Summary of Decommissioning and Contaminated Water Management

August 29, 2019

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

Main decommissioning work and steps

Fuel removal from the Unit 4 SFP was completed on December 22, 2014 and removal from the Unit 3 SFP has been underway since April 15, 2019. Dust density in the surrounding environment is being monitored and work is being implemented with safety first. Work continues sequentially toward the start of fuel removal from Units 1 and 2 and debris (Note 1) retrieval from Units 1-3.

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

Fuel Removal from SFP: Rubble removal & dose reduction (Units 1 & 2) → Installing Fuel removal machine → Fuel removal (Unit 3) → Storage and handling (Unit 4)

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 around mid-FY2018*
Unit 4: Fuel removal completed in 2014

* Fuel removal started from April 15, 2019.

Fuel Debris Retrieval: Ascertaining the status inside the PCV/ examining the fuel debris retrieval method, etc. (Note 2) (Unit 1-3) → Fuel debris retrieval → Storage and handling

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

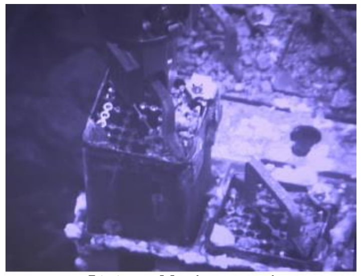
Dismantling Facilities: Scenario development & technology consideration → Design and manufacturing of devices / equipment → Dismantling

Fuel removal from the spent fuel pool

Fuel removal from the Unit 3 SFP started from April 15, 2019. Work continues toward completion of fuel removal within FY2020.

<Reference> Progress to date

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



Status of fuel removal (April 15, 2019)

Three principles behind contaminated water countermeasures

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

1 **Remove** contamination sources

① Purification using Multi-nuclide removal equipment and other measures
② Removal of contaminated water from the trench (Note 3)

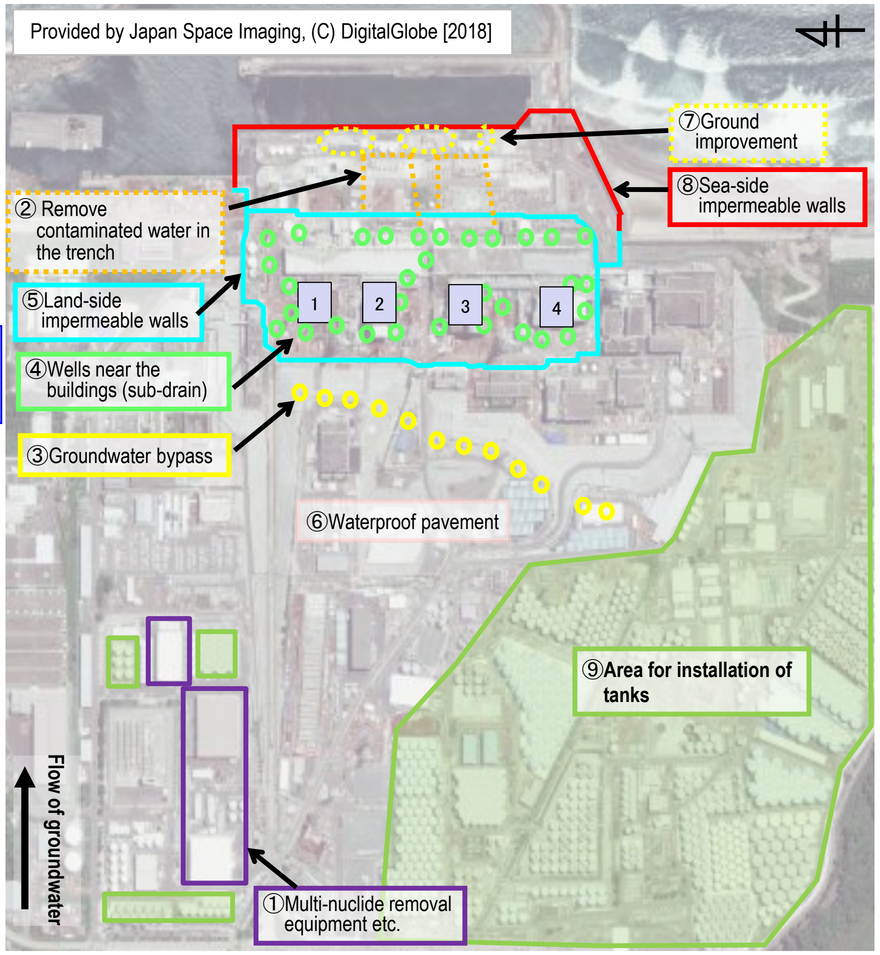
(Note 3) Underground tunnel containing pipes.

2. **Redirect groundwater** from contamination sources

③ Pump up groundwater for bypass
④ Pump up groundwater near buildings
⑤ Land-side impermeable walls (frozen-soil 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 with multi-nuclide removal equipment, additional multi-nuclide removal equipment installed by TEPCO (operation commenced in September 2014) and a Japanese Government subsidy project (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)

Reducing the generation of contaminated water through multi-layered measures

- Multi-layered measures are implemented to suppress the inflow of rainwater and groundwater into buildings.
- Multi-layered contaminated water management measures, including land-side impermeable walls and subdrains, have stabilized the groundwater at a low level. The increase in the amount of contaminated water generated during rainfall is being suppressed by repairing damaged portions of building roofs, facing onsite, etc.
- Through these measures, the generation of contaminated water was reduced from approx. 470 m^3/day (in FY2014) to approx. 170 m^3/day (in FY2018).
- The groundwater level around Unit 1-4 Reactor Buildings will remain limited by steadily operating land-side impermeable walls. In addition, measures to prevent the inflow of rainwater, including repairing damaged parts of building roofs and facing, continue to reduce the generation of contaminated water still further.

Inside the land-side impermeable wall

Outside the land-side impermeable wall

Replacing flanged tanks with welded-joint tanks

- Replacement of flanged tanks with more reliable welded-joint tanks is underway.
- Strontium-treated water stored in flanged tanks was purified and transferred to welded-joint tanks. The transfer was completed in November 2018. Transfer of ALPS-treated water was completed in March 2019.

(Installed welded-joint tanks)

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. 25-35°C*1 over the past month. There was no significant change in the density of radioactive materials newly released from Reactor Buildings into the air*2. It was concluded that the comprehensive cold shutdown condition had been maintained.

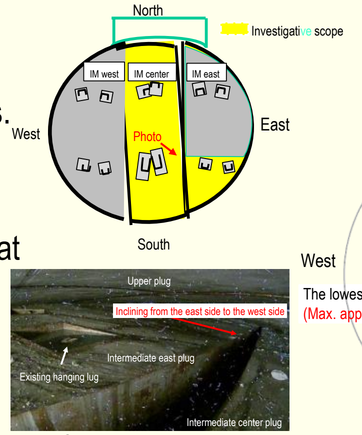
* 1 The values varied somewhat, depending on the unit and location of the thermometer.
* 2 In July 2019, the radiation exposure dose due to the release of radioactive materials from the Unit 1-4 Reactor Buildings was evaluated at less than 0.00024 mSv/year at the site boundary. The annual radiation dose from natural radiation is approx. 2.1 mSv/year (average in Japan).

Photo taking and measurement of the air-dose rate inside the Unit 1 well plug

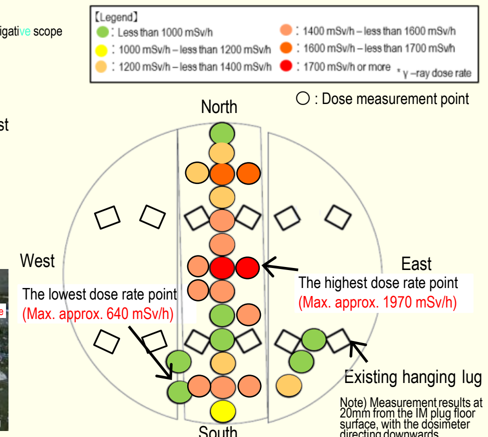
Toward fuel removal from the spent pool, the well plug, which was considered as having been misaligned from the normal position due to the influence of the hydrogen explosion at the time of the accident, was investigated for the period July 17 – August 26, by taking photos using a camera, measuring the air- dose rate and collecting 3D images.

The investigation checked the positional relation of the upper and intermediate plugs, detected an inclination of the plug and confirmed that the air-dose rate peaked at the plug center.

Based on the obtained images and data related to the contamination condition, the method of best handling the plug will be examined.



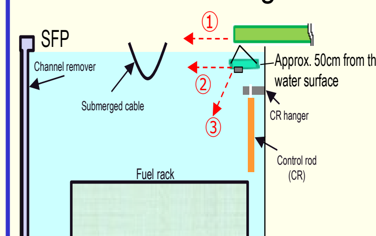
Results of camera investigation



Air-dose rate distribution over the IM well plug

Confirmation of transparency inside the Unit 1 SFP

Toward fuel removal from the spent fuel pool (SFP), before removing the fallen roof on the south side, the SFP will be covered. As preparatory work, the transparency of the pool water was investigated on August 2. The investigation confirmed that a view of approx. 7m would be available by creating an environment such as installing lighting and scope to investigate the upper part of the pool using an underwater camera. This investigation also detected a part of cables of the fuel-handling machine submerged in water and accumulated rubble on the upper surface of the fuel rack. Furthermore, using an underwater camera mounted on an expansible device, obstacles on the upper part of the entire SFP will be investigated in September 2019 and the findings will be reflected in the work plan of the SFP covering.



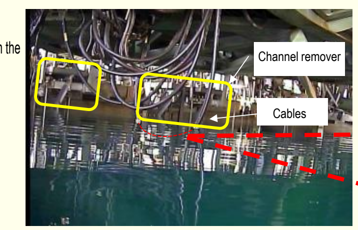


Photo ① Horizontal condition

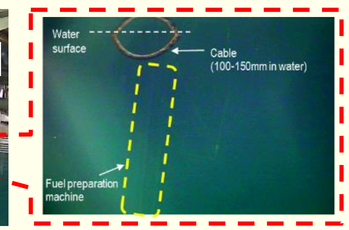
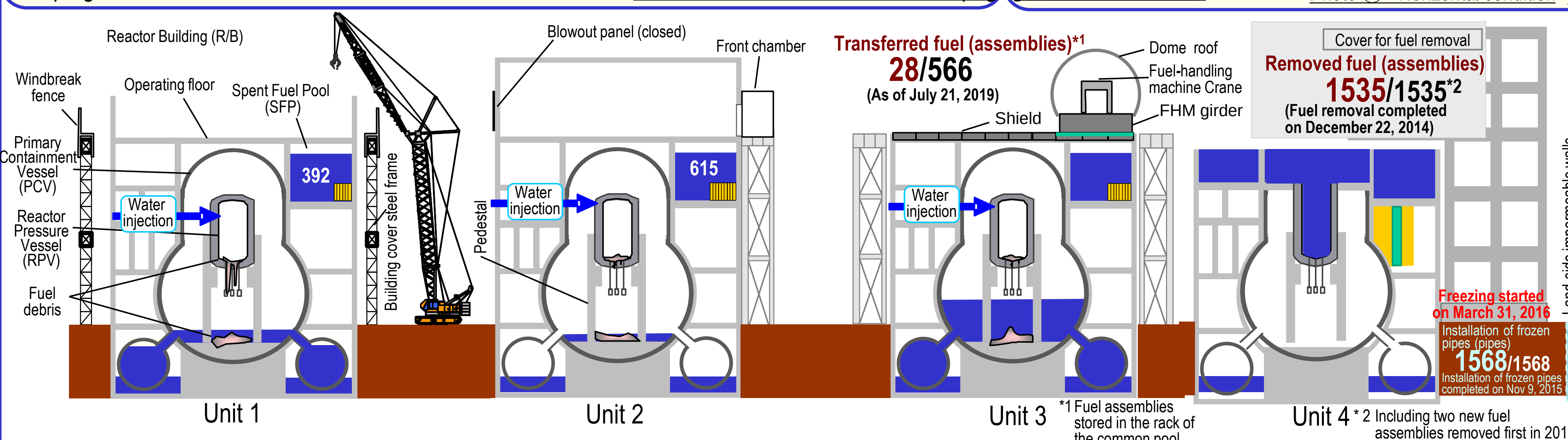


Photo ② Horizontal condition

Photo ③ Diagonally downward condition



*1 Fuel assemblies stored in the rack of the common pool

* 2 Including two new fuel assemblies removed first in 2012.

Resumption of fuel removal at Unit 3 from early September

From July 24, the fuel-handling facility (crane and fuel-handling machine) are being inspected. At the same time, an additional comprehensive facility-wide inspection is also being conducted based on the leakage of working fluid* in July 2019. For defects in the inspection, installation of supports, replacement of parts and other measures are underway.

After completing the facility inspection and following preparatory work, fuel removal will resume from early September and work will continue with safety first.

* Fluid to convey power to operate the equipment.

Resumption of Unit 1/2 exhaust stack dismantling from August 30

Regarding dismantling of the Unit 1/2 exhaust stack, work to cut accessories started from August 1 and cutting of the stack top block got underway from August 7.

On August 21, part of the stack cutter malfunctioned and the work was suspended. A subsequent investigation confirmed disconnection of the power cable. To ensure safe dismantling, similar parts were inspected. After completing the inspection on August 29, dismantling work will be resumed from August 30.

