Mid-and-Long-Term Decommissioning Action Plan 2023

March 30, 2023

Tokyo Electric Power Company Holdings, Inc.

TEPCO

Mid-and-Long-Term Decommissioning Action Plan 2023

The “Mid-and-Long-Term Decommissioning Action Plan” is created by TEPCO for indicating the main work processes involved in decommissioning as a whole, in order to achieve the goals laid out in the Mid-and-Long-Term Road-map and the NRA Risk Map.

This is our “Mid-and-Long-Term Decommissioning Action Plan 2023,” a revised version based on the achievements made during FY2022.

Under the basic principle of “coexistence of reconstruction and decommissioning”, TEPCO aspires to carefully communicate about the future prospects of decommissioning in an easy-to-understand manner, so as to proceed with decommissioning while obtaining the understanding of the region and the people.

Furthermore, an outsourcing plan will be formulated based on the Mid-and-Long-Term Decommissioning Plan 2023 as we strive to expand outsourcing and get more local companies involved in decommissioning.

Moreover, the initiatives undertaken during the work of decommissioning the Fukushima Daiichi Nuclear Power Station are unprecedented in the world, and hence, we will revise this plan regularly in accordance with the progress made and the challenges faced, as we systematically proceed with safe and stable decommissioning.

(Note) The “Mid-and-Long-Term Decommissioning Action Plan 2023” corresponds with the following plan indicated in the Mid-and-Long-Term Road-map.
— Specific plan for achieving the main target processes, etc. specified in the Mid-and-Long-Term Road-map and the goals laid out in the NRA Risk Map.
Mid-and-Long-Term Road-map: Mid-and-Long-term Road-map for decommissioning the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc. (Finalized by the Inter-Ministerial Council for Contaminated Water and Decommissioning Issues on December 27, 2019)
NRA Risk Map: Mid-term risk reduction goal map for TEPCO’s Fukushima Daiichi Nuclear Power Station (Finalized by the NRA on March 1, 2023)

TEPCO

Major revisions in the Mid-Long-Term Decommissioning Plan 2023

○Contaminated water countermeasures

- “Decrease the amount of contaminated water being generated to approximately 50~70m³/day (by the end of FY2028)" set as a new target.

○Spent fuel removal

- The process for removing high-dose radioactive equipment has been laid out in detail.

○Fuel debris retrieval

- Studies aimed at the further enlargement of the scale of retrieval have been accelerated.

○Waste countermeasures

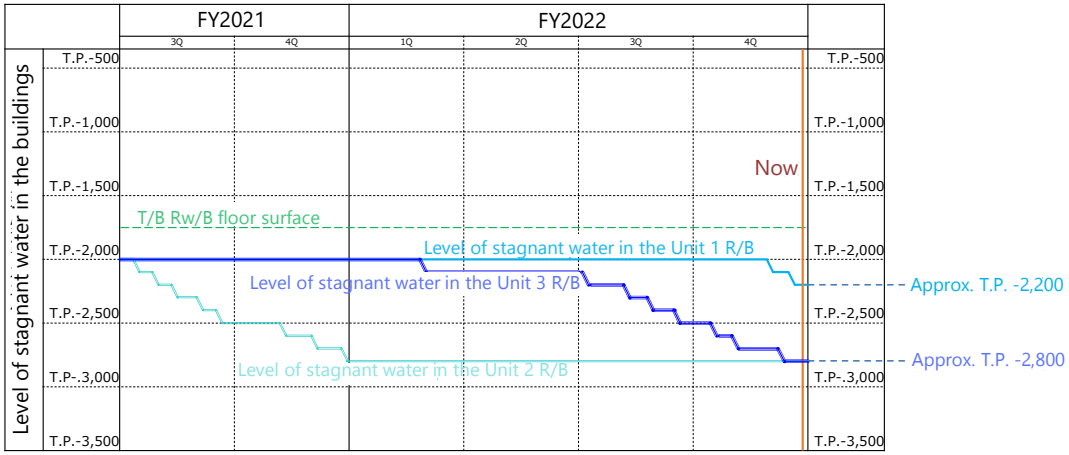
- A melting facility installation plan has been added.

Contaminated water countermeasures

– Progress made in FY2022

○ Progress made in FY2022

- **Stagnant water in buildings**
  - In order to reduce the risk of stagnant water in the reactor buildings leaking outside of the system, we progressed to treat this stagnant water and in March 2023 the amount of stagnant water in the reactor buildings decreased to approximately half what it was at the end of 2020 (achievement of a mid-and-long-term roadmap milestone).
  - In preparation to remove the high-dose zeolite bags from the subfloors of the process main building (PM/B) and high temperature incinerator building (HTI), we have created a mockup of the actual field environment at the Japan Atomic Energy Agency (JAEA) Naraha Remote Technology Development Center.



Most recent reductions in the water levels in the Units 1~3 reactor buildings

Collection ROV

TEPCO

Contaminated water management

-Major work processes going forward (1/4)

○Schedule for achieving the milestones of the Mid-and-Long-Term RM

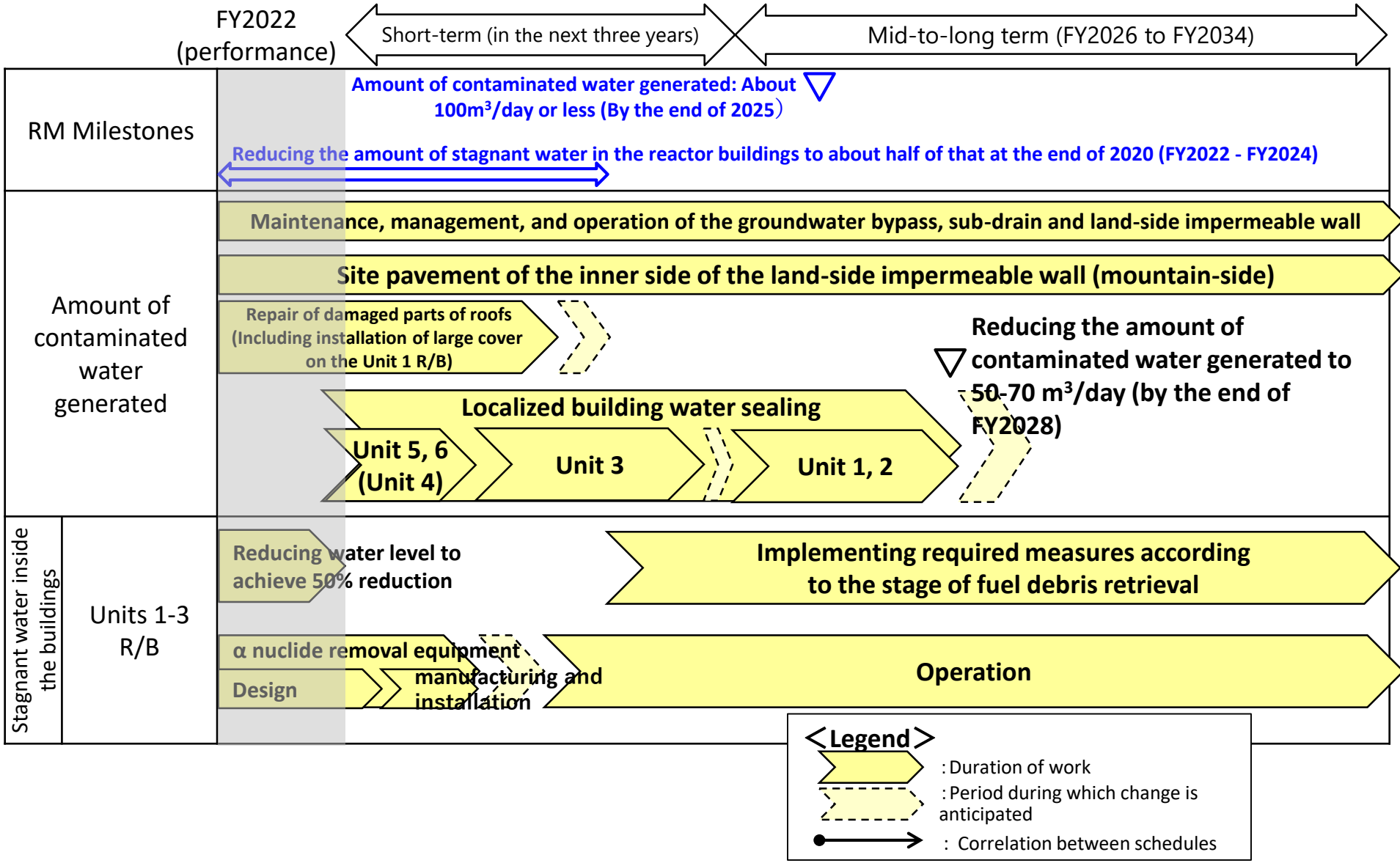
- **Reduce contaminated water generation to about 100 m³/day or less (within 2025)**
  - The maintenance, management and operation of the groundwater bypass, sub-drain and land-side impermeable wall will continue and the level of the groundwater around the buildings will be kept low in a stable manner.
  - As measures to prevent rainwater seepage, site pavement will be carried out on the inner side (mountain-side) of the land-side impermeable wall and the damaged parts of building roofs will be repaired.
  - Reduce contaminated water generation to about 50-70 m³/day (by the end of FY2028)
    - Promote localized building water sealing as a measure to further suppress the amount of groundwater flowing into the buildings.

(Challenges)

- The constraints in carrying out site pavement (radiation environment of the work area, removing existing equipment, etc.)
- The constraints in carrying out rainwater measures for buildings (removing existing equipment, method of closing contaminated piping, etc.)

Contaminated water management

-Major work processes going forward (2/4)



Contaminated water management

-Major work processes going forward (3/4)

○ Other work related to contaminated water countermeasures

- **Countermeasures after removing stagnant water in the Units 1-4 T/B. etc.**
  - Study recovery methods and manufacture/install recovery equipment to handle sludge etc. that exists on the floor.
- **Removal and treatment of stagnant water in Process Main Building (PM/B) and High Temperature Incinerator Building (HTI)**
  - Since the basement of these buildings are being used for storing water before it is treated using cesium adsorption apparatus (KURION/SARRY/SARRY-II), additional tanks will be installed as alternative tanks.
  - The floor will be exposed after removing high radiation zeolite sandbags etc. on the lowermost subfloor.
  - Equipment for removing α nuclides present in the stagnant water will be designed/installed after ascertaining the characteristics of these nuclides.

