to take only by use of the existent, general knowledge, the Committee requested information to collect domestic and overseas intellects, as described in detail in Chapter 5, including, for example, technologies to separate tritium and remove radioactive materials in the seawater.
### Finding conceivable risks and necessary preventative and multilayered measures

<table>
<thead>
<tr>
<th>Risks/problems</th>
<th>Measures taken or decided to be taken until September 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contaminated water in the trenches on the sea side</td>
<td>- Pumping high-concentration contaminated water from inside of the trenches on the sea side [Removing]</td>
</tr>
<tr>
<td>Contaminated soil on the sea side of the turbine buildings</td>
<td>- Installing water glass walls at the seawall of the contaminated area on the sea side of the buildings. Pumping contaminated water from the contaminated area. [Not leaking]</td>
</tr>
<tr>
<td>- Placing the surface of the contaminated area on the sea side of the buildings with asphalt. [Not leaking]</td>
<td></td>
</tr>
<tr>
<td>- Installing seaside water shut-off walls within the plant port. [Not leaking]</td>
<td></td>
</tr>
<tr>
<td>Contaminated water stored in tanks</td>
<td>- Enhancing patrol for tanks and piping. [Not leaking]</td>
</tr>
<tr>
<td>- Installing water level gauges, leak detectors, etc. [Not leaking]</td>
<td>- Strengthening bolted flanges of horizontal steel tanks and transfer systems in tank facility. [Not leaking]</td>
</tr>
<tr>
<td>- Accelerating replacement of bolted joint tanks with welded joint tanks. [Not leaking]</td>
<td>- Purifying contaminated water with the advanced liquid processing systems (ALPS). [Removing]</td>
</tr>
<tr>
<td>- Retrieving contaminated soil from around tanks. [Removing]</td>
<td>- Purifying contaminated water with a more efficient treatment facility. [Removing]</td>
</tr>
<tr>
<td>Contaminated groundwater contamination due to leakage of waste and effluence of the contaminated ground water to the ocean (Leakage from high-performance containers (HIC) storing high-concentration waste after treated by ALPS)</td>
<td>- Reducing volume of waste by a more efficient purification facility. [Not leaking]</td>
</tr>
<tr>
<td>- Installing land-side water shut-off walls of frozen soil type surrounding buildings. [Not allowing approach]</td>
<td>- Installing land-side water shut-off walls of frozen soil type surrounding buildings. [Not allowing approach]</td>
</tr>
<tr>
<td>- Firmly adding necessary tanks to firmly store increasing contaminated water. [Not leaking]</td>
<td>- Firmly adding necessary tanks to firmly store increasing contaminated water. [Not leaking]</td>
</tr>
<tr>
<td>Risks of impossibility of storage of contaminated water due to increase in water volume and lack of storage tanks</td>
<td>- Firmly adding necessary tanks to firmly store increasing contaminated water. [Not leaking]</td>
</tr>
</tbody>
</table>

### Multilayered measures

<table>
<thead>
<tr>
<th>Risks/problems</th>
<th>Preventative and multilayered measures that can be necessary in addition to the above measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contaminated water in the trenches on the sea side</td>
<td>- Soil stabilization in area north of water intake of Reactor 1</td>
</tr>
<tr>
<td>Contaminated soil on the sea side of the turbine buildings</td>
<td>- &quot;Public invitation for collection of techniques: Techniques to remove radioactive materials from seawater.&quot;</td>
</tr>
<tr>
<td>Contaminated water stored in tanks</td>
<td>- Heightening and duplicating embankments, embankments for horizontal tanks, and making concrete foundations. [Not leaking]</td>
</tr>
<tr>
<td>- Using underdrain for side ditch to prevent affluence of contaminated water. [Not leaking]</td>
<td>- &quot;Public invitation for collection of techniques: Welded-joint tanks with a high reliability for a long time:&quot;</td>
</tr>
<tr>
<td>- Further accelerating installation of welded-joint tanks and improving reliability. [Not leaking]</td>
<td>- &quot;Public invitation for collection of techniques: Welded-joint tanks with a high reliability for a long time:&quot;</td>
</tr>
<tr>
<td>Contaminated groundwater contamination due to leakage of waste and effluence of the contaminated ground water to the ocean (Leakage from high-performance containers (HIC) storing high-concentration waste after treated by ALPS)</td>
<td>- Preventing effluence of contaminated groundwater by water leakage from tanks to the sea (preventing expansion of contamination by injection of chemicals, etc.). [Not leaking]</td>
</tr>
<tr>
<td>- Accelerating purification of contaminated water by installation of an additional ALPS. [Removing]</td>
<td>- Accelerating purification of contaminated water by installation of an additional ALPS. [Removing]</td>
</tr>
<tr>
<td>- Detecting minute leakage from tanks (Decontaminating surface ground in the vicinity for easier detection of minute leakage, etc.). [Not leaking]</td>
<td>- &quot;Public invitation for collection of techniques: Techniques to detect minute leakage&quot;</td>
</tr>
<tr>
<td>Measures against contaminated material within plant port. [Not leaking]</td>
<td>- Measures against contaminated material within plant port. [Not leaking]</td>
</tr>
<tr>
<td>Measures to further reduce volume of high-concentration waste and store it stably. [Not leaking]</td>
<td>- Measures to further reduce volume of high-concentration waste and store it stably. [Not leaking]</td>
</tr>
<tr>
<td>Restrictions further affluence of groundwater. [Not allowing approach]</td>
<td>- &quot;Public invitation for collection of techniques: Techniques to construct additional water shut-off walls and facing techniques:&quot;</td>
</tr>
<tr>
<td>- Appropriate treatment of tritium (Ex: Separation of tritium, utilization of great deep space, release to the ocean without impact on environment, etc.)</td>
<td>- &quot;Public invitation for collection of techniques: Techniques to separate tritium, etc.&quot;</td>
</tr>
</tbody>
</table>

*Firms to note measures decided to be taken by the Intergovernmental Council (Sep. 9) and at the time of Prime Minister’s visit to Kumaoka (Sep. 10)*
These days, as an outcome of these, we prepared the preventative and multilayered measures for contaminated water treatment that we can provide at this point on condition that comprehensive risk management would completely be performed.

For the Committee to find out the risks and review the measures, it was necessary to enhance technical reviews with regard to the behavior of groundwater and rainwater and analysis/evaluation with regard to risks of contaminated water leakage. Under the Committee, therefore, we founded the following two subgroups; the Subgroup for understanding and visualization of groundwater and rainwater behavior and the Subgroup for risk assessment in order to have experts in those fields participating for enhancement of the review scheme.

In addition, we made efforts to link with discussions and reviews from the on-site viewpoint by the Intergovernmental Council for Fostering Mutual Understanding on the Contaminated Water Issue that were established to strengthen the cooperation and arrangements among the parties concerned on site including the Government and TEPCO. The overall flow of review is shown in <Figure 2-2>:

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**Preventative measures**

<table>
<thead>
<tr>
<th>Risks against which we will need to take measures in the future</th>
<th>Measures that may be required in the future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leakage of contaminated water from circulating coolant system</td>
<td>○ Reducing the scale of loops by such means as direct transfer of contaminated water from each power plant to the contaminated water treatment facility.  [Not leaking]</td>
</tr>
<tr>
<td></td>
<td>○ Accelerating reduction of concentration of contaminated water within buildings.  [Removing]</td>
</tr>
<tr>
<td></td>
<td>○ Measures to prevent effluence of contaminated water to groundwater (water stopping at through holes in outer walls of buildings and in gaps around buildings, grouting around buildings, etc.).  [Not leaking]</td>
</tr>
<tr>
<td></td>
<td>→ &lt;Public invitation for collection of techniques: Techniques to stop water within buildings&gt;</td>
</tr>
<tr>
<td></td>
<td>○ Controlling groundwater level and contaminated water level by such means as installation of drainage pumps in deep sections of reactor buildings.  [Not leaking]</td>
</tr>
<tr>
<td>Leakage of contaminated water from buildings</td>
<td>○ Installing tide embankments.  [Not leaking]</td>
</tr>
<tr>
<td></td>
<td>○ Ensuring tank volume to make preparation for increasing contaminated water.  [Not leaking]</td>
</tr>
<tr>
<td>Leakage from transfer piping</td>
<td>○ Installing drainage pumps in deep sections of reactor buildings.  [Not leaking]</td>
</tr>
<tr>
<td>Leakage from cesium remover</td>
<td>○ Replacing pipes with those having an excellent radiation resistance performance, making piping redundant, etc.  [Not leaking]</td>
</tr>
<tr>
<td>High-concentration waste after removal of cesium</td>
<td>○ Installing buildings.  [Not leaking]</td>
</tr>
<tr>
<td></td>
<td>○ Preparing measures for volume reduction and stable storage.  [Not leaking]</td>
</tr>
<tr>
<td>Damages to tanks, etc. due to large-scale natural disasters, etc.</td>
<td>○ Establishing a system to prevent effluence to outside by such means as quick transfer of a large amount of contaminated water to buildings, etc.  [Not leaking]</td>
</tr>
</tbody>
</table>

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<Figure 2-1: Finding of risks and preventative and multilayered measures>  
(Material for the seventh meeting, the Committee on countermeasures for contaminated water treatment, September 27, 2013)
In order to strengthen the on-site cooperation and arrangements among parties concerned including the Government and TEPCO based on the “Basic Policy with Regard to Contaminated Water Issues at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company”, prepared on September 3, it has been decided to found the Intergovernmental Council for Fostering Mutual Understanding on the Contaminated Water Issue was established, which will help enhance the information sharing scheme among on-site parties and make arrangements among them. In addition, based on the “Response Policy and Concrete Action Plan towards Decommissioning and Contaminated Water Issues (determined by the Inter-Ministerial Council for Contaminated Water and Decommissioning Issues, September 10)”, it was decided and confirmed that the Intergovernmental Council for Fostering Mutual Understanding on the Contaminated Water Issue should collect every voice from the on-site parties, review and correct the measures, and find out the potential risks. Based on this, various efforts have been made.

The meetings so far held by the Intergovernmental Council for Fostering Mutual Understanding on the Contaminated Water Issue and the decisions made are as follows:

(Reference) Situation of review by Intergovernmental Council

In order to strengthen the on-site cooperation and arrangements among parties concerned including the Government and TEPCO based on the “Basic Policy with Regard to Contaminated Water Issues at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company”, prepared on September 3, it has been decided to found the Intergovernmental Council for Fostering Mutual Understanding on the Contaminated Water Issue was established, which will help enhance the information sharing scheme among on-site parties and make arrangements among them. In addition, based on the “Response Policy and Concrete Action Plan towards Decommissioning and Contaminated Water Issues (determined by the Inter-Ministerial Council for Contaminated Water and Decommissioning Issues, September 10)”, it was decided and confirmed that the Intergovernmental Council for Fostering Mutual Understanding on the Contaminated Water Issue should collect every voice from the on-site parties, review and correct the measures, and find out the potential risks. Based on this, various efforts have been made.

The meetings so far held by the Intergovernmental Council for Fostering Mutual Understanding on the Contaminated Water Issue and the decisions made are as follows:
September 9  First meeting of Intergovernmental Council for Fostering Mutual Understanding on the Contaminated Water Issue

➢ To systematically sort the predicted conceivable risks and successively report them to the Intergovernmental Council for Fostering Mutual Understanding on the Contaminated Water Issue.

➢ To use underdrain for the line-B side ditch to reduce the risk of effluence of contaminated water to the sea in case of leakage from tanks (clarifying the process and the schedule).

➢ To heighten the embankments around tanks (sorting the ideas of height of embankments and clarifying the process and the schedule).