Work will continue with safety first to complete dismantling within this fiscal year.


Cutting of stack accessories

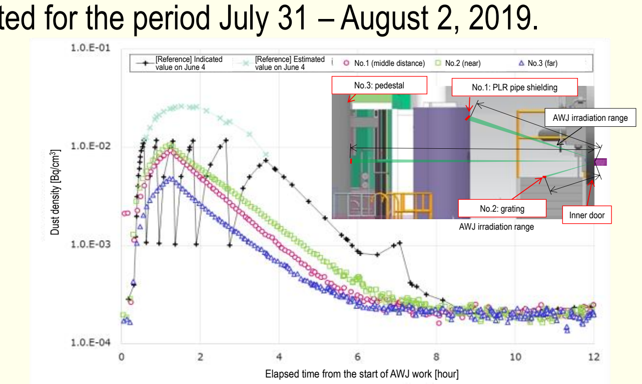

Installation of the dismantling equipment to the stack

Collection of more basic data toward creation of the Unit 1 access route

Before constructing an access route for the internal investigation of the Primary Containment Vessel (PCV), more data concerning variation in dust density during the drilling work was collected for the period July 31 – August 2, 2019.

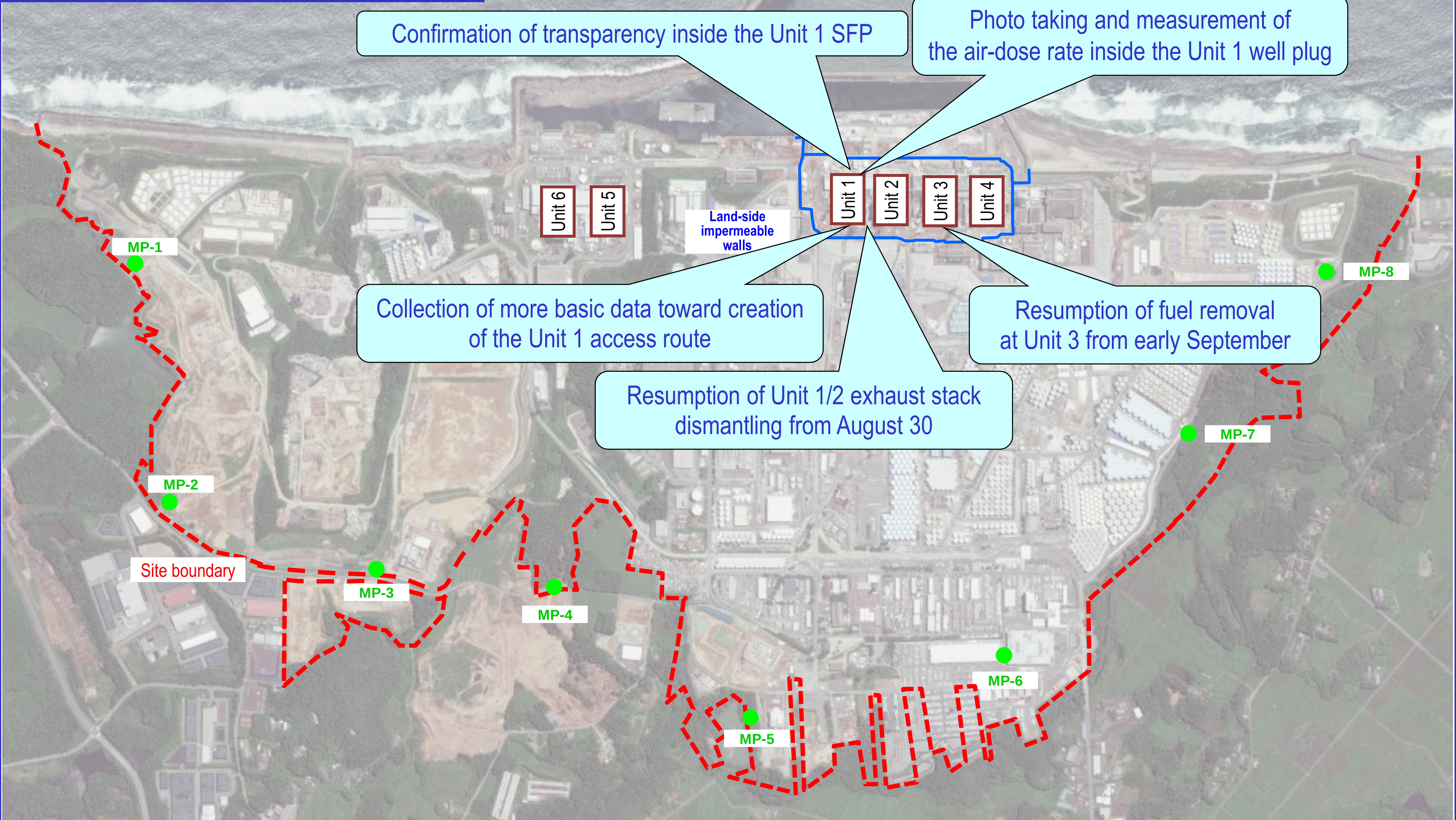
The results showed that the max. dust density of the temporary monitor was declining with the distance from PCV internals. It was also confirmed that regardless of the distance from PCV internals, the dust density increased approx. 10 minutes after starting the work, peaked approx. one hour later, then reverted to the level within several hours. More data needs to be collected for short-time work.

To collect more data, an additional monitoring system will be installed near the PCV with any potential increase in PCV pressure in mind before assessing the feasibility of resuming the work.



Change in the dust density of the temporary monitor during AWJ work

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 0.413 – 1.384 μSv/h (July 24 – August 27, 2019).

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

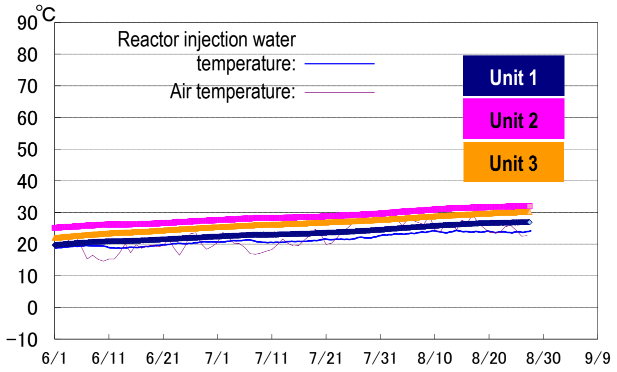
Therefore, monitoring results at these points are lower than elsewhere in the power plant site.

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.

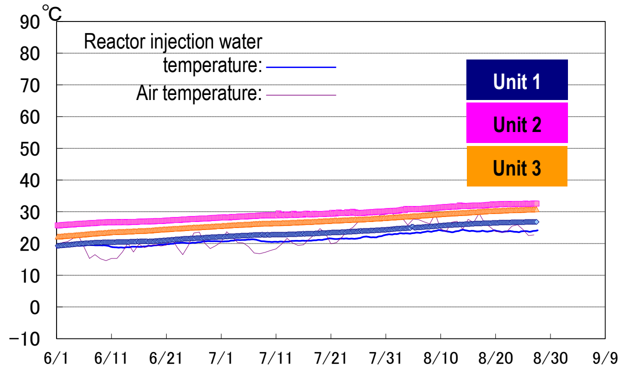
I. Confirmation of the reactor conditions

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. 25 to 35°C for the past month, though they varied depending on the unit and location of the thermometer.



RPV bottom temperatures (recent quarter)



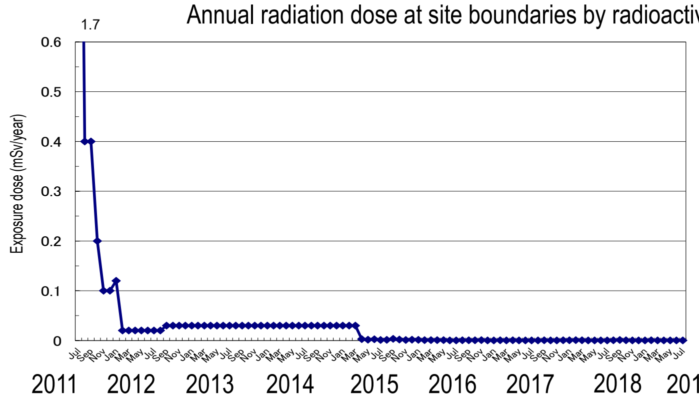
PCV gas phase temperatures (recent quarter)

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

2. Release of radioactive materials from the Reactor Buildings

As of July 2019, the density of radioactive materials newly released from Reactor Building Units 1-4 into the air and measured at the site boundary was evaluated at approx. 2.4×10^{-12} Bq/cm³ and 5.8×10^{-12} Bq/cm³ for Cs-134 and Cs-137 respectively, while the radiation exposure dose due to the release of radioactive materials there was less than 0.00024 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 air dose rate around the site boundary showed 0.413 – 1.384 μSv/h (July 24 – August 27, 2019).
  To measure the variation in the air dose 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.

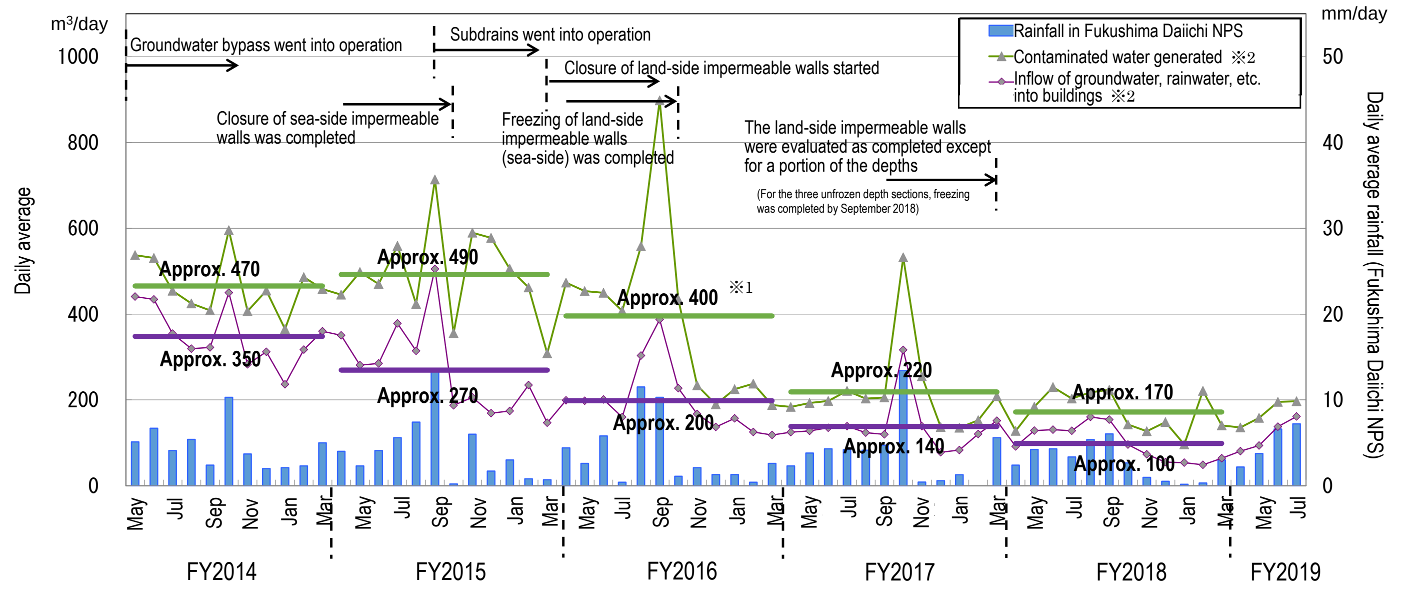
II. Progress status by each plan

1. Contaminated water management

In accordance with the three principles "remove" contamination sources, "redirect" groundwater from contamination sources and "prevent leakage" of contaminated water, multi-layered contaminated water management measures have been implemented to stably control groundwater.

➢ 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, suppress the groundwater inflow into buildings.
- Following the steady implementation of "redirecting" measures (groundwater bypass, subdrains, land-side impermeable walls and other measures), the generation amount reduced from approx. 470 m³/day (the FY2014 average) when the measures were first launched to approx. 170 m³/day (the FY2018 average).
- Measures will continue to further reduce the volume of contaminated water generated.



*1 Values differ from those announced at the 20th Committee on Countermeasures for Contaminated Water Treatment (held on August 25, 2017) because the method of calculating the 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.

*2: The monthly daily average is derived from the daily average from the previous Thursday to the last Wednesday, which is calculated based on the data measured at 7:00 on every Thursday.

Figure 1: Changes in contaminated water generated and inflow of groundwater, rainwater, 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 then 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 August 27, 2019, 491,225 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.