(Challenges)

- Studying safety measures to be taken with regard to handling or implementing measures for high radiation zeolite sandbags etc.
- Studying detailed methods for separating/removing α nuclides in the stagnant water

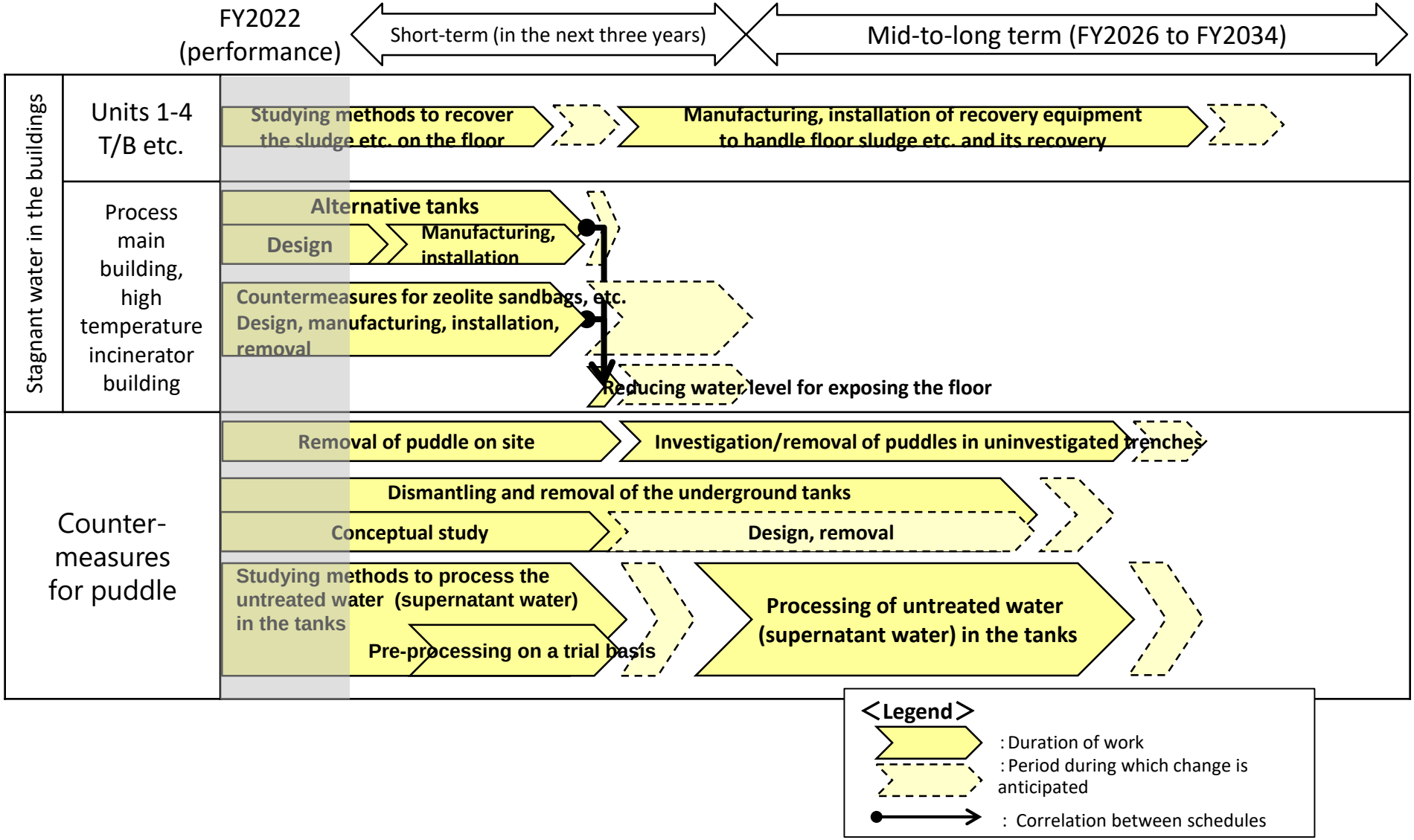
- **Countermeasures for puddle**
  - Puddle will be removed from the premises.
  - Puddles in trenches that have yet to be investigated because the areas in which they are located cannot be accessed due to high radiation levels will be investigated and removed.
  - The underground water storage tanks will be removed after studying the method of dismantling them while ensuring that dust is not scattered.
  - Untreated water in tanks (supernatant water) will be treated after trial pre-treatment.

(Challenges)

- Measures for volume reduction and storage of contaminated waste generated when the underground water storage tanks that store stagnant water are dismantled.

Contaminated water management

-Major work processes going forward (4/4)

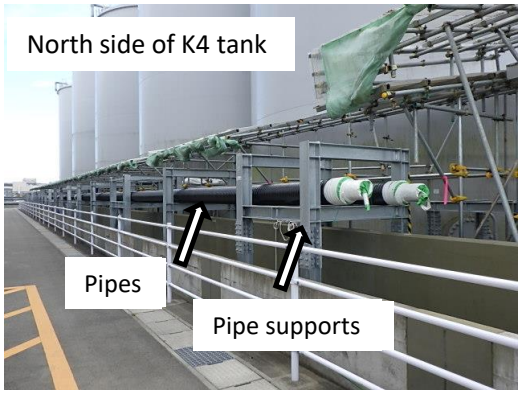


Treated water management

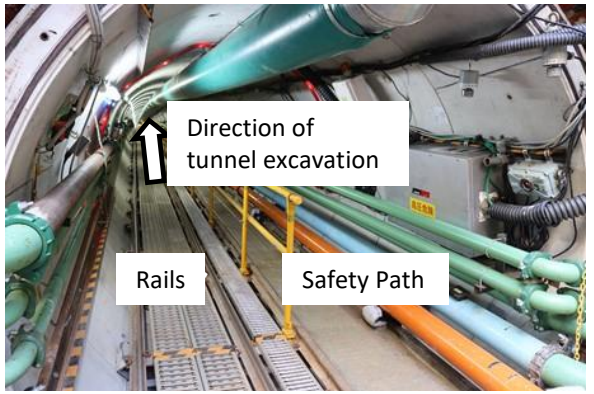
-Progress made in FY2022

○Progress made in FY2022

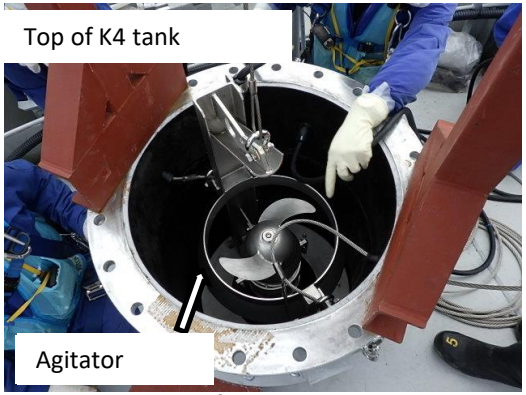
- **Treated water management**
  - Commencement of construction of ALPS treated water dilution/discharge facilities, etc.
  - Commencement of specimen sampling based upon the sea area monitoring plan in order to ascertain ordinary sea water and the status of marine organisms



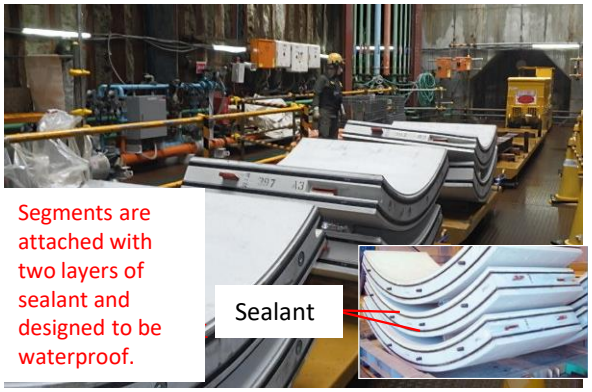
Installation of circulation pipes and supports



Safety precautions inside the tunnel



Installation of agitation equipment



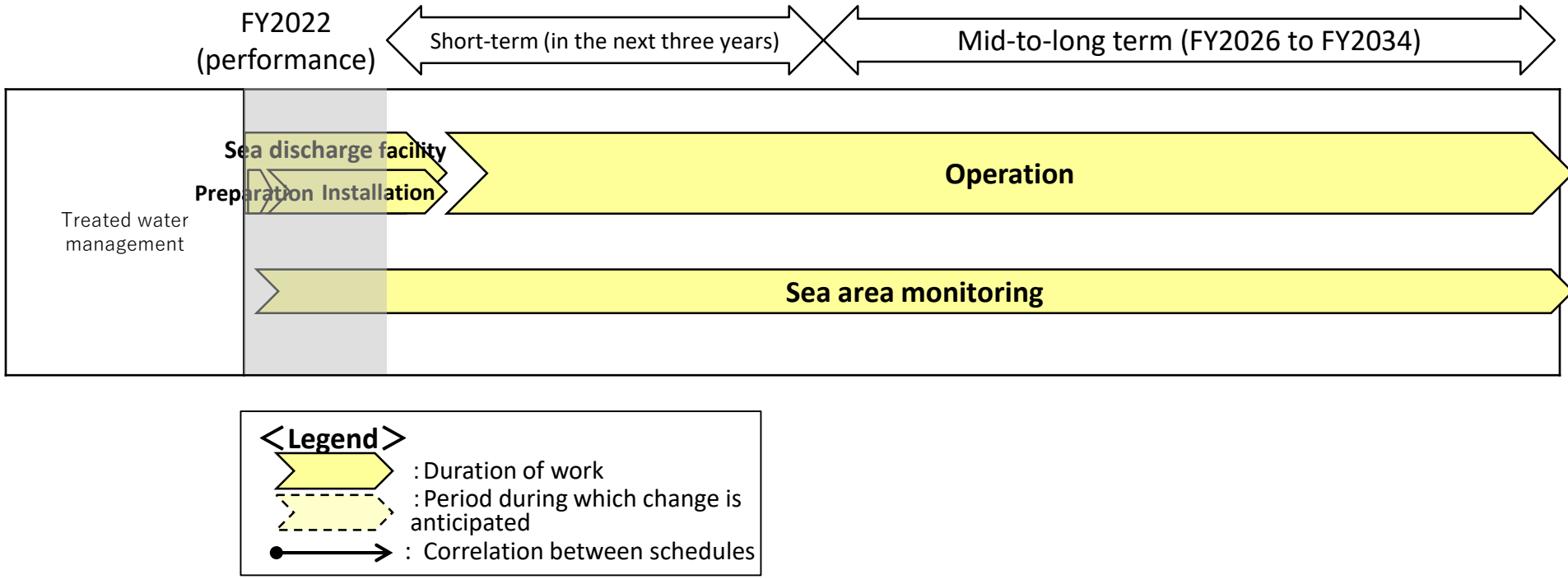
Segment loading

Treated water management

-Major work processes going forward (1/2)

○Work to achieve the government policy

- **Treated water management**
  - Preparatory work and installation work for ALPS treated water dilution/discharge facility and other related facilities will be conducted.
  - Sea area monitoring will be conducted to see how tritium is diffused in the sea area, and how the radioactive materials are transferred into the fish and seaweed.



