Summary of Decommissioning and Contaminated Water Management

November 29, 2018

Secretariat of the Team for Countermeasures for Decommissioning and Contaminated Water Treatment

Main decommissioning works and steps

All fuel had been removed from Unit 4 SFP by December 22, 2014. Work continues toward fuel removal and debris (Note 1) retrieval from Unit 1-3.

(Note 1) Fuel assemblies having melted through in the accident.

Fuel Removal from SFP

Units 1 & 2 | Unit 3 | Unit 4

Rubble removal & dose reduction → Installing a Fuel removal handling machine → Fuel removal → Storage and handling

Unit 1: Fuel removal scheduled to start in FY2023
Unit 2: Fuel removal scheduled to start in FY2023
Unit 3: Fuel removal scheduled to start in around mid-FY2018
Unit 4: Fuel removal completed in 2014

* The process is currently being examined.

Fuel Debris Retrieval

Unit 1-3

Capturing the status inside the PCV/ examining the fuel debris retrieval method, etc. (Note 2) → Fuel debris retrieval → Storage and handling

(Note 2)
The method employed to retrieve fuel debris for the first unit will be confirmed in FY2019.

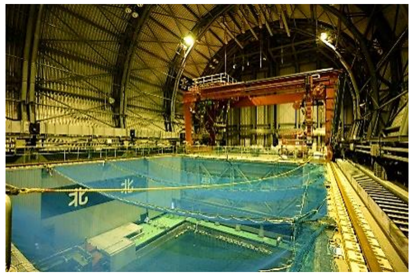
Dismantling Facilities

Scenario development & technology consideration → Design and manufacturing of devices / equipment → Dismantling

Toward fuel removal from the spent fuel pool

Toward fuel removal from Unit 3 SFP, after confirming the cause of the failures in the FHM and crane and implementing measures for similar parts, works will continue putting safety first.

As measures to reduce the dose on the Reactor Building operating floor, the decontamination and installation of shields were completed in June and December 2016 respectively. Installation of a fuel removal cover started from January 2017 and installation of all dome roofs was completed in February 2018.



Status inside the cover for fuel removal (March 15, 2018)

Three principles behind contaminated water countermeasures:

Countermeasures for contaminated water are implemented in accordance with the following three principles:

1 Eliminate contamination sources

① Multi-nuclide removal equipment, etc.

② Remove contaminated water from the trench (Note 3)

(Note 3) Underground tunnel containing pipes.

2. Isolate water from contamination

③ Pump up groundwater for bypassing

④ Pump up groundwater near buildings

⑤ Land-side impermeable walls

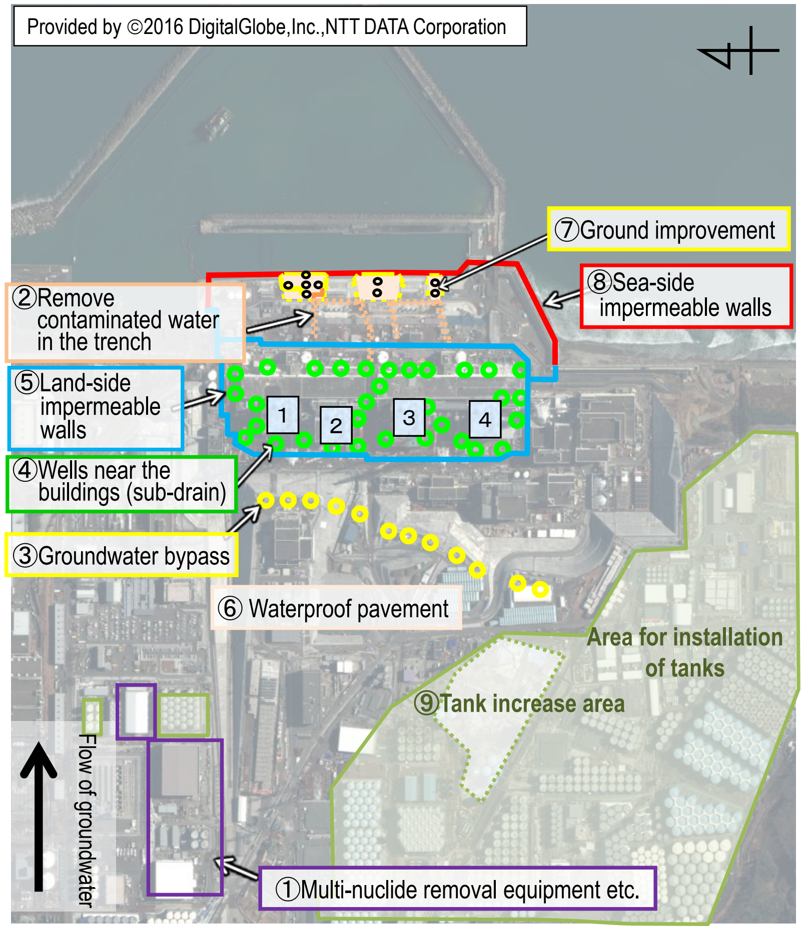
⑥ Waterproof pavement

3. Prevent leakage of contaminated water

⑦ Enhance soil by adding sodium silicate

⑧ Sea-side impermeable walls

⑨ Increase the number of (welded-joint) tanks



Multi-nuclide removal equipment (ALPS), etc.

- This equipment removes radionuclides from the contaminated water in tanks and reduces risks.
- Treatment of contaminated water (RO concentrated salt water) was completed in May 2015 via multi-nuclide removal equipment, additional multi-nuclide removal equipment installed by TEPCO (operation commenced in September 2014) and a subsidy project of the Japanese Government (operation commenced in October 2014).
- Strontium-treated water from equipment other than ALPS is being re-treated in ALPS.

(High-performance multi-nuclide removal equipment)

Land-side impermeable walls

- Land-side impermeable walls surround the buildings and reduce groundwater inflow into the same.
- Freezing started on the sea side and part of the mountain side from March 2016 and on 95% of the mountain side from June 2016. Freezing of the remaining unfrozen sections advanced with a phased approach and freezing of all sections started in August 2017.
- In March 2018, the land-side impermeable walls were considered completed except for a portion of the depths; based on a monitoring result showing that the underground temperature had declined below 0℃ in almost all areas, while on the mountain side, the difference between the inside and outside increased to approx. 4-5 m. Multi-layered contaminated water management measures, including subdrains and facing, have kept the groundwater level stable. Consequently, a water-level management system to isolate the buildings from groundwater was considered to have been established. The Committee on Countermeasures for Contaminated Water Treatment, held on March 7, clearly recognized the effect of the land-side impermeable walls in shielding groundwater and evaluated that the land-side impermeable walls had allowed a significant reduction in the amount of contaminated water generated.

(Inside the land-side impermeable wall)

(Outside the land-side impermeable wall)

Sea-side impermeable walls

- Impermeable walls are being installed on the sea side of Units 1-4, to prevent contaminated groundwater from flowing into the sea.
- The installation of steel pipe sheet piles was completed in September 2015 and they were connected in October 2015. These works completed the closure of the sea-side impermeable walls.

(Sea-side impermeable wall)

Progress Status and Future Challenges of the Mid- and Long-Term Roadmap toward Decommissioning of TEPCO Holdings' Fukushima Daiichi Nuclear Power Station Units 1-4 (Outline)

Progress status

◆ The temperatures of the Reactor Pressure Vessel (RPV) and Primary Containment Vessel (PCV) of Units 1-3 have been maintained within the range of approx. 20-30°C*1 over the past month. There was no significant change in the density of radioactive materials newly released from Reactor Buildings in the air*2. It was evaluated that the comprehensive cold shutdown condition had been maintained.

* 1 The values varied somewhat, depending on the unit and location of the thermometer
* 2 In October 2018, the radiation exposure dose due to the release of radioactive materials from the Unit 1-4 Reactor Buildings was evaluated as less than 0.00044 mSv/year at the site boundary. The annual radiation dose from natural radiation is approx. 2.1 mSv/year (average in Japan).

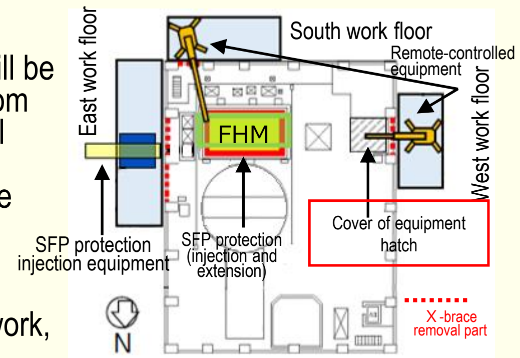
Plan to protect Unit 1 SFP, etc.

As preparatory work to protect the spent fuel pool (SFP), X-braces are being removed from September 19. The removal was completed by September 25 on the west side and November 21 on the south side.

The remaining two sections on the east side will be removed by the end of December.

After removing the X-braces, the nearby opening (equipment hatch) will be covered to create an access route from the west work floor and prevent small rubble falling.

After removing small rubble near the SFP, which may prevent work to protect the SFP, etc., from each of the work floors on the east, south and west sides, the SFP protection work, etc. will be implemented.



Layout for SFP protection, etc.

Investigation start on the Unit 2 operating floor after moving the remaining objects

Work to move and contain the remaining objects, which was implemented before investigating the contamination status, etc. on the entire operating floor, was completed on November 6.

During the investigation started after the work, photos were taken using a gamma camera by November 20 to check the contamination distribution and hot spots.

The surface dose and airborne radiation dose of the lower part will be measured during the period from November 29 to early December.

Investigation including the upper part will continue until around January.

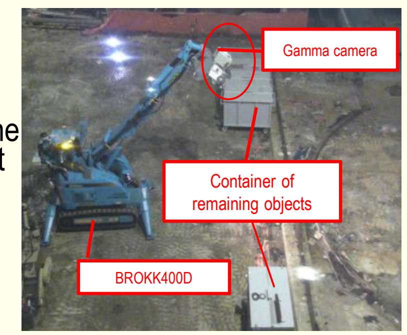


Photo taking using a γ camera

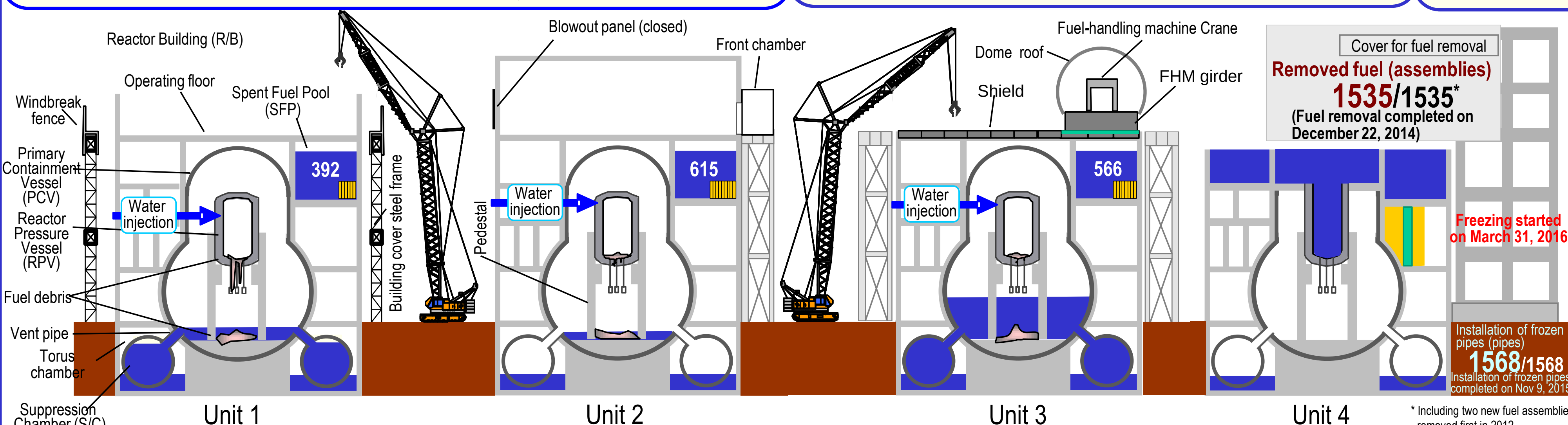
Progress status of defect recurrence prevention measures toward Unit 3 fuel retrieval

Safety inspections are being implemented to determine the defect occurrence risks of the fuel removal system. An operational check using a series of simulated works was completed on November 21 and 13 defects were detected. Based on the results, including those of the facility inspection, which started from November 20, implementation of the necessary measures will continue.

Based on a series of past defects, the reliability of components was also evaluated as part of a quality control check.

During the reliability evaluation, consistency between the design and procurement requirements and the conformity of the product with quality requirements will be checked using records, etc. by around the end of December.

In addition, in response to the defect in the fuel-handling machine (FHM) cable connection, work to exchange the cable and connector will start from around mid-December.



Progress status of the exhaust stack dismantling mockup test

Toward dismantling the Unit 1/2 stack from March 2019, a demonstration test outside the site has been underway from August. As part of the demonstration test, work to verify the performance of the dismantling equipment was completed on November 12 and the results did not indicate any significant issues which could affect the dismantling plan.

Items to be improved and work procedures detected in the performance test will be verified.

In conjunction with the inspection, preparatory work for dismantling inside the power station site will start from December 2018.

Start of work to reduce the risk of the mega float

The mega float, which was utilized to temporarily store stagnant water of Units 5 and 6 generated due to the earthquake, is at risk of drifting and damaging nearby facilities when a tsunami occurs.

To reduce the risk from an early stage, off-shore work to anchor the mega float within the port and utilize it as a bank and Shallow Draft Quay started from November 12.

Thorough environmental measures are being implemented and environmental monitoring within the port continues during the work with safety first.

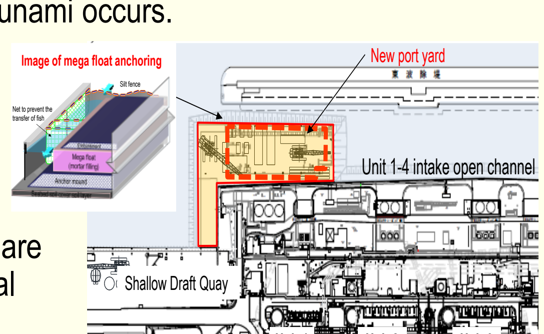


Image of the completed construction

IAEA review mission

Japan received the 4th visit of the review mission (review team) from the International Atomic Energy Agency (IAEA) during the period November 5-13 and a summary report on November 13.

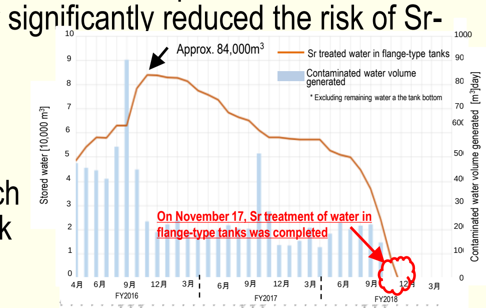
The report includes comments stating that "significant progress has already been accomplished to move Fukushima Daiichi from an emergency situation to a stabilized situation" and 17 Acknowledgements and 21 Advisory Points are provided.