➢ Operation of the 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, in the presence of officials from the Intergovernmental Liaison Office for the Decommissioning and Contaminated Water Issue of the Cabinet Office. Up until August 27, 2019, a total of 746,091 m³ had been drained after TEPCO and a third-party organization had confirmed that its quality met operational targets.
- Due to the rising level of the groundwater drain pond after the sea-side impermeable walls had been closed, pumping started on November 5, 2015. Up until August 27, 2019, a total of approx. 210,003 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 July 18 – August 21, 2019).
- As one of the multi-layered contaminated-water management measures, in addition to waterproof pavement (facing: as of the end of July 2019, approx. 94% of the planned area had been completed) to prevent rainwater infiltrating the ground, facilities to enhance the subdrain treatment system were installed and went into operation from April 2018, increasing the treatment capacity from 900 to 1,500 m³/day and improving reliability. Operational efficiency was also improved to treat up to 2,000 m³/day for almost one week during the peak period.
- To maintain the level of groundwater pumped up from the subdrains, work to install additional subdrain pits and recover

those already in place is underway. The additional pits are scheduled to begin operation sequentially from a pit for which work was completed (12 of 14 pits went into operation). For recovered pits, work for all three pits scheduled was completed, all of which went into operation from December 26, 2018. Work to recover another pit will start within FY2019 (No. 49 pit).

- 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.

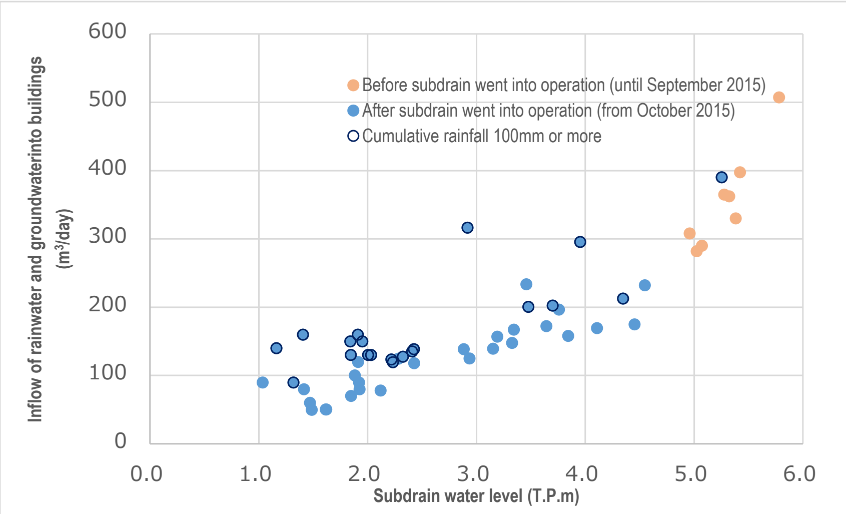


Figure 2: Correlation between inflow such as groundwater and rainwater into buildings and the water level of Unit 1-4 subdrains

➢ Construction status of the land-side impermeable walls and status of groundwater levels around the buildings

- An operation to maintain the land-side impermeable walls and prevent the 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 sufficiently thick frozen soil was identified. The scope of the maintenance operation was expanded in March 2018.
- In March 2018, construction of the land-side impermeable walls was completed, except for a portion of the depth, based on a monitoring result showing that the underground temperature had declined below 0°C in almost all areas, while on the mountain side, the difference between the inside and outside increased to approx. 4-5 m. The 21st Committee on Countermeasures for Contaminated-Water Treatment, held on March 7, 2018, evaluated that together with the function of subdrains and other measures, a water-level management system to stably control groundwater and isolate the buildings from it had been established and allowed the amount of contaminated water generated to be reduced significantly.
- A supplementary method was implemented for the unfrozen depth and it was confirmed that the temperature of this portion had declined below 0°C by September 2018. From February 2019, maintenance operation started at all sections.
- The groundwater level in the area inside the land-side impermeable walls has been declining every year. On the mountain side, the difference between the inside and outside increased to approx. 4-5 m. The water level in the bank area has remained low (T.P. 1.6-1.7 m) compared to the ground surface (T.P. 2.5 m).

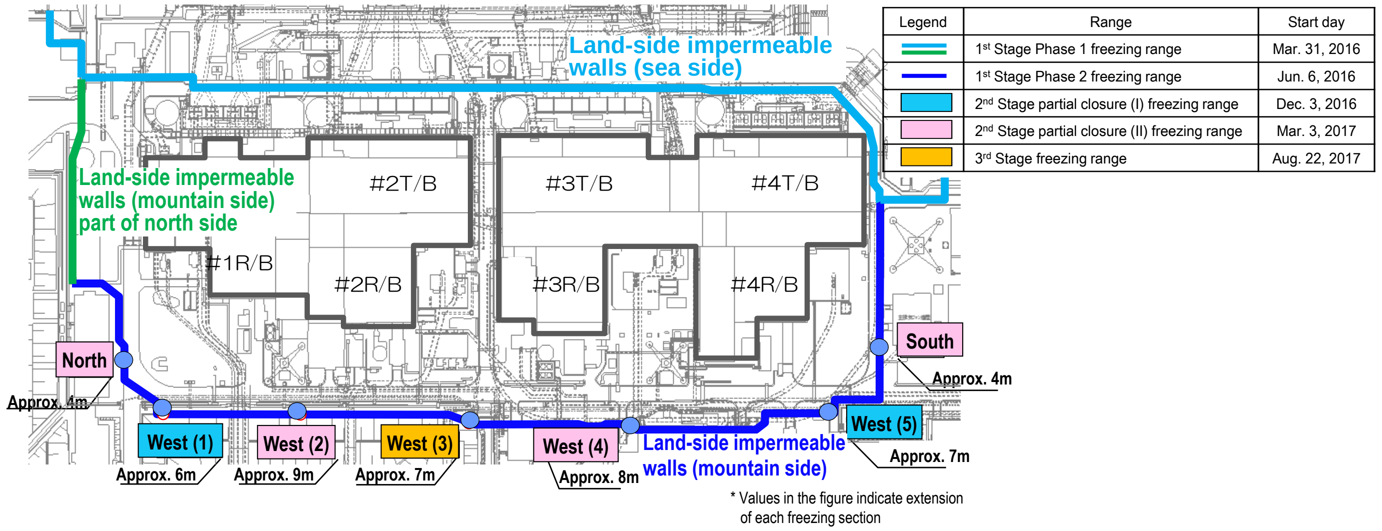


Figure 3: Closure of part of the land-side impermeable walls (on the mountain side)

➢ 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 August 22, 2019, the volumes treated by existing, additional and high-performance multi-nuclide removal equipment were approx. 411,000, 580,000 and 103,000 m³, respectively (including approx. 9,500 m³ stored in the J1(D) tank, which contained water with highly concentrated 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 August 22, 2019, approx. 620,000 m³ had been treated.

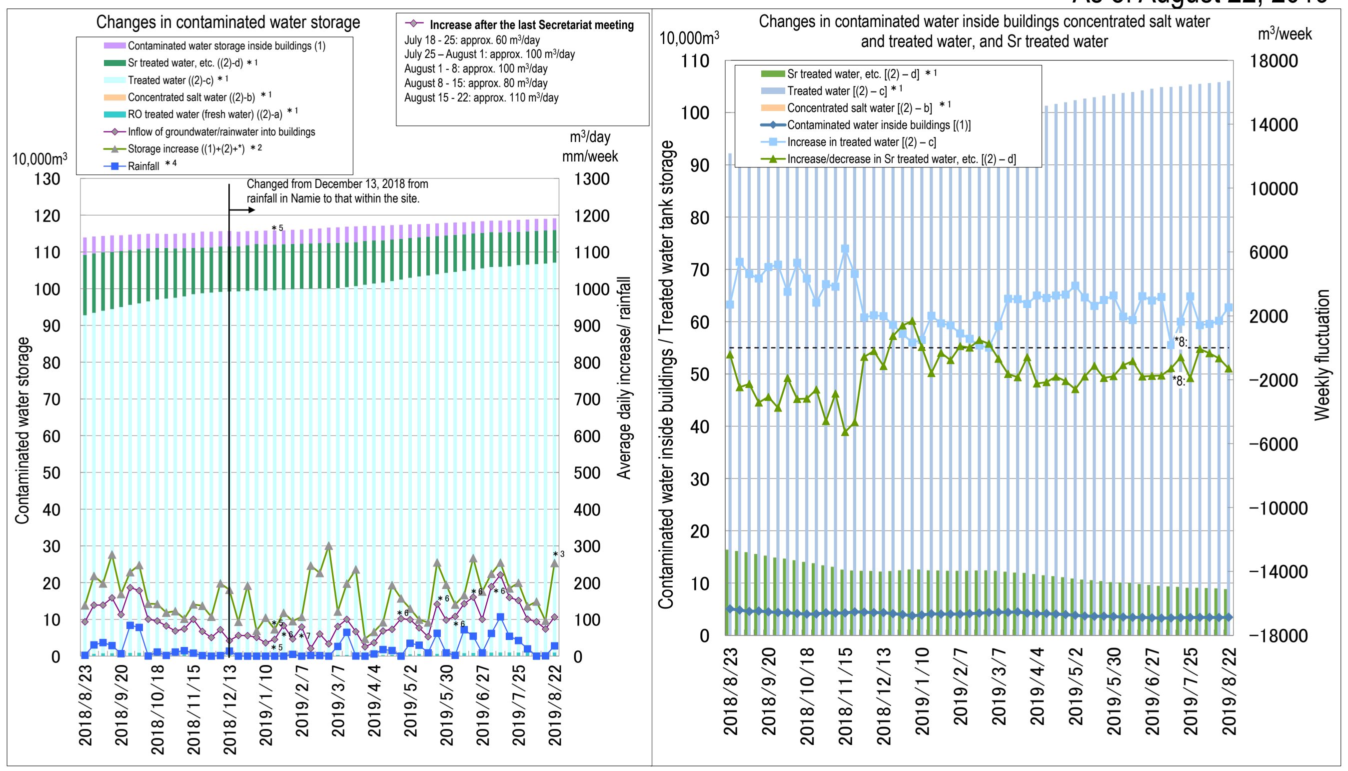
➢ Toward reducing the risk of contaminated water stored in tanks

- Treatment measures comprising the removal of strontium by cesium-adsorption apparatus (KURION) (from January 6, 2015), the secondary cesium-adsorption apparatus (SARRY) (from December 26, 2014) and the third cesium-adsorption apparatus (SARRY II) (from July 12, 2019) have been underway. Up until August 22, 2019, approx. 532,000 m³ had been treated.

➢ 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 August 26 2019, a total of 136,131 m³).

As of August 22, 2019



*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: The storage amount increased due to transfer to buildings in association with the decommissioning work.
(The transferred amount comprised (①Transfer from On-site Bunker Building to Process Main Building: approx. 110 m³/day, ②ALPS waste chemical: 13 m³/day, ③Transfer from wells and groundwater drains: approx.13 m³/day, others)

*4: Changed from December 13, 2018 from rainfall in Namie to that within the site.

*5: Since January 17, 2019, Unit 3 C/B contaminated water has been managed in addition to contaminated water storage in buildings. For the inflow of groundwater, rainwater, and others to buildings and increase in storage have been reflected since January 24, 2019.

*6: Considered attributable to the increased inflow of groundwater, rainwater, and others to buildings due to the decline in the level of contaminated water in buildings.
(January 17, April 22, May 16 and 30, June 13 and 27, 2019)

*7: Water-level gauges were replaced (February 7 – March 7, 2019)

*8: Calculation methods for water volume and the capacity of tanks, which had varied in each tank area, were unified in all areas. By this unification, the calculated increase in treated water and variation in Sr-treated water, and others changed. However, the actual treated volumes were approx. 2200 m³/week for treated water and approx. 1100 m³/week for Sr-treated water, and others (July 11, 2019).

Figure 4: Status of contaminated water storage

➢ Measures to shutoff groundwater inflow to the Onsite Bunker Building

- From mid-November 2018, the groundwater inflow to the Onsite Bunker Building increased.
- On June 20, 2019, the core was removed near the funnel where groundwater inflow was confirmed and the inflow condition of the core section was investigated. The investigation detected a vinyl hose laid there, which continued to near the outer walls of the building.
- On August 6, 2019, cement-based liquid glass was injected to fill the vinyl hose, although the scheduled amount of filling injected into the hose was insufficient for closure. This was considered attributable to a water path formed by groundwater inflow pressure before cement-based liquid glass coagulated.
- On August 30, 2019, foam-type urethane liquid, workability of which was verified by a mockup, will be injected to stop inflow.

➢ Transfer of accumulated water in the connection of the Unit 2 seawater pipe trench and the building

- For the Unit 2 seawater pipe trench, filling and closure work started from November 2014 and was completed in March 2017 except for the connection with the Unit 2 Turbine Building south side. From March 2019, filling and closure of the connection with the building started.
- From June 19, 2019, transfer of accumulated water (gross β radiation density: 1.8×10^8 Bq/L) to the area underground the Unit 2 Turbine Building started. However, obstacles were detected in the drilling part during the work prior to water transfer. The drilling part was relocated and transfer of approx. 115 m³ of water was completed on August 2, 2019. Filling of the part will be completed in late August 22, 2019.

➢ Leakage from downstream of the additional multi-nuclide removal equipment drain sump 1 sink

- On July 29, 2019, leakage was detected from the flexible pipe under the additional multi-nuclide removal equipment sump 1 sink. The leakage over an area of approx. 1 m × 2 m × 1 mm (depth) remained within the fenced-in area and had no external influence. The leakage ceased subsequently.
- Analysis of the leaked water revealed gross β radioactivity: 1.8×10^5 Bq/L. The water was wiped away.
- Based on the on-site investigation, the leakage was from a damaged portion of the flexible pipe. After removing the pipe and installing a closure flange to prohibit the use of the sump 1 sink, operation was restored.
- The leakage was considered attributable to corrosion of the flexible pipe. This pipe and others in which similar corrosion is anticipated will be replaced.