Treated water management

-Major work processes going forward (2/2)

Secondary treatment facility（newly installed reverse osmosis membrane facility）

Secondary treatment of treated water to be re-purified (sum of the ratios of nuclides, excluding tritium, is between 1 and 10)

Secondary treatment facility（ALPS）

Secondary treatment of Treated water to be re-purified (sum of the ratios of nuclides, excluding tritium, is 1 or higher)

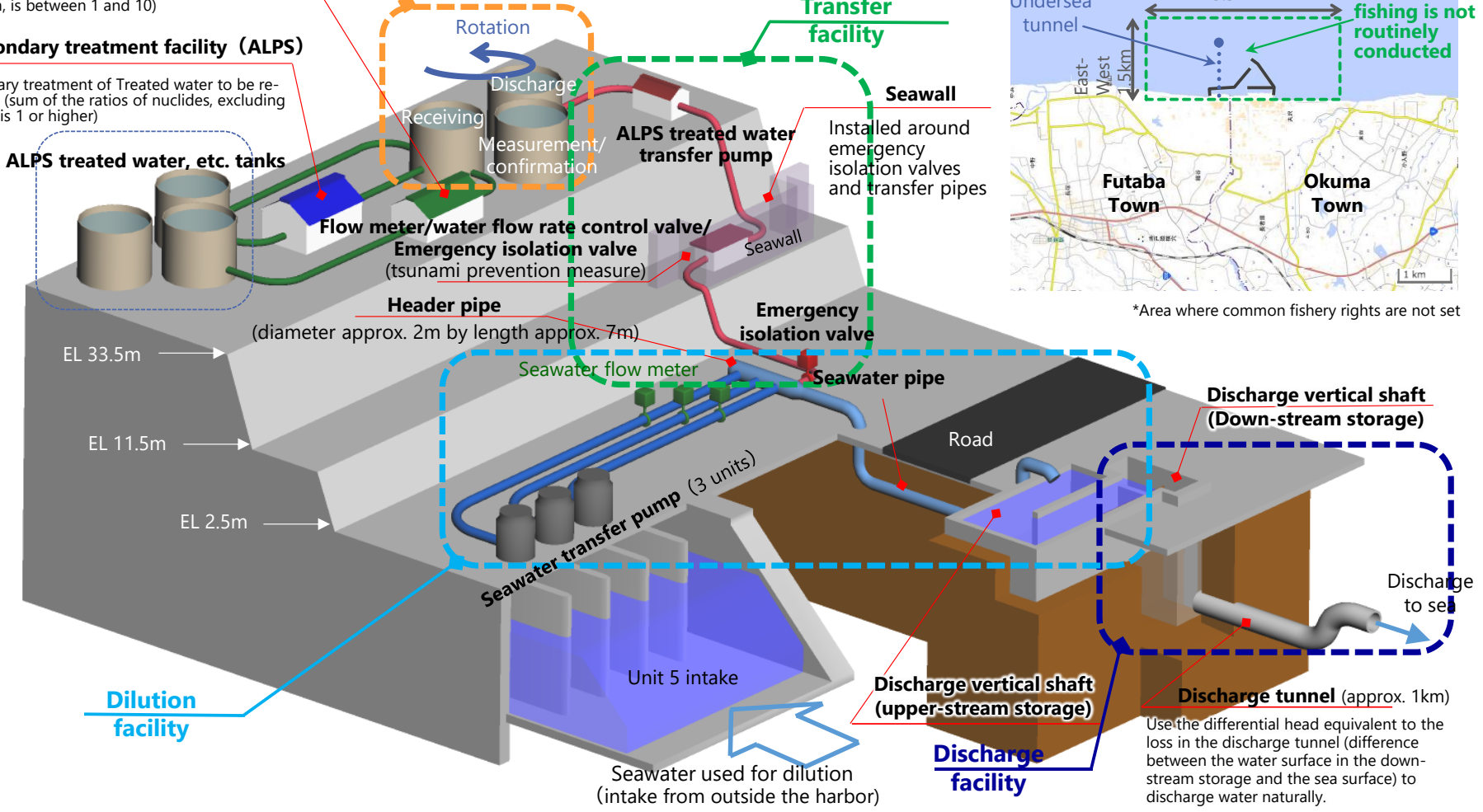
Measurement/confirmation facility (K4 tank group)

Comprised of three sets of tank groups each with the role of receiving, measurement/confirmation, and discharge. In the measurement/confirmation stage, water that has been made homogenized through circulation and agitating is sampled and analyzed (approx. 10,000m³ × 3 groups)

Transfer facility

Seawall

Installed around emergency isolation valves and transfer pipes



Source: Developed by Tokyo Electric Power Company Holdings, Inc. based on the map developed by the Geospatial Information Authority of Japan (electronic territory web)
https://maps.gsi.go.jp/#13/37.422730/141.044970/&base=std&ls=std&disp=1&vs=c1j0h0k0l0u0t0z0r0s0m0f1

*Area where common fishery rights are not set

Discharge tunnel (approx. 1km)

Use the differential head equivalent to the loss in the discharge tunnel (difference between the water surface in the down-stream storage and the sea surface) to discharge water naturally.

Overview of ALPS treated water dilution/discharge facility and related facilities

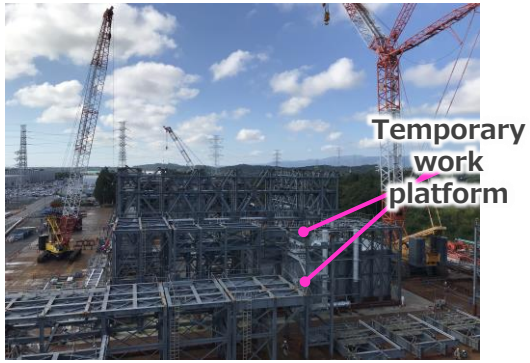
TEPCO

Spent fuel removal

– Progress made in FY2022

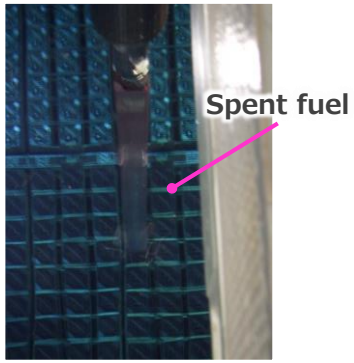
○ Progress made in FY2022

- **Unit 1**
  - Preassembly of the steel frame, etc. is underway in the off-site yard in preparation for large cover installation. On-site, installation of anchors, etc. for supporting the large cover began.
- **Unit 2**
  - The foundation of the gantry for fuel removal was completed in November 2022 and steel frame assembly began in January 2023.
  - Preassembly of the steel frame began off-site in August 2022 and is ongoing.
- **Unit 3**
  - Removal of high-dose radioactive equipment stored in the spent fuel pool began in March 2023 (risk map target achieved).
- **Unit 6**
  - Fuel removal began in August 2022 (risk map target achieved).



Preassembly of steel frame, etc. in off-site yard (September 2022)

Unit 2 reactor building south side yard (gantry foundation work)



Unit 6 fuel removal

TEPCO

Spent Fuel Removal

-Major work processes going forward (1/6)

○ **Schedule for achieving the milestones of the Mid-and-Long-Term RM**

- **Complete installation of the large cover at Unit 1 (around FY2023)**

– A large cover will be installed to control scattering of dust while removing rubble.

- **Start fuel removal from Unit 1 (FY2027 – FY2028)**

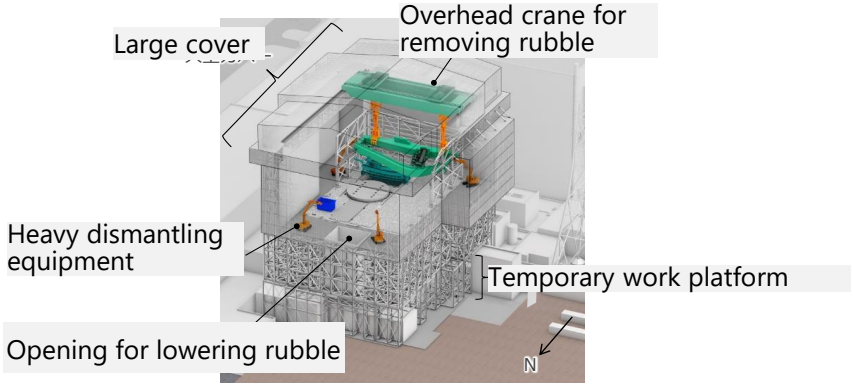
– Fuel handling equipment required for fuel removal will be fabricated.

– The fuel handling equipment will be installed after removing rubble, collapsed overhead crane, etc., handling the well plug (shielding concrete installed on top of the reactor containment vessel) that has gotten out of alignment due to the accident, and reducing the dose by means of decontamination and shielding, etc.

– Fuel removal will be started after conducting training on fuel handling.