➢ To review how to enhance the measures against leakage in the vicinity of the three tanks used to store water in the water treatment circulation line (installing embankments and making concrete foundations). To quickly carry this out based on the risk assessment and by prioritization.

October 9  Second meeting of Intergovernmental Council for Fostering Mutual Understanding on the Contaminated Water Issue

➢ To heighten the embankments around tanks and duplicate the tank embankments (enhancing the earth dikes and concreting them) (To complete construction work within FY 2013).

➢ To review changing the drainage ditch routes to the plant port.

➢ To install a new circulation line used to purify stagnant, contaminated underground water in the HTI (High Temperature Incineration for miscellaneous solid waste volume reduction) buildings, the process building, the reactor buildings and the turbine buildings and reduce the amount of contaminated water (to start operation in the middle of FY 2014).

➢ To accelerate the pace of welded-joint tank installation to double or more room (currently 15 tanks/month) until the next fiscal year. In order to replace the existent bolted-joint tanks and horizontal steel tanks, we will consider the future pace of installation of additional tanks, retain the capacity to store contaminated water, minutely review the preconditions of the amount of contaminated water and the order of tanks to be replaced, and then quickly prepare the tank replacement plan.

November 11 Third meeting of Intergovernmental Council for Fostering Mutual Understanding on the Contaminated Water Issue

➢ To install level gauges to welded-joint steel cylindrical tanks, review the policy of treatment of waste from replaced tanks, and re-evaluate the measures against lightning from the viewpoint of prevention of contaminated water leakage.

➢ In addition to heightening and duplicating the embankments, to enlarge the tanks used to temporarily store rainwater, and to review methods to pump and measure the water in a short time.

➢ To confirm the progress of the items that have already started (such as installation of tank level gauges and tank gutters).

➢ To perform management and supervision with regard to the progress of the methods to enhance the on-site management scheme.
3. Risk Assessment with Regard to Contaminated Water

(1) Grasping conditions of presence of contaminated water (locations, amount of stored water, concentrations of radioactive materials, storage forms, etc.)

In the premises of the Fukushima Daiichi Nuclear Power Station, there are various types of contaminated water with different amounts, concentrations, and forms of presence. For example, looking only at the contaminated water stored in tanks, we can find highly contaminated water with only cesium removed, water containing tritium after treated by the advanced liquid processing system (ALPS), and so forth. In addition there are various types of tanks, including the flange-type (bolted-joint type) tanks, which have had leakage, and the welded-joint tank. Correctly grasping the conditions of presence of these types of contaminated water is a precondition to evaluate the current risks, review the measures, and evaluate the risks after taking the measures.

To this end, we sorted what amount of contaminated water of what concentration was present in what condition and where in the premises of the Fukushima Daiichi Nuclear Power Station.

<Figure 3-1> shows the amount of stored water and the degree of radioactive material concentration at each location of contaminated water:

To link this basic information to the risk assessment, based on the stored water amount and the radioactive material concentration of each source of contaminated water, we sorted nuclide-by-nuclide contaminated water inventory (Bq), assumed events of occurrence of contaminated water leakage and
scenarios of effluence of contaminated water to the sea as described in (2), and made a relative evaluation ready from the frequency of leakage occurrence and the degree of impact in case of occurrence of leakage. As the conditions of presence of contaminated water is the most essential information to review and take the measures, it is required, as before, to continuously grasp and systematically sort and accumulate the information on the conditions, so that it can be used for the risk management including confirmation of the effects of measures and management of progress.

Note that there is contaminated water in part of underground in the premises after the nuclear power plant accident and in addition, there are pollutants in part of the sea in the vicinity of the premises though the radioactive material concentrations outside of the plant port and at the entrance thereof are at low levels. Therefore the groundwater and the water quality in the sea area are continuously monitored. It will be required in the future to additionally sort and accumulate these conditions grasped as such, in an easy-to-understand manner and by referring to the above descriptions.

The risks with regard to contaminated water can be grouped mainly to those of leakage of stored contaminated water and those of stringent storage capacity due to increase of contaminated water. Sections (2) and (3) below describe the reviews about the former. The latter is described in Chapter 6.

(2) Causes and probability of occurrence of contaminated water leakage events and scenarios of effluence of contaminated water to sea

It seems that the causes of occurrence of contaminated water leakage and its frequency differ depending on the conditions of presence of the water. It is assumed that the causes of occurrence of contaminated water leakage include the causes derived from facilities such as aged deterioration of and damages to the related facilities, the human factors such as human errors, and the causes by natural disasters such as earthquakes, tsunami and heavy rain. It is required to reduce the frequency of occurrence of leakage by these causes by enhancing the facilities and the management scheme. However, the risks cannot be avoided only by expecting those efforts. With regard to aged deterioration of the facilities and human errors, it is required to predict that they will occur several times a year even if preventative and multilayered measures are fully taken in order to be prepared for emergency. As to the natural disasters, we evaluated that the risks of occurrence of local heavy rain and a set of large-scale earthquake and tsunami would be, respectively, several times in some decades and several times in some centuries, which were the orders assumed in the facility plan.

In case of occurrence of contaminated water leakage, the amount of leaked water differs each time and the route of effluence to the sea also differs depending on the location of contaminated water and the conditions of presence thereof.
Therefore, the amount of radioactive materials leaked to the sea considering absorption into the soil, etc., i.e., the degree of impact on the sea differs by the assumed scenario of effluence. <Attachment 1> shows the result of sorting by the cause of occurrence, the frequency of occurrence, and the scenario of effluence to the sea.

(3) Analysis of risks of contaminated water leakage under current condition

The important factors for assessment of risks of each of the sources of pollution located in different places are the impact in case of occurrence of a leakage event and the frequency of occurrence of that event (As to the impact, we used the sum total of (1) amount of leakage, (2) concentration of nuclide, and (3) product of dose factors of each nuclide as the relative index). Even an event like a set of large-scale earthquake and tsunami that hardly occurs should be considered as a large risk if it causes leakage and the impact is very great. In addition, even an event like leakage of low-level contaminated water, the impact of which is small, should be considered as a large risk if it frequently occurs.

Accordingly, to describe the degrees of risks in an easy-to-understand manner, we created a "risk map" with regard to events of contaminated water leakage, which has the vertical axis of occurrence frequency and the horizontal axis of impact degree in case of occurrence.

<Figure 3-2> shows a risk map in the current condition:

This graph shows that the events positioned more upper right are more risky and those positioned more lower left, less risky.
4. Grasping Behaviors of Groundwater, Rainwater and So Forth

(1) Sorting measurement data related to groundwater, rainwater, etc.

As to the information on topography, geology, etc. around the Fukushima Daiichi Nuclear Power Station, necessary investigation was carried out at the time of construction and the obtained information was sorted. In the vicinity of important facilities such as the reactor buildings, in particular, they performed examination including minute boring exploration and observation of groundwater. However, part of these data is difficult to confirm mainly due to the accident. In addition, by investigation after the earthquake, enough data have not been collected in some locations due to the problems of work environment with high dose. Obtainment of enough measurement data is important to predict and evaluate the behaviors of groundwater and rainwater and thus data collection will be necessary in the future, too. As the contaminated water is increasing due to unremitting affluence of groundwater, we must take measures as soon as possible. To this end, we collected and sorted data necessary to grasp the hydrology and the geography including flow of groundwater and water cycle, though the scope was limited under various restrictive conditions.

The result of sorting of existing data is shown in <Attachment 2>.

In order to perform comprehensive reviews by fully utilizing these data after grasping the overall mechanism based on the information (data) on move of water including affluence of groundwater, penetration and affluence to the ground surface of rainwater, and the impacts of artificial operation such as pumping for purification of contaminated water, we founded the Subgroup for understanding and visualization of groundwater and rainwater behavior, which consisted of experts of groundwater flow and geology, under the Committee for intensive reviews and discussions, as described above.

- To fully collect information (data), minutely examine and sort it from the scientific and technical viewpoints, and then sort it as a technical material that can be effectively used, in order to fully utilize the existing information (data).
- To make possible efforts for investigation in order to obtain information necessary for reviews though the on-site conditions are difficult due to high dose, etc.
- To acknowledge that we have performed scientific and technical sorting and reviews in the possible scope based on the information obtained at that time even under condition where sufficient information cannot be necessarily obtained, and that we will need to enhance and accumulate information in the future, too.
- To acknowledge that we need to review the contents we sorted this time as we proceeded with enhancement, analyses and reviews of information in
(2) Sorting hydrological phenomena and geological structure

The premises of the Fukushima Daiichi Nuclear Power Station were originally a coastal terrace on the beach having an altitude of O.P. (altitude from the base level for construction work in Onahama port) +35 meters or so. However, the land was developed into a level ground having an altitude of O.P. +10 meters for construction of the power station. The strata consist of the terrace deposit (including backfill soil) around the surface and thereunder, a stratum called the Tomioka stratum, which was deposited in the Neocene Period. From the top of the Tomioka stratum, there are a middle-grained sandstone stratum (stratum I), a muddy part (stratum II), alternation of strata (stratum III), etc. Of these, the muddy part (stratum II) and the alternation of strata (stratum III) thereunder are the supporting soil of the buildings of the nuclear power station. The muddy part (stratum IV) under the alternation of strata (stratum III) contains highly permeable sandstone strata (fine-grained sandstone stratum and coarse-grained sandstone stratum) but these sandstone strata have not been disturbed by construction of the buildings.

Based on the boring data and observation of the exposed strata, it is presumed that these strata incline to the east by about two degrees to the seaside and continues to the sea area almost in parallel. It is presumed that the groundwater flowing in the middle-grained sandstone stratum (stratum I) is mainly the penetrated rainwater in the premises, that the majority of the groundwater flowing in the alternation of strata (stratum III) is mainly the penetrated rainwater in the premises but partially include groundwater flowing from outside of the premises, and that the groundwater flowing in the deeper strata including the fine-grained sandstone stratum and the coarse-grained sandstone stratum is mainly the groundwater flowing from outside of the premises.

Of these, for discussion of the contaminated water issues, we mainly consider the unconfined groundwater (groundwater flowing over the impermeable stratum closest to the surface) flowing in the middle-grained sandstone stratum where the trenches and the buildings exist in which high-concentration contaminated water exists. In addition, however, we need to pay attention to the confined groundwater (groundwater flowing in a permeable stratum between impermeable strata, the top surface of which undergoes a pressure higher than the atmospheric pressure) that flows in the alternation of strata (stratum III), which is partially connected with the unconfined groundwater in the middle-grained sandstone stratum (stratum I) due to construction work.

Radioactive materials are detected in the groundwater taken from the middle-grained sandstone stratum (stratum I) by an observation well. We are currently checking the quality of the water in the alternation of stratum (stratum III). Radioactive materials are hardly detected in the groundwater taken recently from
the alternation of stratum (stratum III) on the sea side of the buildings (as of December 9, 2013). Based on this, though further examination is necessary, it seems that the degree of contamination of the groundwater in the alternation of stratum (stratum III) is low. It also seems that the possibility of contamination of the groundwater flowing in the fine-grained sandstone stratum and the coarse-grained sandstone stratum under the alternation of stratum (stratum III) is low. In order to heighten the certainty of this judgment, we need to continuously observe the concentration of the radioactive material in the groundwater flowing in the alternation of stratum (stratum III).

In the deeper strata, there is an aquifer with groundwater that penetrates near the Futaba fault or flows from the Abukuma mountain system, etc. It is presumed, however, that this hardly affects the groundwater flowing in the middle-grained sandstone stratum (stratum I) and the alternation of strata (stratum III).

At present, the alternation of strata (stratum III) does not seem contaminated so much. However, because partial excavation to the bottom of the alternation of strata and backfill were carried out during the foundation work, we think it appropriate to prepare water shut-off until the alternation of strata (stratum III) for more safety.