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

- From January 22, 2018, toward fuel removal from the spent fuel pool (SFP), careful work began to remove rubble on the north side of the operating floor using suction equipment. Once removed, the rubble is stored in solid waste storage facilities or elsewhere depending on the dose level.
- To create an access route for preparatory work to protect the SFP, work to remove four sections of X-braces (one each on the west and south sides and two on the east side, respectively) started from September 19, 2018 and all planned four sections had been removed by December 20, 2018.
- From March 18, 2019, the removal of small rubble in the east-side area around the SFP started using pliers and suction equipment. From July 9, 2019, small rubble removal on the south side of the SFP started.
- The well plug, which was considered as having been misaligned from the normal position due to the influence of the hydrogen explosion at the time of the accident, was investigated for the period July 17 – August 26, 2019, by taking photos using a camera, measuring the air-dose rate and collecting 3D images.
- The investigation checked the positional relation of the upper and intermediate plugs, detected an inclination of the plug and confirmed that the air-dose rate peaked at the plug center. Based on the obtained images and data related to the contamination condition, the method of best handling the plug will be examined.
- Before removing the fallen roof on the south side, the SFP will be covered. As preparatory work, the transparency of the pool water was investigated on August 2, 2019. The investigation confirmed that a view of approx. 7m would be available by creating an environment such as installing lighting and scope to investigate the upper part of the pool using an underwater camera. This investigation also detected a part of cables of the fuel-handling machine submerged in water and accumulated rubble on the upper surface of the fuel rack. Furthermore, using an underwater camera mounted on an expansible device, obstacles on the upper part of the entire SFP will be investigated in September 2019 and the findings will be reflected in the work plan of the SFP covering.

➢ Main work to help spent fuel removal at Unit 2

- On November 6, 2018, before the investigation toward formulating a work plan to dismantle the Reactor Building rooftop and for other tasks, work to move and contain the remaining objects on the operating floor (1st round) was completed.
- On February 1, 2019, an investigation to measure the radiation dose on the floor, walls and ceiling inside the operating floor and confirm the contamination status was completed. After analyzing the investigative results, the "contamination density distribution" throughout the entire operating floor was obtained, based on which the air-dose rate inside the operating floor could be evaluated. A shielding design and measures to prevent radioactive material scattering will be examined.
- From April 8, 2019, work to move and contain the remaining objects on the operating floor (2nd round) started, such as materials and equipment which may hinder installation of the fuel-handling facility and other work. The 2nd round mainly included moving the remaining small objects and placing them in the container. The work also included cleaning the floor to suppress dust scattering and was completed on August 21, 2019.

- From early September 2019 to the end of this fiscal year, work to move and contain the remaining objects on the operating floor (3rd round) will start, such as materials and equipment which may hinder the installation of the fuel-handling facility and other work. The 3rd round will mainly include moving and containing the remaining large objects. The work will also include transporting containers and remaining objects temporarily stored inside the operating floor outside.

➢ Main process to help 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, 2018.
- On August 8, 2018, an alarm was issued during the pre-operation inspection of the FHM, whereupon operation was suspended. This was attributable to disconnection due to rainwater ingress corrosion into the cable connection. Abnormalities were also detected in several control cables.
- On August 15, 2018, an alarm on the crane was triggered during work to clear materials and equipment, whereupon the crane operation was suspended.
- On September 29, 2018, to determine the risks of defects in fuel-handling facilities, the FHM was temporarily recovered and a safety inspection (operation check and facility inspection) started. For 14 defects detected in the safety inspection, measures were completed on January 27, 2019.
- On February 8, 2019, a function check after cable replacement was completed.
- On February 14, 2019, review of recovery measures in the event of defects started and training for fuel removal using dummy fuel and the transport container got underway. During the training, seven defects were detected, although it was confirmed that these did not constitute safety problems that could lead to fuel or rubble falling.
- From March 15, 2019, the rubble removal training inside the pool started.
- From April 15, 2019, removal of 514 spent fuel assemblies and 52 non-irradiated fuel assemblies (a total of 566assemblies) stored in the spent fuel pool started. Seven non-irradiated fuel assemblies were then loaded in the transport container and transported to the common pool on April 23, 2019. The first fuel removal was completed on April 25, 2019.
- From July 4, 2019, fuel removal was resumed and up until July 21, 2019, 28 of all 566 fuel assemblies had been removed.
- From July 24, the fuel-handling facility (crane and fuel-handling machine) is being inspected. At the same time, an additional comprehensive facility-wide inspection is also being conducted based on the leakage of working fluid in July 2019. For defects detected in the inspection, installation of supports, replacement of parts and other measures are underway.
- After completing the facility inspection and following preparatory work, fuel removal will resume from early September 2019 and work will continue with safety first.

➢ Start of work to dismantle the Unit 1/2 exhaust stack

- Regarding dismantling of the Unit 1/2 exhaust stack, work to cut accessories started from August 1, 2019 and cutting of the stack top block got underway from August 7.
- On August 21, 2019, part of the stack cutter malfunctioned and the work was suspended. A subsequent investigation confirmed disconnection of the power cable. To ensure safe dismantling, similar parts were inspected. After completing the inspection on August 29, dismantling work will be resumed from August 30. Work will continue with safety first to complete dismantling within this fiscal year.

3. Retrieval of fuel debris

➢ Work to create an access route for the internal investigation of the Unit 1 PCV

- Before constructing an access route for the internal investigation of the Primary Containment Vessel (PCV), more data concerning variation in dust density during the drilling work was collected for the period July 31 – August 2, 2019.
- The results showed that the max. dust density of the temporary monitor was declining with distance from PCV internals. It was also confirmed that regardless of the distance from PCV internals, the dust density increased approx. 10 minutes after starting the work, peaked approx. one hour later, then reverted to the original level within several hours. More data needs to be collected for short-time work.
- To collect more data, an additional monitoring system will be installed near the PCV with any potential increase in PCV pressure in mind before assessing the feasibility of resuming the work.

4. 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 July 2019, the total storage volume of the concrete and metal rubble was approx. 273,600 m³ (+900 m³ compared to at the end of June with an area-occupation rate of 68%). The total storage volume of trimmed trees was approx. 134,100 m³ (±0 m³, with an area-occupation rate of 76%). The total storage volume of used protective clothing was approx. 57,100 m³ (+900 m³, with an area-occupation rate of 84%). The increase in rubble was mainly attributable to construction related to tanks and general waste on site, while the increase in used protective clothing was attributable to the acceptance of used protective clothing.

➢ Management status of secondary waste from water treatment

- As of August 1, 2019, the total storage volume of waste sludge was 597 m³ (area-occupation rate: 85%), while that of concentrated waste fluid was 9,392 m³ (area-occupation rate: 91%). The total number of stored spent vessels, High-Integrity Containers (HICs) for multi-nuclide removal equipment and other vessels, was 4,448 (area-occupation rate: 70%).

5. 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

➢ Results of the test to check the cooling condition of the Unit 2 fuel debris and future test plan

- For improvement including optimization of the emergency response procedures, a test involving temporarily suspending water injection to the reactor (3.0 to 0.0 m³/h) was conducted May 13-24, 2019.
- The test confirmed that the temperature increase rate at the RPV bottom was at the same level of 0.2℃/h or less, as expected and that the temperatures at the RPV bottom and inside the PCV during the test also varied almost within expectations. No abnormality was detected in other parameters such as the dust density.
- Based on the test results, tests to temporarily suspend water injection to the reactor will also be planned and implemented in Units 1 and 3. Furthermore, utilization of the results in optimizing the emergency response procedures and improving the operation and maintenance will be examined.

➢ Suspension of nitrogen injection into Unit 2 RPV

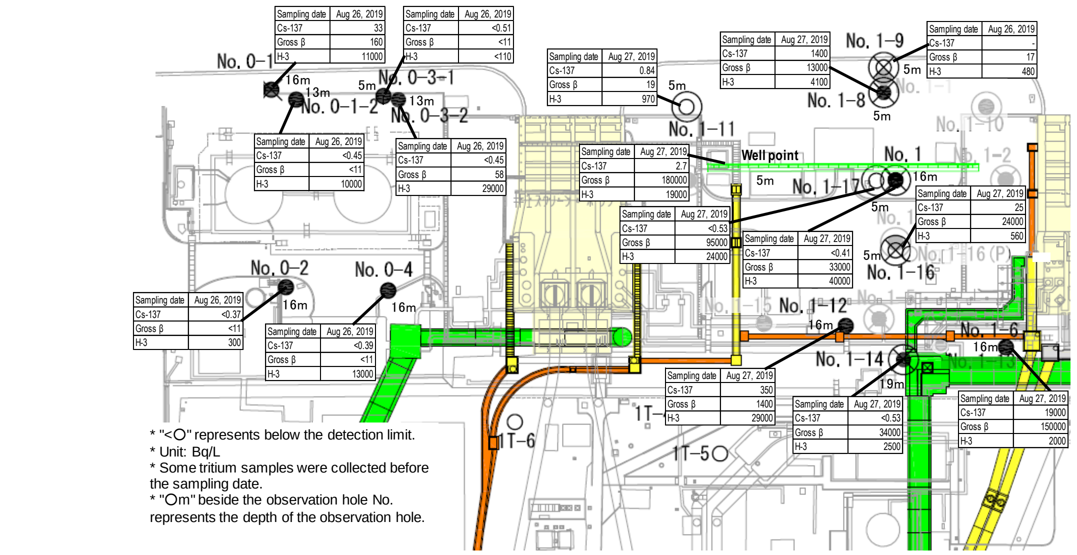
- On August 6, 2019, during work to duplicate the nitrogen injection line, which was implemented as a measure to improve the reliability of the Unit 2 nitrogen injection facility, the injection of nitrogen gas was switched from the RPV injection line to the PCV injection line. When the work line system was isolated to connect the new RPV injection line, the nitrogen injection rate into the PCV declined to 0 Nm³/h. The case was considered to constitute a deviation from the limiting condition for operation (LCO), as specified in the Implementation Plan Chapter III Volume 1 Article 25 “Function to maintain inert atmosphere in the primary containment vessel.” Nitrogen injection resumed when the relevant valve was restored and recovery from the deviation from the LCO was declared.
- No significant variation was detected in plant parameters as well as readings of monitoring posts and continuous dust monitors installed on the site boundaries.
- The event was attributable to discrepancy on the on-site label of the relevant valve, which indicated an unintended system structure during valve operation.
- The cause will be investigated and measures to prevent recurrence examined.

- ➢ Switch of the reactor water injection system toward in-service of the Unit 2 condensate storage tank
  - To duplicate the water source of the reactor water injection system, the Unit 2 condensate storage tank will be restored.
  - On January 8, 2019, during restoration work, all reactor water injection pumps of the condensate storage tank stopped.
  - In response, to investigate any abnormality when the Unit 2 condensate storage tank is used as the water source and check for any influence when the pump is switched and suspended, circulation operations will be conducted for the reactor water injection facility of the Unit 2 condensate storage tank in September 2019. During the circulation operations, reactor water injection of Unit 1-3 will be switched from the reactor water injection system of the condensate storage tank to the high-ground reactor water injection system. Based on the results, water injection will be switched to that using the Unit 2 condensate storage tank as the water source.

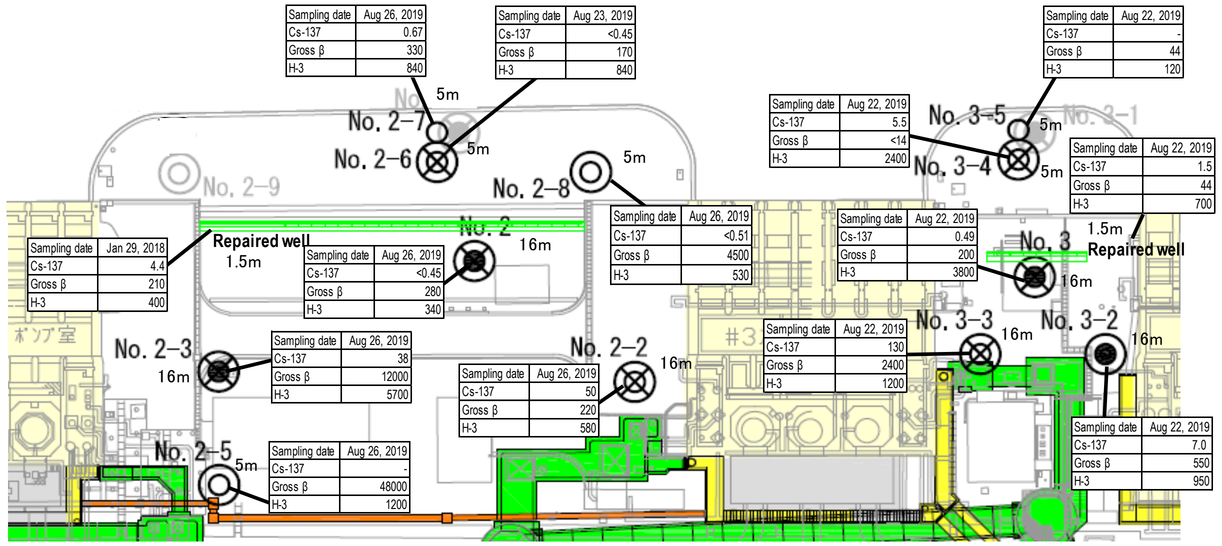
6. Reduction in radiation dose and mitigation of contamination