(Challenges)

- Studying and implementing plans that take into account other interfering work to be conducted in the work areas
- Studying and implementing plans for removing rubble for which dust scattering can be reliably controlled
- Studying and implementing plans for effective decontamination and shielding in order to reduce the dose on the refueling floor
- Studying and implementing plans for handling damaged fuel stored from before the earthquake disaster



Unit 1 Large cover (Image)

Spent Fuel Removal

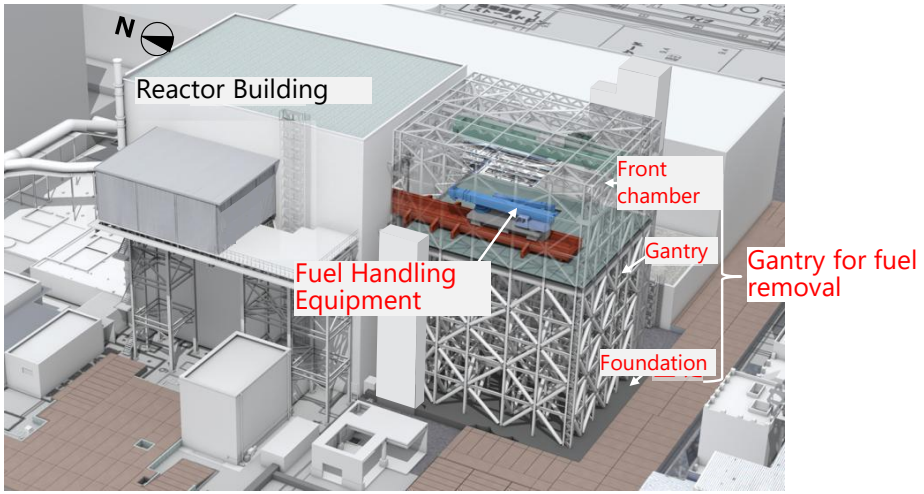
-Major work processes going forward (2/6)

○Schedule for achieving the milestones of the Mid-and-Long Term RM

- **Start fuel removal from Unit 2 (FY2024 - FY2026)**
  - Fuel handling equipment required for fuel removal will be fabricated.
  - A gantry will be installed on the southern side of the Reactor Building for removing fuel from openings of R/B walls.
  - Fuel handling equipment will be installed after reducing the dose on the refueling floor by means of decontamination and shielding.
  - Fuel removal will be started after conducting training on fuel handling.

(Challenges)

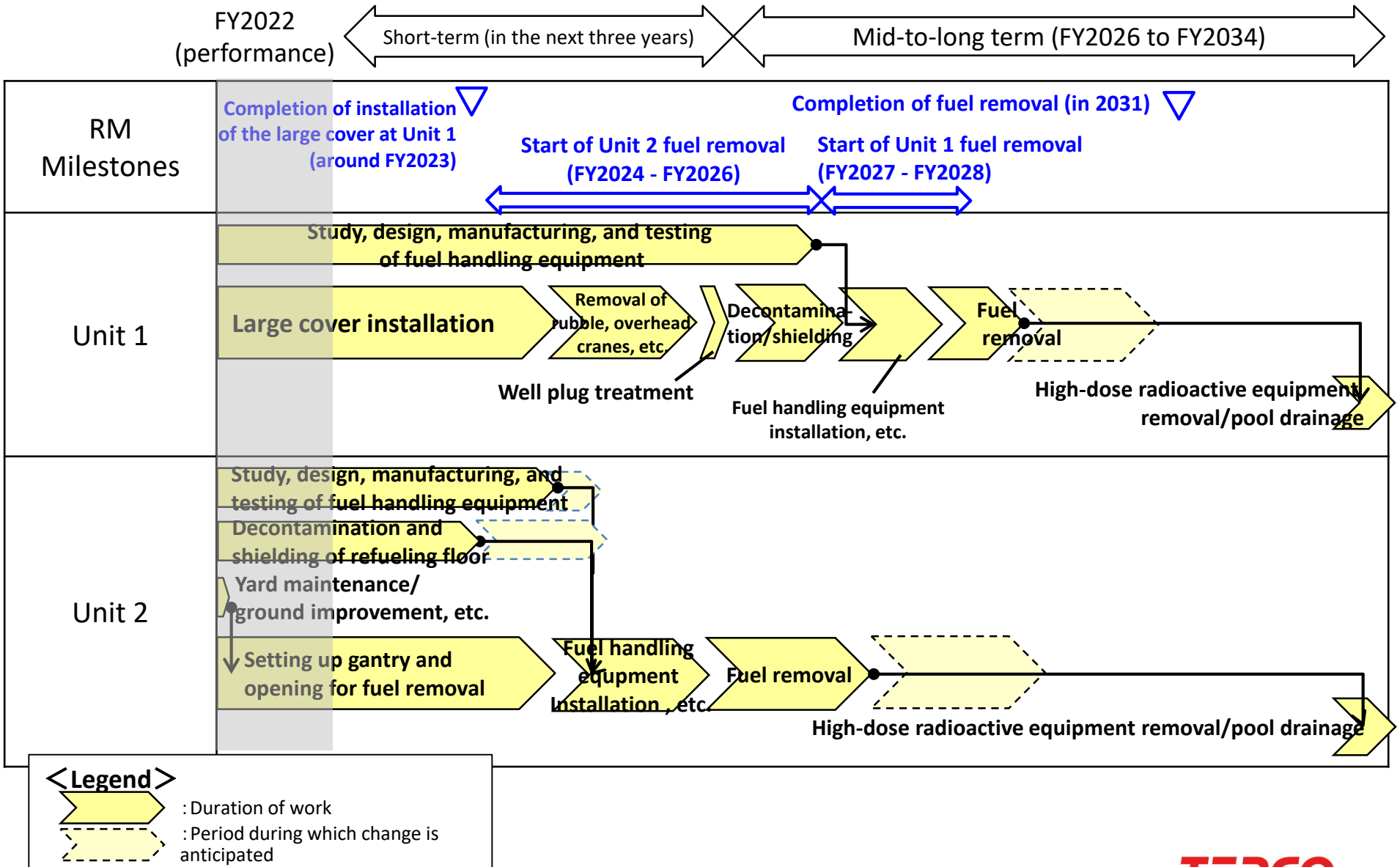
- Studying and implementing plans for effective decontamination and shielding in order to reduce the dose on the refueling floor.



Unit 2 gantry for fuel removal (Image)

Spent Fuel Removal

-Major work processes going forward (3/6)



Spent Fuel Removal

-Major work processes going forward (4/6)

◯Schedule for achieving the milestones of the Mid-and-Long-Term RM

- **Complete fuel removal from Units 1-6 (in 2031)**
  - Fuel will be removed from Units 5 and 6 in a way that does not interfere with work at Units 1 and 2.
  - Since the common pool receives spent fuel from each unit, the spent fuel in the common pool will be stowed in dry storage containers (casks) in advance and stored on high grounds.
  - Additional temporary storage facilities will be installed after securing sites within the premises.

(Challenges)

- Setting up additional temporary storage facilities for dry casks in accordance with the fuel removal plan including fuel removal from Units 5 and 6

◯Other spent fuel removal related work

- After removing fuel from each unit, highly radioactive equipment such as spent control rods will be removed.
- Study, design, and installation of new facilities for storing high-dose radioactive equipment, etc. from Units 1 and 2. Preparations for removing large, high-dose radioactive equipment from the Unit 4 pool will be made.

(Challenges)

- Study of specific method for removing diverse equipment with varying sizes and shapes (remote operation, transfer and storage)

Spent Fuel Removal

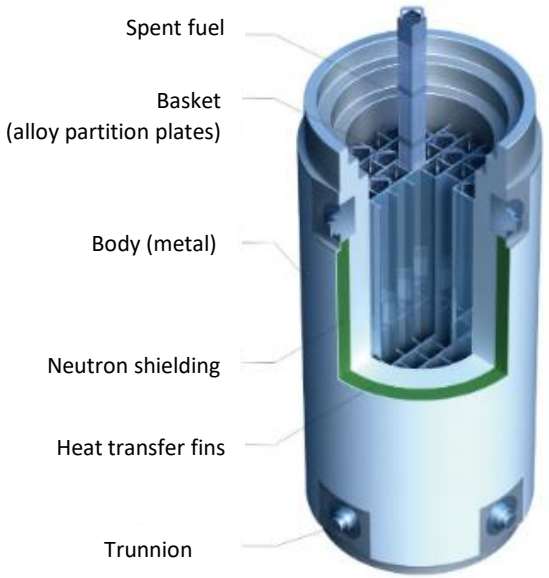
-Major work processes going forward (5/6)

◯Other spent fuel removal related work (continued)

– In addition to existing metal casks, the use of dry storage facilities (concrete casks) that use canisters with a proven track record overseas will be studied as another dry storage option at the high ground for fuel being stored in the common pool.