The summary report was handed over by IAEA Review Team Leader Xerri to METI State Minister Isozaki

Completion of purification of Sr-treated water in flange-type tanks

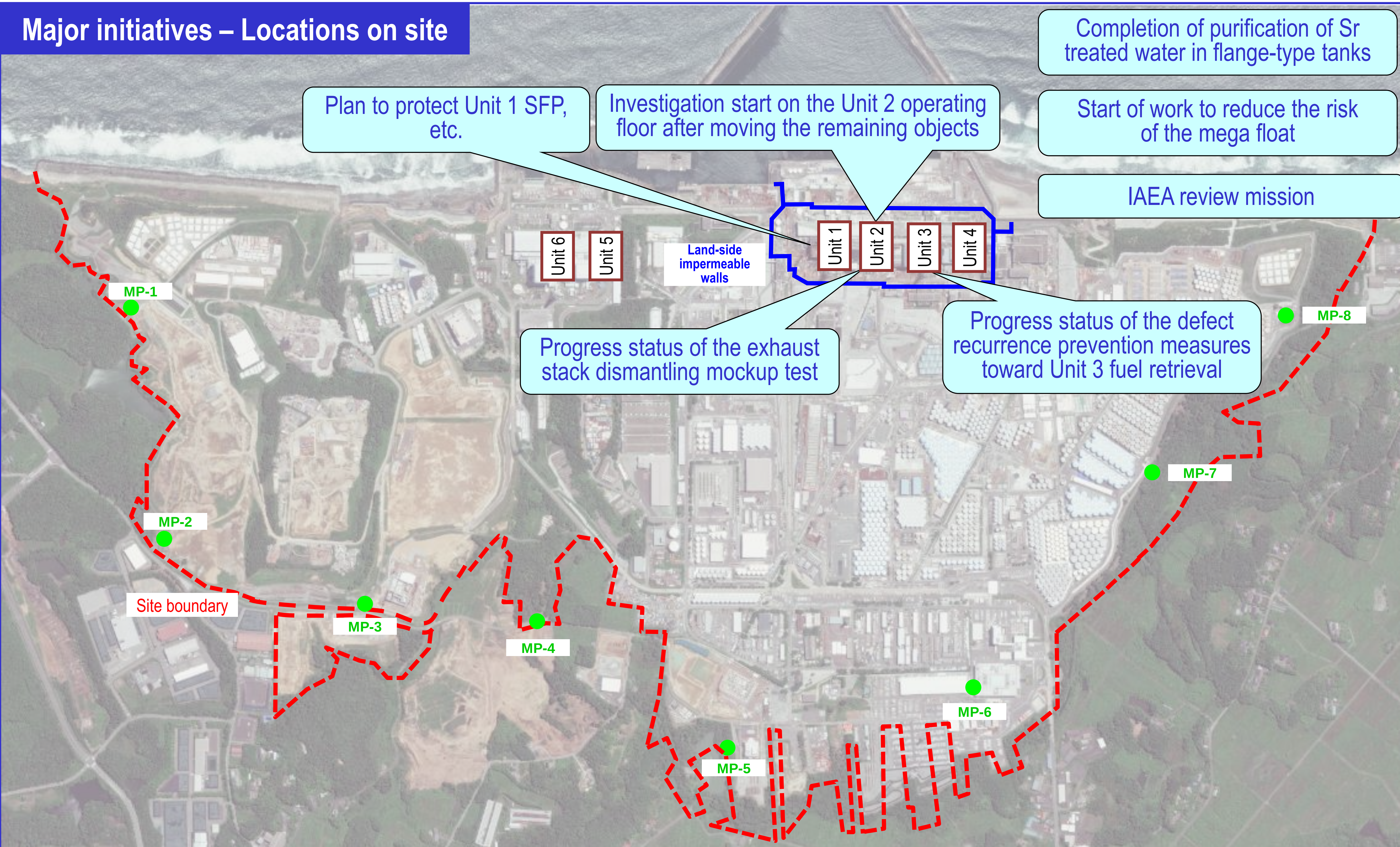
Purification of Sr-treated water having been stored in flange-type tanks was completed on November 17 and purified water is stored in welded tanks. This transfer significantly reduced the risk of Sr-treated water leakage.

ALPS-treated water having been stored in flange-type tanks will be transferred to welded tanks by around March 2019 to further reduce the risk of leakage.



Completion of purification of Sr-treated water in flange-type tanks

Major initiatives – Locations on site



* Data of Monitoring Posts (MP1-MP8.)

Data (10-minute values) of Monitoring Posts (MPs) measuring the airborne radiation rate around site boundaries showed 0.443 – 1.515 μSv/h (October 24 –November 27, 2018).

We improved the measurement conditions of monitoring posts 2 to 8 to measure the air-dose rate precisely. Construction works, such as tree-clearing, surface soil removal and shield wall setting, were implemented from February 10 to April 18, 2012.

Therefore monitoring results at these points are lower than elsewhere in the power plant site.

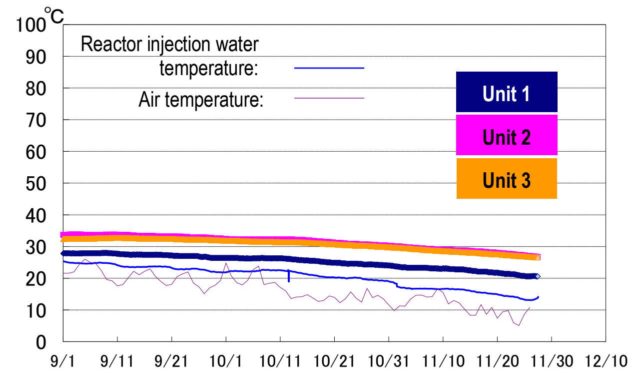
The radiation shielding panels around monitoring post No. 6, which is one of the instruments used to measure the radiation dose at the power station site boundary, were taken off from July 10-11, 2013, since further deforestation, etc. had caused the surrounding radiation dose to decline significantly.

Provided by Japan Space Imaging, photo taken on June 14, 2018
Product(C) [2018] DigitalGlobe, Inc.

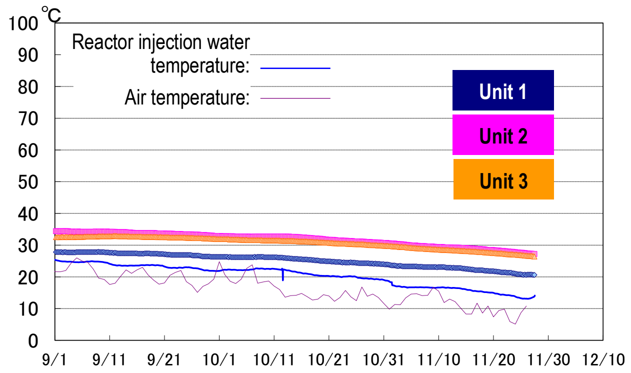
I. Confirmation of the reactor conditions

1. Temperatures inside the reactors

Through continuous reactor cooling by water injection, the temperatures of the Reactor Pressure Vessel (RPV) bottom and the Primary Containment Vessel (PCV) gas phase were maintained within the range of approx. 20 to 30°C for the past month, though it varied depending on the unit and location of the thermometer.



RPV bottom temperatures (recent quarter)



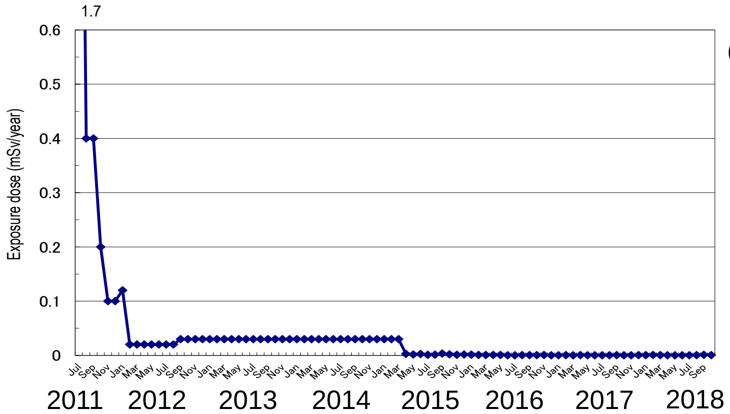
PCV gas phase temperatures (recent quarter)

* The trend graphs show part of the temperature data measured at multiple points.

2. Release of radioactive materials from the Reactor Buildings

As of October 2018, the density of radioactive materials newly released from Reactor Building Units 1-4 in the air and measured at the site boundary was evaluated at approx. 5.3×10^{-12} Bq/cm³ for Cs-134 and 3.0×10^{-11} Bq/cm³ for Cs-137, while the radiation exposure dose due to the release of radioactive materials there was less than 0.00044 mSv/year.

Annual radiation dose at site boundaries by radioactive materials (cesium) released from Reactor Building Units 1-4



(Reference)

- The density limit of radioactive materials in the air outside the surrounding monitoring area:
  [Cs-134]: 2 x 10^{-5} Bq/cm³
  [Cs-137]: 3 x 10^{-5} Bq/cm³
- Data of Monitoring Posts (MP1-MP8).
  Data of Monitoring Posts (MPs) measuring the airborne radiation rate around the site boundary showed 0.443 – 1.515 μSv/h (October 24 – November 27, 2018).
  To measure the variation in the airborne radiation rate of MP2-MP8 more accurately, environmental improvement (tree trimming, removal of surface soil and shielding around the MPs) was completed.

Note: Different formulas and coefficients were used to evaluate the radiation dose in the facility operation plan and monthly report. The evaluation methods were integrated in September 2012. As the fuel removal from the spent fuel pool (SFP) commenced for Unit 4, the radiation exposure dose from Unit 4 was added to the items subject to evaluation since November 2013. The evaluation has been changed to a method considering the values of continuous dust monitors since FY2015, with data to be evaluated monthly and announced the following month.

3. Other indices

There was no significant change in indices, including the pressure in the PCV and the PCV radioactivity density (Xe-135) for monitoring criticality, nor was any abnormality in the cold shutdown condition or criticality sign detected.

Based on the above, it was confirmed that the comprehensive cold shutdown condition had been maintained and the reactors remained in a stabilized condition.

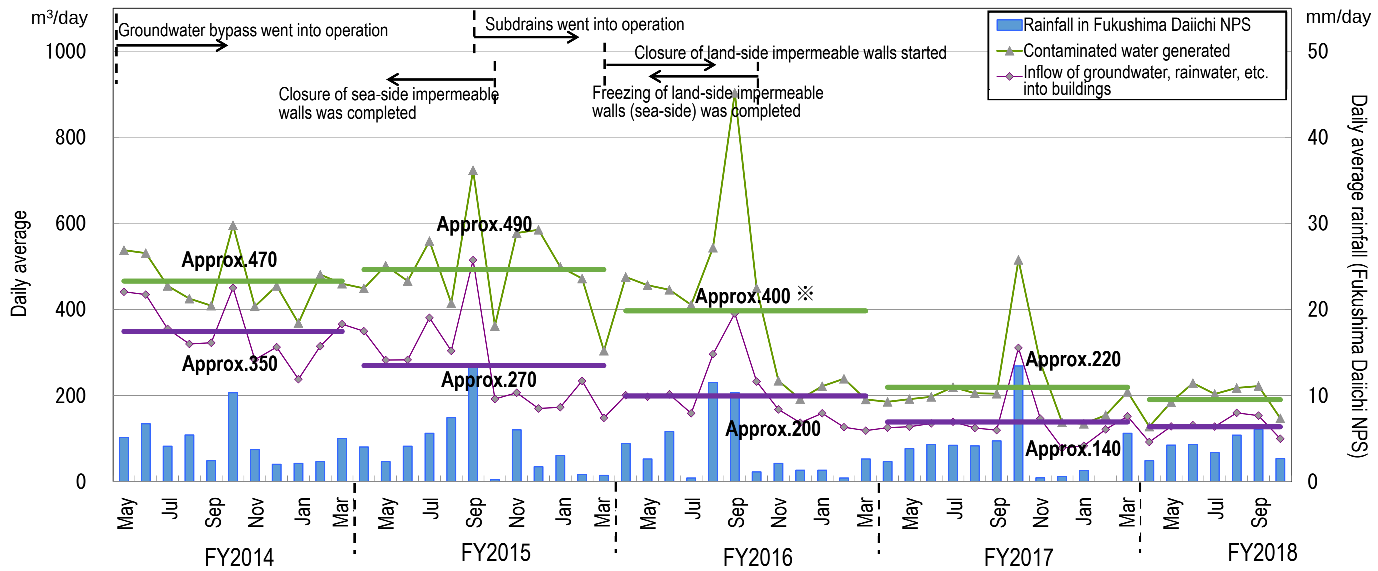
II. Progress status by each plan

1. Contaminated water management

To tackle the increase in stagnant water due to groundwater inflow, fundamental measures to prevent such inflow into the Reactor Buildings will be implemented, while improving the decontamination capability of water treatment and preparing facilities to control the contaminated water

➢ Status of contaminated water generated

- Multi-layered measures, including pumping up by subdrains and land-side impermeable walls, which were implemented to control the continued generation of contaminated water, reduced groundwater inflow into buildings.
- As a result of steady implementation of "isolation" measures (groundwater bypass subdrains, frozen walls, etc.), the inflow reduced from approx. 470 m³/day (the FY2014 average) when the measures were first launched to approx. 220 m³/day (the FY2017 average), though the figure varied depending on rainfall, etc.
- Measures will continue to further reduce the volume of contaminated water generated.



※ Values differ from those announced at the 20th Committee on Countermeasures for Contaminated Water Treatment (held on August 25, 2017) because the calculation method of contaminated water volume generated was reviewed on March 1, 2018. Details of the review are described in the materials for the 50th and 51st meetings of the Secretariat of the Team for Countermeasures for Decommissioning and Contaminated Water Treatment.

Figure 1: Changes in contaminated water generated and inflow of groundwater, rainwater, etc. into buildings

➢ Operation of the groundwater bypass

- From April 9, 2014, the operation of 12 groundwater bypass pumping wells commenced sequentially to pump up groundwater. The release started from May 21, 2014 in the presence of officials from the Intergovernmental Liaison Office for the Decommissioning and Contaminated Water Issue of the Cabinet Office. Up until November 27, 2018, 426,198 m³ of groundwater had been released. The pumped-up groundwater was temporarily stored in tanks and released after TEPCO and a third-party organization had confirmed that its quality met operational targets.
- Pumps are inspected and cleaned as required based on their operational status.

➢ Water Treatment Facility special for Subdrain & Groundwater drains

- To reduce the level of groundwater flowing into the buildings, work began to pump up groundwater from wells (subdrains) around the buildings on September 3, 2015. The pumped-up groundwater was then purified at dedicated facilities and released from September 14, 2015 onwards. Up until November 27, 2018, a total of 634,052 m³ had been drained after TEPCO and a third-party organization had confirmed that its quality met operational targets.
- Due to the level of the groundwater drain pond rising after the sea-side impermeable walls had been closed, pumping started on November 5, 2015. Up until November 27, 2018, a total of approx. 195,709 m³ had been pumped up and a volume of under 10 m³/day is being transferred from the groundwater drain to the Turbine Buildings (average for the period October 18 – November 14, 2018).
- As one of the multi-layered contaminated water management measures, in addition to waterproof pavement (facing:as of the end of October 2018,approx.94% of the planed area was completed.) to prevent rainwater infiltrating the ground, etc., facilities to enhance the subdrain treatment system were installed and went into operation from April 2018; increasing the treatment capacity to 1,500 m³ and improving reliability.
- To maintain the level of groundwater pumped up from subdrains, work to install additional subdrain pits and recover those already in place is underway. They will go into operation sequentially from a pit for which work is completed (the number of pits which went into operation: 12 of 14 additional pits; 0 of 3 recovered pits).
- To eliminate the need to suspend water pumping while cleaning the subdrain transfer pipe, the pipe will be

duplicated. Installation of the pipe and ancillary facilities was completed.

- Since the subdrains went into operation, the inflow into buildings tended to decline to under 150 m³/day when the subdrain water level declined below T.P. 3.0 m but increased during rainfall.

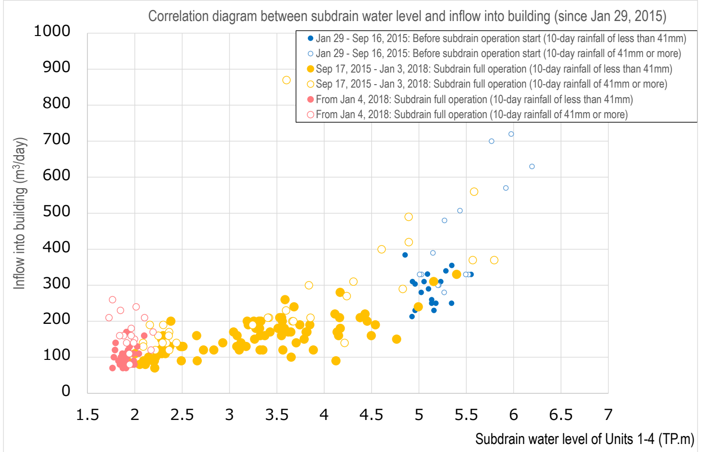


Figure 2: Correlation between inflow such as groundwater and rainwater into buildings and the water level of Unit 1-4 subdrains

➢ Construction status of the land-side impermeable walls

- A maintenance operation for the land-side impermeable walls to prevent frozen soil from thickening further continued from May 2017 on the north and south sides and started from November 2017 on the east side, where frozen soil of sufficient thickness was identified. The scope of the maintenance operation was expanded in March 2018.
- In March 2018, the land-side impermeable walls were considered completed except for a portion of the depths; based on a monitoring result showing that the underground temperature had declined below 0℃ in almost all areas, while on the mountain side, the difference between the inside and outside increased to approx. 4-5 m. Multi-layered contaminated water management measures, including subdrains and facing, have kept the groundwater level stable. Consequently, a water-level management system to isolate the buildings from groundwater was considered to have been established. The Committee on Countermeasures for Contaminated Water Treatment, held on March 7, clearly recognized the effect of the land-side impermeable walls in shielding groundwater and evaluated that the land-side impermeable walls had allowed a significant reduction in the amount of contaminated water generated.