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
  - At No. 1-8, the H-3 density had been increasing from around 2,000 Bq/L since December 2018 and currently stands at around 4,000 Bq/L.
  - At No. 1-9, the density of gross β radioactive materials has been repeatedly increasing and declining around 20 Bq/L since April 2019 and currently stands at around 17 Bq/L.
  - At No. 1-12, the density of gross β radioactive materials had been increasing from around 200 Bq/L since December 2018 and currently stands at around 1,400 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).
  - At No. 2-3, the H-3 density had been increasing from around 4,000 Bq/L since March 2019 and currently stands at around 5,800 Bq/L. The density of gross β radioactive materials at the same point had been increasing from around 8,000 Bq/L since April 2019 and currently stands at around 13,000 Bq/L.
  - At No. 2-5, the H-3 density had been decreasing from around 2,300 Bq/L to less than 120 Bq/L since June 2019, then increasing and currently stands at around 1,200 Bq/L. The density of gross β radioactive materials at the same point had been decreasing from around 80,000 Bq/L to around 1,800 Bq/L since June 2019, then increasing and currently stands at around 48,000 Bq/L.
  - At No. 2-6, the density of gross β radioactive materials had been increasing from around 100 Bq/L since May 2019 and currently stands at around 180 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 densities of radioactive materials in drainage channels have remained constant, despite increasing during rainfall.
  - In the Unit 1-4 intake open channel area, densities of radioactive materials in seawater have remained below the legal discharge limit, while increasing in Cs-137 and Sr-90 below the legal discharge limit during 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 Cs-137 has been variated since March 20, 2019, when the silt fence was transferred to the center of the open channel by mega float related construction.
  - In the area within the port, densities of radioactive materials in seawater have remained below the legal discharge limit, while increasing in Cs-137 and Sr-90 below the legal discharge limit during rain. They have remained below the level of those in the Unit 1-4 intake open channel area and been declining following the completed installation and connection of steel pipe sheet piles for the sea-side impermeable walls.
  - In the area outside the port, regarding the densities of radioactive materials in seawater, those of Cs-137 and Sr-90 declined and remained low after steel pipe sheet piles for the sea-side impermeable walls were installed and connected.



<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

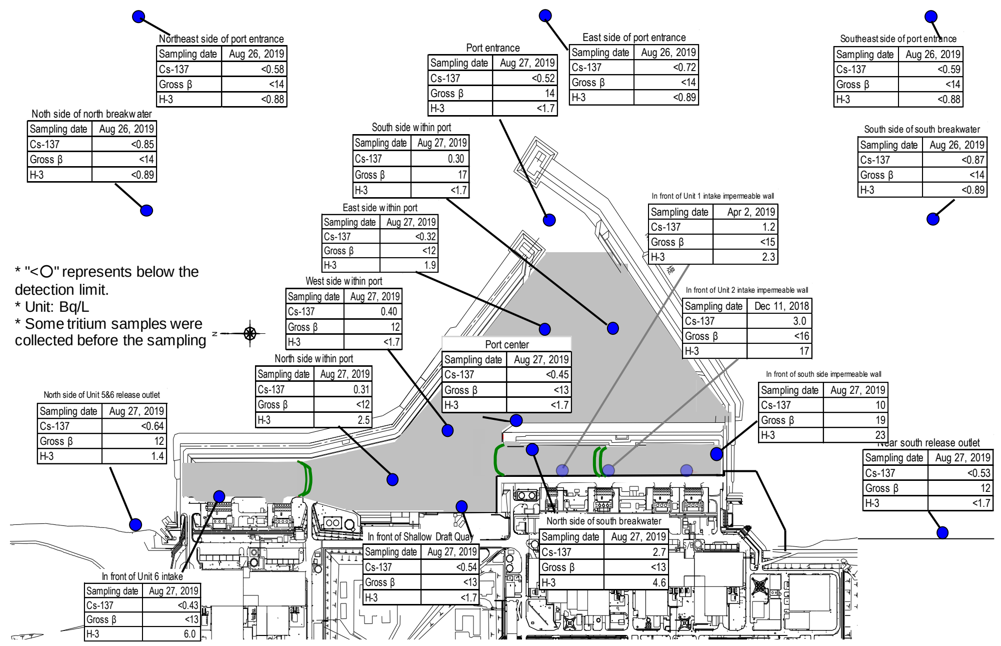


Figure 6: Seawater density around the port

➢ Issuance of the “radiation density very high” alarm at drainage channel K

- On August 22, 2019, the “radiation density very high” alarm (3,000Bq/L) was issued at drainage channel K. The gate of the drainage channel was closed.
- It was considered that there was no leakage of contaminated water for the following reasons: no significant variation in β-ray was detected at the new monitor for drainage channel K, a different type of monitor for which verification was underway and no abnormality was detected during patrol; as well as based on the analytic results of water quality. The gate of the drainage channel was opened.
- The alarm issuance was considered attributable to an increase of the drainage channel K monitor due to influence of remaining radioactive materials, which was released in the environment at the time of the earthquake. No significant increase was detected in the seawater radiation monitor at the port entrance before and after the alarm issuance.

7. 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 personnel registered for at least one day per month to work on site during the past quarter from April to June 2019 was approx. 8,800 (TEPCO and partner company workers), which exceeded the monthly average number of actual workers (approx. 6,400). Accordingly, sufficient personnel are registered to work on site.
- It was confirmed with the prime contractors that the estimated manpower necessary for the work in September 2019 (approx. 3,460 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. 3,400 to 5,600 since FY2017 (see Figure 7).
- The number of workers within Fukushima Prefecture increased. The local employment ratio (TEPCO and partner company workers) as of July 2019 has remained constant at around 60%.
- The monthly average exposure dose of workers remained at approx. approx. 0.39 mSv/month during FY2016, approx. 0.36 mSv/month during FY2017 and approx. approx. 0.32 mSv/month during FY2018. (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.

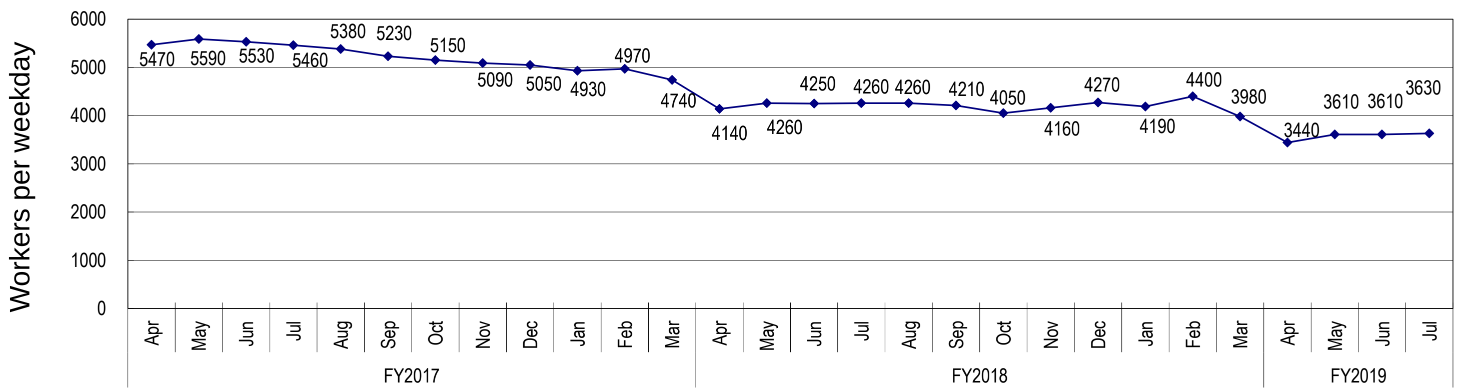


Figure 7: Changes in the average number of workers per weekday for each month since FY2017 (actual values)

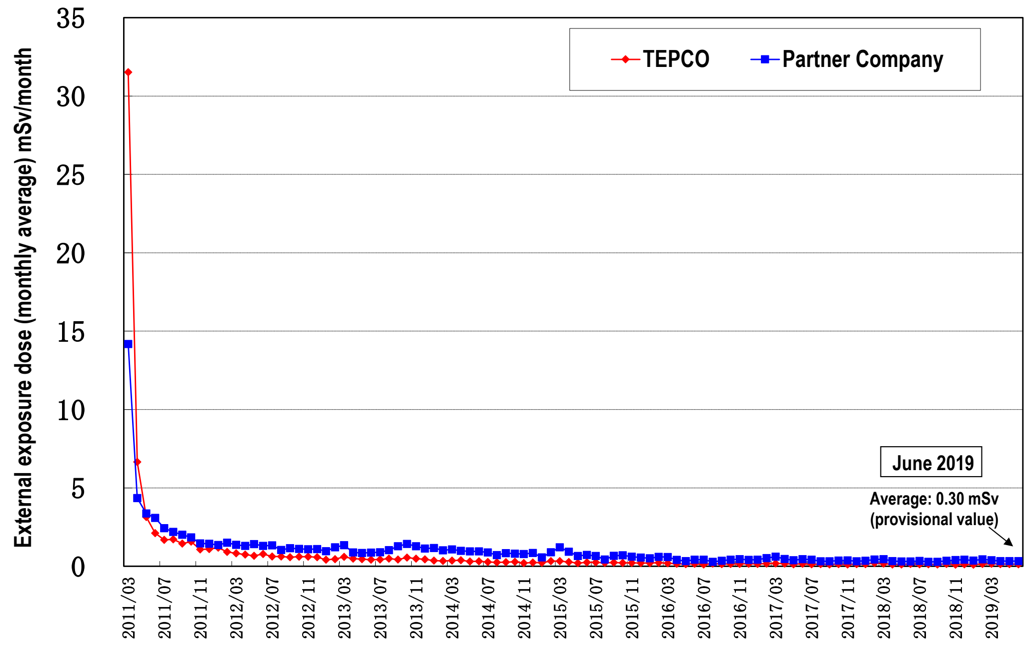


Figure 8: Changes in monthly individual worker exposure dose (monthly average exposure dose since March 2011)

➢ Status of heat stroke cases

- In FY2019, measures to further prevent heat stroke commenced from April to cope with the hottest season.
- In FY2019, seven workers suffered heat stroke due to work up until August 26 (in FY2018, six workers up until the end of August). Continued measures will be taken to prevent heat stroke.

➢ Survey to improve the work environment

- With the aim of improving the work environment for workers at the power station, an annual survey is being conducted. Distribution of the 10th survey questionnaire sheet started from August 29, 2019.
- The answers will be collected by the end of September 2019 and the results compiled in December 2019 and utilized to improve the work environment.
- The effect of items which were improved based on the results of the previous-year survey will be verified and the questionnaires are designed to ease the burden on workers by reflecting the opinions of prime contractors..

8. Others

➢ Emission of smoke from the transmission line (Futaba line 1) of the Fukushima Daiichi Nuclear Power Station Unit 5 and 6

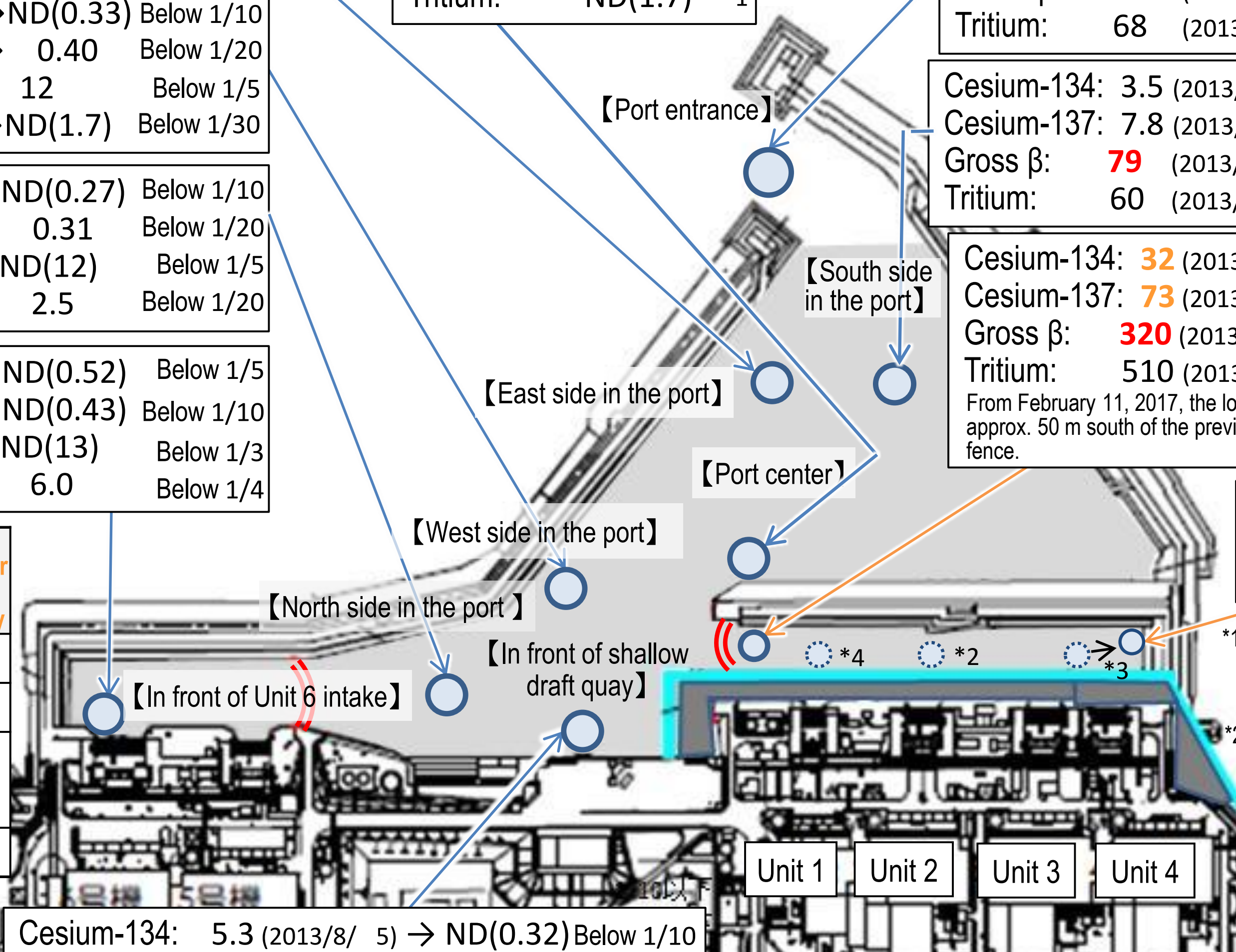
- On July 25, 2019, smoke and sparks were emitted from the 66kV Futaba line 1 black cable head mount of Units 5 and 6, but the smoke and sparks ceased after suspending the transmission line. An on-site inspection detected fire damage to the anticorrosive layer protection equipment, which was installed to protect against lightning.
- Based on the investigative results, the incident was considered attributable to a lack of sheath grounding of the cable from the transmission line. Current induced to the cable sheath flowed to the ground via the layer of corrosion protection equipment, causing overheating and subsequently damaging the equipment.
- On August 9, sheath grounding and installation of the protective anticorrosive layer were completed.
- The cause will be investigated and the anticorrosive layer protection equipment analyzed to identify the ignition mechanism.