(Challenges)

- Study of dry storage methods for damaged fuel that was in storage prior to the disaster



Metal casks (example)

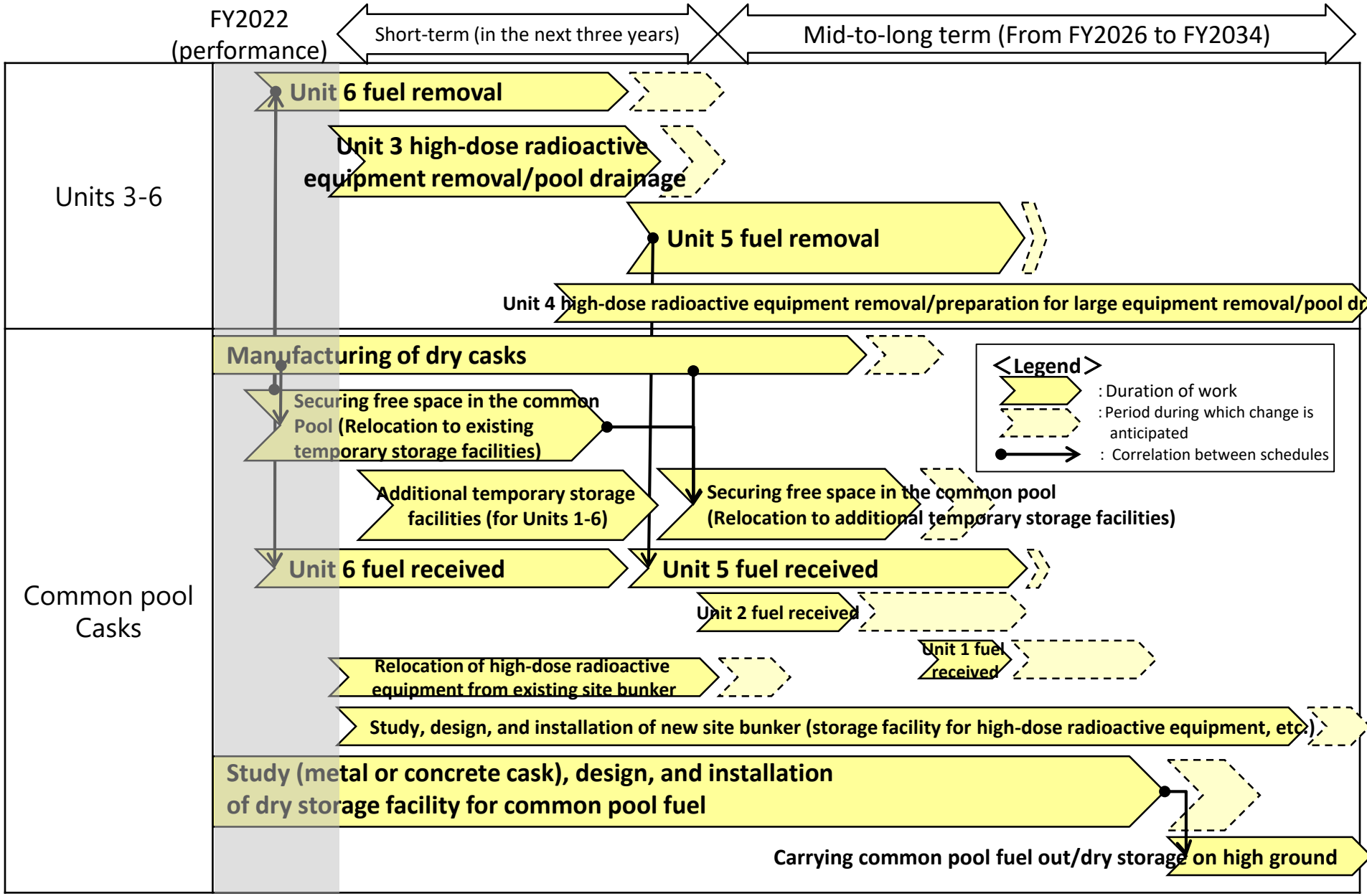
Concrete casks (example)

Source: Federation of Electric Power Companies “Spent Fuel Storage Countermeasure Initiatives” (in Japanese only)
https://www.fepc.or.jp/library/pamphlet/pdf/18_chozo_taisaku_torikumi.pdf

TEPCO

Spent Fuel Removal

-Major work processes going forward (6/6)

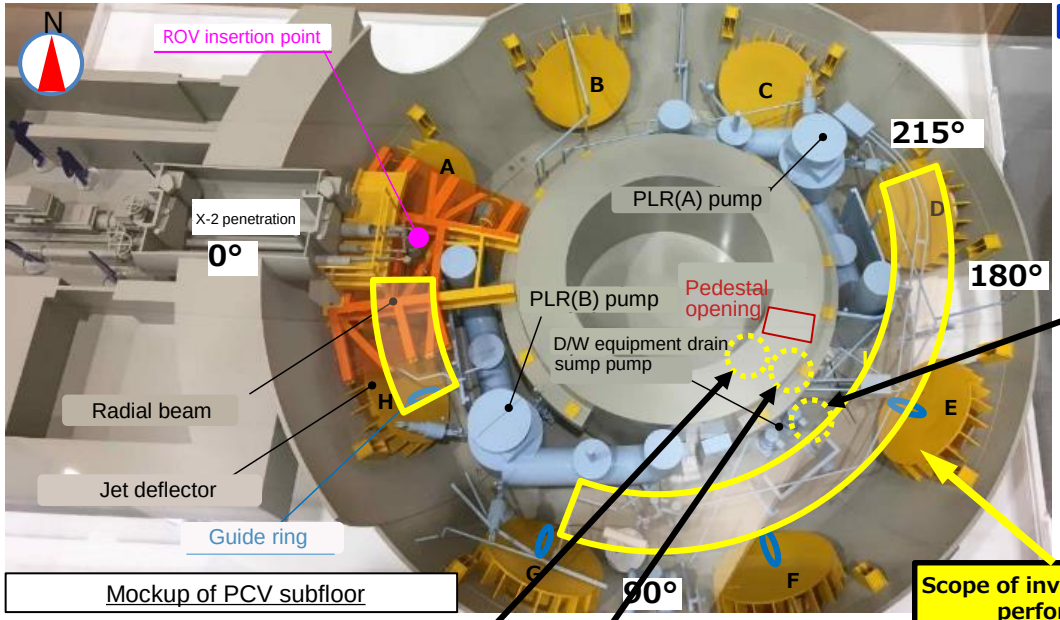


Fuel debris retrieval

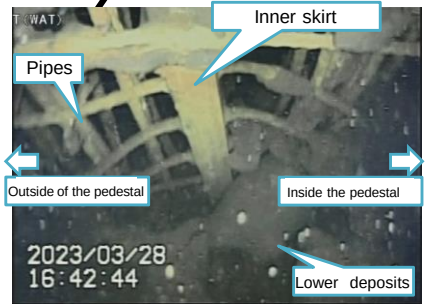
– Progress made in FY2022

○ Progress made in FY2022

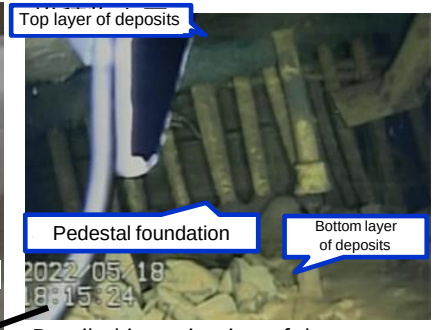
- **Unit 1 primary containment vessel internal investigation (underwater investigation)**
  - The following internal investigations of the primary containment vessel have been implemented since February 2022.



Mockup of PCV subfloor



Near the pedestal opening (March 2023)



Detailed investigation of the outer circumference of the pedestal (May 2022)

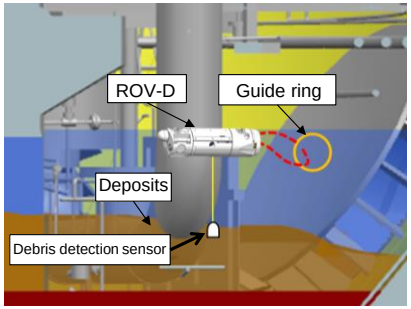


Image of detecting debris in deposits (December 2022)

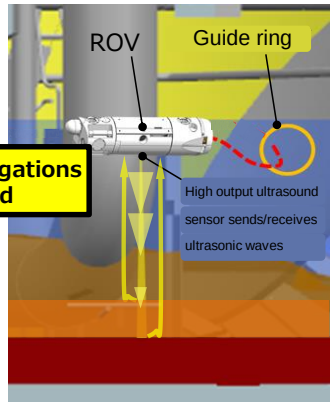
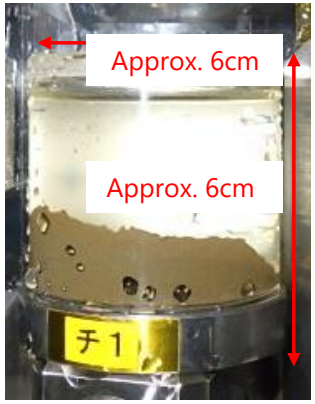


Image of measuring the thickness of deposits (June 2022)



Samples taken (February 2023)

※This document leverages the results of the International Research Institute for Nuclear Decommissioning (IRID).

TEPCO

Fuel debris retrieval

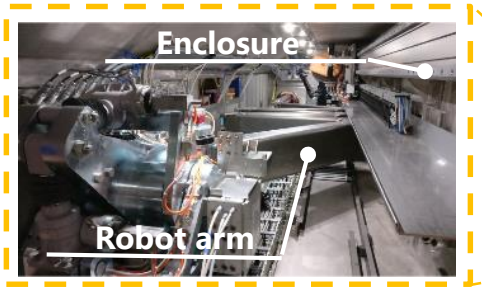
-Major work processes going forward (1/4)

○Schedule for achievement the milestones of the Mid-and-Long-Term RM

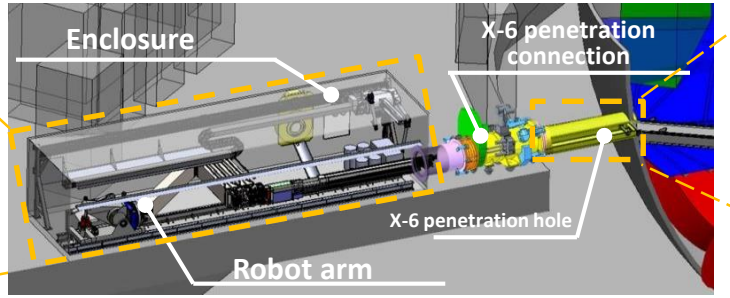
- **Start fuel debris retrieval from the first implementing unit**
  - Towards the trial retrieval in Unit 2, research and development will be undertaken, engineering work will be carried out to apply the results of R&D on site, and fuel debris retrieval equipment (access equipment, recovery equipment, etc.) will be manufactured and installed. Primary Containment Vessel (PCV) internal investigation will be implemented in accordance with retrieval. Furthermore, device development in the UK was delayed approximately one year due to the Covid-19 pandemic, and we have added another year to 18 months of preparations in order to improve the safety and reliability of trial retrieval (internal investigations/debris sampling), so trial retrieval is now set to begin during the later half of FY2023.
  - The operation of the existing gas management system will be changed for enhancing the function of monitoring radioactive substances and for preventing dust from scattering to outside the PCV.
  - The deposits or obstacles in the existing opening (X-6 penetration hole) that leads to the inside of the PCV will be removed.