Based on these existent data, new observation results, on-site investigation, etc., we sorted the hydrological phenomena and the geological structure as much as possible, including muddy hidden-layer into the middle-grained sandstone stratum (stratum I). <Figures 4-1 to 4-6> show the result of sorting of the tectonic map, etc. Note, however, that as we cannot say that the number of observations is sufficient, we need to continuously observe the groundwater level, the water head, concentrations of radioactive materials, etc. and at the same time to try to enhance observation by such means as retaining appropriate accuracy corresponding to what should be understood. To improve the accuracy of the groundwater flow analysis in the future, it is necessary to clarify the details of relationship between the muddy hidden-layer in the middle-grained sandstone stratum (stratum I) and the distribution of groundwater.
<Figure 4-1: Geological map of land area in vicinity of premises>
<Figure 4-2: Cross sections of geology of land area in vicinity of premises>

Geology legend

Land area

Sea area

Cross section

Source: Application for license of installation of nuclear reactor at Fukushima Daiichi Nuclear Power Station (Unit 6)

<Figure 4-3: Plan of geology in vicinity of premises>
### Geological age

<table>
<thead>
<tr>
<th>Geological age</th>
<th>Stratum name</th>
<th>Major lithofacies/sedimentary facies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary period</td>
<td>Alluvium</td>
<td>Dark green-gray to brown clay and sand, not solidified</td>
</tr>
<tr>
<td></td>
<td>Terrace deposit</td>
<td>Yellow-brown grit and sand, half solidified</td>
</tr>
<tr>
<td></td>
<td>Member T3</td>
<td>Sandy mudstone to mudstone, containing pumice particles and tuff</td>
</tr>
<tr>
<td></td>
<td>Tomioka stratum Member T2</td>
<td>Containing sandstone in upper part</td>
</tr>
<tr>
<td></td>
<td>Sen-Tomioka stratum Member T1</td>
<td>Graywacke, containing pumice particles and tuff</td>
</tr>
<tr>
<td>Miocene epoch</td>
<td>Tomioka stratum Member T3</td>
<td>Graywacke, containing a lot of pumice particles and tuff</td>
</tr>
<tr>
<td></td>
<td>Oligocene epoch</td>
<td>Graywacke to mudstone, containing pumice particles, scoria particles, tuff, etc.</td>
</tr>
</tbody>
</table>

### Geological age

<table>
<thead>
<tr>
<th>Geological age</th>
<th>Stratum name</th>
<th>Major lithofacies/sedimentary facies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neogene epoch</td>
<td>Sen-Tomioka stratum Stratum V</td>
<td>Mainly consisting of pelite of a thickness of approx. 50 m.</td>
</tr>
<tr>
<td></td>
<td>Member T2 of Tomioka stratum</td>
<td>Mainly consisting of pelite of a thickness of approx. 35 m.</td>
</tr>
<tr>
<td></td>
<td>Member T1 of Tomioka stratum</td>
<td>Mainly consisting of pelite of a thickness of approx. 70 to 30 m.</td>
</tr>
</tbody>
</table>

### Figure 4-4: Succession of strata around Fukushima Daiichi Nuclear Power Station

- **Stratum class**: Sedimentary facies
- **Existing information on hydrology**
  - Coefficient of permeability of middle-grained sandstone: $2.17 \times 10^{-3}$ - $4.47 \times 10^{-3}$
  - Coefficient of permeability of middle-grained sandstone: $1.33 \times 10^{-6}$ - $1.18 \times 10^{-6}$
  - Coefficient of permeability of middle-grained sandstone: $6.20 \times 10^{-4}$ - $4.40 \times 10^{-3}$

- **Middle-grained sandstone (Stratum I)**
  - Muddy part (Stratum II)
  - Alternative part (Stratum III)
  - Muddy part (Stratum IV)

- **Terrace deposit**
Cross section (3)-(3)

Histogram legend
- Landfill
- Clay/silt
- Sand
- Pebbles
- Mudstone
- Sandy mudstone
- Greywacke
- Sandstone
- Tuff
- Pumice

Geology legend
- Landfill
- Terrace deposit of Quaternary period
- Middle-grained sandstone stratum in T3 member of Tomioka stratum (Stratum I)
- Mudly part in T3 member of Tomioka stratum (Strata I, II and III)
- Alternative part in T3 member of Tomioka stratum (Stratum II)
- Fine-grained sandstone stratum in T3 member of Tomioka stratum (Stratum IV)
- Coarse-grained sandstone stratum in T3 member of Tomioka stratum (Stratum IV)
- T2 member of Tomioka stratum
- Mudstone layer contained in middle-grained sandstone
- Levels of water within hole and groundwater
- Middle-grained sandstone (Stratum I)
- Alternative stratum (Stratum I)

As of December 2013

Cross section (14)-(14)'

Horizontal: Vertical = 1:10

As of December 2013

Current analysis model
(3) Establishing a groundwater flow analysis model (Confirmation of reproducibility)

At TEPCO, they have analyzed the groundwater flow and planned and taken some measures based on the result. In the consideration so far, we focused on how to restrict the groundwater flow in the vicinity of the buildings and thus analyzed the groundwater flow within the boundary of the premises. The validity of this small area analysis has been recognized. However, in order to consider the hydrological phenomena and the geological structure we sorted this time and review preventative and multilayered measures in a wider area, we decided to greatly expand the analysis area. Note that, according to the area for which data have been available and the contents of the measures to be taken and taking into account the time for analysis, we differentiated the analysis meshes by light and dark colors and used smaller meshes in the vicinity of the buildings, etc. and larger meshes in further areas.

In the landside area, the expanded analysis area was set based on the distribution of member T3 of the Tomioka stratum (mainly in the northern area) and the distribution of alluvia rivers (hydrostatic pressure boundary conditions that allow effluence/affluence of water) (mainly in the southern area). In the seaside area, we set an area made by extending the southern and northern ends of the landside area by 2.0 km offshore in a direction orthogonal to the coastline. As to the boundary conditions of the eastern end of the seaside area, we considered whether we should further expand the analysis area offshore by comparing the analysis results of the conditions where water effluence/affluence is allowed (hydrostatic pressure boundary) and the conditions where water effluence/affluence is not allowed (impermeable boundary). Because we recognized little difference as a result, we found no necessity to expand the area more offshore and have carried out analysis under the hydrostatic pressure boundary conditions. The analysis area, the boundary conditions and the analysis conditions are shown in <Figures 4-7 to 4-9> and <Table 4-10>.

To minutely evaluate the measures such as the time necessary before manifestation of the effects, unsteady-state analyses are required. Considering the time for calculation base on the urgency of review, however, we prioritized analyses of a number of combinations of measures and thus mainly performed steady-state analyses. In the future, therefore, it is advisable to have additional reviews by steady-state analyses to further improve the maturity of reviews.
For the current analysis model, we used the area before the watershed presumed based on the topography for evaluation of measures to reduce the groundwater pressure around the buildings. However, we set a wider analyzed area for evaluation of measures for a wide area.

**Figure 4-7: Analysis area**

**Figure 4-8: Bird's-eye view of analysis model**
<Figure 4-9: Meshes and cross sectional views>
Under these analysis conditions, we compared the analysis results with the representative values of actual groundwater levels measured through the year after the earthquake. As a result, for both the unconfined groundwater (middle-grained sandstone stratum) and the confined groundwater (alternation of strata), we could reproduce the conditions before taking the measures well to some extent and find a comparatively good corresponding relationship between the actually measured values and the analyzed values as to the amount of groundwater pumped up from the sub-drains around the buildings. Based on the groundwater flow analyses using these analysis conditions, therefore, we decided to review the measures to be taken and their effects. The analyses were based on limited data of groundwater and geology for both the land and sea areas and thus it is recommended to make efforts to further improve the analysis accuracy in the future based on the newly obtained knowledge. However, we determined that the result of our groundwater flow analyses by use of these analysis conditions would be helpful to generally review the measures to be taken and their effects though it included errors to some extent.

<Figure 4-11> shows comparison between the result of groundwater flow analysis before taking measures and the actually measured data:

![Figure 4-11: Comparison between Groundwater Flow Analysis and Actual Measurement](chart.png)
Unconfined groundwater (Middle-grained sandstone stratum (Stratum I) contour)

Comparison with actually measured unconfined groundwater levels (Middle-grained sandstone stratum (Stratum I))

Pressed (Alternative stratum (Stratum III) groundwater contour)

Comparison with actually measured pressed (Alternative stratum (Stratum III)) groundwater levels

<Figure 4-11: Comparison with actually measured data>
5. Gathering Domestic and Overseas Intellects

(1) Request for information and collected proposals

In order to review preventative and multilayered measures based on the risks thoroughly found out, we broadly asked for technical information to gather domestic and overseas intellects because we had more than a few problems that had technical difficulties.

We required technical information in the following six fields: (1) Storage of contaminated water, (2) Treatment of contaminated water, (3) Purification of seawater within plant port, (4) Control of contaminated water within buildings, (5) Premise management to restrict affluence of groundwater, and (6) Understanding of behaviors of groundwater, radioactive nuclides, etc. <Table 5-1> shows the number of proposals collected to date by the field:

<Table 5-1: Proposals collected to date>

<table>
<thead>
<tr>
<th>Technical fields collected as “Proposals and advice especially needed”</th>
<th>Number of proposals</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Storage of contaminated water (storage tanks, minute leakage detection techniques, etc.)</td>
<td>206</td>
</tr>
<tr>
<td>(2) Treatment of contaminated water (tritium separation techniques, methods of long-term, stable storage of tritium, etc.)</td>
<td>182</td>
</tr>
<tr>
<td>(3) Purification of seawater within plant port (techniques to remove radioactive Cs and Sr from seawater, etc.)</td>
<td>151</td>
</tr>
<tr>
<td>(4) Control of contaminated water within buildings (techniques for water stoppage within buildings, techniques for soil stabilization, etc.)</td>
<td>107</td>
</tr>
<tr>
<td>(5) Premise management to restrict affluence of groundwater (techniques to construct water shut-off walls, facing techniques, etc.)</td>
<td>174</td>
</tr>
<tr>
<td>(6) Understanding of behaviors of groundwater, etc. (systems for measurement of data on geology and groundwater, water analysis techniques, etc.)</td>
<td>115</td>
</tr>
<tr>
<td>Others (other than items (1) to (6) above)</td>
<td>34</td>
</tr>
</tbody>
</table>

(Note 1) The fields are as applied by the proposers.
(Note 2) Some proposals are considered to relate to two or more fields.

The technical information was collected through the International Research Institute for Nuclear Decommissioning (hereinafter referred to as “IRID”) for about one month from September 25, 2013 to October 23, 2013. During this period, we received 780 proposals in total for the six fields from Japan and overseas, of which about 30% were sent from overseas.

(2) Sorting and Classifying technical proposals

The results of collection of technical information were sorted and classified by the IRID. Those proposals that were considered to relate to two or more fields were classified to the most representative, deeply related field, and based on the contents of descriptions in the forms, classified to (1) those indicating that they have been practically applied to an environment similar to that at Fukushima
Daiichi Nuclear Power Station, (2) those indicating that they have been practically applied in other fields, (3) those indicating that their principles have been established and productions have been made to some extent at a lab level, (4) those indicating that they were proposals of ideas, etc. The IRID carried out hearing from experts in the individual fields.
To consider applicability of the proposals in addition to sorting and classification by the IRID, we asked TEPCO to give us field-by-field comments.
The summary of these is shown in <Attachment 3>.