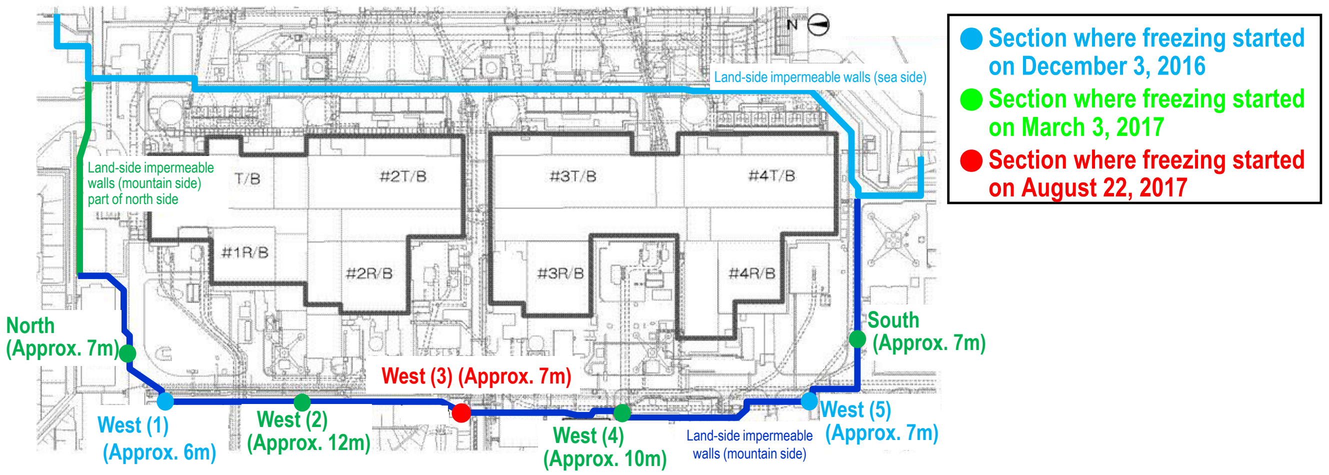


Figure 3: Closure of part of the land-side impermeable walls (on the mountain side)

➢ Operation of multi-nuclide removal equipment

- Regarding the multi-nuclide removal equipment (existing and high-performance), hot tests using radioactive water were underway (for existing equipment, System A: from March 30, 2013, System B: from June 13, 2013, System C: from September 27, 2013; and for high-performance equipment, from October 18, 2014). The additional multi-nuclide removal equipment went into full-scale operation from October 16, 2017.
- As of November 22, the volumes treated by existing, additional and high-performance multi-nuclide removal equipment were approx. 397,000, 514,000 and 103,000 m³ respectively (including approx. 9,500 m³ stored in the J1(D) tank, which contained water with a high density of radioactive materials at the System B outlet of the existing multi-nuclide removal equipment).
- To reduce the risks of strontium-treated water, treatment using existing, additional and high-performance multi-nuclide removal equipment has been underway (existing: from December 4, 2015; additional: from May 27, 2015; high-performance: from April 15, 2015). Up until November 22, approx. 550,000 m³ had been treated.

➢ Toward reducing the risk of contaminated water stored in tanks

- Treatment measures comprising the removal of strontium by cesium-adsorption apparatus (KURION) (from January 6, 2015) and the secondary cesium-adsorption apparatus (SARRY) (from December 26, 2014) have been underway. Up until November 22, approx. 491,000 m³ had been treated.

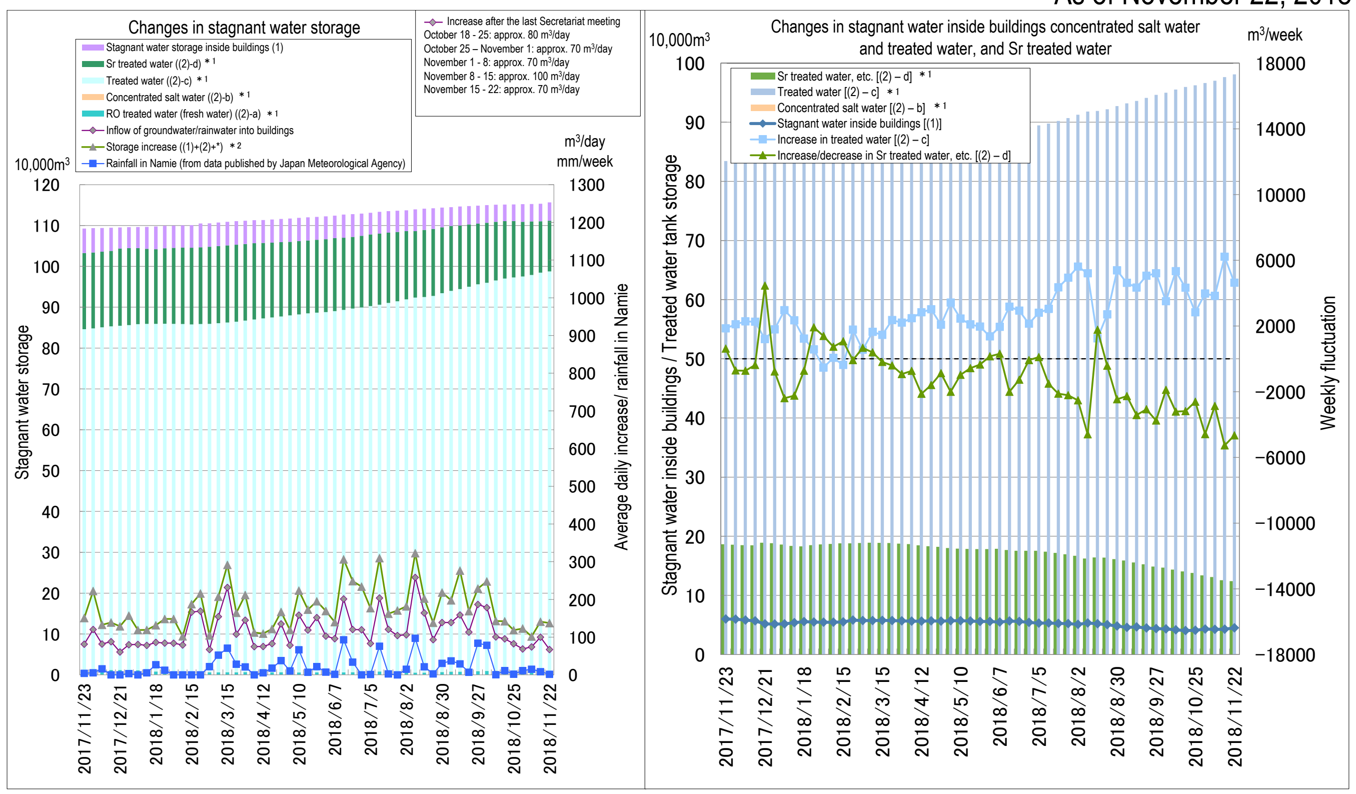
➢ Completion of purification of Sr-treated water in flange-type tanks

- Purification of Sr-treated water having been stored in flange-type tanks was completed on November 17 and purified water is stored in welded tanks. This transfer significantly reduced the risk of contaminated water leakage.
- ALPS-treated water having been stored in flange-type tanks will be transferred to welded tanks by around March 2019 to further reduce the risk of leakage.

➢ Measures in the Tank Area

- Rainwater, under the release standard and having accumulated within the fenced-in area of the contaminated water tank area, was sprinkled on site after eliminating radioactive materials using rainwater-treatment equipment since May 21, 2014 (as of November 26, 2018, a total of 122,930 m³).

As of November 22, 2018



*1: Water amount for which the water-level gauge indicates 0% or more
*2: To detect storage increases more accurately, the calculation method was reviewed as follows from February 9, 2017: (The revised method was applied from March 1, 2018) [(Inflow of groundwater/rainwater into buildings) + (other transfer) + (chemical injection into ALPS)]
*3: Reevaluated by adding groundwater and rainwater inflow into the residual water areas (January 18 and 25, 2018).
*4: Reviewed because SARRY reverse cleaning water was added to "Storage increase." (January 25, 2018)
*5: The effect of calibration for the building water-level gauge was included in the following period: March 1-8, 2018 (Unit 3 Turbine Building).
*6: The method used to calculate the chemical injection into ALPS was reviewed as follows: (Additional ALPS: The revised method was applied from April 12, 2018) [(Outlet integrated flow rate) – (inlet integrated flow rate) – (sodium carbonate injection rate)]
*7: Reevaluated based on the revised calculation formula of stagnant water storage volume in Unit 2-4 Turbine Building seawater system pipe trenches. (Period of reevaluation: December 28, 2017 – June 7, 2018)
*8: Reevaluated based on the revised method to manage the transfer volume from the Unit 1 seawater pipe trench. (Period of reevaluation: May 31 – June 28, 2018)
*9: Inflow into buildings increased due to the effect of repair work on the K drainage channel.
*10: The storage increase rate rose due to the effect of water transfer to buildings in association with construction, etc. (the transferred water comprised (1) rainwater from the 3uT/B roof: approx. 60m³/day, and (2) condensed rainwater from the desalination equipment RO: approx. 10m³/day).

Figure 4: Status of stagnant water storage

- Response status to the unsatisfied Cs removal performance of the 3rd cesium-adsorption apparatus
  - In the performance test of the 3rd cesium-adsorption apparatus (SARRY II) on July 31, 2018, it was confirmed that the pre-operation test check item "the criterion concerning the reduction in density of the Cs-137 radioactive material (removal performance)" had not been satisfied during the operation performance test (internal pre-check test).
  - The scheduled pre-operation test was postponed and the cause of the unsatisfactory Cs removal performance was investigated by passing water through the equipment and verifying the analytical data during this process.
  - Based on the cause investigation results, it was assumed that the Cs performance was temporarily unsatisfied because adsorbent particles having adsorbed Cs flew to the outlet when operation was initiated and increased the Cs density of the outlet water.
  - In response, countermeasures were implemented comprising the removal of particles in advance by cleaning adsorbents before filling in the adsorption vessels in the factory, reverse cleaning when the system pressure was higher during operation and reviewing the adsorption vessel replacement operation.
  - Work will continue to resume the pre-operation test and start operation.
- Installation of purification materials in the Turbine Building (the small attached annex) rainwater pipes
  - As measures to reduce the radiation concentration in rainwater of building rooftops, for which it was difficult to early remove contamination sources due to the high dose involved and difficulty in accessing the heavy machinery, purification materials were installed on September 16, 2017 in the rain gutters for the small attached annex of the Unit 1 Turbine Building as a trial. The installation of purification materials was completed on September 21, 2018, in three rain gutters for the small attached annexes of the Unit 1-3 Turbine Buildings.
  - The results of rainwater sampling showed that the Cs-137 density declined significantly after purification.
  - Through continued rainwater sampling, the purification performance and dose rate data will be verified to examine sustainable operation methods for the purification function.
- Progress status of earthquakes and tsunami countermeasures (review of risks in association with the closure of openings)
  - To prevent any outflow of stagnant water from buildings and reduce any increase in stagnant water in buildings due to tsunamis, work to close off building openings is underway (61 of 122 openings were closed off).
  - For parts with openings that are difficult to close, measures to prevent outflow due to tsunami will be implemented according to their priorities).
- LCO deviation due to increased indication of the exposed water-level gauge (3-T2-1) in the Unit 3 Turbine Building northwest area
  - On October 1, 2018, an alarm of the "TR Unit 3 T/B northwest area water level (3-T2-1)" was issued, indicating that the stagnant water level in buildings in the Unit 3 Turbine Building northwest area (exposed area) had reached the re-flooding limit (T.P. 650 mm).
  - The event was judged as a deviation from the limiting condition for operation (LCO) stipulating that "stagnant water in buildings shall not exceed the subdrain water level near the building," based on an inspection result that could not deny the probability of the stagnant water level in the building actually increasing. All the subdrain pumps around the Unit 1-4 buildings suspended operation.
  - After measuring the level of stagnant water in buildings in the area and confirming no increase, recovery from the LCO deviation was declared and all subdrain pumps around the Unit 1-4 buildings resumed operation.
  - Regarding gauges to determine the level of stagnant water in buildings in exposed areas, when the indication reached the re-flooding limit of the gauge, the value was compared with the subdrain water level after recovering the alarm circuit. This operational procedure did not appropriately fit the water-level management in areas connecting to an exposed area or respond to the status variation associated with the decline in stagnant water in buildings and subdrain water.
  - The method used to handle water-level gauges in exposed areas will be clearly defined and the operational procedures reviewed.
- Issuance of an alarm from the leakage detector at the pipe trough near the Unit 4 Turbine Building
  - On October 25, 2018, an alarm was issued from the leakage detector at the pipe trough for the inner RO circulation facility near the Unit 4 Turbine Building.
  - The inside of the pipe trough was inspected on site and the event was judged as attributable to condensation water, based on the lack of leakage detected from the pipe and the presence of condensed water in the relevant section.
- Leakage from the detection hole of the No. 1 underground reservoir
  - On November 22, flooding from the catch basin to which the transfer pump was installed was detected during water transfer in the leakage detection hole of the No. 1 underground reservoir. The transfer pump was suspended and cessation of the leakage was confirmed.
  - Some of the leakage (5,000 × 4,000 mm) infiltrated into the ground (estimated amount: approx. 230L). The analytical results of the leakage: Cs-134 was below the detection limit (5.1 Bq/L); Cs-137 was below the detection limit (4.1 Bq/L); gross β was 73,000 Bq/L; tritium was 124.4 Bq/L.
  - The leakage had no external influence because the area around the transfer pump was covered and there was no drainage channel near the transfer pump.
  - The leakage was considered attributable to a bolt used to fix the stoppage plate for the transfer pump drain hole falling out, the cause of which is being investigated.
  - Water in the catch basin was collected by November 26.
  - Crushed stones around the leakage water infiltration will be collected, the cause identified and recurrence prevention measures examined.

2. Fuel removal from the spent fuel pools

Work to help remove spent fuel from the pool is progressing steadily while ensuring seismic capacity and safety. The removal of spent fuel from the Unit 4 pool commenced on November 18, 2013 and was completed by December 22, 2014

- Main work to help spent fuel removal at Unit 1
  - The installation of windbreak fences, which will reduce dust scattering during rubble removal, started on October 31, 2017 and was completed by December 19, 2017.
  - As preparatory work to remove fuel from the spent fuel pool (SFP), rubble removal on the operating floor north side started from January 22.
  - Rubble is being removed carefully by suction equipment. No significant variation was identified around the site boundaries where the density of radioactive materials was monitored and at on-site dust monitors during the above removal work.
  - Once removed, rubble is stored in solid waste storage facilities or other storage areas depending on the dose level.
  - Before formulating a plan to remove rubble around the spent fuel pool, an on-site investigation started from July 23 and was completed on August 2.
  - To create an access route for preparatory work to protect the spent fuel pool, etc., four sections of X-braces (one on the west side, one on the south side and two on the east side respectively) are being removed.
  - The removal started from September 19 and one section on the west side had been removed by September 25.
  - Radiation and dust were thoroughly managed during the work and no significant variation was detected at dust monitors and monitoring posts.
  - Removal of one section on the south side started from October 19 and was completed on November 21.
  - The remaining two sections of X-braces on the east side will be removed by the end of December.
  - After removing the X-braces, the nearby opening (equipment hatch) will be covered to create an access route from the west work floor and prevent small rubble falling.
  - After removing small rubble near the SFP, which may prevent the work to protect the SFP, etc., from each of the work floors on the east, south and west sides, the SFP protection work, etc. will be implemented.

➢ Main work to help spent fuel removal at Unit 2

- An investigation near the opening wall on the operating floor using a remote-controlled unmanned robot detected no significant scattering obstacles to operate the robot.
- Contamination of the robot was below the level that would prevent maintenance by workers in the front room.
- To formulate a work plan to dismantle the Reactor Building rooftop, etc., the entire operating floor will be investigated.
- Before this investigation, work to move and contain the remaining objects was completed on November 6.
- Photos were taken using a gamma camera by November 20 to check the contamination distribution and hot spots.
- The surface dose and airborne radiation dose of the lower part will be measured during the period from November 29 to early December.
- Investigation including the upper part will continue until around January.

➢ Main work to help spent fuel removal at Unit 3

- Regarding the fuel-handling machine (FHM) and crane, consecutive defects have occurred since the test operation started on March 15.
- For the FHM, an alarm was issued during the pre-operation inspection on August 8, whereupon operation was suspended. It was confirmed as attributable to disconnection due to corrosion by rainwater ingress to the cable connection. Investigation of the cause detected an abnormality in several control cables.
- For the crane, an alarm was issued during the work to clear materials and equipment on August 15 and operation was suspended. The cause is being investigated.
- To determine the risks of defects, these facilities were temporarily recovered on September 29 and a safety inspection (operation check and facility inspection) is underway.
- An operational check using a series of simulated works was completed on November 21 and 13 defects were detected.
- Based on the results, including those of the facility inspection, which started from November 20, implementation of the necessary measures will continue.
- Based on a series of past defects, the reliability of components was also evaluated as part of a quality control check.
- During the reliability evaluation, consistency between the design and procurement requirements and the conformity of the product with quality requirements will be checked using records, etc. by around the end of December.
- In response to the defect in the FHM cable connection, work to exchange the cable and connector will start from around mid-December.

➢ Progress status toward dismantling the Unit 1/2 exhaust stack

- For the Unit 1/2 exhaust stack, in which damage and breakage were detected, the upper half will be dismantled using remote-controlled equipment, reflecting the need to further reduce risks.
- Toward dismantling the Unit 1/2 stack from March 2019, a demonstration test outside the site has been underway from August.
- As a part of the demonstration test, work to verify the performance of the dismantling equipment was completed on November 12 and the results did not detect any significant issues which could affect the dismantling plan.
- Items to be improved and work procedures detected in the performance test will be verified.
- In conjunction with the inspection, preparatory work for dismantling inside the power station site will start from December 2018.