(Challenges)

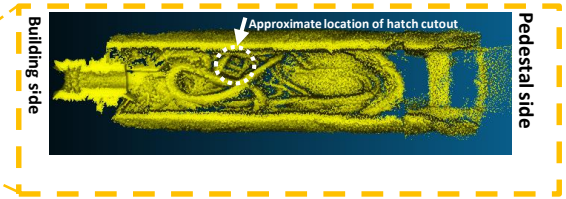
- Study on measures to control scattering of dust while removing the deposits or obstacles from the access route, and developing relevant devices



Enclosure and robot arm



Overview of equipment for trial retrieval



3D scan from above the X-6 penetration

*This document leverages the results of the International Research Institute for Nuclear Decommissioning (IRID).

Fuel debris retrieval

-Major work processes going forward (2/4)

○ **Other fuel debris retrieval related work**

● **Expansion of the scale of retrieval gradually (Unit 2)**

– In preparation to expand the scale of retrieval in stages, research and development will be undertaken, and engineering work will be carried out to apply the achievements of such R&D to the field. Taking also into account the knowledge, etc. obtained through trial retrieval, design, manufacturing and installation of fuel debris retrieval equipment, safety systems (containment, maintaining cooling, criticality control, etc.), fuel debris storage facilities and equipment for the maintenance of the retrieval equipment will be carried out as well.

– For improving the environment inside the building, the radiation dose in the west-side area on the first floor of the reactor building will be further reduced.

– Internal investigation of the Unit 2 reactor pressure vessel (RPV) will be studied.

(Challenges)

- Study on measures to control scattering of dust while crushing fuel debris or removing structures from inside the PCV

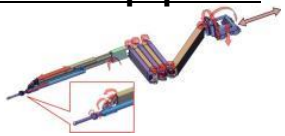
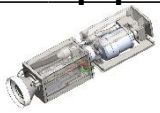
● **Efforts for determining methods for processing and disposal of fuel debris**

– After starting fuel debris retrieval, analysis, etc. of fuel debris properties will be performed.

● **Further expansion of the scale of retrieval (Units 1/3)**

– In preparation to further expand the scale of retrieval, research and development will be undertaken, and engineering work will be carried out to apply the achievements of such R&D to the field. Taking also into account the knowledge, etc. obtained through retrieval at Unit 2, a retrieval method will be decided. Preparations for the retrieval will be implemented as well, such as design and manufacturing of fuel debris retrieval equipment, environmental improvement around installation locations, as well as installation of such equipment. Furthermore, we will build training facilities where required skills can be acquired.

– In addition to the Unit 1 PCV internal investigation (underwater investigation), implementation of more investigations will be studied, such as investigations inside and outside of the pedestal, which will include aerial investigations of the inside of the Unit 1 PCV, an internal investigation of the Unit 3 PCV, and an internal investigation of the RPV. In conjunction with this, the investigation results to be obtained will be assessed, and countermeasures will be studied as well.

Trial retrieval (Unit 2)		**Gradual expansion of the scale of retrieval (Unit 2)**	
Access equipment	**Fuel debris retrieval equipment**	**Access equipment**	**Fuel debris retrieval equipment**
	 Proposed metal brush  Proposed vacuum container		 Proposed gripper tool  Proposed digging recovery tool

*This document leverages the results of the International Research Institute for Nuclear Decommissioning (IRID).

Fuel debris retrieval

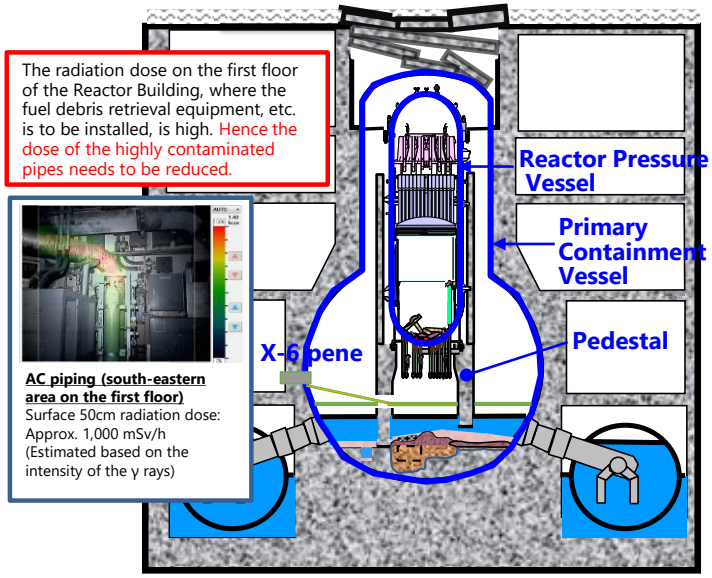
-Major work processes going forward (3/4)

- In order to improve the environment inside the buildings, radioactive sources will be investigated and eliminated for reducing the radiation dose at the work site (in particular, highly contaminated pipes). In addition, equipment, etc. that could hinder future work will be removed. Moreover, the PCV water level will be reduced by developing equipment that draws water from the Unit 3 PCV.
- For improving the environment outside the building, facilities that pose an impediment (Unit 1/2 exhaust stack, Unit 3/4 exhaust stack, etc.) will be removed, thereby securing space for fuel debris retrieval equipment, etc.

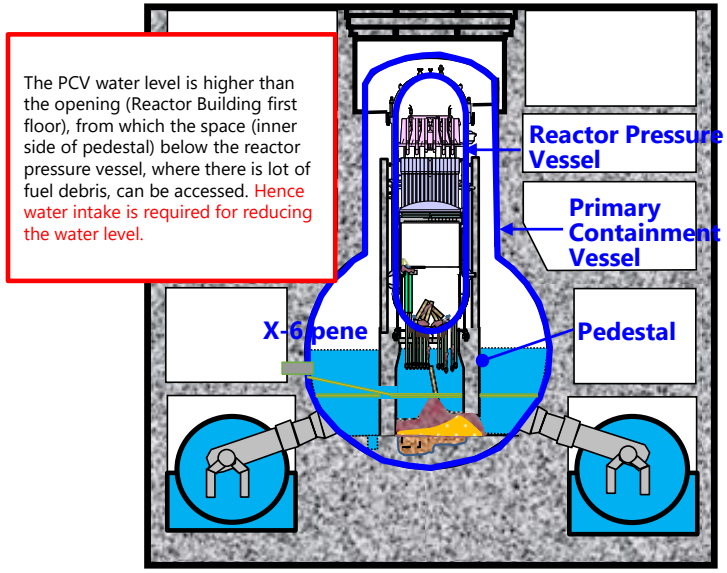
(Challenges)

- Study on the method of reducing the dose of highly contaminated pipes by means of remote operations (removal or decontamination) and the method of installing equipment for retrieval and water intake, etc., since the dose at the work site in Units 1/3 is higher compared to that in Unit 2
- Accumulated hydrogen gas that may be found during fuel debris retrieval preparations, etc.

Unit 1

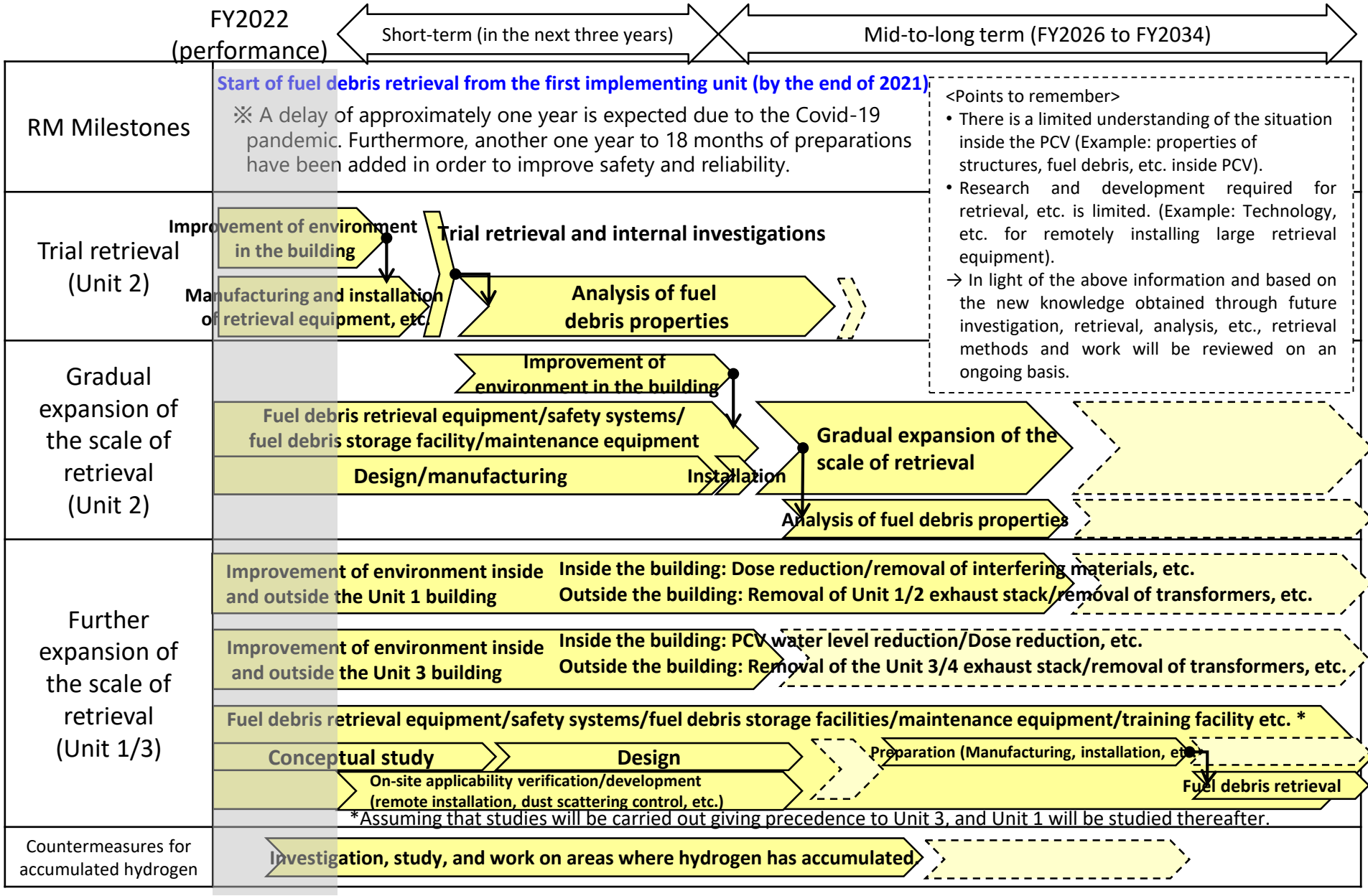


Unit 3



Fuel debris retrieval

-Major work processes going forward (4/4)