(3) Extracting applicable technical proposals

Based on the application forms of the technical proposals and the result of sorting and classification by the IRID, we at the Committee on countermeasures for contaminated water treatment reviewed the proposals.
The 780 technical proposals included various types of items, from those immediately feasible to those that would become usable after future research and development work. Obtaining many proposals with regard to contaminated water treatment, we were able to view the overall image of technologies with regard to contaminated water treatment and these proposals are important data. The Government and TEPCO should refer to these when taking future measures and we would like to thank all the parties that provided us with proposals.
Comprehensively considering the maturity of technologies, the urgency of measure taking, the applicability to the site, etc., and focusing those techniques we should immediately utilize and those we could utilize after verification to some extent, we at the Committee have prepared the following ideas from the viewpoint of necessity to take preventative and multilayered measures for contaminated water treatment:

(1) Storage of contaminated water

1) Storage of contaminated water is unavoidable even if we take measures to restrict increase of contaminated water by such means as contaminated water treatment, water stopping within buildings, and restriction of affluence of groundwater. In addition, considering that the events of leakage from tanks have occurred, improvement in reliability of the storage facilities is one of the highly prioritized measures to be taken. Like highly reliable large tanks such as double-shell steel tanks, the offered technical proposals include those satisfying the specifications such as short-term construction period, prevention of leakage, use of larger storage facilities, and seismic resistance. On completion of confirmation of on-site applicability such as means of transport, installation and inspection, we should immediately use those techniques that are feasible.
2) For long-term stable storage of contaminated water, we had many
proposals about tankers on the sea, underground storage, etc. For the time being we will proceed with addition and use of larger tanks but as preventative measures to be prepared for lack of storage capacity in the future at the worth, we will need to comprehensively review the possibility of response to legal, social and technical problems and the risks of contaminated water treatment and storage.

3) The techniques for minute leakage detection are highly prioritized measures to be taken because they will help find leakage in the early phase. However, as many of the offered technical proposals are those that are currently being developed and those for which on-site applicability should be verified, we should immediately verify such ideas as the lead-free, light-weight shielding sheet, the improvement of probes, and the individual dyestuffs, and then quickly review introduction of these proposals.

4) It is required to remove the bolted-joint tanks in parallel to replacement with tanks with higher reliability and thus, this is a highly prioritized measure to be taken. However, as it is important not to increase contaminated water due to decontamination, of the offered proposals, we should immediately and mainly verify those methods that use no water such as decontamination using super high pressure liquid nitrogen and fiber lasers, and then quickly review introduction thereof.

Items to be considered with regard to methods for long-term, stable storage of a large amount of contaminated water (examples)

The technical proposals related to contaminated water storage include many with regard to management on the sea such as use of tankers and mega-floats and underground storage. In our review of each method, we need to consider the following legal, social and technical problems:

○ Tankers on the ocean
  • Regular inspection (detailed examination every five years) and intermediate inspection (simplified examination every year for large ships) are required based on the Ship Safety Law
  • During inspection, it is required to make the tank empty and workers enter it for examination and therefore it is required to decontaminate the tank for every inspection.
  • It is required to retain tanker crewmen and facilities for protection from radioactive dose.

○ Mega-floats
  • Regular inspection (detailed examination every five years) and intermediate inspection (simplified examination every year for large ships) are required based on the Ship Safety Law
  • During inspection, it is required to make the inside empty and workers enter it for
examination and therefore it is required to decontaminate the inside of the mega-floats for every inspection.

- Measures are needed not to leak contaminated water by damages to the mega-floats due to stranding caused by tsunami.

- Underground storage
  - It is needed to consider measures to prevent leakage and methods to detect leakage.

(2) Contaminated water treatment

1) We are planning to accelerate contaminated water treatment by addition of the advanced liquid processing systems (including high-performance facilities) but they cannot separate tritium. So far, we could not find any effective method to separate tritium. We have had many technical proposals related to tritium separation. As it is necessary to check the efficiencies, etc., however, we should collect and sort existing intellects in addition to the techniques for tritiated water storage, and evaluate the treatment performances and cost effectiveness of the proposals including the CECE method, the freeze concentration method and the hydration.

2) On the other hand, we were provided with many technical proposals saying that we should perform comprehensive evaluation of the risks of continuous storage of Tritiated water, for example by comparison with the risks of other options such as discharge to the environment. We should make efforts for comprehensive evaluation to consider the methods of tritium treatment in the future.

(3) Purification of seawater within plant port

1) At present, the concentrations of the radioactive materials outside of the plant port and at the entrance thereof are low. However, in some areas in front of the intake channels of units 1 to 4, the concentrations do not go lower than an extent. Therefore, we should immediately introduce those methods that can easily be introduced such as contamination preventing membranes only after simple verification without waiting for the result of more accurate effectiveness verification.

2) On the other hand, we were provided with many technical proposals of methods of deposition, absorption, separation, etc. However, no proposal described that it could remove only the radioactive materials and for many techniques, on-site applicability could not be checked. So we should choose those techniques the results of which have been checked at a lab level and should perform evaluations, etc. prior to review of introduction thereof.
(4) Control of contaminated water within buildings

1) Water stopping within and around the buildings is highly prioritized from the viewpoints of “not to bring” water near the contamination sources and “not to leak” contaminated water. The given technical proposals include organic and inorganic materials, filling materials and injection materials, which have actually used in Japan and overseas. We should use these proposals after review of on-site applicability.

2) Note, however, that because we need to choose appropriate methods taking into consideration the on-site conditions of the Fukushima Daiichi Nuclear Power Station, we should review them by advance tests, etc. In addition, as difficulties are expected in selection of appropriate materials under the environment where there are various restrictions, we should consider introduction of necessary test facilities to the site.

3) As to the methods to lower the exposure doses, we had proposals about use of underground space, unmanned execution, etc. Not all of these methods have been used under high doses and thus we need to perform experimental construction while avoiding use of the areas the underground condition of which we do not fully understand and the areas having complex structures, and check their applicability prior to expanding the construction area.

(5) Premise management to restrict affluence of groundwater

1) As to restriction of groundwater affluence, we were provided with many proposals of installation of new impermeable walls as multilayered measures to be added to the frozen soil walls or as alternative measures in place of the frozen soil walls. They do not necessarily indicate where the impermeable walls be installed but many of them propose that the walls be placed outside of the impermeable walls or around the premises. As to the construction methods, some proposals recommend continuous walls of concrete, steel or clay, and grout injection.

2) Some proposals recommend installation of walls, trenches, tunnels, etc. around the premises to restrict groundwater affluence into the premises. In addition, we had a proposal that we should have premise facing as a measure to restrict rainwater penetration.

3) These measures are likely to be useful as multilayered measures in case where the measures for groundwater affluence restriction that are taken or planned to be taken do not sufficiently function. Therefore, we should review these measures after analyzing behaviors of groundwater, rainwater, etc. and understanding the effects and problems we will have
when carrying out one of these measures and some of them in combination.

4) Many technical proposals include construction methods and materials that have been actually used in Japan and overseas and thus we should consider how to select and utilize appropriate methods. As to the facing methods, some construction methods such as concrete and asphalt have been actually used. Considering restrictions including complex topography, however, some proposals recommend use of lining materials such as spraying. As these construction methods have not necessarily been actually used under high doses, we should evaluate them prior to consideration of application to the site.

5) As to collection of radioactive strontium in soil, we had various proposals including use of organic and inorganic materials and microbes. We also had technical proposals about permeable walls, etc., which we can expect to use near the plant port. We should evaluate them, including evaluation with regard to measures against waste, prior to consideration of application to the site.

(6) Understanding of behaviors of groundwater, etc.

1) As the techniques to understand behaviors of groundwater, etc., we were provided with many proposals with regard to data collection, water quality analyses, techniques to install observation holes, analyses of groundwater flow and nuclide transfer, etc.

2) We at the Committee on countermeasures for contaminated water treatment also prioritize understanding of behaviors of groundwater, etc. and thus have reviewed it by founding a subgroup. However, the review was carried out within a scope of information limitedly obtained under restricted on-site conditions due to such difficulties as high doses. In the future, therefore, it will be recommended to enhance observation by arranging the observation network and collect and analyze further temporal and spatial data in an attempt to improve the accuracy.

3) The proposed techniques include many of those that are helpful towards future improvement of accuracy. As we listed the techniques we thought helpful, we expect them to be appropriately utilized in accordance with the examination objectives. This list of techniques is shown in <Attachment 4>.
Major techniques, etc. that should be newly utilized based on the technique collection of this time

(1) Techniques that should immediately be utilized after confirmation of on-site applicability:
   - Large and reliable tanks, etc. including double-shell steel tanks
   - Light-weight shielding sheets that do not use lead
   - Contamination preventing membranes (silt fence, etc.)
   - Water stopping techniques (Water stopping within and around buildings)
   - Arranging network for examination and observation of geology and groundwater

(2) Techniques that should be utilized after selection of application methods based on workability and cost effectiveness:
   - Techniques for measures for water stopping (facing, water stopping, etc.)

(3) Techniques that are expected effective but need confirmation and verification prior to utilization:
   - Techniques to detect minute leakage (including dyestuffs)
   - Techniques to decontaminate tanks without water
   - Techniques to store and separate tritiated water
   - Techniques to purify seawater within plant port
   - Techniques to collect strontium in soil
   - Techniques for unmanned boring
   * We will arrange a scheme to support confirmation and verification in accordance with the details of confirmation and verification of each technique.

(4) Measures to be taken based on reviews by the Committee on countermeasures for contaminated water treatment, etc.:
   - Comprehensive evaluation of handling of tritiated water
   - Consideration of measures to be taken to solve problems with regard to tankers, underground storage, etc.
6. Overview of the Measures Based on Groundwater Flow Analysis and Risk Assessment

(1) Plan for reviewing an overview of the countermeasures against contaminated water treatment

The countermeasures against contaminated water treatment are broadly separated into basic three categories: “removing” contamination sources, “Isolating” water from the contamination sources, and “Preventing” leakage of contaminated water, and there are several ways for each countermeasure. Considering restrictions regarding time, human, budget, and site (e.g. workspaces), it is difficult to start and complete all possible countermeasures simultaneously. As a result, there is a need to optimize a combination of countermeasures and its implementation time taking the priority of each countermeasure into consideration.

However, the countermeasures—“Removing” contamination sources, “Isolating” water from the contamination sources, and “Preventing” leakage of contaminated water—have a different aim respectively as well as are different in approach for hard countermeasures such as maintaining facilities and for soft countermeasures such as reinforcing patrols. Therefore, it is difficult to organize all countermeasures by using identical index and idea. As the result, we organized the idea about priority, combination of countermeasures, implementation time, etc. for each category of countermeasures, and then proceeded with the investigation.

(2) Countermeasure for “removing” contaminated water

The countermeasure for removing contamination sources is important as a drastic measure for contaminated water treatment and can be divided into “Removal” and “Purification.” We studied the priority for each “Removal” and “Purification” in consideration of a relative index which shows the level of risk reduction.

For the priority of the removal measure, the pumping up and blocking of the high concentration contaminated water inside a trench on the sea-side of the building have the highest priority, and the collecting of contaminated soil leakage and pumping up of the contaminated water around the tank where leakage was detected have the second highest priority. Especially the former is, as a risk map shown in Figure 3-2 shows, now a major risk factor and shall immediately be taken.