3. Plans to store, process and dispose of solid waste and decommission of reactor facilities

Promoting efforts to reduce and store waste generated appropriately and R&D to facilitate adequate and safe storage, processing and disposal of radioactive waste

➢ Management status of the rubble and trimmed trees

- As of the end of October 2018, the total storage volume of concrete and metal rubble was approx. 250,700 m^3 (+800 m^3 compared to at the end of September, with an area-occupation rate of 60%). The total storage volume of trimmed trees was approx. 133,900 m^3 (- m^3, with an area-occupation rate of 76%). The total storage volume of used protective clothing was approx. 53,800 m^3 (-2,500 m^3, with an area-occupation rate of 76%). The increase in rubble was mainly attributable to construction related to tanks. The decrease in used protective clothing was mainly attributable to the incineration of used protective clothing.

➢ Management status of secondary waste from water treatment

- As of November 8, 2018, the total storage volume of waste sludge was 597 m^3 (area-occupation rate: 85%), while that of concentrated waste fluid was 9,364 m^3 (area-occupation rate: 88%). The total number of stored spent vessels, High-Integrity Containers (HICs) for multi-nuclide removal equipment, etc., was 4,178 (area-occupation rate: 66%).

➢ Analytical results of waste samples (boring core of the Unit 4 Reactor Building, soil, treated water of the multi-nuclide removal equipment)

- To understand the characteristics of waste, which were needed to obtain the safety outlook of waste treatment and disposal, samples continued to be collected from buildings, which were assumed to become waste as the dismantling work progressed and analyzed. The analytical results were announced as they were obtained.
- Recently, the analytical results of samples taken from the Unit 4 Reactor Building and soil within the site were reported. In addition, regarding the multi-nuclide removal equipment currently operating, pre-treated water of the equipment and post-treated water of each process were sampled to estimate the characteristics of the adsorbent and the analytical results were also reported.
- The analytical results showed that the characteristics of samples at the sampling points inside the Unit 4 Reactor Building were up to the legally specified surface density limit of objects which may be touched by human beings, such as walls of the controlled area.
- The main nuclide involved in the on-site soil contamination was Cs-137. However, a high radioactivity density of Sr-90 was also confirmed in soil sampled near the H4 tank, in which leakage of contaminated water was detected in 2013.
- The main nuclides considered to have been adsorbed in each adsorbent of the multi-nuclide removal equipment, were identified.
- Based on the conditions under which waste was generated, work to understand the characteristics will continue and the results obtained will be utilized to estimate the characteristics of waste, examine methods of treating and disposing of the same and ensuring the safety of the work environment, etc.

➢ Defect in dust collectors in large-equipment inspection buildings

- On November 20, in the building of the large-equipment decontamination facility for decontaminating dismantled flange tank pieces, the dust collector to remove decontaminated radioactive materials through filters was inspected to adjust the exhaust flow rate. During the inspection work, the rupture disk of dust collector C triggered, whereupon dust containing radioactive material was scattered around the large-equipment inspection building.
- The dust measurement result inside the building was 2.1×10^{-4} Bq/cm^3 (during normal time, below the detection limit (around 7.3×10^{-6} Bq/cm^3)). Exhaust air in the building was released through HEPA filters, no variation was detected on the ventilation outlet side and subsequently no external influence.
- The cause will be identified and work on early recovery will continue.

4. Reactor cooling

The cold shutdown condition will be maintained by cooling the reactor by water injection and measures to complement the status monitoring will continue

➢ Suspension of one system and both systems in association with duplication of the control panel for the Unit 2 and 3 PCV gas management facility

- Currently, a motor control panel for the Unit 2 and 3 PCV gas management facility is shared by Systems A and B and function loss of the motor panel only will result in both systems losing function. In response, work is underway to divide the control panel into two screens for Systems A and B and separate the power and instrument circuits.
- For this work, the operation systems of the PCV gas management facility will be intermittently suspended during the period December 2018 to February 2019.
- During the suspension of the PCV gas management facility, sub-criticality monitoring, as stipulated in the Implementation Plan, cannot be satisfied. Prior to implementing the work, the necessary safety measures (monitoring or evaluation by alternative measures) will be decided and the operation will be shifted to the limiting condition for operation (LCO) as planned.

➢ Test to check the cooling condition of Unit 2 fuel debris

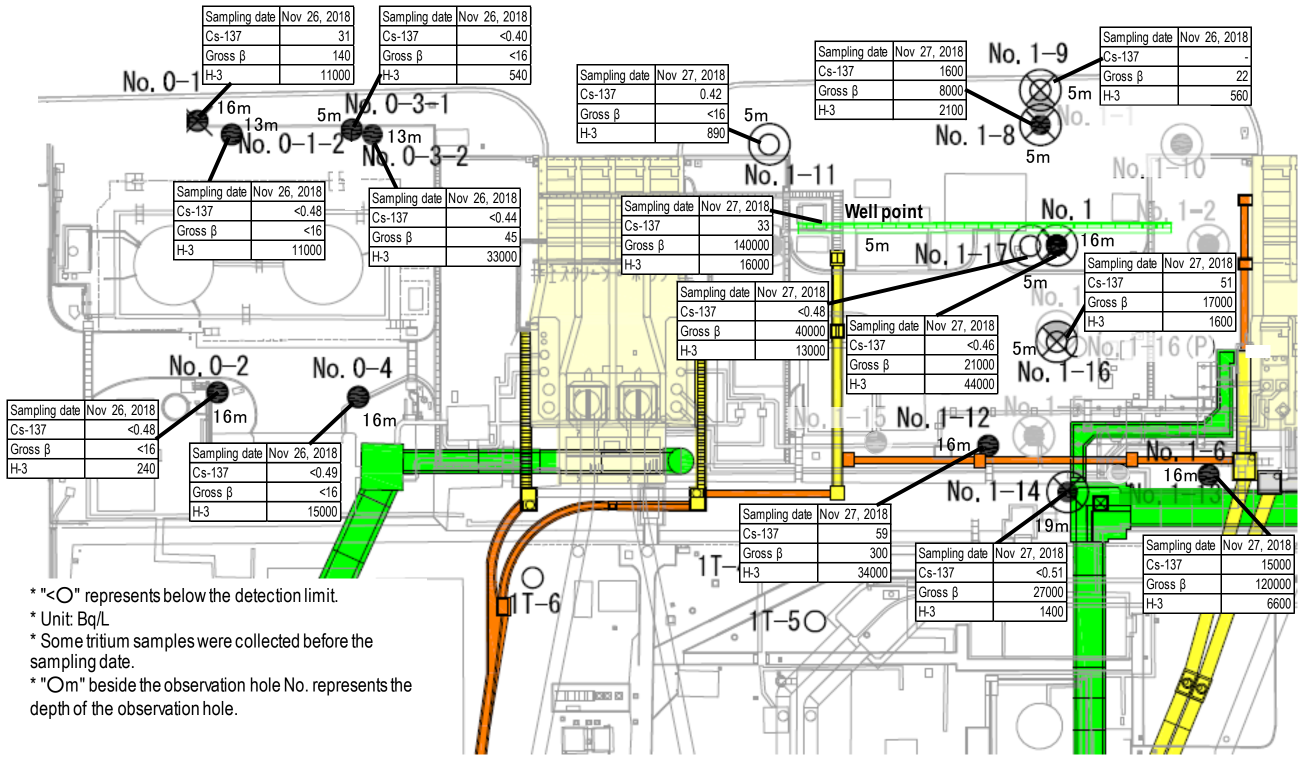
- Currently, the decay heat of fuel debris has declined significantly over time.
- Evaluation of temperature change during the potential suspension of water injection into the reactor does not take temperature decline, etc. due to natural heat release into air, which actually occurs, into consideration.
- Water injection into the reactor will be temporarily reduced and suspended to determine the status of the cooling condition of fuel debris. In addition, the accuracy of temperature change evaluation, which conveys the actual status more accurately while taking the heat release to air into consideration, will be checked.
- By understanding the temperature variation closer to the actual status, emergency response procedures will be optimized and operation and maintenance management improved.
- For Unit 2, offering highly reliable temperature measurement, the first test to reduce the water injection volume from 3.0 to 1.5m^3/h (for about seven days) and the second test to suspend water injection (for about seven hours) will be conducted in January and March 2019 respectively.
- Prior to the tests, the necessary safety measures will be decided.

5. Reduction in radiation dose and mitigation of contamination

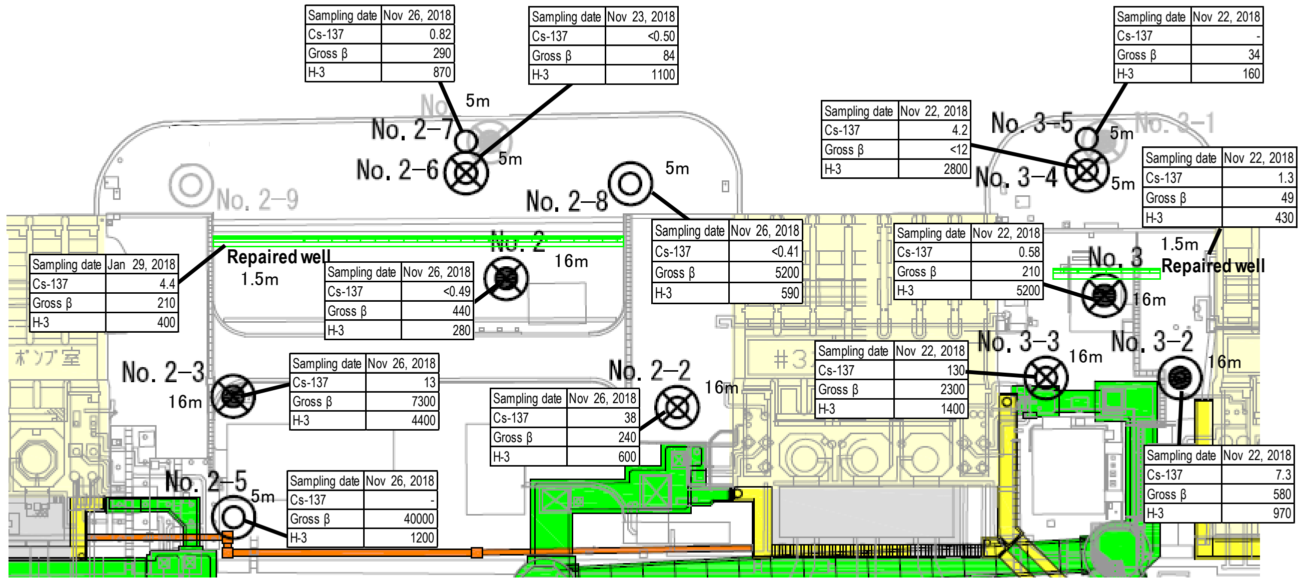
Effective dose-reduction at site boundaries and purification of port water to mitigate the impact of radiation on the external environment

➢ Status of groundwater and seawater on the east side of Turbine Building Units 1-4

- The H-3 density at No. 0-3-1 had been increasing from around 120 Bq/L since October 2018 to around 1,900 Bq/L, before decreasing and currently stands at around 600 Bq/L.
- Since March 2018, the H-3 density at No. 1-6 has been repeatedly declining and increasing and currently stands at around 6,000 Bq/L.
- The density of gross β radioactive materials at No. 1-12 had been increasing from around 300 Bq/L since September 2018 to around 800 Bq/L. It has then been declining and currently stands at around 300 Bq/L.
- The H-3 density at No. 1-14 remained constant at around 3,000 Bq/L, then declined since September 2018 and currently stands at around 1,500 Bq/L. Since August 15, 2013, pumping of groundwater continued (at the well point between the Unit 1 and 2 intakes: August 15, 2013 – October 13, 2015 and from October 24; at the repaired well: October 14 - 23, 2015).
- The H-3 density at No. 2-3 had been increasing from around 1,000 Bq/L since November 2017 and currently stands at around 4,600 Bq/L. The density of gross β radioactive materials at the same point had been increasing from around 600 Bq/L since December 2017 and currently stands at around 7,000 Bq/L. Since December 18, 2013, pumping of groundwater continued (at the well point between the Unit 2 and 3 intakes: December 18, 2013 - October 13, 2015; at the repaired well: from October 14, 2015).
- The H-3 density at No. 3-4 had been declining from around 2,000 Bq/L since January 2018 to around 900 Bq/L, then increasing and currently stands at around 2,800 Bq/L. Since April 1, 2015, pumping of groundwater continued (at the well point between the Unit 3 and 4 intakes: April 1 – September 16, 2015; at the repaired well: from September 17, 2015).
- Regarding the radioactive materials in seawater in the Unit 1-4 intake open channel area, densities have remained below the legal discharge limit except for the increase in cesium 137 and strontium 90 during heavy rain. They have also been declining following the completed installation and the connection of steel pipe sheet piles for the sea-side impermeable walls. The density of cesium 137 has been increasing since January 25, 2017, when a new silt fence was installed to accommodate the relocation.
- Regarding the radioactive materials in seawater in the area within the port, densities have remained below the legal discharge limit except for the increase in cesium 137 and strontium 90 during heavy rain but have been declining following the completed installation and the connection of steel pipe sheet piles for the sea-side impermeable walls.
- Regarding the radioactive materials in seawater in the area outside the port, densities of cesium 137 and strontium 90 have been declining, but remained unchanged and below the legal discharge limit following the completed installation and the connection of steel pipe sheet piles for the sea-side impermeable walls.



<Unit 1 intake north side, between Unit 1 and 2 intakes>



<Between Unit 2 and 3 intakes, between Unit 3 and 4 intakes>

Figure 5: Groundwater density on the Turbine Building east side

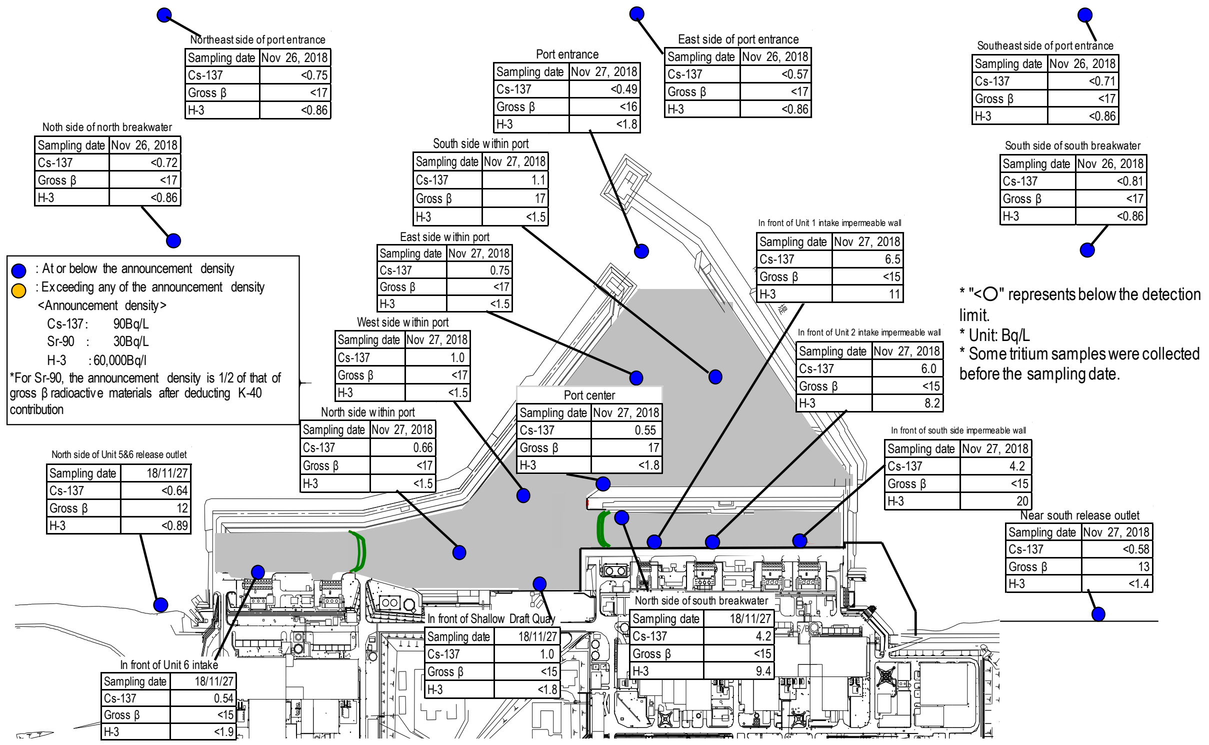


Figure 6: Seawater density around the port

6. Outlook of the number of staff required and efforts to improve the labor environment and conditions

Securing appropriate staff long-term while thoroughly implementing workers' exposure dose control. Improving the work environment and labor conditions continuously based on an understanding of workers' on-site needs

➢ Staff management

- The monthly average total of people registered for at least one day per month to work on site during the past quarter from July to September 2018 was approx. 9,600 (TEPCO and partner company workers), which exceeded the monthly average number of actual workers (approx. 7,200). Accordingly, sufficient people are registered to work on site.
- It was confirmed with the prime contractors that the estimated manpower necessary for the work in December 2018 (approx. 4,320 per day: TEPCO and partner company workers) would be secured at present. The average numbers of workers per day per month (actual values) were maintained, with approx. 4,000 to 6,200 since FY2016 (see Figure 7).
- The number of workers from within and outside Fukushima Prefecture remained constant. The local employment ratio (TEPCO and partner company workers) as of October has also remained constant at around 60%.
- The monthly average exposure dose of workers remained at approx. 0.59 mSv/month during FY2015, approx. 0.39 mSv/month during FY2016 and approx. 0.36 mSv/month during FY2017. (Reference: Annual average exposure dose 20 mSv/year ≒ 1.7 mSv/month)
- For most workers, the exposure dose was sufficiently within the limit and allowed them to continue engaging in radiation work.