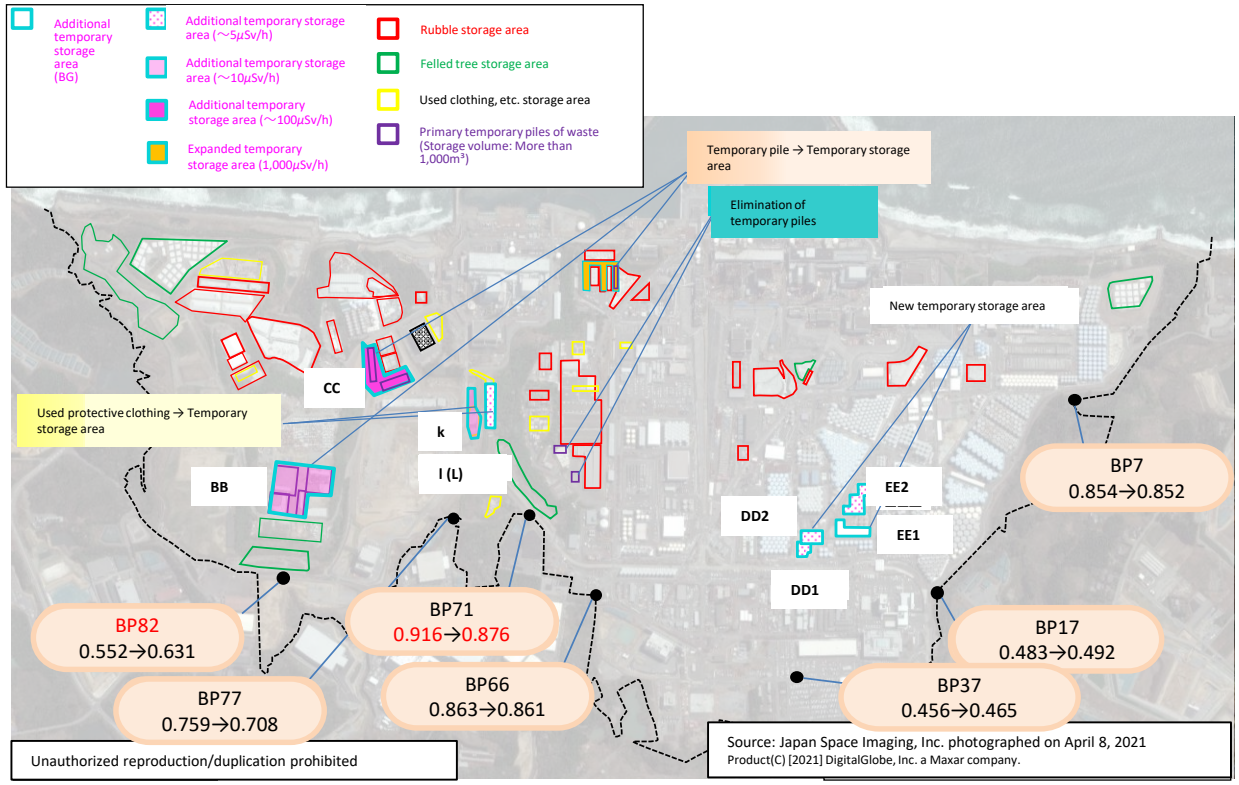
Waste management

- Progress made in FY2022

○ Progress made in FY2022

- **Rubbles, etc.**

  Inspection, etc. work became complicated due to the leaks of radioactive substances from containers occurred during 2021, thereby hampering the relocation of rubble to the temporary storage area.
  As a result, temporary piles of waste had grown and remained untouched for a long period of time. The situation was improved and waste management optimization was completed in March 2023.



Waste management

-Major work processes going forward (1/4)

○ Work processes for achieving the milestones of the Mid-and-Long-Term RM

- **Eliminate temporary storage areas outside for rubble and other waste (in FY2028)**
  - Additional miscellaneous solid waste incineration facilities for reducing the volume of combustible materials or volume reduction equipment, etc., for reducing the volume of incombustible materials (metal, concrete) will be installed and their operation will be started.
  - Incineration and volume reduction of waste that is temporarily stored outdoors, will be carried out and it will be stored in the solid waste storage vaults.
  - If the projection of the amount of solid waste that will be generated in the future fluctuates and the capacity of storage facilities is short, additional storage facilities will be built after securing space within the premises.

(Challenges)

- Reflection of fluctuation in the projection of the amount of waste that will be generated in the future into the storage management plan

Waste management

-Major work processes going forward (2/4)

○Other work related to waste countermeasures

- We will study the additional construction of solid waste storage vaults by FY2030.
- Based on the status of progress of future decommissioning work, characterization required for studying treatment and disposal of solid waste will be carried out utilizing the radioactive substance analysis and research facility that is currently in preparation.
- Melting facilities will be built in order to decontaminate/reduce the volume of objects to be melted. The types of waste to be melted shall be revised as necessary going forward in accordance with design progress.

● Secondary waste generated from water treatment

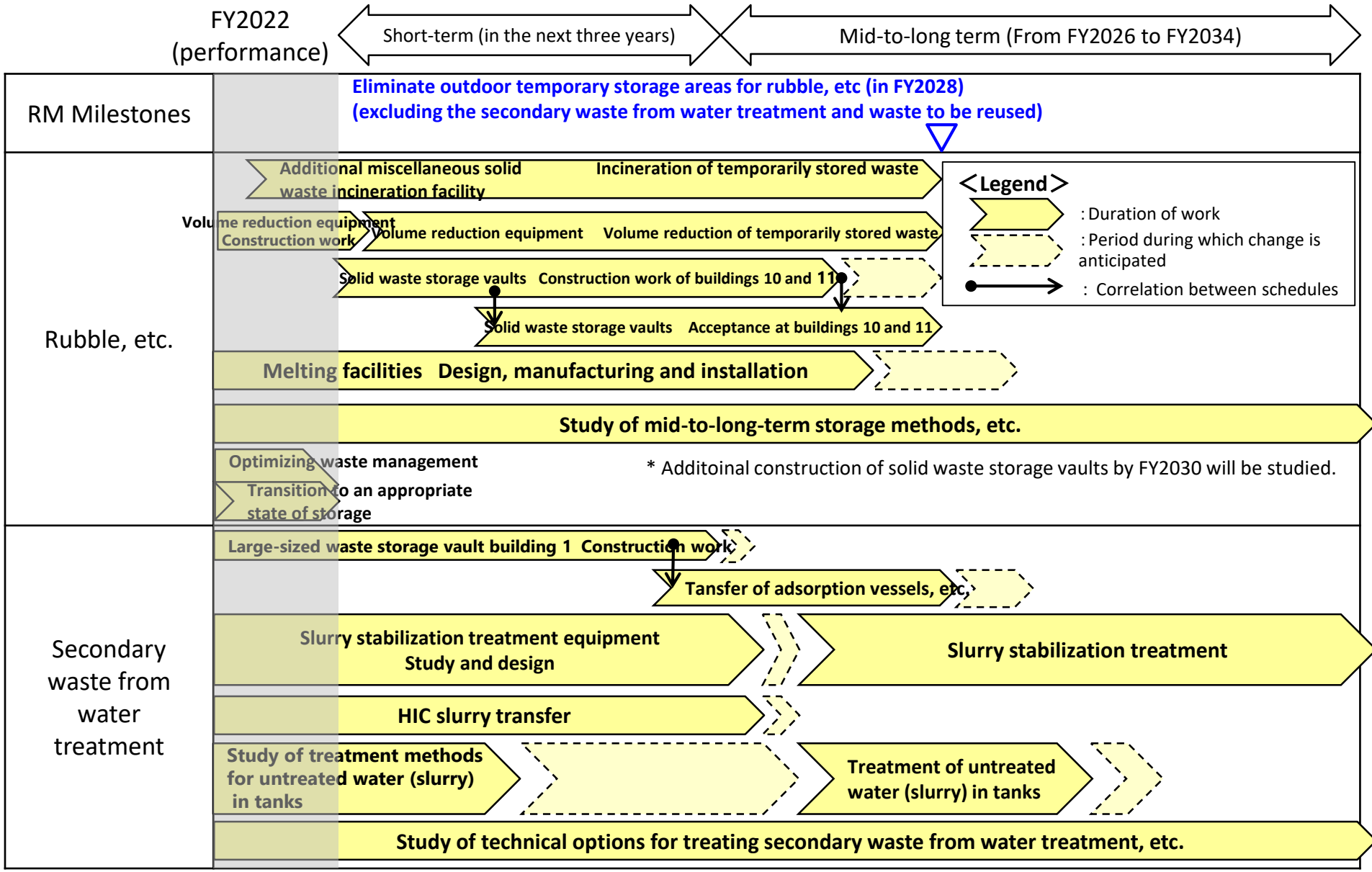
- Secondary waste generated from water treatment (adsorption vessels, etc.) will be moved to the large-sized waste storage vaults.
- Since the slurry, which is secondary waste generated from water treatment using multi-nuclide removal equipment, has lots of water content, dehydration and stabilization treatment will be carried out.
- The slurry is stored in high integrity containers (HIC). While it will not leak if the HICs are stationary, the slurry will be transferred from HICs whose integrity cannot be confirmed if it were to fall in consideration of the effects of slurry radiation, before the start of operation of the slurry stabilization treatment facility.
- Untreated water in tanks (slurry) will be treated with slurry stabilization treatment equipment. Treatment will commence after testing, etc.