For the priority of the purification measure, the purifying contaminated water through multi-nuclide removal equipment and accelerating contamination cleaning through equipment extensions as well as the introducing multi-nuclide removal equipment have higher processing efficiency, and the high concentration contaminated water inside a trench on the sea-side of the building have the
highest priority and shall immediately be taken. In addition to the above, the purification of the high concentration contaminated water in buildings shall be taken. For preventing the outflow of groundwater contaminated by water leaked from tanks (injecting agents and capturing strontium contained in the soil) and for cleaning sea water inside the plant port through water deposition, adsorption, separation and the like, we should handle the measures after verifying the effectiveness. In parallel with such verification, the following countermeasures for preventing the proliferation of radioactive substances should be taken: purification of sea water inside the plant port using simple facilities (contamination preventing membrane, etc.), covering marine soil inside the plant port, etc.

(3) Countermeasures for "isolating" water from contamination sources, and for “preventing leakage” of contaminated water (that have influence on the flow of groundwater)

The measures for isolating water from contamination source are integrated with the measures that effect on groundwater floating among measures for preventing leakage of contaminated water. The effects when each measure is executed individually are determined using the model given in chapter 4. Furthermore, the individual effects and effects by combining several measures are determined from the inflow amount to buildings and outflow amount into the sea and the results are used as one of indicators for determining priority. When considering the effect of a combination of the multiple countermeasures, the conditions for the combination have been set for some scenarios (risk that part of measures to be reviewed may work poorly, etc.) from the point of view of preventive and multi-layered measures. Over fifty analysis cases were performed, and main analysis cases and their results are shown in <Table 6-1>.

Note that groundwater drain for the impermeable walls on the sea-side in <Table 6-1> refers to the effect subject to the operation of the groundwater drains (water pumping facility around the shore protection; the same shall apply hereinafter). For the groundwater bypassing and sub-drains, it must be noted that the effects depend on the operating condition, etc. Other analysis cases are shown in <Attachment 5>.

From the result of this study, it was confirmed that a large amount of inflow into the buildings (that are contamination source) can be substantially reduced if only the countermeasures already determined to be implemented (measures with O.P. +4m board, groundwater bypassing, impermeable walls on the sea-side, sub-drains, and land-side impermeable walls) are fully worked.
<table>
<thead>
<tr>
<th>Case</th>
<th>4m board countermeasures</th>
<th>Groundwater bypass</th>
<th>Sea-side impermeable walls</th>
<th>Mountain-side SD</th>
<th>Land-side SD</th>
<th>Facing</th>
<th>Mountain-side impermeable walls</th>
<th>Pumping up volume details (ton/day)</th>
<th>Groundwater bypassing</th>
<th>Sub-drain</th>
<th>Groundwater drain / Note 2</th>
</tr>
</thead>
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<tr>
<td>No measures</td>
<td></td>
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<td>Case 17-2</td>
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</table>

**Note 1:** The "outflow amount of contaminated water into the sea" means the outflow in the areas of Unit 1-4 buildings.

**Note 2:** The "pumping up volume" is the inflow volume into buildings plus the pumping up volume from groundwater bypassing/Sub-drain (SD), etc.

**Note 3:** The "pumping up volume" is the inflow volume into buildings plus the pumping up volume from groundwater bypassing/Sub-drain (SD), etc.

**Note 4:** For Sea-side impermeable walls, the effect assuming operation of groundwater drain is listed.

**Note 5:** The "Groundwater drain" means "water pumping facility around the shore protection".

**Note 6:** The "pumping up volume" is the inflow volume into buildings plus the pumping up volume from groundwater bypassing/Sub-drain (SD), etc.

**Note 7:** Upper cells of Groundwater bypassing refer to the minimum cases where inflow to buildings is suppressed, and middle cells refer to cases where pumping up to alternation strata is executed, as well as lower cells refer to the maximum cases where additional wells are added to medium-grained sandstone strata.
For the above determined countermeasures, the measures with O.P. +4m board and impermeable walls on the sea-side, which already implemented, are capable of substantially reducing the outflow amount of contaminated water to the sea and essential as countermeasures for preventing leakage of contaminated water.

In addition, since the land-side impermeable walls and sub-drains produce extensive effects to reduce the inflow amount of contaminated water to the building, we confirmed those countermeasures are important as a measure for isolating water from contamination source (from case 4, 5, and 6). However, this means the countermeasures for suppressing inflow of groundwater may work poorly if the land-side impermeable walls and sub-drains do not adequately function or are stopped in the future.

To take preventive and multi-layered measures, we should consider countermeasures by assuming the case where the land-side impermeable walls or the sub-drains do not work. We considered the additional countermeasures for that case, and confirmed that the effects of the water shut-off (impermeable walls, bypass, etc.) around the premise boundary area can hardly be expected (from case 9). On the other hand, we confirmed that the “Surface water shut-off through wide-area facing” for the water shut-off within the premise has a large effect, but the “Surface water shut-off through partial-area facing” has limited effect on some working areas (from case 7, 7-2 and 8). Also, we confirmed that implementing “Additional water shut-off and its inside facing” allows us to achieve the same effects as that of wide-are facing (from case 7-2 and 8-2).

For facing, however, it has turned out that facing has a tendency to require a long time until it exhibits an effect from the non-stationary groundwater flow analysis results, but the details need to be further studied. Therefore, the building vicinity countermeasures including the land-side impermeable walls may have advantages from the viewpoint of an earlier onset of effect.

Although facing allows for controlling the deep percolation of rainfall, it may involve the following risks:

1) Increasing of flow rate and outlet velocity of surface water,
2) The need for water pouring should be higher due to a water level control inside and outside buildings.

As the results, required measures have to be taken.

1) To treat adequately surface water, the water quality of drainage ditch network should be monitored, while paying attention to prevent any rainwater from being mixed with contaminated water by (1) setting the outflow amount with occurring of heavy rain and changing of outflow form in mind, (2) planning the drainage network and drainage ditches having cross-sections which can satisfactorily correspond to the outflow, with the possibility of occurrence of outflow whose amount surpasses the setting outflow amount, (3) setting appropriately the overflow route from the drainage ditches in case of unexpected flow rates, etc.
Additionally, 2) the facility planning and groundwater observation should be adequately done to ensure the smooth conduct of water level control for inside and outside of the building.

To implement the additional water shut-off and its inside facing, required measures should be taken in consideration that the interference with other elements such as underground embedded objects and other construction works may be produced if the need for pouring water into the inside and outside of the building should be higher.

The above mentioned evaluation study is the results at present mainly of steady-state analysis based on the model configured on the basis of restricted information and is expected to be enhanced in future.

In addition to the above final effect derived from the steady-state groundwater flow analysis, the effect should be comprehensively evaluated base on various indexes such as the time it takes for the effect to work, the difficulty (easiness) for implementing the countermeasures, water level controls inside and outside the buildings, the presence or the absence of generation of new water accompanied with the execution of countermeasures, impact on other countermeasures, and mutual connections among countermeasures.

For example, as mentioned previously, though the wide-area facing has a significant effect, it takes a long time to exhibit effects. Therefore, using wide-area facing independently may not produce immediate effects, but is expected to take a supplemental role for other preceding countermeasures.

The land-side frozen soil impermeable walls and sub-drains to be implemented around buildings have a profound effect and have an early effect development time. However, those countermeasures have great technical and social difficulties in implementation, and there is high risk when we adopt only either one. We can reduce the risk by implementing them concurrently so as to mutually complement each other.

That is to say, in addition to accelerating the existing countermeasures with a combination of the existing land-side impermeable walls, groundwater bypassing, sub-drain, etc., additional implementation of “wide-area facing” or “Additional water shut-off and its inside facing” (it may take time but may be effective) as multi-layered measures may be effective.

While taking the above mentioned points into considerations, it is important to examine further other indexes for taking multi-layered countermeasures based on a comprehensive evaluation.

It is required to promote the countermeasures for decommissioning by implementing the water stopping of the building (through holes on the exterior wall of buildings, gaps between buildings, and around buildings) while implementing the above existing countermeasures and additional countermeasures to prevent the groundwater flow into the building.
(4) Countermeasures for “preventing leakage” of contaminated water
(that have no influence on the flow of groundwater)

Among the countermeasures for “preventing leakage” of contaminated water, the
countermeasures such as localized one that have no influence on the flow of
groundwater of the whole site were reviewed for its priority by estimating the
effects of each countermeasure (the degree of risk reduction), etc.
The following measures have the highest priority and shall immediately be taken:
Replacing bolt-joint tanks and steel horizontal tanks with welded-joint tanks.
Increasing the height of duplicate the embankment. Realizing drainage ditches
using underdrain and changing its route to the plant port. Taking measures
against water leakage at the bottom of bolt-joint tanks. Preparing
countermeasures against tsunami (measures for improving the water resistance
of buildings), Controlling the water level in buildings for groundwater level lowering
(installation of drainage pumps on the deep part of the nuclear reactor building,
etc.). After that, decreasing contaminated water accumulated in the HTI buildings
and process buildings, reducing contaminated water transport loop, changing to a
safer piping route, replacing pipes with ones that excellent in radiation-resistant,
etc. should be implemented sequentially.
The implementation of countermeasures against tsunami (additional measures
such as construction of breakwaters, etc.) as well as of the configuration of the
system to prevent an outflow into the oceans at the time of a large volume of
contaminated water leakage are should be considered after surveying and
reviewing those options.

(5) Countermeasure to “preventing leakage” of contaminated water
(ensuring of tank capacity)

To prevent the occurrence of situations that contaminated water cannot be stored
due to a shortage of storage tanks, etc., the countermeasures such as those to
accelerate installation of additional contaminated water storage tanks should be
immediately implemented.
According to TEPCO’s announcements in October this year on their plan of
installing additional accumulated water storage tanks, storage capacity of the
water processed by the water treatment facilities (As of October 29 this year) is
about 370,000 cubic meters and the capacity of the tanks are about 410,000 cubic
meters. After December 2013, additional tanks are to be installed sequentially on
J1, J2, and J3 areas on the south side of the site to realize about 15 tanks per
month (15,000 cubic meters) in FY2013. Furthermore, they plan to speed up the
pace of the installation of additional tanks after FY 2014 to increase the total
capacity up to about 800,000 cubic meters by the end of FY2015.
In this plan, the balance between tank capacity and the contaminated water
storing quantity is evaluated for the following four cases:
Groundwater bypassing | Sub-drain | Rainwater | Groundwater drain
---|---|---|---
1) Performed Pumping up | Drainage | Drainage | Drainage
2) Performed Pumping | Drainage | Water reservoir | Water reservoir
3) Not performed | Not performed | Drainage | Water reservoir
4) Performed Pumping | Water reservoir | Water reservoir | Water reservoir

As shown in Figure 6-2, the tanks have sufficient capacity in the case of (1) (where facility such as groundwater bypass, sub-drains, and groundwater drain are work) while the tanks have no spare capacity in the case of (2) (where water from the groundwater drain cannot be discharged) as shown in Figure 6-3. Furthermore, as shown in Figure 6-4, the capacity of the tanks gets deficient (where both groundwater bypassing and sub-drain do not work) and the storage capacity could run out by around April 2015.

For the case (4) in Figure 6-5, it shows that the free space capacity of the tanks becomes smaller because rainwater cannot be discharged, in addition to the case (2).

As seen above, at this point, by taking some strict conditions including the above the four cases into account, the risk that the capacity of the contaminated water storage might become tight cannot be eliminated, and it is required to suppress an increase of contaminated water to a minimum. Therefore, the acceleration of the existing countermeasures including the land-side impermeable walls, sub-drains, and groundwater bypassing (as the countermeasures for suppressing inflow of groundwater that have a profound effect and have an early effect development time) is thought to be important.