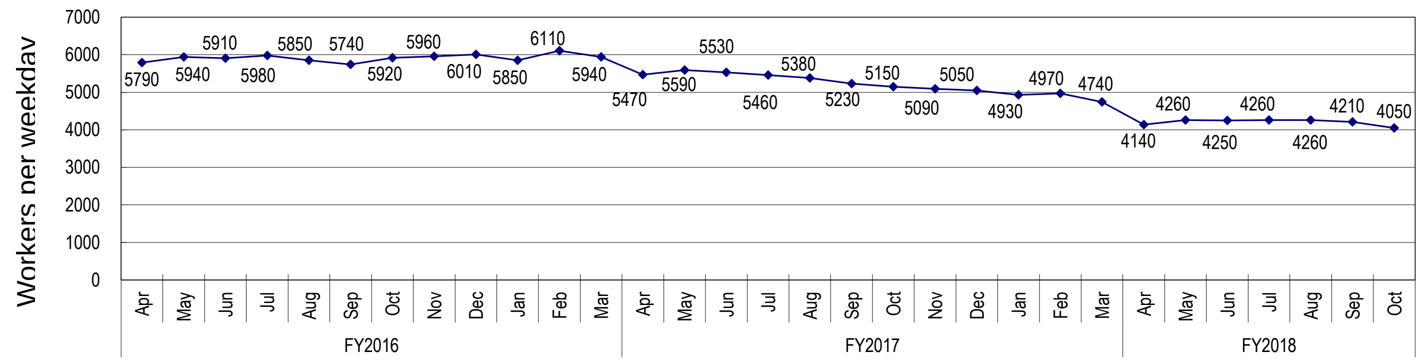


Figure 7: Changes in the average number of workers per weekday for each month since FY2016

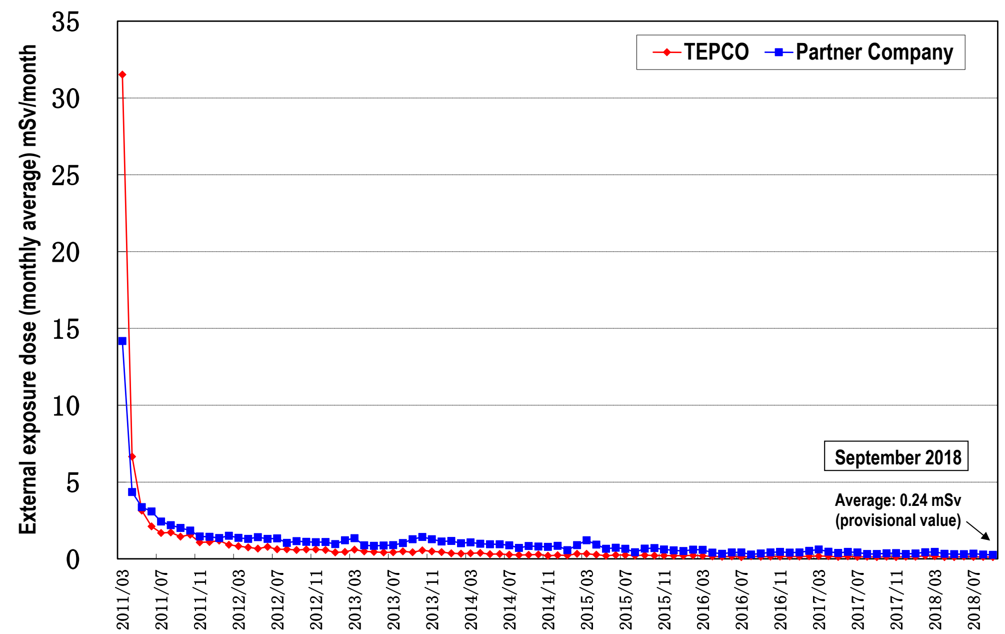


Figure 8: Changes in monthly individual worker exposure dose
(monthly average exposure dose since March 2011)

➢ Status of heat stroke cases

- In FY2018, measures to further prevent heat stroke commenced from April to cope with the hottest season (in FY2017, from May) and continued until October (in FY2017, until September). As a result, in FY2018, eight workers suffered heat stroke due to work up until November 26 (in FY2017, six workers up until the end of November). Ongoing measures will be taken to prevent heat stroke.
- This fiscal year, due to unprecedented extreme heat, the number of heat stroke patients sent to hospitals in Japan almost doubled compared to the figure last year, while in the Fukushima Daiichi Nuclear Power Station, there were only two more heat stroke cases than in FY2017.
- In FY2019, ongoing measures will continue to be implemented, including: the use of WBGT*; prohibiting outdoor work from 14:00 to 17:00; wearing cool vests; prohibiting work at WBGT 31˚C or higher in principle; and checking health conditions using check sheets to detect workers in poor physical condition at an early stage, as well as identifying workers with less experience in the Fukushima Daiichi NPS, to further improve the work environment.

- In FY2018, heat stroke cases also occurred in October for the third consecutive year. In FY2019, measures to prevent heat stroke cases in October will be implemented, including extending the ongoing intensive heat stroke prevention period to October and seeking to attract workers attention with the significant temperature difference in October in mind.

* WBGT (heat index): Index using three perspectives of humidity, radiation heat and temperature, which significantly affect the heat balance of human bodies

➢ Measures to prevent infection and expansion of influenza and norovirus

- Since November, measures for influenza and norovirus have been implemented, including free influenza vaccinations (subsidized by TEPCO HD) in the Fukushima Daiichi Nuclear Power Station (from October 24 to November 30) and medical clinics around the site (from November 1 to January 31, 2019) for partner company workers. As of November 22, a total of 4,548 workers had been vaccinated. In addition, a comprehensive range of other measures is also being implemented, including daily actions to prevent infection and expansion (measuring body temperature, health checks and monitoring infection status) and response after detecting possible infections (swift exit of possible patients and control of entry, mandatory wearing of masks in working spaces, etc.).

➢ Status of influenza and norovirus cases

- Until the 47th week of 2018 (November 19-25, 2018), no influenza infections and three norovirus infections were recorded. The totals for the same period for the previous season showed one case of influenza and two norovirus infections.

➢ Status of work environment improvement in the Fukushima Daiichi NPS

- As a result of environmental improvement in areas where workers could move without additional equipment except for gloves, the classification of these areas was revised so that workers could move there without additional equipment, including gloves from October 1 and the areas were expanded to the pavement, etc. connecting the area around the rest house and that around the Main Anti-Earthquake Building, etc. The areas were also expanded to include the high ground on the west side of Units 1-4 from November 1, where visitors could observe the site without additional equipment.
- This improvement will eliminate the burden of wearing additional equipment on visitors and reduce the time required to prepare for entry to the site.

7. Other

➢ Work to reduce the risk of tsunamis, etc. to the mega float

- The mega float, which was utilized to temporarily store stagnant water of Units 5 and 6 generated due to the earthquake, is at risk of drifting and damaging nearby facilities when a tsunami occurs.
- To reduce the risk from an early stage, offshore work to anchor the mega float within the port and utilize it as a bank and Shallow Draft Quay started from November 12.
- Thorough environmental measures are being implemented and environmental monitoring within the port continues during the work.

➢ IAEA review mission

- Japan received the 4th visit of the review mission team from the International Atomic Energy Agency (IAEA) during the period November 5-13 (after three and half years from February 2015).
- The main findings and conclusions in the summary report of the review mission:
  "The IAEA Review Team considers that significant progress has already been accomplished to move Fukushima Daiichi from an emergency situation to a stabilized situation. Many improvements have been recorded since the previous mission in 2015."
- 17 Acknowledgements and 21 Advisory Points are provided:

[Contaminated water] The team acknowledges that through multi-layered measures to reduce the contaminated water generated and prevent leakage, the influence on the public environment has been reduced. Regarding ALPS-treated water, in consideration of the on-site tank construction plan and pretreatment TEPCO will implement before disposal, a decision on the disposition path should be taken urgently in engaging all stakeholders.

[Spent fuel removal/ debris retrieval] The team acknowledges progress in environmental preparation for spent fuel removal, particularly at Unit 3 and investigations inside the reactor of each unit toward debris retrieval.

[Waste management] The team acknowledges the progress taken in measures for storage within the site and reductions of amounts, etc. and the planning shall also include sustainability and long-term aspects such as waste management including the waste streams which will come from the decommissioning of the facilities on site.

[Communications] The Team advises to the Government of Japan and TEPCO to take a proactive and timely approach to communicating with the public on matters directly relevant to public concerns. This includes not only disclosing relevant information and data on a regular basis, but providing the general public the information in an easy-to-understand manner, including an explanation of its potential impact on the health and safety of the workforce and public as well as the protection of the environment.

Status of seawater monitoring within the port (comparison between the highest values in 2013 and the latest values)

"The highest value" → "the latest value (sampled during November 19-27)"; unit (Bq/L); ND represents a value below the detection limit

Source: TEPCO website Analysis results on nuclides of radioactive materials around Fukushima Daiichi Nuclear Power Station http://www.tepco.co.jp/nu/fukushima-np/f1/smp/index-j.html

Sea side impermeable wall
Silt fence

Cesium-134: 3.3 (2013/10/17) →ND(0.24) Below 1/10
Cesium-137: 9.0 (2013/10/17) → 0.75 Below 1/10
Gross β: 74 (2013/ 8/19) →ND(17) Below 1/4
Tritium: 67 (2013/ 8/19) →ND(1.5) Below 1/40

Cesium-134: 4.4 (2013/12/24) →ND(0.31) Below 1/10
Cesium-137: 10 (2013/12/24) → 1.0 Below 1/10
Gross β: 60 (2013/ 7/ 4) →ND(17) Below 1/3
Tritium: 59 (2013/ 8/19) →ND(1.5) Below 1/30

Cesium-134: 5.0 (2013/12/2) → ND(0.27) Below 1/10
Cesium-137: 8.4 (2013/12/2) → 0.66 Below 1/10
Gross β: 69 (2013/8/19) → ND(17) Below 1/4
Tritium: 52 (2013/8/19) → ND(1.5) Below 1/30

Cesium-134: 2.8 (2013/12/2) → ND(0.49) Below 1/5
Cesium-137: 5.8 (2013/12/2) → 0.54 Below 1/10
Gross β: 46 (2013/8/19) → ND(15) Below 1/3
Tritium: 24 (2013/8/19) → ND(1.9) Below 1/10

Cesium-134: ND(0.57)
Cesium-137: 0.55
Gross β: 17
Tritium: ND(1.8) *

Cesium-134: 3.3 (2013/12/24) → ND(0.56) Below 1/5
Cesium-137: 7.3 (2013/10/11) → ND(0.49) Below 1/10
Gross β: 69 (2013/ 8/19) → ND(16) Below 1/4
Tritium: 68 (2013/ 8/19) → ND(1.8) Below 1/30

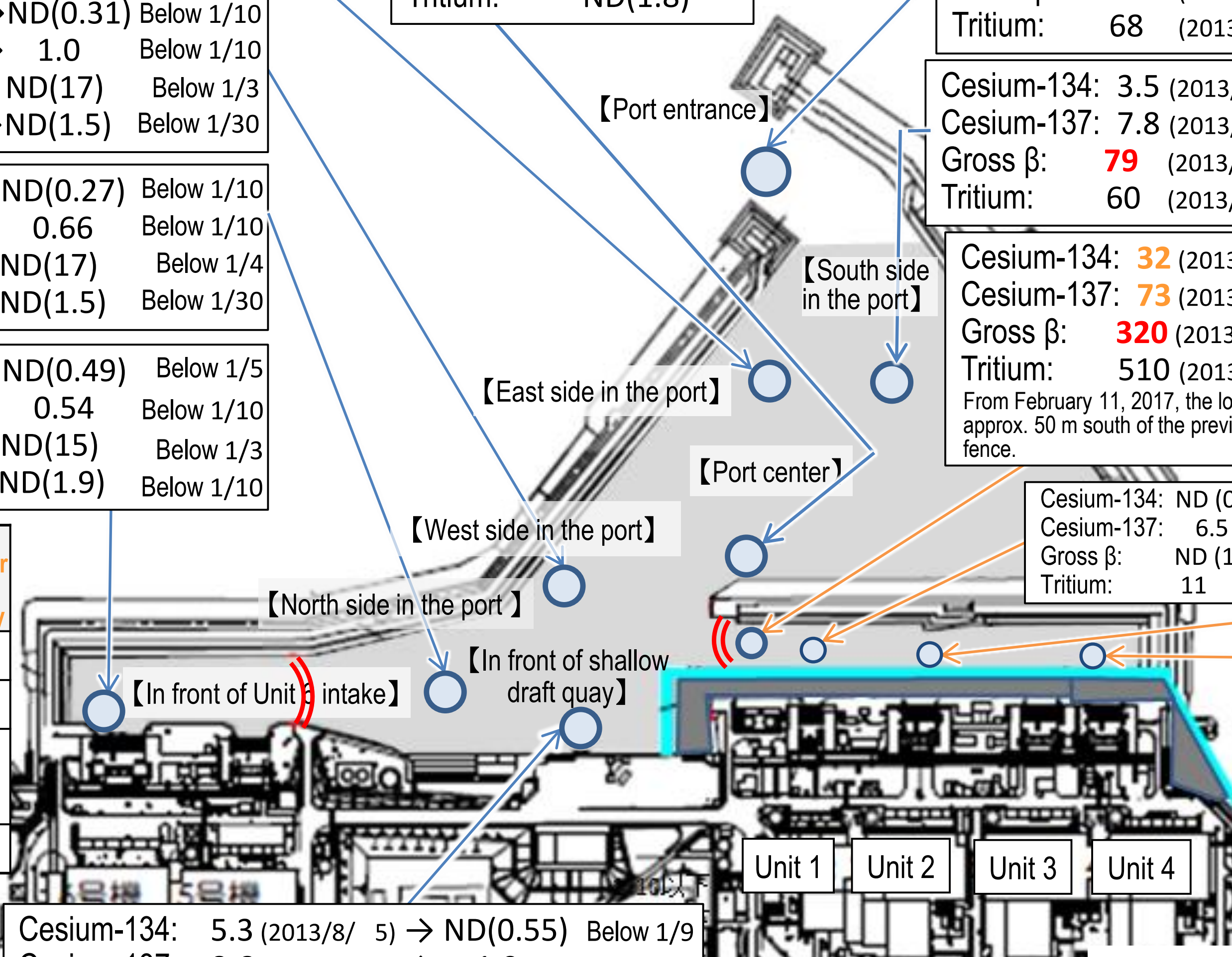
Cesium-134: 3.5 (2013/10/17) → ND(0.30) Below 1/10
Cesium-137: 7.8 (2013/10/17) → 1.1 Below 1/7
Gross β: 79 (2013/ 8/19) → 17 Below 1/4
Tritium: 60 (2013/ 8/19) → ND(1.5) Below 1/40

Cesium-134: 32 (2013/10/11) → ND(0.57) Below 1/50
Cesium-137: 73 (2013/10/11) → 4.2 Below 1/10
Gross β: 320 (2013/ 8/12) → ND(15) Below 1/20
Tritium: 510 (2013/ 9/ 2) → 9.4 Below 1/50
From February 11, 2017, the location of the sampling point was shifted approx. 50 m south of the previous point due to the location shift of the silt fence.

Cesium-134: ND (0.45)
Cesium-137: 6.5
Gross β: ND (15)
Tritium: 11 *

Cesium-134: ND (0.60)
Cesium-137: 6.0
Gross β: ND (15)
Tritium: 8.2 *

Cesium-134: ND (0.48)
Cesium-137: 4.2
Gross β: ND (15)
Tritium: 20 *



	Legal discharge limit	WHO Guidelines for Drinking Water Quality
Cesium-134	60	10
Cesium-137	90	10
Strontium-90 (strongly correlate with Gross β)	30	10
Tritium	60,000	10,000

Cesium-134: 5.3 (2013/8/ 5) → ND(0.55) Below 1/9
Cesium-137: 8.6 (2013/8/ 5) → 1.0 Below 1/8
Gross β: 40 (2013/7/ 3) → ND(15) Below 1/2
Tritium: 340 (2013/6/26) → ND(1.8) Below 1/100

* Monitoring commenced in or after March 2014.
Monitoring inside the sea-side impermeable walls was finished because of the landfill.

Note: The gross β measurement values include natural potassium 40 (approx. 12 Bq/L). They also include the contribution of yttrium 90, which radioactively balance strontium 90.