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 August 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(0.28) Below 1/10
Cesium-137: 9.0 (2013/10/17) →ND(0.32) Below 1/20
Gross β: 74 (2013/ 8/19) →ND(12) Below 1/6
Tritium: 67 (2013/ 8/19) → 1.9 Below 1/30

Cesium-134: 4.4 (2013/12/24) →ND(0.33) Below 1/10
Cesium-137: 10 (2013/12/24) → 0.40 Below 1/20
Gross β: 60 (2013/ 7/ 4) → 12 Below 1/5
Tritium: 59 (2013/ 8/19) →ND(1.7) Below 1/30

Cesium-134: 5.0 (2013/12/2) → ND(0.27) Below 1/10
Cesium-137: 8.4 (2013/12/2) → 0.31 Below 1/20
Gross β: 69 (2013/8/19) → ND(12) Below 1/5
Tritium: 52 (2013/8/19) → 2.5 Below 1/20

Cesium-134: 2.8 (2013/12/2) → ND(0.52) Below 1/5
Cesium-137: 5.8 (2013/12/2) → ND(0.43) Below 1/10
Gross β: 46 (2013/8/19) → ND(13) Below 1/3
Tritium: 24 (2013/8/19) → 6.0 Below 1/4

Cesium-134: ND(0.55)
Cesium-137: ND(0.45)
Gross β: ND(13)
Tritium: ND(1.7) *1

Cesium-134: 3.3 (2013/12/24) → ND(0.41) Below 1/8
Cesium-137: 7.3 (2013/10/11) → ND(0.52) Below 1/10
Gross β: 69 (2013/ 8/19) → 14 Below 1/4
Tritium: 68 (2013/ 8/19) → ND(1.7) Below 1/40

Cesium-134: 3.5 (2013/10/17) → ND(0.25) Below 1/10
Cesium-137: 7.8 (2013/10/17) → 0.30 Below 1/20
Gross β: 79 (2013/ 8/19) → 17 Below 1/4
Tritium: 60 (2013/ 8/19) → ND(1.7) Below 1/30

Cesium-134: 32 (2013/10/11) → ND(0.48) Below 1/60
Cesium-137: 73 (2013/10/11) → 2.7 Below 1/20
Gross β: 320 (2013/ 8/12) → ND(13) Below 1/20
Tritium: 510 (2013/ 9/ 2) → 4.6 Below 1/100
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: 0.49
Cesium-137: 10
Gross β: 19
Tritium: 23 *1

	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(0.32) Below 1/10
Cesium-137: 8.6 (2013/8/ 5) → ND(0.54) Below 1/10
Gross β: 40 (2013/7/ 3) → ND(13) Below 1/3
Tritium: 340 (2013/6/26) → ND(1.7) Below 1/200

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

*2: For the point, monitoring was finished from December 12, 2018 due to preparatory work for transfer of mega float.

*3: For the point, monitoring point was moved from February 6, 2019 due to preparatory work for transfer of mega float.

*4: For the point, monitoring was finished from April 3, 2019 due to preparatory work for transfer of mega float.

Summary of TEPCO data as of August 28, 2019

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.

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 August 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 (0.67)
Cesium-137: ND (2013) → ND (0.58)
Gross β: ND (2013) → ND (14)
Tritium: ND (2013) → ND (0.88)

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

Cesium-134: ND (2013) → ND (0.70)
Cesium-137: 1.6 (2013/10/18) → ND (0.72) Below 1/2
Gross β: ND (2013) → ND (14)
Tritium: 6.4 (2013/10/18) → ND (0.89) Below 1/7

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

Cesium-134: ND (2013) → ND (0.61)
Cesium-137: ND (2013) → ND (0.59)
Gross β: ND (2013) → ND (14)
Tritium: ND (2013) → ND (0.88)

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

Cesium-134: ND (2013) → ND (0.67)
Cesium-137: ND (2013) → ND (0.85)
Gross β: ND (2013) → ND (14)
Tritium: 4.7 (2013/ 8/18) → ND (0.89) Below 1/5

【Port entrance】

Cesium-134: 3.3 (2013/12/24) →ND (0.41) Below 1/8
Cesium-137: 7.3 (2013/10/11) →ND (0.52) Below 1/10
Gross β: 69 (2013/ 8/19) → 14 Below 1/4
Tritium: 68 (2013/ 8/19) →ND (1.7) Below 1/40

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

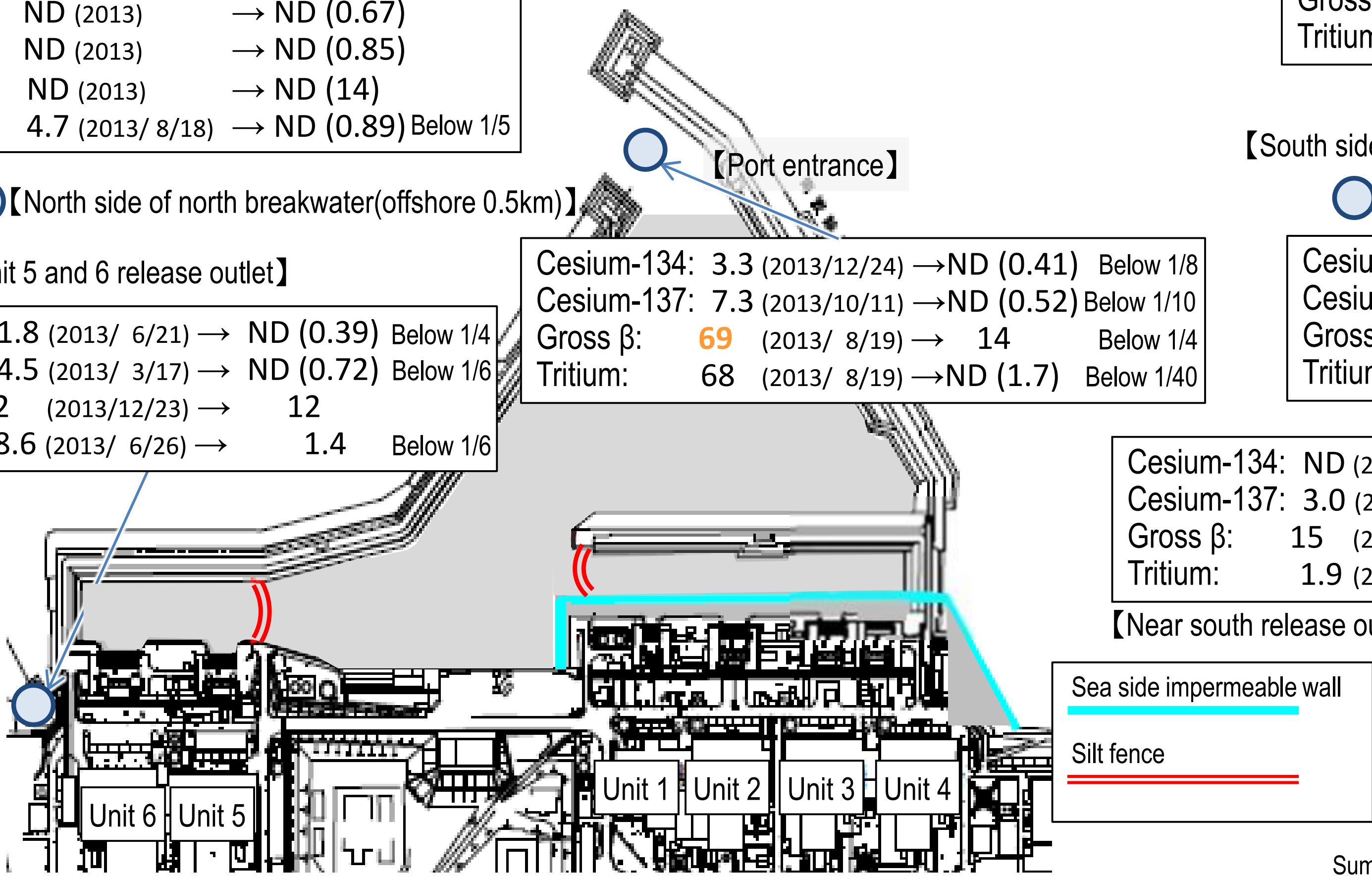
Cesium-134: ND (2013) → ND (0.66)
Cesium-137: ND (2013) → ND (0.87)
Gross β: ND (2013) → ND (14)
Tritium: ND (2013) → ND (0.89)

【North side of Unit 5 and 6 release outlet】

Cesium-134: 1.8 (2013/ 6/21) → ND (0.39) Below 1/4
Cesium-137: 4.5 (2013/ 3/17) → ND (0.72) Below 1/6
Gross β: 12 (2013/12/23) → 12
Tritium: 8.6 (2013/ 6/26) → 1.4 Below 1/6

【Near south release outlet】

Cesium-134: ND (2013) → ND (0.63)
Cesium-137: 3.0 (2013/ 7/15) → ND (0.53) Below 1/5
Gross β: 15 (2013/12/23) → 12
Tritium: 1.9 (2013/11/25) → ND (0.82) Below 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

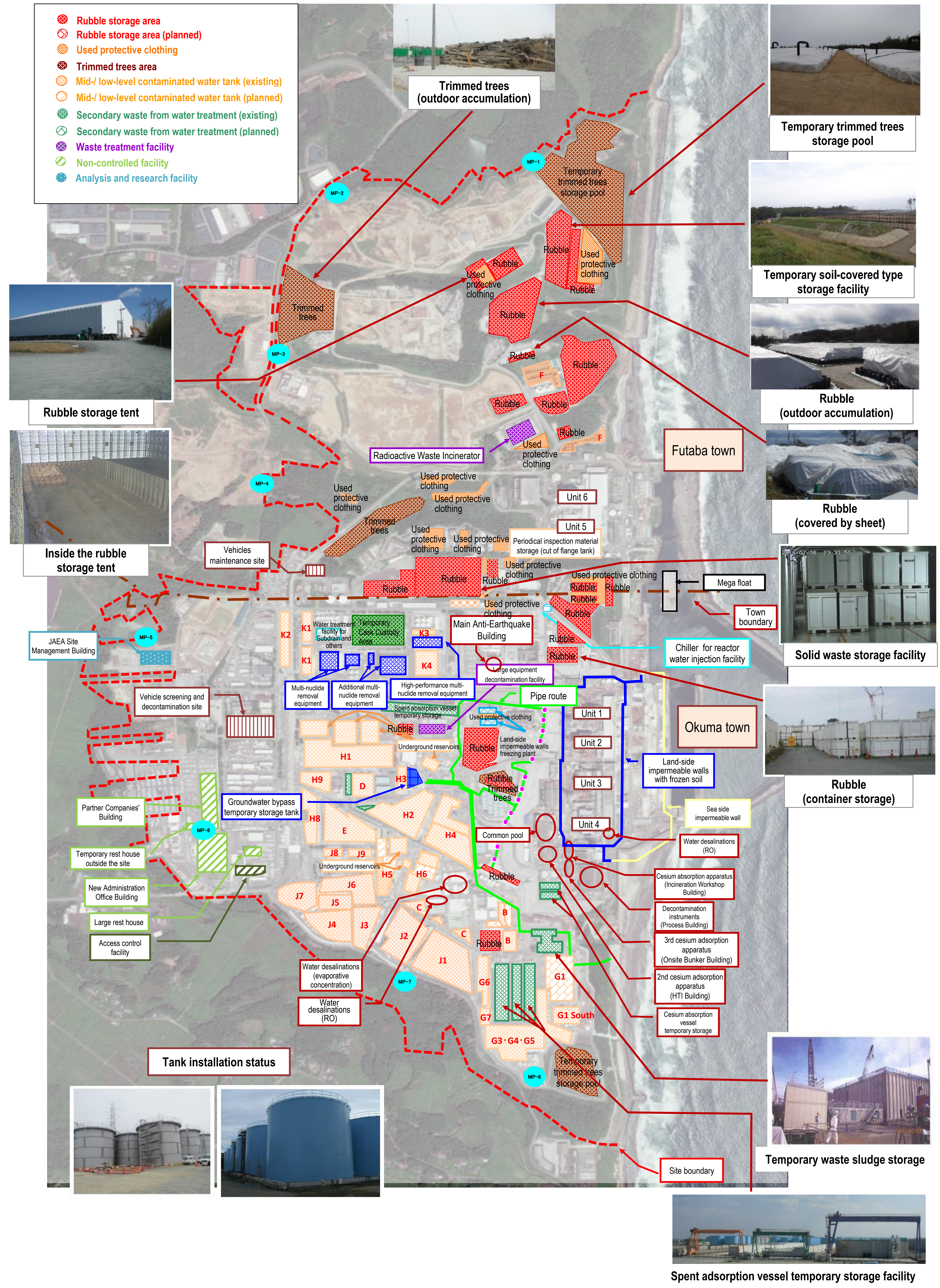
Summary of TEPCO data as of August 28, 2019