However, the efforts to review tritium processing technologies and to comprehensively evaluate the risk of tritiated water are important because the balance between the capacity of the tanks and the required storage amount of contaminated water is closely related to not only the facility operation plan, but also the treatment and storage of tritium. Considering the relationship between current additional tank installation plan and the required storage amount, the tank capacity may not occur during FY 2014. However, the tank capacity level will reach its maximum earlier in the case to ensure that the tanks have a margin in their water level by considering the risk of sloshing at the time of earthquake. Therefore, it is required to identify the risks in the quickest time period in FY 2014 and then to enable the additional countermeasures to be taken as needed.
Case 1 (Groundwater bypassing, Sub-drain pumping, Rainwater drainage, Groundwater drainage)

*Evaluation condition
- Operation of groundwater bypassing November 2013 - 
- Operation of sub-drain October 2014 - 
- Operation of multi-nuclide removal equipment having higher processing efficiency October 2014 - 
- Operation of Additional multi-nuclide removal equipment October 2014 - 
- Groundwater inflow suppressing effect by land-side impermeable walls (It refers to the period that the measure exhibits a significant effect after starting operation) September 2015 -

*Quoted from "Plan of installing additional accumulated water storage tanks at Units 1-4 of Fukushima Daiichi Nuclear Power Station (As of October 2013)" (October 31, 2013/TEPCO)

<Figure 6-2: Additional tank installment plan (case 1)>

Case 2 (Groundwater bypassing, Sub-drain pumping, Rainwater drainage, Groundwater drain storage)

*Evaluation condition
- Operation of groundwater bypassing November 2013 - 
- Operation of sub-drain October 2014 - 
- Operation of multi-nuclide removal equipment having higher processing efficiency October 2014 - 
- Operation of Additional multi-nuclide removal equipment October 2014 - 
- Groundwater inflow suppressing effect by land-side impermeable walls (It refers to the period that the measure exhibits a significant effect after starting operation) September 2015 -

*Quoted from "Plan of installing additional accumulated water storage tanks at Units 1-4 of Fukushima Daiichi Nuclear Power Station (As of October 2013)" (October 31, 2013/TEPCO)

<Figure 6-3: Additional tank installment plan (case 2)>
For soft countermeasures such as reinforcing patrols, it is an issue to be reviewed according to the on-site management systems, and we (as committee members) urge the TEPCO to develop and disseminate the appropriate management policy and operation manual, etc.
(6) Overview of preventive and multi-layered measures (execution schedule)

A brief overview of each measure is given in <Appendix 6> and a list of all measures is given in <Table 6-6>. It also includes information about technologies which can be used immediately considering public recruitment of technology and those which require confirmation and verification in utilizing them.

<Table 6-6: List of measures>

<table>
<thead>
<tr>
<th>No.</th>
<th>Countermeasure items</th>
<th>Countermeasures</th>
<th>Status and plans of efforts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Existing countermeasures</td>
<td>Pumping up and blocking the high concentration contaminated water inside trenches on the sea-side of the building</td>
<td>The preparatory work related to the pumping up and blocking of contaminated water was started in October this year. The work related to frozen water stoppings was started in December. Drainage will be started in April 2014. Blocking work will be started in July 2014 and completed in March 2015.</td>
</tr>
<tr>
<td>2</td>
<td>Existing countermeasures</td>
<td>Purifying the high concentration contaminated water inside trenches on the sea-side of the building</td>
<td>Purifying contaminated water was started in November this year. The operation periods are to be determined based on the concentration in the trench.</td>
</tr>
<tr>
<td>3</td>
<td>Existing countermeasures</td>
<td>Collecting contaminated soil and pumping up contaminated water around the tank where leakage was detected</td>
<td>Collecting contaminated soil was started in September this year. Pumping up contaminated water was started in November.</td>
</tr>
<tr>
<td>4</td>
<td>Existing countermeasures</td>
<td>Purifying contaminated water with multi-nuclide removal equipment (ALPS)</td>
<td>Purifying contaminated water with multi-nuclide removal equipment (ALPS) is underway.</td>
</tr>
<tr>
<td>5</td>
<td>Existing countermeasures</td>
<td>Purifying contaminated water and reducing the waste volume with the multi-nuclide removal equipment having higher processing efficiency</td>
<td>The demonstration project will be implemented and the operation will be started during 2014.</td>
</tr>
<tr>
<td>6</td>
<td>Multi-layered measures</td>
<td>Acceleration of purifying contaminated water by additional installment of multi-nuclide removal equipment (ALPS)</td>
<td>Preparation related to the introduction is underway. The operation will be started in the middle of FY2014.</td>
</tr>
<tr>
<td>7</td>
<td>Multi-layered measures</td>
<td>Preventing outflow of contaminated groundwater occurred by water leaked from tanks into the sea (injecting agents, capturing strontium contained in the soil, etc.).</td>
<td>This countermeasure will be performed after the technologies for capturing strontium contained in the soil are reviewed and verified, and their effectiveness is proven.</td>
</tr>
<tr>
<td>8</td>
<td>Multi-layered measures</td>
<td>Cleaning sea water inside the plant port by water deposition, adsorption, separation and the like</td>
<td>This will be implemented after the verification of technologies related to purification is performed and their effectiveness is proven.</td>
</tr>
<tr>
<td>9</td>
<td>Multi-layered measures</td>
<td>Purifying sea water inside the plant port using simple facilities (contamination preventing membrane, etc.)</td>
<td>Purification using contamination preventing membranes that can adsorb radioactive material, and other methods should be immediately implemented.</td>
</tr>
<tr>
<td>10</td>
<td>Multi-layered measures</td>
<td>Covering marine soil inside the plant port</td>
<td>A concrete implementing method and others related to the covering marine soil will be reviewed and started as soon as possible.</td>
</tr>
<tr>
<td>11</td>
<td>Preventative measures</td>
<td>Purifying high concentration contaminated water inside the buildings</td>
<td>Installing pipelines, which return contaminated water after cesium removal to the turbine building and process building, and then purify contaminated water with the margin of water treatment capacity. It is planned that the configuration line design will be completed in FY2013 and piping work will be completed in the first semester of FY2014.</td>
</tr>
<tr>
<td>No.</td>
<td>Countermeasure items</td>
<td>Countermeasures</td>
<td>Status and plans of efforts</td>
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<tr>
<td>12</td>
<td>Existing countermeasures</td>
<td>Installing land-side frozen soil impermeable walls around buildings.</td>
<td>A demonstration project for land-side impermeable walls will be started and completed within the current fiscal year. The operation will be started within FY 2014.</td>
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<tr>
<td>13</td>
<td>Existing countermeasures</td>
<td>Pumping up groundwater from wells near building (sub-drain)</td>
<td>Restoration work for sub-drain pits is in operation. The sub-drain purification facility will be completed in September 2014.</td>
</tr>
<tr>
<td>14</td>
<td>Existing countermeasures</td>
<td>Pumping up groundwater on the mountain side of the buildings (Groundwater bypassing)</td>
<td>Installation work of groundwater bypassing will be completed in March this year. To commence operations as early as possible.</td>
</tr>
<tr>
<td>15</td>
<td>Existing countermeasures</td>
<td>Paving the ground surface in the contaminated area on the sea-side of the building (with asphalt etc.)</td>
<td>The paving work will be completed in March 2014.</td>
</tr>
<tr>
<td>16</td>
<td>Multi-layered measures</td>
<td>Installing gutters at top of tanks</td>
<td>Installing tanks in highly-dosed area will be completed in December in this year. Installing tanks in other areas will be completed in March next year.</td>
</tr>
<tr>
<td>17</td>
<td>Multi-layered measures</td>
<td>Additional countermeasures for suppressing inflow of groundwater (&quot;Wide-are facing (surface water shut-off)&quot; or &quot;Additional water shut-off and its inside facing&quot;)</td>
<td>The method of this countermeasure should be determined as soon as possible, as multi-layered measures added to land-side impermeable walls, sub-drain, etc. The approaches with consideration given to work environment improvement by reducing the dose (through surface decontamination, etc.) as well as the proper treatment method for waste generated with decontamination will be examined when executing countermeasures.</td>
</tr>
<tr>
<td>No.</td>
<td>Countermeasure items</td>
<td>Countermeasures</td>
<td>Status and plans of efforts</td>
</tr>
<tr>
<td>-----</td>
<td>---------------------------</td>
<td>-----------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>18</td>
<td>Existing countermeasures</td>
<td>Installing sea-side impermeable walls in the plant port.</td>
<td>The work will be completed in September 2014.</td>
</tr>
<tr>
<td>19</td>
<td>Existing countermeasures</td>
<td>Implementing ground improvement (using sodium silicate etc.) for the shore protection of the contaminated areas in the sea-side to the buildings/Pumping up contaminated water from contaminated areas</td>
<td>Sodium silicate is already being installed in the sea-side areas between Unit 1 buildings and Unit 2 buildings, and the pumping is also in operation. Sodium silicate between in the sea-side areas between Unit 2 buildings and Unit 3 buildings as well as Unit 3 buildings and Unit 4 buildings will be completed by the end of December 2013. For the side portion (along the screen pump room), it will be completed in March 2014. For other areas, TEPCO is confirming those contaminated sources.</td>
</tr>
<tr>
<td>20</td>
<td>Multi-layered measures</td>
<td>Ground improvement on the north side area of Unit 1 water intake</td>
<td>Groundwater observation holes (five pcs) will be installed by December this year. The range of ground improvement and others will be determined according to the cause.</td>
</tr>
<tr>
<td>21</td>
<td>Existing countermeasures</td>
<td>Installing further contaminated water storage tanks</td>
<td>The capacity of storage tanks will be increased to 800,000 tons by the end of FY2015.</td>
</tr>
<tr>
<td>22</td>
<td>Existing countermeasures</td>
<td>Replacing steel horizontal tanks</td>
<td>The replacements are to be started based on the replacing priority as early as possible.</td>
</tr>
<tr>
<td>23</td>
<td>Existing countermeasures</td>
<td>Accelerating the replacement from bolt-joint tanks to welded-jointed tanks</td>
<td>This will be started as soon as TEPCO gets ready.</td>
</tr>
<tr>
<td>24</td>
<td>Existing countermeasures</td>
<td>Reinforcing patrols related to tanks and piping</td>
<td>Patrols have been reinforced.</td>
</tr>
<tr>
<td>25</td>
<td>Existing countermeasures</td>
<td>Installing level gauge (flange die) will be completed by November in this year, and installing on the steel cylindrical tank (welding end) will be completed by February FY 2014.</td>
<td>Installing level gauge on the steel cylindrical tank (flange die) will be completed by November in this year, and installing on the steel cylindrical tank (welding end) will be completed by February FY 2014.</td>
</tr>
<tr>
<td>26</td>
<td>Multi-layered measures</td>
<td>Detecting minute leakage from tanks</td>
<td>TEPCO will implement the detection if the effectiveness is proven after confirming and verifying technologies for detecting minute leakage.</td>
</tr>
<tr>
<td>27</td>
<td>Multi-layered measures</td>
<td>Accelerating the installation of welded-joint tanks and employing reliable large tanks such as double-shell steel tanks</td>
<td>The schedule will be moved forward and those are to be implemented as early as possible.</td>
</tr>
<tr>
<td>28</td>
<td>Multi-layered measures</td>
<td>Decontaminating used tanks associated with tank replacement</td>
<td>TEPCO will implement the decontamination if the effectiveness is proven after verifying the decontamination technology.</td>
</tr>
<tr>
<td>29</td>
<td>Multi-layered measures</td>
<td>Increasing height of and duplicating the tank embankment</td>
<td>The installation work will be completed in March 2014.</td>
</tr>
<tr>
<td>30</td>
<td>Multi-layered measures</td>
<td>Measures against water leakage at the bottom of bolt-joint tanks</td>
<td>The measures will be started as early as possible.</td>
</tr>
<tr>
<td>31</td>
<td>Multi-layered measures</td>
<td>Using underdrains for drainage ditches</td>
<td>Underdrains are already used for the drainage ditch C line. The drainage ditch B line using underdrain will be completed in December in this year.</td>
</tr>
<tr>
<td>No.</td>
<td>Countermeasure items</td>
<td>Countermeasures</td>
<td>Status and plans of efforts</td>
</tr>
<tr>
<td>-----</td>
<td>----------------------</td>
<td>-----------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>32</td>
<td>Multi-layered measures</td>
<td>Changing its route to the plant port of drainage ditches</td>
<td>The route change work will be completed in March 2014.</td>
</tr>
<tr>
<td>33</td>
<td>Preventative measures</td>
<td>Configuring a system to prevent an <strong>outflow into the oceans</strong> at the time of a large volume of contaminated water leakage</td>
<td>The concrete implementation methods will be reviewed and then executed sequentially.</td>
</tr>
<tr>
<td>34</td>
<td>Preventative measures</td>
<td>Measures against large-scale tsunami (improving the water proofness of buildings and considering additional measures including breakwaters)</td>
<td>Building water proofness measures will completed in the second semester of FY2014. The additional measures including breakwaters will be reviewed.</td>
</tr>
<tr>
<td>35</td>
<td>Preventative measures</td>
<td>Controlling water level in buildings for groundwater level lowering (install drainage pumps on the deep part of the nuclear reactor building, etc.)</td>
<td>Pumps will be installed in the deep parts of building at the time of installation of land-side impermeable walls.</td>
</tr>
<tr>
<td>36</td>
<td>Preventative measures</td>
<td>Decreasing contaminated water accumulated in the HTI buildings and process buildings</td>
<td>The configuration line design will be completed in FY2013 and piping work will be completed in the first semester of FY2014. After that, pumping of convention water in buildings will be performed accordingly to the water level of storage tanks.</td>
</tr>
<tr>
<td>37</td>
<td>Preventative measures</td>
<td>Reducing contaminated water transport loop (circulation in buildings)</td>
<td>The construction work of the circulation in buildings, where the loop is reduced by transferring contaminated water in each building directly into the contaminated water treatment facilities, will be completed by the end of FY 2014.</td>
</tr>
<tr>
<td>38</td>
<td>Preventative measures</td>
<td>Water stopping for the buildings (through hole on exterior wall of buildings, gaps between buildings, and around buildings)</td>
<td>The water stopping for the through holes on the exterior wall of Unit 1 and HTI building will be completed in March 2014. For water stopping method, the technologies to be adopted will be selected and implemented after confirming the leakage parts. The measures to prevent leakage from spreading outside the system in the event of leakage from the cesium removing apparatus after the process buildings and HTI buildings are dried up will be implemented.</td>
</tr>
<tr>
<td>39</td>
<td>Preventative measures</td>
<td>Changing to a safer piping route / Replacing pipes with ones that excellent in radiation-resistant</td>
<td>The works for changing to a safer piping route will be completed in January 2014. Pressure hoses will be replaced with polyethylene tubes sequentially.</td>
</tr>
<tr>
<td>40</td>
<td>Multi-layered measures</td>
<td>Measures to prevent waste leakage from high performance container (HIC) as well as volume reduction/stable storage</td>
<td>For HIC storage facility, it is under operation by closing embankment for HIC carry-in entrance. Measures against leakage will be implemented sequentially after reviewing their methods. The volume reduction/stable storage will be investigated and reviewed as long-term issues, and the measures will be designed.</td>
</tr>
<tr>
<td>41</td>
<td>Preventative measures</td>
<td>Measures to prevent waste leakage from cesium adsorption tower as well as volume reduction/stable storage</td>
<td>Measures against leakage will be implemented sequentially after reviewing their methods. The volume reduction/stable storage will be investigated and reviewed as long-term issues, and the measures will be designed.</td>
</tr>
</tbody>
</table>
Countermeasures that have been added as preventative and multi-layered measures include:

(1) Further multi-layered measure capable of dealing with the risks in case of troubles in the existing measures
   1) Measure for suppressing inflow of groundwater [Isolating]
      • Additional countermeasures: additional measures for suppressing inflow to groundwater ("Wide-are facing (surface water shut-off)"
         or "Additional water shut-off and its inside facing")
         * The approaches with consideration given to work environment improvement by reducing dose (through surface decontamination, etc.),
           as well as the proper treatment method for waste generated with decontamination will be examined when executing countermeasures.
      • Existing measures: land-side impermeable walls, pumping up groundwater from sub-drains, pumping via groundwater bypassing, etc.
   2) Measures against contaminated water stored in tanks and the like. [Removing] [Preventing leakage]
      • Additional measures: increasing height of and duplicating the tank embankment
         Using underdrains for drainage ditches, Changing the drainage ditch route to the plant port
         Capturing strontium contained in the soil
         Accelerating the installation of welded-joint tanks and employing reliable large tanks such as double-shell steel tanks
         Detecting minute leakage from tanks, etc.
      • Existing measures: purifying contaminated water with multi-nuclide removal equipment
         Introducing of purifying equipment having higher processing efficiency
         Accelerating the replacement to welded-jointed tanks
         Reinforcing patrols, installing level gauge, etc.
   3) Measures for sea-side area [Removing] [Preventing leakage]
      • Additional measures: cleaning sea water inside the plant port by water deposition, adsorption, separation and the like
         Utilization of contamination preventing membranes that can adsorb radioactive material, and other methods
         Covering marine soil inside the plant port, etc.
      • Existing measures: Pumping up and blocking the high concentration contaminated water inside trenches
         Implementing ground improvement using sodium silicate and others, installing sea-side impermeable walls, etc.
   4) Items which should be comprehensively evaluated and reviewed against risks that contaminated water cannot be stored
      [Preventing leakage]
      • Comprehensive evaluation related to the treatment of tritiated water
         (which is reviewed in the tritiated water task force)
      • Reviews related to the feasibility of handling other issues related to
tankers and underground storages, etc.
* It is required to identify the risks in the quickest time period in FY 2014 and then to enable the additional countermeasures to be taken as needed.

(2) Preventive measures capable of dealing with the risks which have not been covered by the existing measures

1) Measures against large-scale tsunami [Preventing leakage]
   • Additional measures: Implementing measures for improving the water resistance of buildings
   Reviewing additional measures such as construction of breakwaters, etc.

2) Measures against contaminated water leakage from buildings
   • Additional measures: Water stopping of the buildings (through hole on exterior wall of buildings, gaps between buildings, and around buildings)
   Reducing contaminated water transport loop, etc.

(7) Steady implementation of the existing measures (task force, etc.)

The measures already being decided should be implemented steadily. Especially, measures for suppressing inflow of groundwater to buildings and the purifying contaminated water through multi-nuclide removal equipment and its acceleration are critical countermeasures to avoid the situation where contaminated water may continue to increase, causing situations including tightness of tank storage capacity and the occurrence of leakage events. Therefore, our government has taken budgetary steps to realize building land-side frozen soil impermeable walls and high-performance multi-nuclide removal equipment which require efforts mainly from country due to their technical difficulties.

For the land-side frozen soil impermeable walls, a task force consisting of specialists in freezing method as well as specialists in civil engineering has been established under the committee. This task force evaluates the design, construction plan and the like, as well as manage the progress while appropriately coordinating with a sub-group for understanding and visualization of groundwater and rainwater behavior.

In advancing maintenance and demonstrations on the land-side frozen soil impermeable walls, they shall verify the likelihood of (1) the frozen soil walls, (2) execution techniques for places where buried substances exist, (3) execution techniques where the flow velocity of groundwater is high, and (4) techniques for controlling groundwater level. Furthermore, based on the results, the detailed specifications are determined, while the status is confirmed periodically to ensure the maintenance and demonstrations can exhibit their effects.

For high-performance multi-nuclide removal equipment, a task force consisting of specialists in water as well as specialists in plants has been also established under the committee. They should confirm the corrosion resistance and should
implement the maintenance and demonstrations steadily while decreasing waste generated accompanying the removal of multiple nuclide as well as improving the removal performance by developing new filter and adsorbent treatment.

(8) Others

For implementing water stopping of the buildings (through holes on exterior walls of buildings, gaps between buildings, and around buildings), facings, and additional water shut-off, a system should be organized in such away as to conduct onsite tests because it is necessary to select materials according to local condition.

Note that regulatory authorities shall review the execution of each measure based on an application for the implementation plan from business operators. Nuclear Regulatory Agency participates in the committee not as members related to create countermeasures but as members in a position to give technical advices. For the technical advices given to the committee from Nuclear Regulatory Agency and points of regulatory requests being discussed in Nuclear Regulation Authority (NRA), see Reference 1 and Reference 2, respectively.
Points of regulatory requirements for measures against contaminated water at Tokyo Electric Power Company Fukushima Daiichi Nuclear Power Station

October 23, 2013

1. To design and plan countermeasures against contaminated water so as not to prevent the high concentration contaminated water accumulated in the inside of turbine buildings and others* from leaking into the peripheral soil due to groundwater level fluctuation.

* Buildings such as a turbine building, a reactor building and a radioactive waste treatment building, into which contaminated water is integrally being poured, and the connecting parts.

2. To take measures to prevent the trench, located in the sea-side to the sea water piping trenches and others, from being the path for the spreading of contamination after removing accumulated high concentration contaminated water.

3. The storage facilities including contaminated water tanks shall have the leak tightness based on the contaminated water status. It also shall be updated within a period of endurance.

To accelerate removing of radioactive material from the storage contaminated water, minimizing the effect in case of leakage.

4. To monitor the concentration of radioactive substances in soil on the site and groundwater, while getting a grasp on the volume of contaminated water accumulated and stored in each facility, as well as on the concentrations of each radionuclide.

5. To take measures for suppressing the spread of significant radioactive contamination to sea water and marine biota outside of the plant port.

6. To store the containers (HIC) that house the radioactive waste of high radioactive concentration occurred from the multi-nuclide removal equipment (ALPS) into a storage facility having sufficient shielding and being provided with a measure for preventing the spreading of leakage.

Note: A more rational method for confirming the cooling state of damaged reactor cores and an ambient temperature of the container vessel should be considered.

The end
The current opinions about the above discussions include:

1. It is necessary to design and plan countermeasures against contaminated water so as not to prevent the high concentration contaminated water accumulated in the inside of turbine buildings and others from leaking into the peripheral soil due to groundwater level fluctuation.

2. For the horizontal tanks also described in this report, it is necessary to create specific measure and implement it as soon as possible because this type of tanks is likely to cause leakage of contaminated water due to damage of joint parts, etc.

3. Executors of each measure, and their position within the Nuclear Reactor Regulation Law, as well as the location of the responsibility should be made clear.

4. If liquid radioactive waste is to be discharged, it should meet the requirements provided in a public notice, etc.

5. For tanks and piping which accumulate contaminated water as well as water treatment equipment, etc., we should continue to pay special attention to the leakage due to freezing.

6. For risks in the risk map described in this report, the risks are only a part of the all. Furthermore, for “the possibility of event occurrence” in this report, the way that the quantitative evaluations are performed should be clear.

7. For measures to be materialized in execution scheme, etc., they will be applied through the implementation plan of TEPCO's Fukushima Daiichi Nuclear Power Station specified as Specified Reactor Facilities. However Nuclear Regulation Authority (NRA) shall evaluate and confirm the safety, etc. related to the measures. Key points about regulation demand for evaluations and confirmations, which are described in this report as reference, shall be refined by Nuclear Regulation Authority (NRA) and used as a reference for evaluation and confirmation in the future.
7. Prospect of Preventive and Multi-Layered Measures (risk reduction)

Of the risks that broadly divided into a risk of stored contaminated water leaking and a risk of storage capacity running short as contaminated water increases, this chapter describes prospect of being able to reduce the former by taking measures. The present risk of contaminated water leakage is shown in <Figure 3-2>. Based on the overall process described above, it was assessed how much the risk can be lowered until when. <Figures 7-1 to 7-6> show how much each measure can alleviate the impact of the frequency and occurrence of leakage.