Summary of TEPCO data as of November 28, 2018

Status of seawater monitoring around outside of the port
(comparison between the highest values in 2013 and the latest values)

(The latest values sampled during November 19-27)

	Legal discharge limit	WHO Guidelines for Drinking Water Quality
Cesium-134	60	10
Cesium-137	90	10
Strontium-90 (strongly correlate with Gross β)	30	10
Tritium	60,000	10,000

Unit (Bq/L); ND represents a value below the detection limit; values in ( ) represent the detection limit; ND (2013) represents ND throughout 2013

【Northeast side of port entrance(offshore 1km)】

Cesium-134: ND (2013) → ND (0.60)
Cesium-137: ND (2013) → ND (0.75)
Gross β: ND (2013) → ND (17)
Tritium: ND (2013) → ND (0.86)

【East side of port entrance (offshore 1km)】

Cesium-134: ND (2013) → ND (0.85)
Cesium-137: 1.6 (2013/10/18) → ND (0.57) Below 1/2
Gross β: ND (2013) → ND (17)
Tritium: 6.4 (2013/10/18) → ND (0.86) Below 1/7

【Southeast side of port entrance(offshore 1km)】

Cesium-134: ND (2013) → ND (0.73)
Cesium-137: ND (2013) → ND (0.71)
Gross β: ND (2013) → ND (17)
Tritium: ND (2013) → ND (0.86)

【North side of north breakwater(offshore 0.5km)】

Cesium-134: ND (2013) → ND (0.58)
Cesium-137: ND (2013) → ND (0.72)
Gross β: ND (2013) → ND (17)
Tritium: 4.7 (2013/ 8/18) → ND (0.86) Below 1/5

【Port entrance】

Cesium-134: 3.3 (2013/12/24) →ND (0.56) Below 1/5
Cesium-137: 7.3 (2013/10/11) →ND (0.49) Below 1/10
Gross β: 69 (2013/ 8/19) →ND (16) Below 1/4
Tritium: 68 (2013/ 8/19) →ND (1.8) Below 1/30

【South side of south breakwater(offshore 0.5km)】

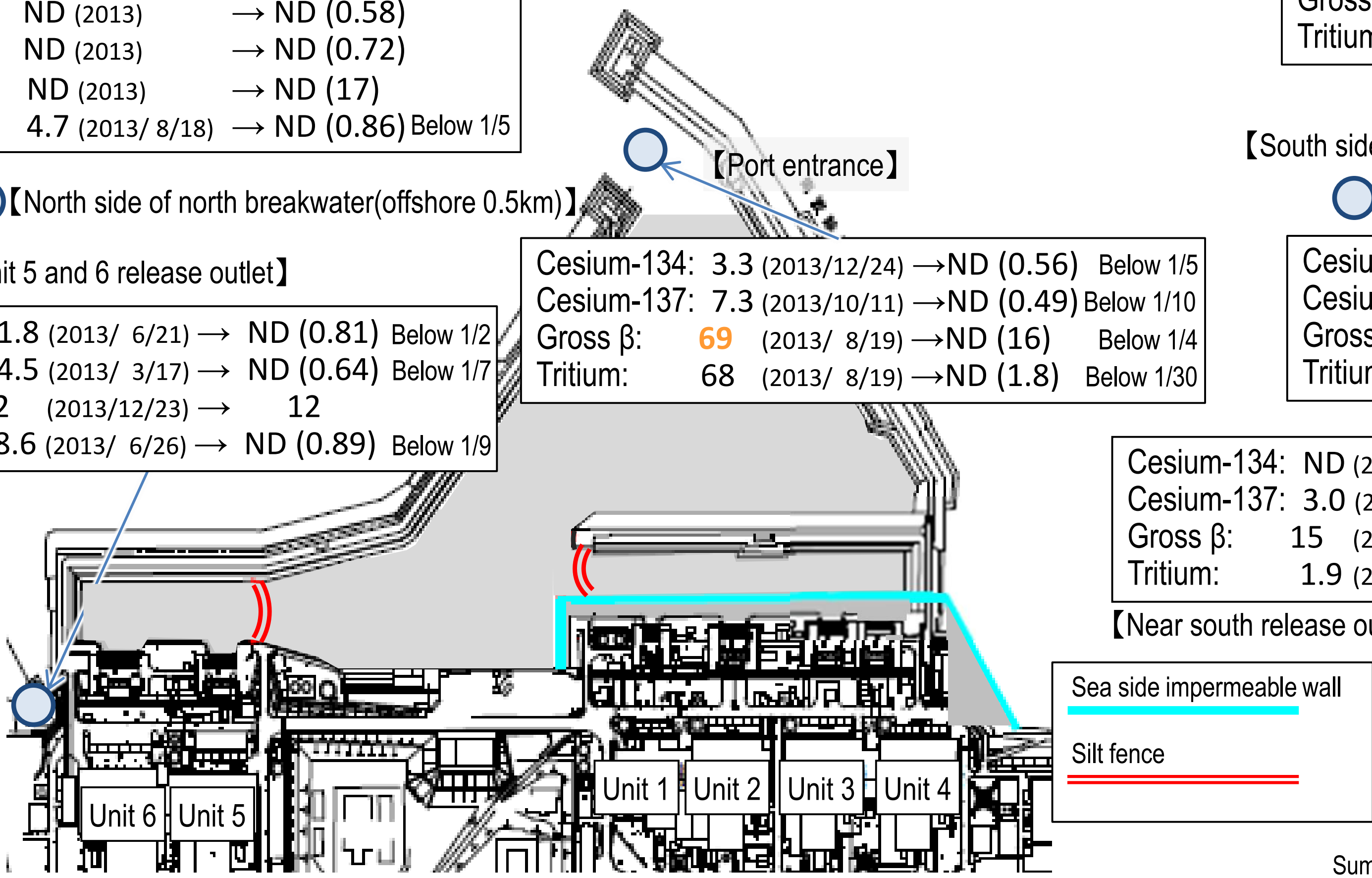
Cesium-134: ND (2013) → ND (0.77)
Cesium-137: ND (2013) → ND (0.81)
Gross β: ND (2013) → ND (17)
Tritium: ND (2013) → ND (0.86)

【North side of Unit 5 and 6 release outlet】

Cesium-134: 1.8 (2013/ 6/21) → ND (0.81) Below 1/2
Cesium-137: 4.5 (2013/ 3/17) → ND (0.64) Below 1/7
Gross β: 12 (2013/12/23) → 12
Tritium: 8.6 (2013/ 6/26) → ND (0.89) Below 1/9

【Near south release outlet】

Cesium-134: ND (2013) → ND (0.51)
Cesium-137: 3.0 (2013/ 7/15) → ND (0.58) Below 1/5
Gross β: 15 (2013/12/23) → 13
Tritium: 1.9 (2013/11/25) → 1.2



Note: The gross β measurement values include natural potassium 40 (approx. 12 Bq/L). They also include the contribution of yttrium 90, which radioactively balance strontium 90.

Note: Because safety of the sampling points was unassured due to the influence of Typhoon No. 10 in 2016, samples were taken from approx. 330 m south of the Unit 1-4 release outlet. Samples were also taken from a point approx. 280m south from the same release outlet from January 27, 2017 and approx. 320m from March 23, 2018

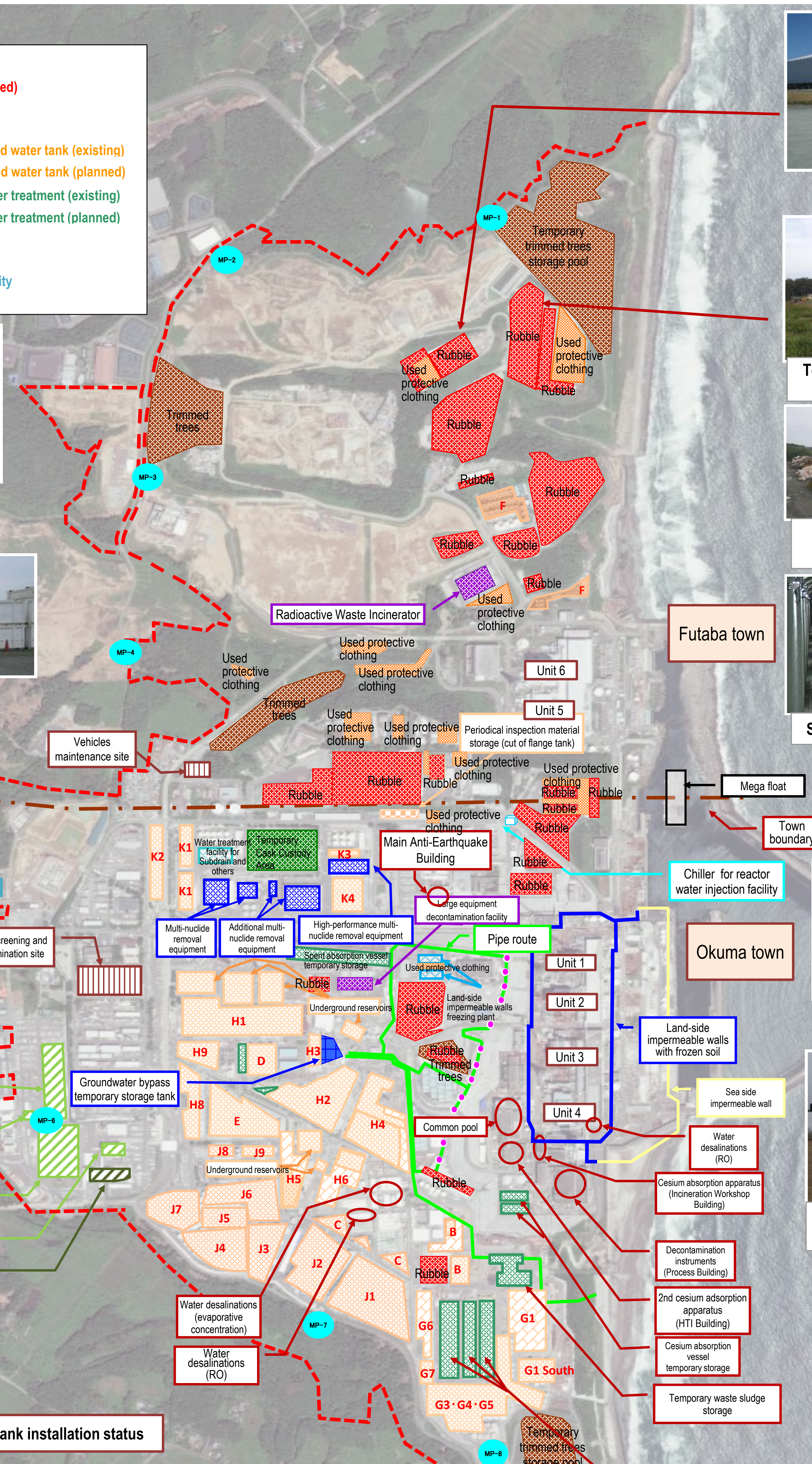
Summary of TEPCO data as of November 28, 2018

Source: TEPCO website, Analysis results on nuclides of radioactive materials around Fukushima Daiichi Nuclear Power Station, http://www.tepco.co.jp/nu/fukushima-np/f1/smp/index-j.html

Appendix 2

November 29, 2018

TEPCO Holdings Fukushima Daiichi Nuclear Power Station Site Layout




Rubble storage tent


Temporary soil-covered type storage facility


Inside the rubble storage tent


Rubble (outdoor accumulation)


Rubble (container storage)

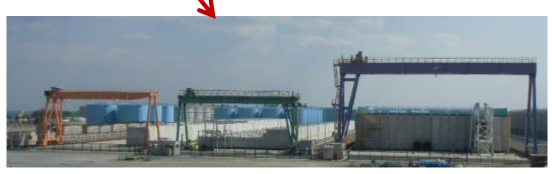

Solid waste storage facility


Rubble (outdoor accumulation)


Temporary trimmed trees storage pool


Trimmed trees (outdoor accumulation)


Temporary waste sludge storage



Provided by Japan Space Imaging, photo taken on June 14, 2018
Product(C) [2018] DigitalGlobe, Inc.

0m 100m 500m 1000m

Progress toward decommissioning: Fuel removal from the spent fuel pool (SFP)

Immediate target	Commence fuel removal from the Unit 1-3 Spent Fuel Pools

Unit 1

Regarding fuel removal from Unit 1 spent fuel pool, there is a plan to install a dedicated cover for fuel removal over the top floor of the Reactor Building (operating floor). All roof panels and wall panels of the building cover were dismantled by November 10, 2016.
Removal of pillars and beams of the building was completed on May 11, 2017. Modification of the pillars and beams of the building cover and installation of building cover were completed by December 19.
Rubble removal from the operating floor north side started from January 22, 2018. Rubble is being removed carefully by suction equipment.
No significant variation was identified around site boundaries where the density of radioactive materials was monitored and at onsite dust monitors during the above removal work.

<Installation status (January 22)>

<Status of the operating floor>

Unit 2

To facilitate removal of fuel assemblies and retrieval of debris in the Unit 2 spent fuel pool, the scope of dismantling and modification of the existing Reactor Building rooftop was examined. From the perspective of ensuring safety during the work, controlling impacts on the outside of the power station, and removing fuel rapidly to reduce risks, we decided to dismantle the whole rooftop above the highest floor of the Reactor Building.
Examination of the following two plans continues: Plan 1 to share a container for removing fuel assemblies from the pool and retrieving fuel debris; and Plan 2 to install a dedicated cover for fuel removal from the pool.

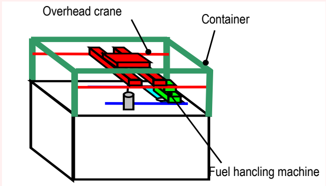


Image of Plan 1

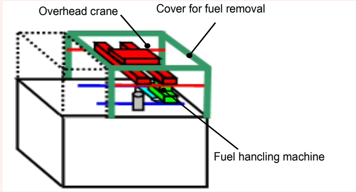


Image of Plan 2

Unit 3

Prior to the installation of a cover for fuel removal, removal of large rubble from the spent fuel pool was completed in November 2015.
To ensure safe and steady fuel removal, training of remote control was conducted at the factory using the actual fuel-handling machine which will be installed on site (February – December 2015). Measures to reduce dose on the Reactor Building top floor (decontamination, shields) were completed in December 2016. Installation of a cover for fuel removal and a fuel-handling machine is underway from January 2017. Installation of the fuel removal cover was completed on February 23, 2018.
Toward fuel removal, after confirming the cause of the failures in the FHM and crane and implementing measures for similar parts, works will continue with safety first.

Installation of dome roof (February 21)

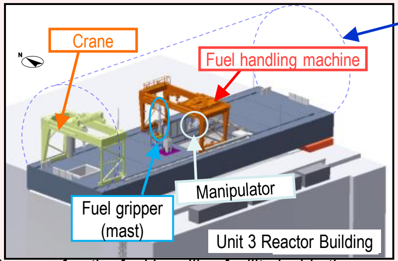


Image of entire fuel handling facility inside the cover

Unit 4

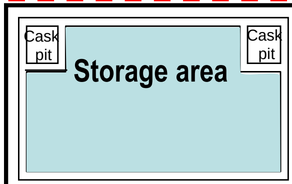
In the Mid- and Long-Term Roadmap, the target of Phase 1 involved commencing fuel removal from inside the spent fuel pool (SFP) of the 1st Unit within two years of completion of Step 2 (by December 2013). On November 18, 2013, fuel removal from Unit 4, or the 1st Unit, commenced and Phase 2 of the roadmap started.


Fuel removal status

On November 5, 2014, within a year of commencing work to fuel removal, all 1,331 spent fuel assemblies in the pool had been transferred. The transfer of the remaining non-irradiated fuel assemblies to the Unit 6 SFP was completed on December 22, 2014. (2 of the non-irradiated fuel assemblies were removed in advance in July 2012 for fuel checks)
This marks the completion of fuel removal from the Unit 4 Reactor Building.
Based on this experience, fuel assemblies will be removed from Unit 1-3 pools.

* A part of the photo is corrected because it includes sensitive information related to physical protection.

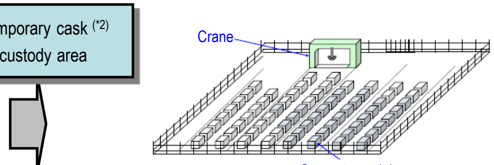
Common pool



An open space will be maintained in the common pool (Transfer to the temporary cask custody area)

Progress to date
- The common pool has been restored to a condition allowing it to re-accommodate fuel to be handled (November 2012)
- Loading of spent fuel stored in the common pool to dry casks commenced (June 2013)
- Fuel removal from the Unit 4 spent fuel pool began to be received (November 2013 - November 2014)

Temporary cask (*2) custody area



Spent fuel is accepted from the common pool

Operation commenced on April 12, 2013; from the cask-storage building, transfer of 9 existing dry casks completed (May 21, 2013); fuel stored in the common pool sequentially transferred.

<Glossary>
(*1) Operating floor: During regular inspection, the roof over the reactor is opened while on the operating floor, fuel inside the core is replaced and the core internals are inspected.
(*2) Cask: Transportation container for samples and equipment, including radioactive materials.