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

August 29, 2019

TEPCO Holdings Fukushima Daiichi Nuclear Power Station Site Layout



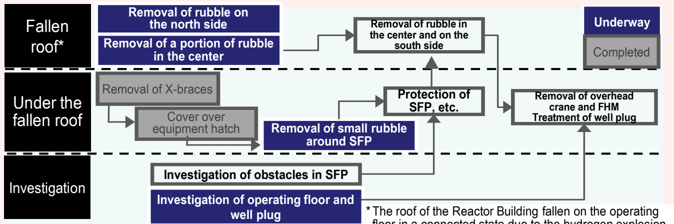
Provided by Japan Space Imaging, photo taken on June 14, 2018
Product(C) [2018] DigitalGlobe, Inc.

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

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

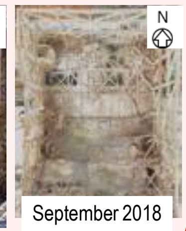
Unit 1

Toward fuel removal from the 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). On November 10, 2016, removal of all roof panels and wall panels of the building cover was completed. On May 11, 2017, removal of pillars and beams of the building cover was completed. On December 19, 2017, modification of the pillars and beams of the building cover and installation windbreak fences were completed. From March 18, 2019, removal of small rubble in the east-side area around the SFP started as an initial step using pliers and suction equipment. From July 9, 2019, small rubble removal on the south side of the SFP started. Rubble removal and investigation prior to protecting the SFP, etc. are currently underway.



Steps of rubble removal

October 2015



September 2018

<Status of the operating floor>

Unit 2

Toward fuel removal and debris retrieval in the Unit 2 spent fuel pool, the scope of dismantling and modification of the existing Reactor Building rooftop is examined. Based on the investigative results inside the operating floor, etc., methods are being examined from the perspective of ensuring safety during work, controlling influence on the outside of the power station, and removing fuel rapidly to reduce risks.

In addition to Plan (1) in which the whole upper part of the operating floor is dismantled and the container of poor fuel is shared with debris retrieval and Plan (2) in which a cover for pool fuel retrieval is separately installed, a method which minimizes the range of dismantling the upper part of the operating floor and accesses from the south side is being examined.

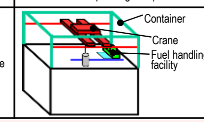
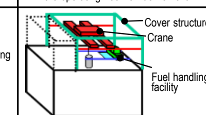
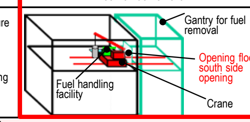
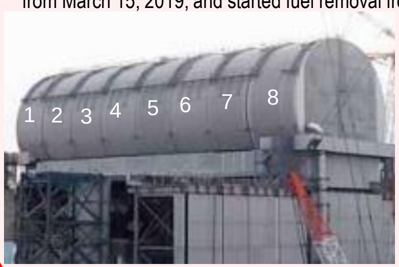
Method	Plan (1) Container shared with debris retrieval (Dismantling of the whole upper part of the operating floor)	Plan (2) Dismantling of the whole upper part of the operating floor for fuel removal	Plan (3) Method to remain the upper part of the operating floor for fuel removal
Image			

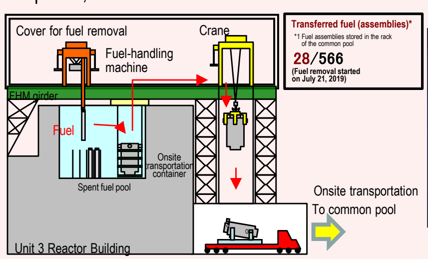
Image of fuel removal methods

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, the rubble retrieval training inside the pool, which was scheduled in conjunction with fuel removal training, started from March 15, 2019, and started fuel removal from April 15, 2019.

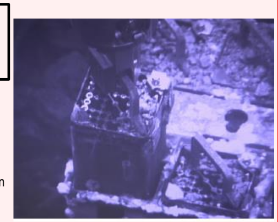


Installation of dome roof (February 21, 2019)



Overview of the fuel-handling facility inside the cover

Transferred fuel (assemblies)*
*1 Fuel assemblies stored in the rack of the common pool
28/566
(Fuel removal started on July 21, 2019)


Fuel removal status
(April 15, 2019)

Unit 4

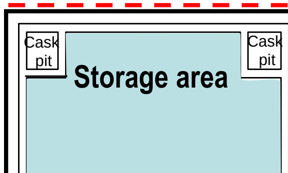
In the Mid- and Long-Term Roadmap, the target of Phase 1 involved commencing fuel removal from inside the spent fuel pool (SFP) of the 1st Unit within two years of completion of Step 2 (by December 2013). On November 18, 2013, fuel removal from Unit 4, or the 1st Unit, commenced and Phase 2 of the roadmap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

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.


Fuel removal status

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

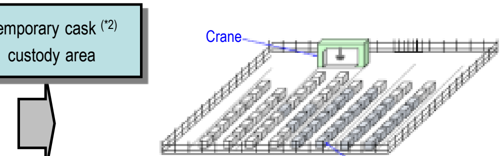
Common pool



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)
- Fuel removal from the Unit 3 spent fuel pool began to be received (from April 2019)

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

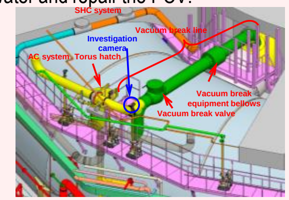
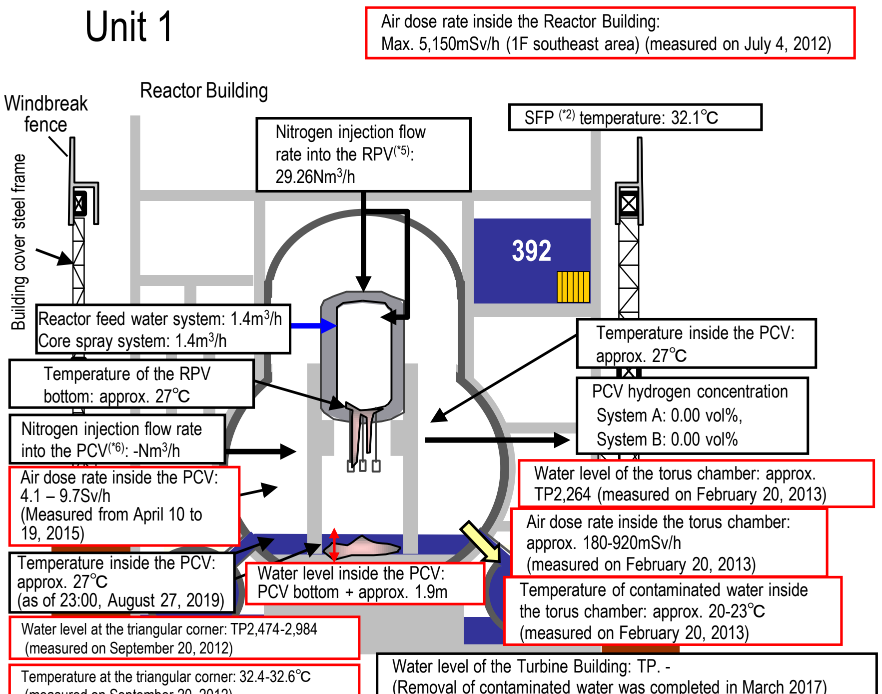


Image of the S/C upper part investigation

Unit 1



* Indices related to the plant are values as of 11:00, August 28, 2019

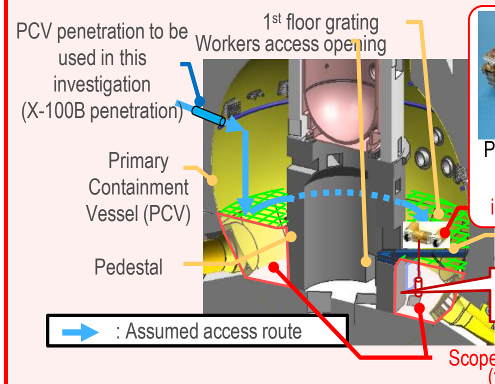
Investigations inside PCV	1st (Oct 2012)	- Acquiring images - Measuring air temperature and dose rate - Measuring water level and temperature - Sampling contaminated water - Installing permanent monitoring instrumentation
	2nd (Apr 2015)	Confirming the status of PCV 1st floor - Acquiring images - Measuring 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>

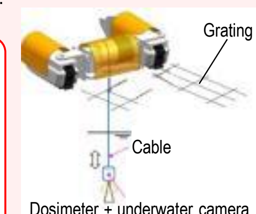


Image of hanging of dosimeter and camera

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

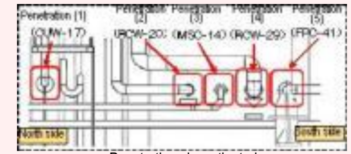
- As the thermometer installed at the Unit 2 RPV bottom after the earthquake had broken in February 2014, it was excluded from the monitoring thermometers.
- In April 2014, removal of the broken thermometer failed and was suspended. Rust-stripping chemicals were injected and the broken thermometer was 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

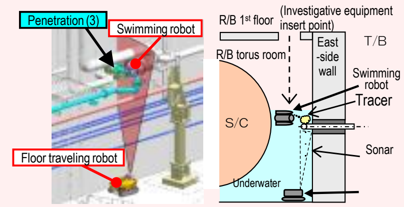
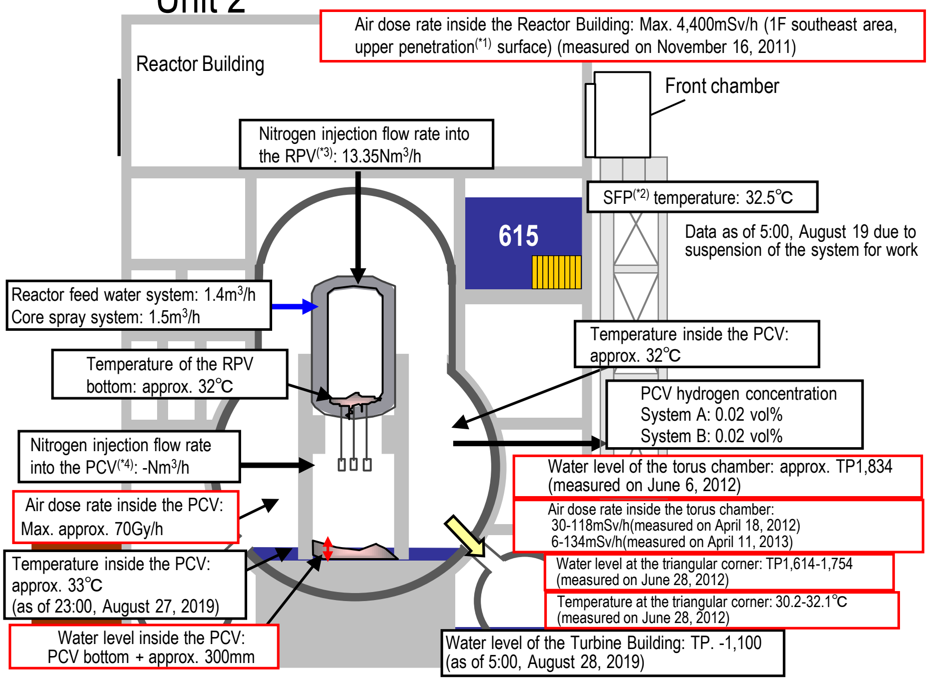


Image of the torus chamber east-side cross-sectional investigation

Unit 2



* Indices related to plant are values as of 11:00, August 28, 2019

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 contaminated 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

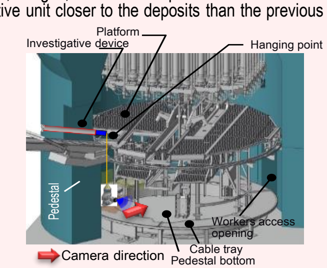
Prior to fuel debris retrieval, an investigation inside the PCV will be conducted to inspect the status there including the location of fuel debris.