[Legend]
- * shows the location of contaminated water at the top and the cause of occurrence of the leakage at the bottom.
- "Influences of event occurrence" (horizontal axis) on the risk map is partially for reference only because the effect of countermeasure is difficult to measure quantitatively.
- There is no difference in probability of occurrence of the risks that are divided into each category (high, middle, or low) on “Degree of possibility of event occurrence” (vertical axis).
- "HE" stands for “Human Error”.

<<Figure 7-1: Risk map of contaminated water event occurrence [trench]>
<Figure 7-2: Risk map of contaminated water event occurrence [each building]>

<Figure 7-3: Risk map of contaminated water event occurrence [bolted-joint tank and aging]>
Figure 7-4: Risk map of contaminated water event occurrence [bolted-joint tank and human error]

Figure 7-5: Risk map of contaminated water event occurrence [bolted- and welded-joint tanks/earthquake]
These figures indicate that, for example, the impact in case contaminated water leaks can be mitigated if measures to eliminate or clean the sources of contamination, such as cleaning the high-concentration contaminate water in the seaside trench of the building, are taken and the frequency of leakage can be lowered if measures to improve the reliability of the facility, such as replacing the existing bolted-joint tanks with welded-joint tanks, are taken.  

<Figures 7-7 to 7-10> show the risk maps at the end of 2013, 2014, 2018, and 2020, which were created by compiling the effects of these measures.
<Figure 7-7: Verification of risk reduction effect (assumed at the end of 2013)>

<Figure 7-8: Verification of risk reduction effect (assumed at the end of 2014)>
It could be made clear by these risk maps how much risk can be lowered by the measures to be taken until when.
What became clear again as a result is that the risk of water treated by multi-nuclide removal system ALPS (hereafter referred to as “tritiated water”) would eventually remain even if necessary steps, including identifying the existing risks, were taken. When treated water that must be stored in tanks increases and thus the number of tanks to be managed increases, the frequency of occurrence of a leakage event can also rise. Therefore, how to handle a large amount of tritiated water to be stored can be said a problem.
8. Future issues

(1) Handling a large amount of tritiated water

The preceding chapters describe the perspective of measures and prospect (risk reduction effect) of implementing the measures. It has been made clear as a result that risks can substantially be reduced by the end of 2020, if the measures are smoothly moved forward, but the tank capacity may run short depending on how the facility is operated and/or how much rain falls, and a risk involving storage of a large amount of tritiated water will remain. Since technologies that have a quick effect in separating tritium have not been found after collecting technical proposals from both inside and outside of Japan, it will be necessary in the future to assess measures proposed in response to our requests for information. Based on an advice “every alternatives should be verified” given by an International Atomic Energy Agency (IAEA) research group that visited Japan at the end of November this year, the Committee should set up a task force under its management for comprehensive assessment of the long-term storage of a large amount of tritium, risk of discharging contaminated water, influences of doing so on the environment, and cost effectiveness to rearrange and analyze scientific information and knowledge collected thus far and make efforts toward building social consensus.

(2) Disseminating appropriate information at home and abroad

Restoring and reconstructing the area hit by the accident at Fukushima No. 1 nuclear power plant is the most important issue. Many technical proposals sent from both inside and outside of Japan to the Committee in response to its request for information in a bid to gather wisdom indicate great interest both at home and abroad. It is therefore important to distribute appropriate information which is based on scientific basis, including the progress of implementing measures and the effect of these measures to reduce risks, as well as steadily put forward the project.

(3) Reviewing project as necessary

In compiling the aforementioned measures, studies were conducted based on limited ground water and geological data. Collecting and analyzing more data is
necessary.
As the IAEA research group gave an advice “Continuing efforts is recommended” while evaluating the measures compiled this time around as “a series of comprehensive, clearly defined measures”, it is necessary to steadily implement these measures and, at the same time, appropriately and continuously monitor the progress of management of the measures and events that occur at site. Equally necessary is to add and review the measures as necessary.

This document has described the overall picture of the contaminated water treatment measures. It is important to always consider that information that can be collected is limited and that there is a possibility of occurrence of unexpected events, taking into account uncertainties in pushing forward the measures, and to continuously and thoroughly carry out comprehensive management of the measures to minimize risks so that the best-suited measures can be taken at a given point.
As of December 10, 2013

Members of Committee on Countermeasures for Contaminated Water Treatment

Chairperson: Yuzo Onishi
Specially appointed professor, Kansai University and honorary professor, Kyoto University

Members:
Kazuya Idemitsu
Professor, graduate school of Kyushu University

Makoto Nishigaki
Professor, graduate school of Okayama University

Minoru Yoneda
Professor, graduate school of Kyoto University

Kazuyoshi Yamamoto
Director and vice president, Nagoya University

Masahiro Osako
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Senior project manager, Hitachi-GE Nuclear Energy, Ltd.

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Member, Special Committee for Electricity Measures, Japan Federation of Construction Contractors

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Manager, Nuclear Section, Research and Development Bureau, Ministry of Education, Culture, Sports, Science and Technology

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Manager, River Environment Section, Water Management and National Land Maintenance Bureau, Ministry of Land, Infrastructure, Transport and Tourism

Masashi Hiroki
Planning section chief, Waste and Recycle Measure Headquarters, Minister’s Secretariat, Ministry of the Environment

Kiyoshi Kosaka
Nuclear expert, Fukushima prefecture

Kazuhiro Suzuki
Managing director, International Research Institute for Nuclear Decommissioning
Record of Meetings

[Committee on countermeasures for contaminated water treatment]
Committee on countermeasures for contaminated water treatment (1st meeting) April 26, 2013
Committee on countermeasures for contaminated water treatment (2nd meeting) May 16, 2013
Committee on countermeasures for contaminated water treatment (3rd meeting) May 30, 2013
Committee on countermeasures for contaminated water treatment (4th meeting) August 8, 2013
Committee on countermeasures for contaminated water treatment (5th meeting) August 23, 2013
Committee on countermeasures for contaminated water treatment (6th meeting) September 13, 2013
Committee on countermeasures for contaminated water treatment (7th meeting) September 27, 2013
Committee on countermeasures for contaminated water treatment (8th meeting) October 25, 2013
Committee on countermeasures for contaminated water treatment (site survey) November 11, 2013
Committee on countermeasures for contaminated water treatment (9th meeting) November 15, 2013
Committee on countermeasures for contaminated water treatment (10th meeting) December 3, 2013
Committee on countermeasures for contaminated water treatment (11th meeting) December 10, 2013

[Task force for land-side impermeable walls]
Task force for land-side impermeable walls (1st meeting) July 1, 2013
Task force for land-side impermeable walls (2nd meeting) August 8, 2013
Task force for land-side impermeable walls (3rd meeting) August 20, 2013
Task force for land-side impermeable walls (4th meeting) November 15, 2013
Task force for land-side impermeable walls (5th meeting) November 27, 2013
Task force for land-side impermeable walls (6th meeting) December 3, 2013

[Task force for high performance multi-nuclide removal equipment]
Task force for high performance multi-nuclide removal equipment (1st meeting) November 29, 2013

[Sub-group for understanding and visualization of groundwater and rainwater behavior and risk assessment]
Sub-group (1st meeting) October 11, 2013
Sub-group (2nd meeting) October 16, 2013
Sub-group (3rd meeting) October 23, 2013
Sub-group (4th meeting) October 30, 2013
Sub-group (5th meeting) November 6, 2013
Sub-group (6th meeting) November 13, 2013
Sub-group (7th meeting) November 20, 2013
Sub-group (8th meeting) November 27, 2013
As of November 27, 2013

Members of Task Force for Land-Side Impermeable Walls

Chief: Yuzo Onishi  Specially appointed professor, Kansai University and honorary professor, Kyoto University
Makoto Nishigaki  Professor, Graduate School of Environmental and Life Science, Okayama University
Yuzuru Ito  Professor, Urban Environment Engineering Department, Science and Technology Department, Tetsunan University
Tatsuya Ishikawa  Professor, Laboratory for Ground Environment Analysis in Disaster prevention Engineering Field, Division of Field Engineering for the Environment, Graduate School of Engineering, Hokkaido University
Koichi Fujita  Research Councilor, National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure, Transport and Tourism
Atsuhisa Marui  Supervisor and chief researcher, Geosphere Resource Environment Research Department, National Institute of Advanced Industrial Science and Technology, and chief of Ground Water Research Group
Hirobumi Kamata  Member, Special Committee for Electricity Measures, Japan Federation of Construction Contractors
Satoshi Akagawa  Representative, Low-temperature Zone Engineering Laboratory

Secretariat: Tatsuya Arakawa  Chief, Nuclear Power Plant Accident Response Room, Agency of Natural Resources and Energy

As of November 29, 2013

Members of Task Force for High Performance Multi-Nuclide Removal Equipment

Chief: Satoru Tanaka  Professor, School of Engineering, Tokyo University
Tokuhiro Yamamoto  Vice chief, Reprocessing Technology Development Center, Japan Atomic Energy Agency
Takeshi Tsukada  Next generation area leader, Nuclear Technology Laboratory, Central Research Institute of Electric Power
Hiroaki Tao  Chief, Environment Management Technology Department, National Institute of Advanced Industrial Science and Technology
Masahiro Yamamoto  Vice chief, Nuclear Fundamental Engineering Department, Japan Atomic Energy Agency
Masami Hasegawa  Chief, Seawater General Laboratory, Salt Industry Center of Japan
Mamoru Numata  Deputy manager, Third Project Headquarters, JGS Corporation

Secretariat: Tatsuya Arakawa  Chief, Nuclear Plant Accident Solution Room, Agency of Natural Resources and Energy
Study System of “Sub-Group for Understanding and Visualization of Groundwater and Rainwater Behavior and Risk Assessment”

[Study system]
A study was conducted with the following members added to the Secretariat of the Committee on countermeasures for contaminated water treatment and Tokyo Electric Power Co. The members of the Committee on countermeasures for contaminated water treatment voluntarily participated as advisers.

[National Institute of Advanced Industrial Science and Technology]
- Hitoshi Tsukamoto  Leader, Long-term Deformation Study Group, Geological Information Research Department
- Reo Ikawa  Fellow, Groundwater Study Group, Ground Zone Resources Environment Study Department

[Japan Atomic Energy Agency]
- Hiromitsu Saegusa  Assistant director, Geological Disposal Study Department
- Atsushi Sawada  Assistant director, Geological Disposal Study Department

[Public Works Research Institute]
- Yasuhiko Wakisaka  Geological supervisor

[National Institute for Land and Infrastructure Management]
- Hidetoshi Kobashi  Construction management researcher
- Masaki Kawasaki  Chief, Water Circulation Laboratory, River Research Department
- Hiroshi Mori  Chief researcher, River Research Laboratory, River Research Department

Study System of Sub-Group for Risk Assessment

[Study system]
A study was conducted with the following members added to the Secretariat of the Committee on countermeasures for contaminated water treatment and Tokyo Electric Power Co. The members of the Committee on countermeasures for contaminated water treatment voluntarily participated as advisers.

[National Institute of Advanced Industrial Science and Technology]
- Issei Ito  Leader, Water Environment Research Group, Geological Information Research Department

[Japan Atomic Energy Agency]
- Keiichiro Wakasugi  Assistant director, Geological Disposal Study Department
- Masahisa Watanabe  Technical assistant director, Recovery Technology Department, Fukushima Technology Headquarters