Progress toward decommissioning: Works to identify the plant status and toward fuel debris retrieval

Immediate target	Identify the plant status and commence R&D and decontamination toward fuel debris retrieval

Investigation into TIP Room of the Unit 1 Reactor Building

- To improve the environment for future investigations inside the PCV, etc., an investigation was conducted from September 24 to October 2, 2015 at the TIP Room(*1). (Due to high dose around the entrance in to the TIP Room, the investigation of dose rate and contamination distribution was conducted through a hole drilled from the walkway of the Turbine Building, where the dose was low)
- The investigative results identified high dose at X-31 to 33 penetrations(*2) (instrumentation penetration) and low dose at other parts.
- As it was confirmed that work inside the TIP room would be available, the next step will include identification of obstacles which will interfere the work inside the TIP Room and formulation of a plan for dose reduction.

Investigation in the leak point detected in the upper part of the Unit 1 Suppression Chamber (S/C(*3))

Investigation in the leak point detected in the upper part of Unit 1 S/C from May 27, 2014 from one expansion joint cover among the lines installed there. As no leakage was identified from other parts, specific methods will be examined to halt the flow of water and repair the PCV.

Leak point

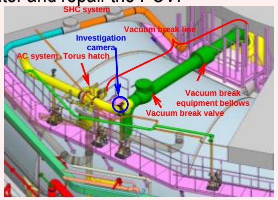
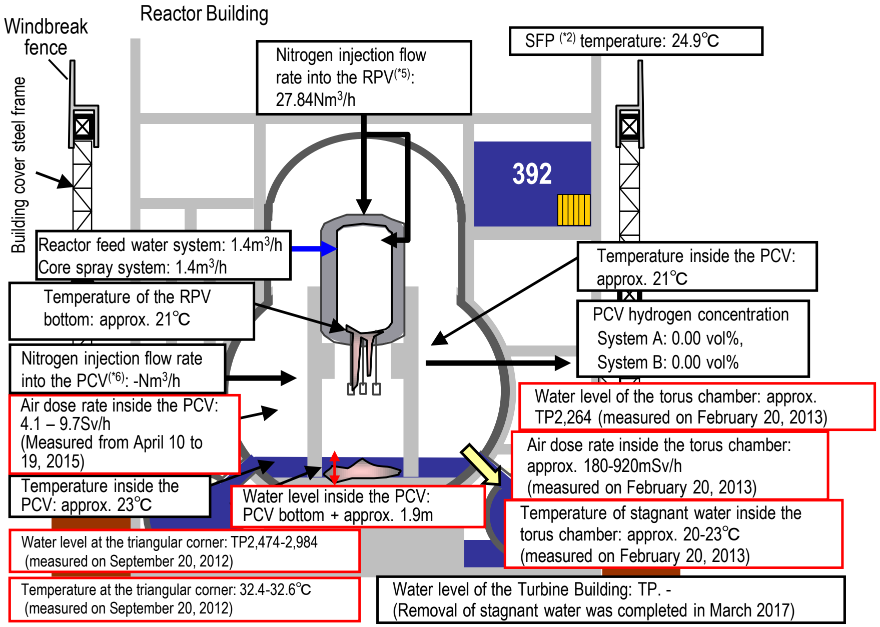


Image of the S/C upper part investigation

Unit 1

Air dose rate inside the Reactor Building: Max. 5,150mSv/h (1F southeast area) (measured on July 4, 2012)



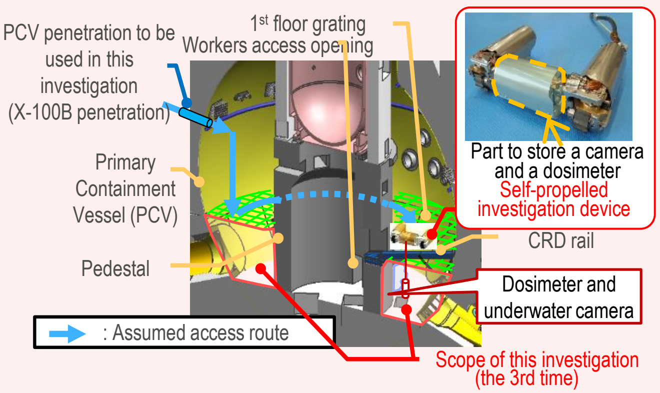
* Indices related to the plant are values as of 11:00, November 28, 2018

Investigations inside PCV	1st (Oct 2012)	- Acquiring images - Measuring air temperature and dose rate - Measuring water level and temperature - Sampling stagnant water - Installing permanent monitoring instrumentation
	2nd (Apr 2015)	Confirming the status of PCV 1st floor - Acquiring images - Measuring air temperature and dose rate - Replacing permanent monitoring instrumentation
	3rd (Mar 2017)	Confirming the status of PCV 1st basement floor - Acquiring images - Measuring and dose rate - Sampling deposit - Replacing permanent monitoring instrumentation
Leakage points from PCV		- PCV vent pipe vacuum break line bellows (identified in May 2014) - Sand cushion drain line (identified in November 2013)

Status of investigation inside the PCV

Prior to fuel debris retrieval, an investigation inside the PCV will be conducted to inspect the status there including the location of fuel debris.

[Investigative outline]
- In April 2015, a device, which entered the inside of the PCV through a narrow access opening (bore: ϕ 100 mm), collected information such as images and airborne dose inside the PCV 1st floor.
- In March 2017, the investigation using a self-propelled investigation device, conducted to inspect the spreading of debris to the basement floor outside the pedestal, took images of the PCV bottom status for the first time. The status inside the PCV will continue to be examined based on the collected image and dose data.



<Image of investigation inside the PCV>

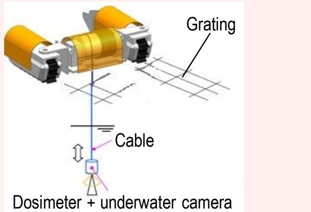


Image of hanging of dosimeter and camera

Image near the bottom

Capturing the location of fuel debris inside the reactor by measurement using muons

Period	Evaluation results
Feb - May 2015	Confirmed that there was no large fuel in the reactor core.

<Glossary>
(*1) TIP (Traversing In-core Probe)
(*2) Penetration: Through-hole of the PCV
(*3) S/C (Suppression Chamber): Suppression pool, used as the water source for the emergent core cooling system.
(*4) SFP (Spent Fuel Pool):
(*5) RPV (Reactor Pressure Vessel)
(*6) PCV (Primary Containment Vessel)

Progress toward decommissioning: Works to identify the plant status and toward fuel debris retrieval

Immediate target	Identify the plant status and commence R&D and decontamination toward fuel debris retrieval

Installation of an RPV thermometer and permanent PCV supervisory instrumentation

(1) Replacement of the RPV thermometer

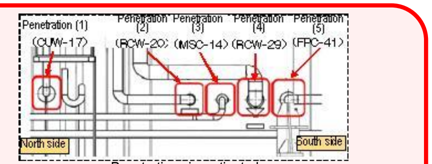
- As the thermometer installed at the Unit 2 RPV bottom after the earthquake had broken in February 2014, it was excluded from the monitoring thermometers.
- In April 2014, removal of the broken thermometer failed and was suspended. Rust-stripping chemicals were injected and the broken thermometer was removed in January 2015. A new thermometer was reinstalled in March. The thermometer has been used as a part of permanent supervisory instrumentation since April.

(2) Reinstallation of the PCV thermometer and water-level gauge

- Some of the permanent supervisory instrumentation for PCV could not be installed in the planned locations due to interference with existing grating (August 2013). The instrumentation was removed in May 2014 and new instruments were reinstalled in June 2014. The trend of added instrumentation will be monitored for approx. one month to evaluate its validity.
- The measurement during the installation confirmed that the water level inside the PCV was approx. 300mm from the bottom.

Investigative results on torus chamber walls

- The torus chamber walls were investigated (on the north side of the east-side walls) using equipment specially developed for that purpose (a swimming robot and a floor traveling robot).
- At the east-side wall pipe penetrations (five points), "the status" and "existence of flow" were checked.
- A demonstration using the above two types of underwater wall investigative equipment showed how the equipment could check the status of penetration.
- Regarding Penetrations 1 - 5, the results of checking the sprayed tracer (*5) by camera showed no flow around the penetrations. (investigation by the swimming robot)
- Regarding Penetration 3, a sonar check showed no flow around the penetrations. (investigation by the floor traveling robot)



Penetrations investigated

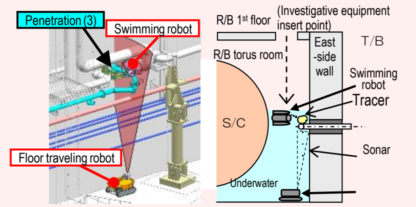
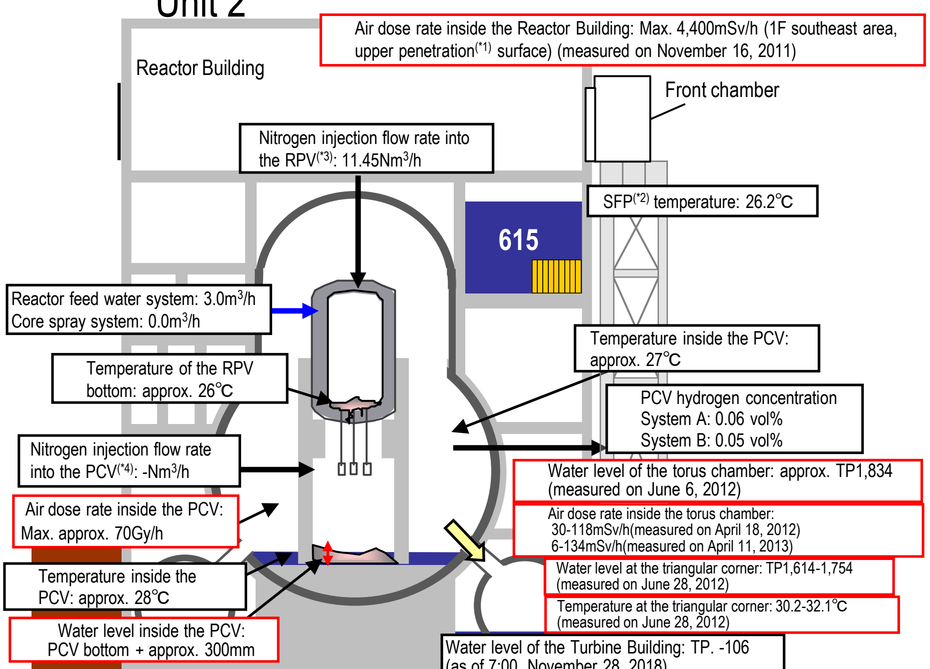


Image of the torus chamber east-side cross-sectional investigation

Unit 2



* Indices related to plant are values as of 11:00, November 28, 2018

Investigations inside PCV	1st (Jan 2012)	- Acquiring images - Measuring air temperature
	2nd (Mar 2012)	- Confirming water surface - Measuring water temperature - Measuring dose rate
	3rd (Feb 2013 – Jun 2014)	- Acquiring images - Sampling stagnant water - Measuring water level - Installing permanent monitoring instrumentation
	4th (Jan – Feb 2017)	- Acquiring images - Measuring dose rate - Measuring air temperature
Leakage points from PCV		- No leakage from torus chamber rooftop - No leakage from all inside/outside surfaces of S/C

Status of investigation inside the PCV

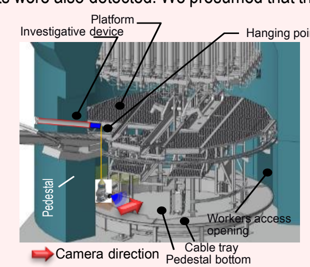
Prior to fuel debris retrieval, an investigation inside the PCV will be conducted to inspect the status there including the location of fuel debris.

[Investigative outline]

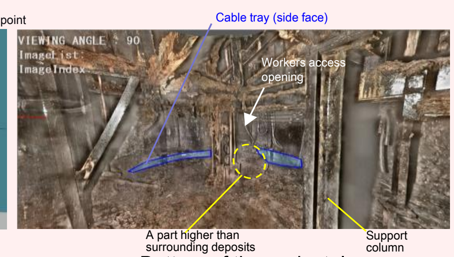
- Investigative devices such as a robot will be injected from Unit 2 X-6 penetration(*1) and access the inside of the pedestal using the CRD rail.

[Progress status]

- On January 26 and 30, 2017, a camera was inserted from the PCV penetration to inspect the status of the CRD replacement rail on which the robot will travel. On February 9, deposit on the access route of the self-propelled investigative device was removed and on February 16, the inside of the PCV was investigated using the device.
- The results of this series of investigations confirmed fallen and deformed gratings and a quantity of deposit inside the pedestal.
- On January 19, 2018, the status below the platform inside the pedestal was investigated using an investigative device with a hanging mechanism. From the analytical results of images obtained in the investigation, deposits probably including fuel debris were found at the bottom of the pedestal. In addition, multiple parts higher than the surrounding deposits were also detected. We presumed that there were multiple routes of fuel debris falling.



Investigative status (image)



Bottom of the pedestal

Capturing the location of fuel debris inside the reactor by measurement using muons

Period	Evaluation results
Mar – Jul 2016	Confirmed the existence of high-density materials, which was considered as fuel debris, at the bottom of RPV, and in the lower part and the outer periphery of the reactor core. It was assumed that a large part of fuel debris existed at the bottom of RPV.

<Glossary> (*1) Penetration: Through-hole of the PCV (*2) SFP (Spent Fuel Pool) (*3) RPV (Reactor Pressure Vessel) (*4) PCV (Primary Containment Vessel) (*5) Tracer: Material used to trace the fluid flow. Clay particles

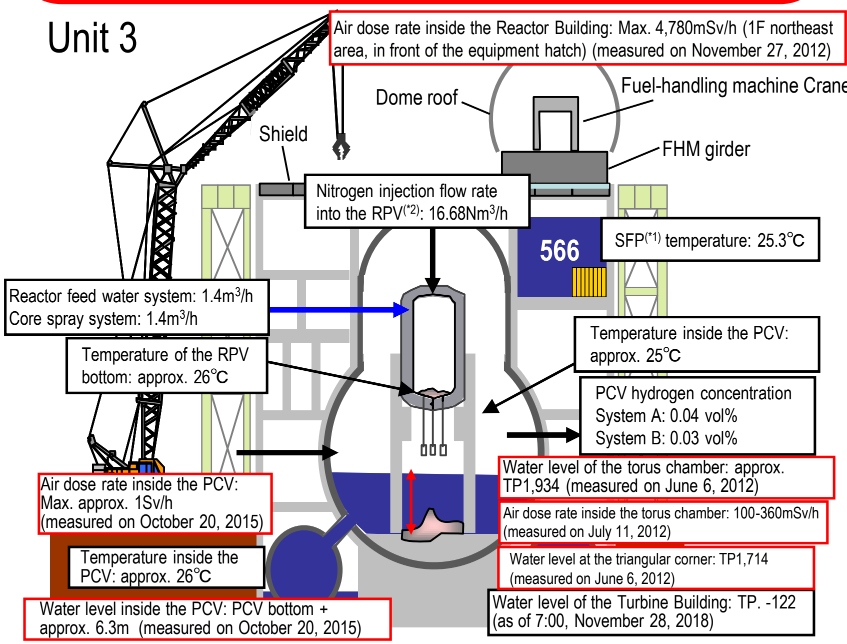
Progress toward decommissioning: Works to identify the plant status and toward fuel debris retrieval

Immediate target	Identify the plant status and commence R&D and decontamination toward fuel debris retrieval

Water flow was detected from the Main Steam Isolation Valve* room

On January 18, 2014, a flow of water from around the door of the Steam Isolation Valve room in the Reactor Building Unit 3 1st floor northeast area to the nearby floor drain funnel (drain outlet) was detected. As the drain outlet connects with the underground part of the Reactor Building, there is no possibility of outflow from the building.
From April 23, 2014, image data has been acquired by camera and the radiation dose measured via pipes for measurement instrumentation, which connect the air-conditioning room on the Reactor Building 2nd floor with the Main Steam Isolation Valve Room on the 1st floor. On May 15, 2014, water flow from the expansion joint of one Main Steam Line was detected.
This is the first leak from PCV detected in the Unit 3. Based on the images collected in this investigation, the leak volume will be estimated and the need for additional investigations will be examined. The investigative results will also be utilized to examine water stoppage and PCV repair methods.