[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. Obtained data were processed in panoramic image visualization to acquire clearer images.
- On February 13, 2019, an investigation touching the deposits at the bottom of the pedestal and on the platform was conducted and confirmed that the pebble-shaped deposits, etc. could be moved and that hard rock-like deposits that could not be gripped may exist.
- In addition, images, etc. would help determine the contour and size of the deposits could be collected by moving the investigative unit closer to the deposits than the previous investigation.



Investigative status (image)

Bottom of the pedestal (after being processed in panoramic image visualization)

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

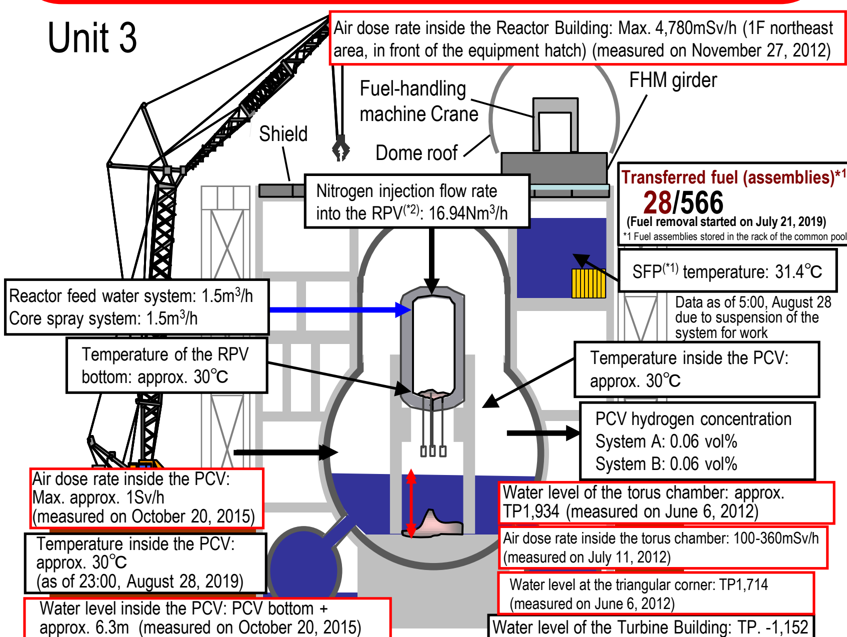
On January 18, 2014, a flow of water from around the door of the Steam Isolation Valve room in the Reactor Building Unit 3 1st floor northeast area to the nearby floor drain funnel (drain outlet) was detected. As the drain outlet connects with the underground part of the Reactor Building, there is no 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

Unit 3

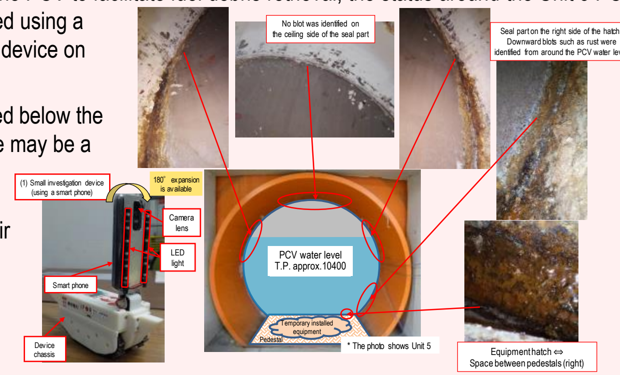


* Indices related to plant are values as of 11:00, August 28, 2019

Investigations inside PCV	1st (Oct – Dec 2015)	- Acquiring images - Measuring air temperature and dose rate - Measuring water level and temperature - Sampling contaminated 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.

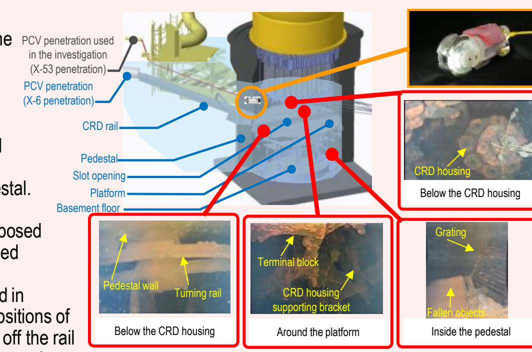


Investigation inside the PCV

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 contaminated 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

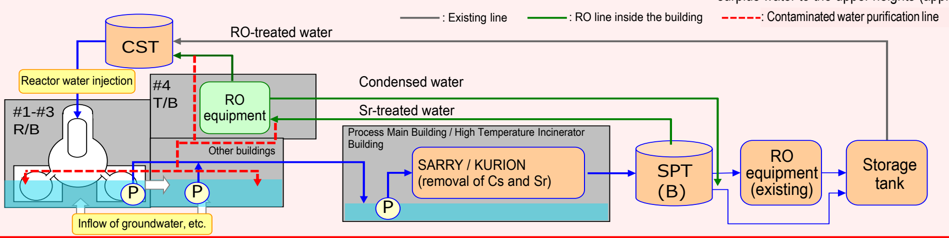
Progress toward decommissioning: Work related to circulation cooling and contaminated water treatment line

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

Work to improve the reliability of the circulation water injection cooling system and pipes to transfer contaminated 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 contaminated water inside the buildings, circulating purification of contaminated 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 (contaminated water purification line) 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 contaminated 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 flanged tanks, dismantling of flanged tanks started in H1 east/H2 areas in May 2015. Dismantling of all flanged 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 (38 tanks) in July 2018, H6 and H6 north areas (24 tanks) in September 2018 and G4 south area (17 tanks) in March 2019.

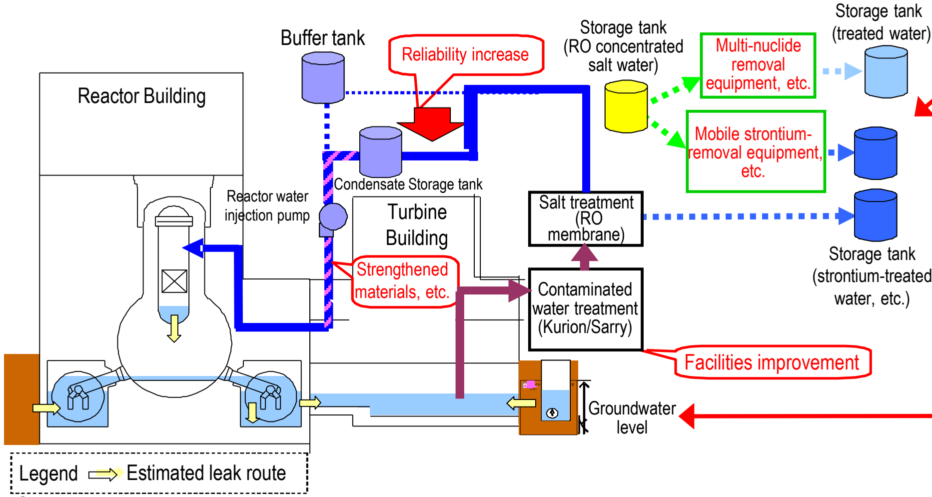
Start of dismantling in H1 east area

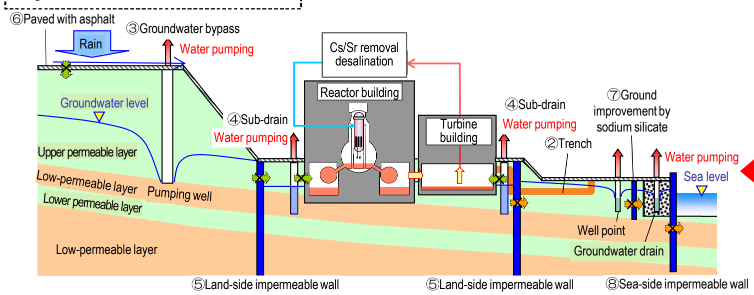
After dismantling in H1 east area

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

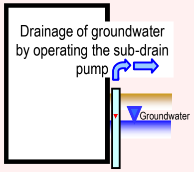
Contaminated water (RO concentrated salt water) is being treated using seven types of equipment including the multi-nuclide removal equipment (ALPS). Treatment of the RO concentrated salt water was completed on May 27, 2015, with the exception of the remaining water at the tank bottom. The remaining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



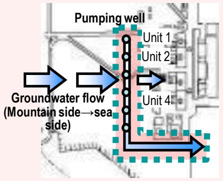


Preventing groundwater from flowing into the Reactor Buildings



Reducing groundwater inflow by pumping sub-drain water

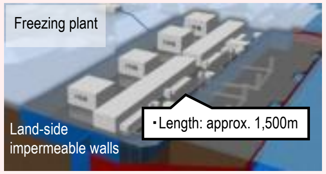
To reduce groundwater flowing into the buildings, pumping-up of groundwater from wells (subdrains) around the buildings started on September 3, 2015. Pumped-up groundwater was purified at dedicated facilities and released after TEPCO and a third-party organization confirmed that its quality met operational 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, construction of the land-side impermeable walls was completed, except for a portion of the depth, 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. The 21st Committee on Countermeasures for Contaminated Water Treatment, held on March 7, 2018, evaluated that together with the function of sub-drains, etc., a water-level management system to stably control groundwater and isolate the buildings from it had been established and had allowed a significant reduction in the amount of contaminated water generated.

For the unfrozen depth, a supplementary method was implemented and it was confirmed that temperature of the part declined below 0℃ by September 2018. From February 2019, maintenance operation started at all sections.

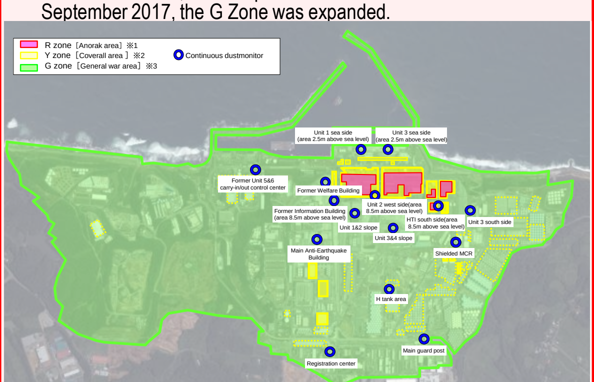
Progress toward decommissioning: Work to improve the environment within the site

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.

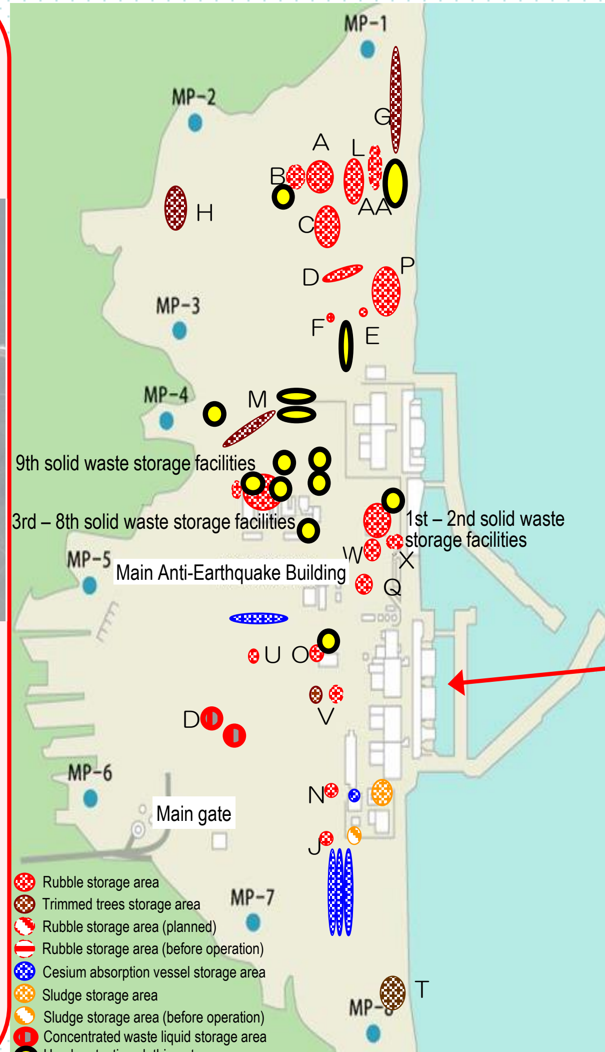
From March 2016, limited operation started. From March and September 2017, the G Zone was expanded.



※1 Inside Unit 1-3 Reactor Buildings, Unit 1-4 Turbine Buildings, and areas of surrounding buildings that contain accumulated water.
※2 Y zones with yellow dot-lines are for works related to contamination such as handling concentrated salt water, etc, where the same protective equipment as in G zone is required for patrol or site visits for work planning. In addition to the area specified above, when engaging in works related to high-dose dust (dismantling of buildings, etc.) or works related to tank transfer lines such as concentrated salt water,etc. in G zone, the area is temporarily designated as Y zone.
※3 In addition to the areas specified above, G zones also include a part of areas on the 2nd and 3rd floors of the common pool building.

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 inspection 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.