* Main Steam Isolation Valve: A valve to shut off the steam generated from the Reactor in an emergency

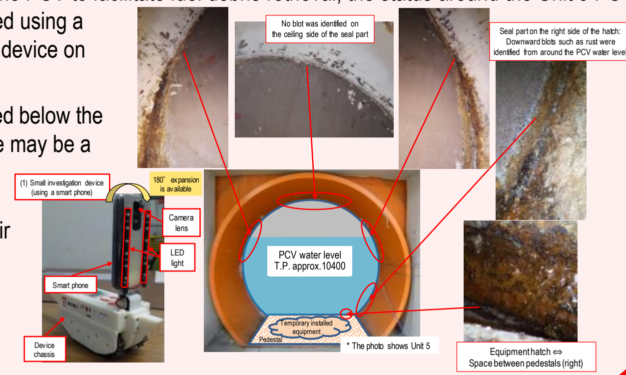


* Indices related to plant are values as of 11:00, November 28, 2018

Investigations inside PCV	1st (Oct – Dec 2015)	- Acquiring images - Measuring air temperature and dose rate - Measuring water level and temperature - Sampling stagnant water - Installing permanent monitoring instrumentation (December 2015)
	2nd (Jul 2017)	- Acquiring images - Installing permanent monitoring instrumentation (August 2017)
Leakage points from PCV	- Main steam pipe bellows (identified in May 2014)	

Investigative results into the Unit 3 PCV equipment hatch using a small investigation device

- As part of the investigation into the PCV to facilitate fuel debris retrieval, the status around the Unit 3 PCV equipment hatch was investigated using a small self-traveling investigation device on November 26, 2015.
- Given blots such as rust identified below the water level inside the PCV, there may be a leakage from the seal to the extent of bleeding.
  Methods to investigate and repair the parts, including other PCV penetrations with a similar structure, will be considered.

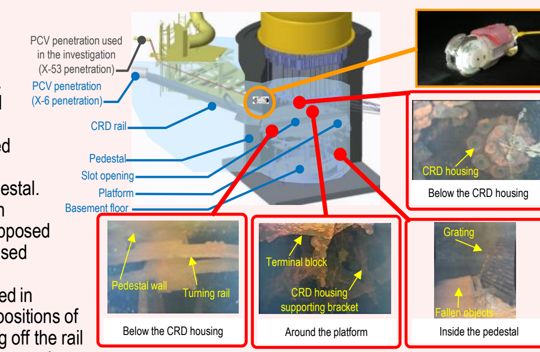


Investigation inside the PCV

Prior to fuel debris retrieval, the inside of the Primary Containment Vessel (PCV) was investigated to identify the status there including the location of the fuel debris.

[Investigative outline]

- The status of X-53 penetration(*4), which may be under the water and which is scheduled for use to investigate the inside of the PCV, was investigated using remote-controlled ultrasonic test equipment. The results showed that the penetration was not under the water (October 22-24, 2014).
- For the purpose of confirming the status inside the PCV, an investigation device was inserted into the PCV from X-53 penetration on October 20 and 22, 2015 to obtain images, data of dose and temperature and sample stagnant water. No damage was identified on the structure and walls inside the PCV and the water level was almost identical with the estimated value. In addition, the dose inside the PCV was confirmed to be lower than in other Units.
- In July 2017, the inside of the PCV was investigated using the underwater ROV (remotely operated underwater vehicle) to inspect the inside of the pedestal.
- Analysis of image data obtained in the investigation identified damage to multiple structures and the supposed core internals. Consideration about fuel removal based on the obtained information will continue.
- Videos obtained in the investigation were reproduced in 3D. Based on the reproduced images, the relative positions of the structures, such as the rotating platform slipping off the rail with a portion buried in deposits, were visually understood.



Status inside the pedestal

Capturing the location of fuel debris inside the reactor by measurement using muons

Period	Evaluation results
May – Sep 2017	The evaluation confirmed that no large lump existed in the core area where fuel had been placed and that part of the fuel debris potentially existed at the bottom of the RPV.

<Glossary>
(*1) SFP (Spent Fuel Pool) (*2) RPV (Reactor Pressure Vessel) (*3) PCV (Primary Containment Vessel) (*4) Penetration: Through-hole of the PCV

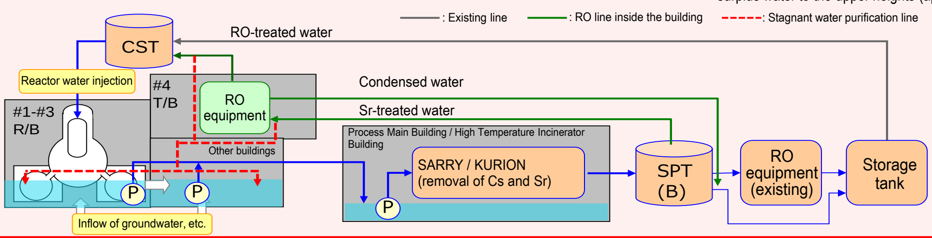
Progress toward decommissioning: Work related to circulation cooling and stagnant water treatment line

Immediate target	Stably continue reactor cooling and stagnant water treatment, and improve reliability

Work to improve the reliability of the circulation water injection cooling system and pipes to transfer stagnant water.

- Operation of the reactor water injection system using Unit 3 Condensate Storage Tank (CST) as a water source commenced (from July 5, 2013). Compared to the previous systems, the reliability of the reactor water injection system was enhanced, e.g. by increasing the amount of water-source storage and enhancing durability.
- To reduce the risk of contaminated-water leakage, the circulation loop was shortened by installing a reverse osmosis (RO) device in the Unit 4 Turbine Building within the circulation loop, comprising the transfer of contaminated water, water treatment and injection into the reactors. Operation of the installed RO device started from October 7 and 24-hour operation started from October 20. Installation of the new RO device inside the building shortened the circulation loop from approx. 3 to 0.8 km.
- To accelerate efforts to reduce the radiation density in stagnant water inside the buildings, circulating purification of stagnant water inside the buildings stared on the Unit 3 and 4 side on February 22 and on the Unit 1 and 2 side on April 11.
- For circulating purification, a new pipe divided from the water treatment equipment outlet line was installed to transfer water purified at the water treatment equipment to the Unit 1 Reactor Building and the Unit 2-4 Turbine Buildings.
- The risks of stagnant water inside the buildings will continue to be reduced in addition to reduction of its storage.

* The entire length of contaminated water transfer pipes is approx. 2.1km, including the transfer line of surplus water to the upper heights (approx. 1.3km).



Progress status of dismantling of flange tanks

- To facilitate replacement of flange tanks, dismantling of flange tanks started in H1 east/H2 areas in May 2015. Dismantling of all flange tanks was completed in H1 east area (12 tanks) in October 2015, in H2 area (28 tanks) in March 2016, in H4 area (56 tanks) in May 2017, in H3 B area (31 tanks) in September 2017, in H5 and H5 north areas (31 tanks) in June 2018 ,in G6 area(38tanks) in July 2018 and H6 and H6 north areas (24 tanks) in September 2018. Dismantling of flange tanks in G4 south area is underway.

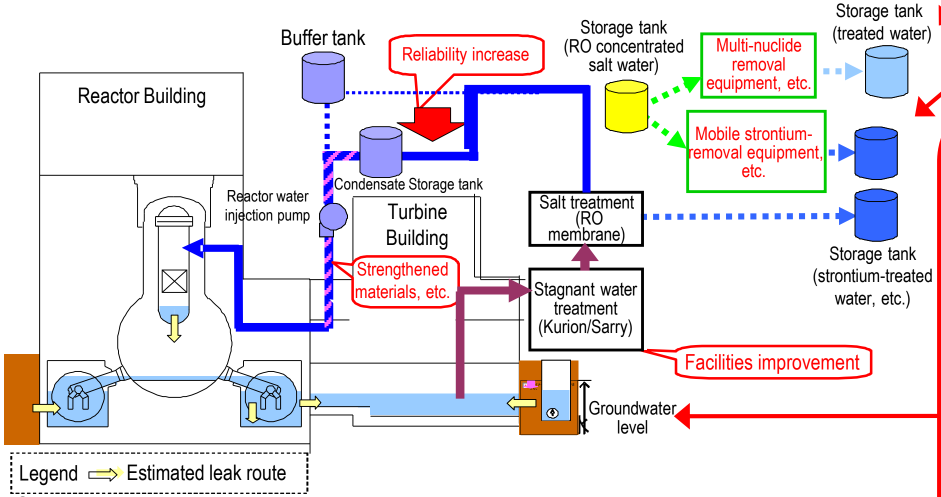

Start of dismantling in H1 east area

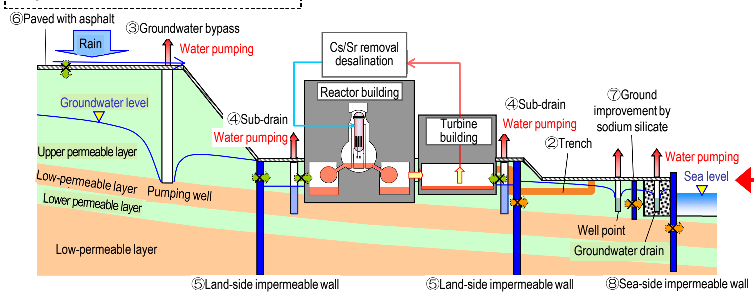

After dismantling in H1 east area

Completion of purification of contaminated water (RO concentrated salt water)

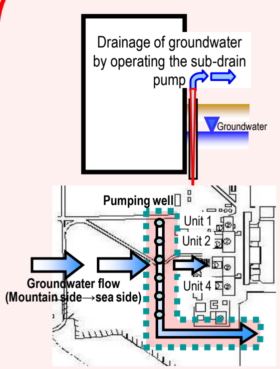
Contaminated water (RO concentrated salt water) is being treated using seven types of equipment including the multi-nuclide removal equipment (ALPS). Treatment of the RO concentrated salt water was completed on May 27, 2015, with the exception of the remaining water at the tank bottom. The remaining water will be treated sequentially toward dismantling the tanks.

The strontium-treated water from other facilities than the multi-nuclide removal equipment will be re-purified in the multi-nuclide removal equipment to further reduce risks.





Preventing groundwater from flowing into the Reactor Buildings



Reducing groundwater inflow by pumping sub-drain water

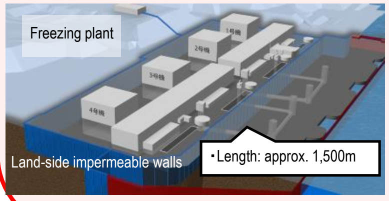
To reduce groundwater flowing into the buildings, pumping-up of groundwater from wells (subdrains) around the buildings started on September 3, 2015. Pumped-up groundwater was purified at dedicated facilities and released after TEPCO and a third-party organization confirmed that its quality met operational targets.

Via a groundwater bypass, reduce the groundwater level around the Building and groundwater inflow into the Building

Measures to pump up groundwater flowing from the mountain side upstream of the Building to reduce the groundwater inflow (groundwater bypass) have been implemented.
The pumped up groundwater is temporarily stored in tanks and released after TEPCO and a third-party organization have confirmed that its quality meets operational targets.
Through periodical monitoring, pumping of wells and tanks is operated appropriately.
At the observation holes installed at a height equivalent to the buildings, the trend showing a decline in groundwater levels is checked.
The analytical results on groundwater inflow into the buildings based on existing data showed a declining trend.

Installing land-side impermeable walls with frozen soil around Units 1-4 to prevent the inflow of groundwater into the building

To prevent the inflow of groundwater into the buildings, installation of impermeable walls on the land side is planned. Freezing started on the sea side and at a part of the mountain side from March 2016 and at 95% of the mountain side from June 2016. Freezing of the remaining unfrozen sections advanced with a phased approach and freezing of all sections started in August 2017.
In March 2018, the land-side impermeable walls were considered completed except for a portion of the depths based on a monitoring result showing that the underground temperature had declined below 0°C in almost all areas and on the mountain side, the difference between the inside and outside increased to approx. 4-5 m. The multi-layered contaminated water management measures, including subdrains and facing, have kept the groundwater level stable. Consequently, a water-level management system to isolate the buildings from groundwater was considered to have been established. The Committee on Countermeasures for Contaminated Water Treatment held on March 7 clearly recognized the effect of the land-side impermeable walls in shielding groundwater and evaluated that the land-side impermeable walls allowed for a significant reduction in the amount of contaminated water generated.



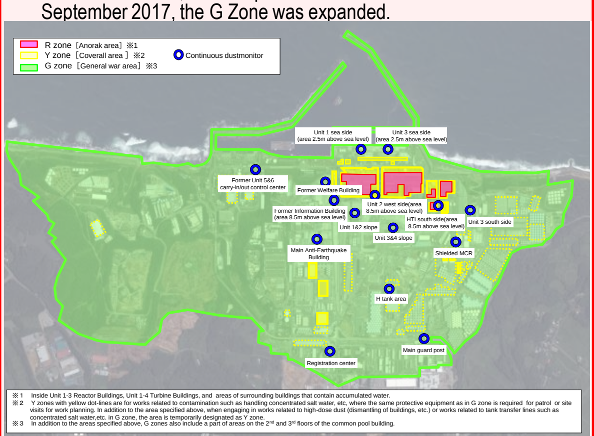
Progress toward decommissioning: Work to improve the environment within the site

Immediate targets	・Reduce the effect of additional release from the entire power station and radiation from radioactive waste (secondary water treatment waste, rubble, etc.) generated after the accident, to limit the effective radiation dose to below 1mSv/year at the site boundaries. ・Prevent contamination expansion in sea, decontamination within the site

Optimization of radioactive protective equipment

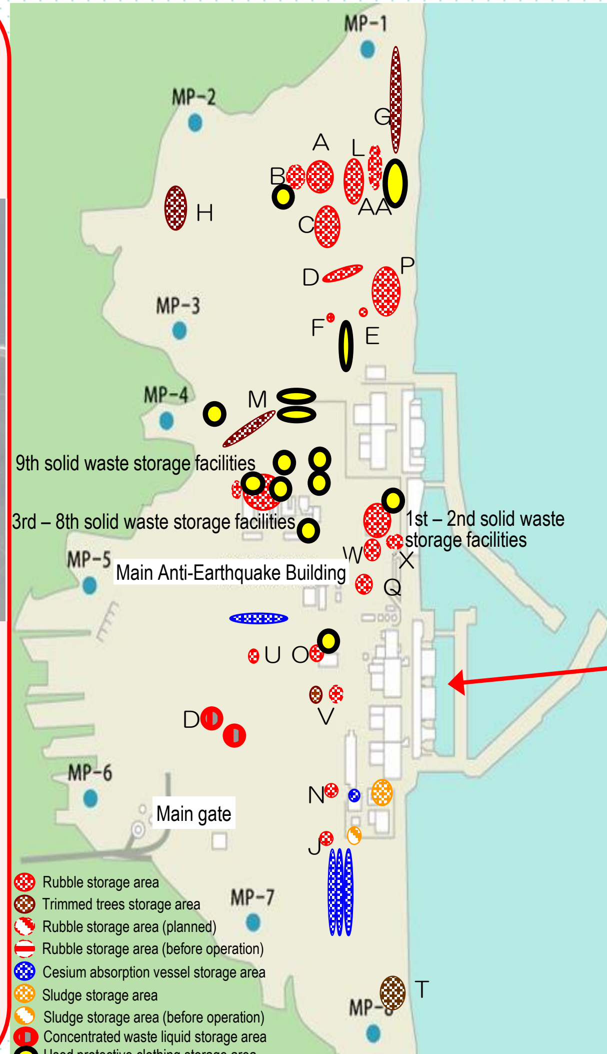
Based on the progress of measures to reduce environmental dosage on site, the site is categorized into two zones: highly contaminated area around Unit 1-4 buildings, etc. and other areas to optimize protective equipment according to each category aiming at improving safety and productivity by reducing load during work.

From March 2016, limited operation started. From March and September 2017, the G Zone was expanded.



R zone (Anorak area)	Y zone (Coverall area)	G zone (General wear)
Full-face mask 	Full-face or half-face masks *1 *2  	Disposable disposable mask 
Anorak on coverall Or double coveralls 	Coverall 	General*3  Dedicated on-site wear 

*1 For works in buildings including water-treatment facilities [multi-nuclide removal equipment, etc.] (excluding site visits), wear a full-face mask.
*2 For works in tank areas containing concentrated salt water or Sr-treated water (excluding works not handling concentrated salt water, etc., patrol, on-site investigation for work planning, and site visits) and works related to tank transfer lines, wear a full-face mask.
*3 Specified light works (patrol, monitoring, delivery of goods brought from outside, etc.)



Installation of dose-rate monitors

To help workers in the Fukushima Daiichi Nuclear Power Station precisely understand the conditions of their workplaces, a total of 86 dose-rate monitors were installed by January 4, 2016.

These monitors allow workers to confirm real time on-site dose rates at their workplaces.

Workers are also able to check concentrated data through large-scale displays installed in the Main Anti-Earthquake Building and the access control facility.

Installation of Dose-rate monitor

Installation of sea-side impermeable walls

To prevent the outflow of contaminated water into the sea, sea-side impermeable walls have been installed.

Following the completed installation of steel pipe sheet piles on September 22, 2015, connection of these piles was conducted and connection of sea-side impermeable walls was completed on October 26, 2015. Through these works, closure of sea-side impermeable walls was finished and the contaminated water countermeasures have been greatly advanced.

Installation of steel pipe sheet piles for sea-side impermeable wall

Status of the large rest house

A large rest house for workers was established and its operation commenced on May 31, 2015.

Spaces in the large rest house are also installed for office work and collective worker safety checks as well as taking rest.

On March 1, 2016 a convenience store opened in the large rest house. On April 11, operation of the shower room started. Efforts will continue to improve convenience of workers.