(Challenges)

- Design of slurry stabilization treatment equipment and study of specific methods for the operation

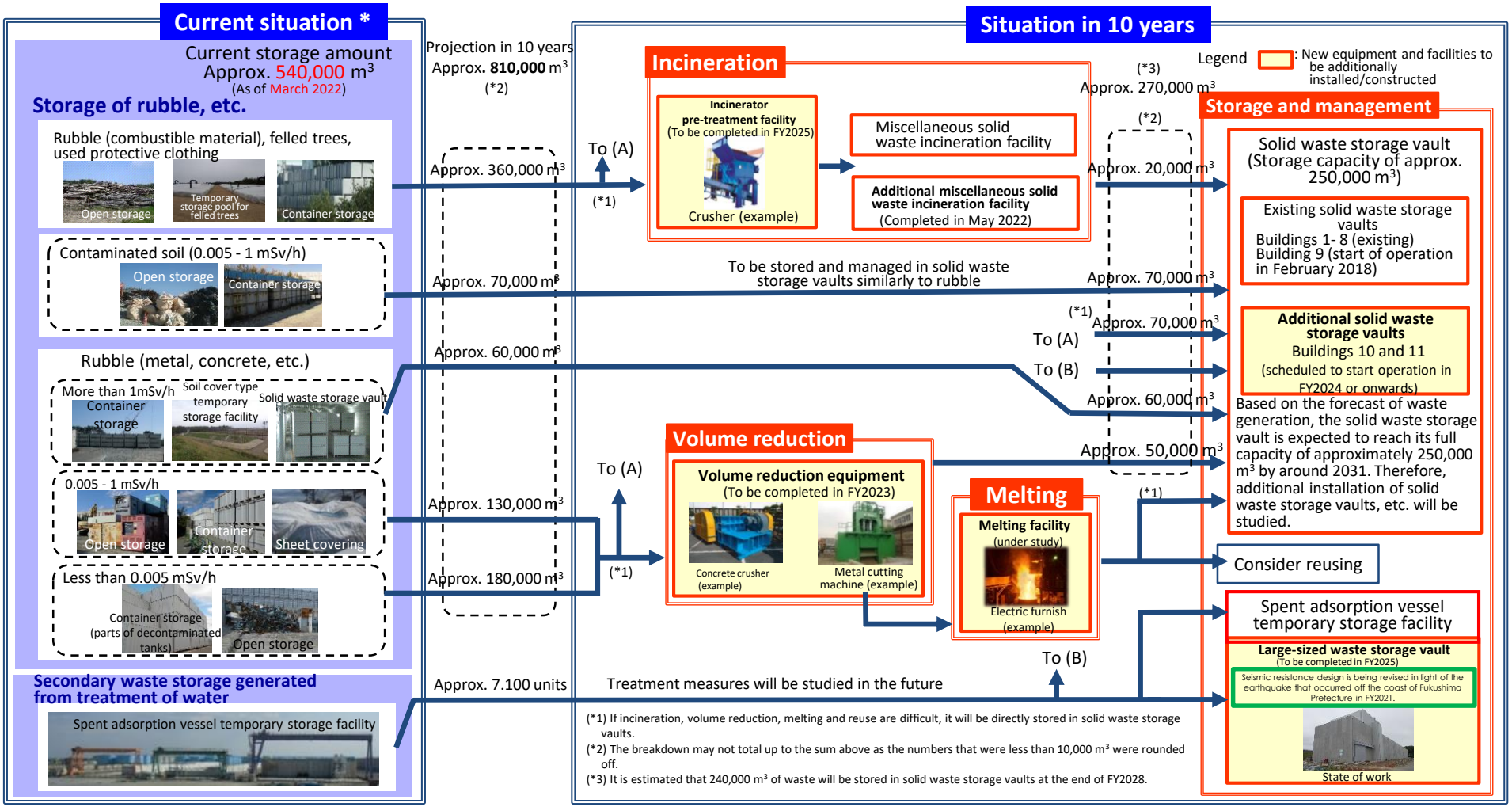
Waste management

-Major work processes going forward (3/4)



Waste management

-Major work processes going forward (4/4)



(*1) If incineration, volume reduction, melting and reuse are difficult, it will be directly stored in solid waste storage vaults.
(*2) The breakdown may not total up to the sum above as the numbers that were less than 10,000 m³ were rounded off.
(*3) It is estimated that 240,000 m³ of waste will be stored in solid waste storage vaults at the end of FY2028.

* Used protective gear that is not yet incinerated and is determined at this point in time to be processed/reused and concrete waste at the BG level are not included.

- The dose on the site boundary is expected to decrease due to incorporation into indoor storage and elimination of outdoor storage.
- The dose of the exhaust gas from the incineration facility and the dose on the site boundary are measured and published on the website, etc.

TEPCO

Other measures

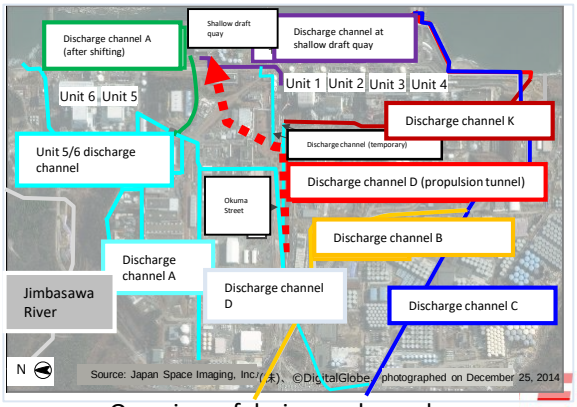
- Progress made in FY2022

○Progress made in FY2022

- **Natural disaster prevention measures**
  - We are currently building a seawall in preparation for the construction of the Japan Trench tsunami seawall.
  - In order to quickly eliminate the risk of flooding around the Units 1~4 buildings caused by torrential rains, we extended drainage channel D and put it into service in August 2022.

Japan Trench tsunami seawall construcion
(Top: Prior to construction; Bottom: During construction)

Completion status of drainage channel propulsion tunnel



Overview of drainage channel

Other measures

-Major work processes going forward (1/3)

○ Other related work

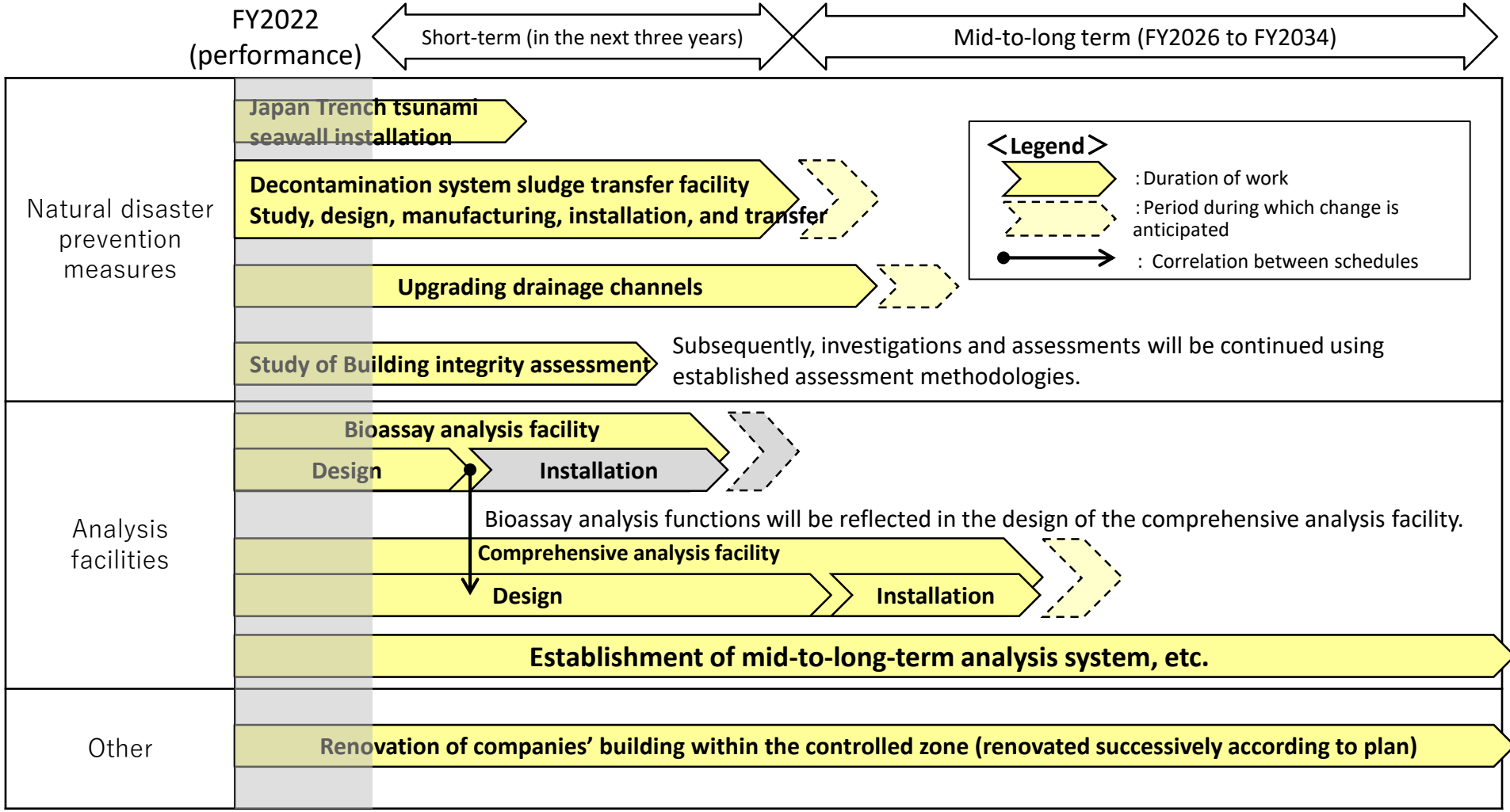
- **Natural disaster prevention measures**
  - Countermeasures for possible tsunami such as installation of Japan Trench tsunami seawall, extraction of decontamination systems sludge, etc. will be implemented.
  - Drainage channels will be upgraded in preparation for large-scale rainfall.
  - The integrity of the Units 1-3 reactor buildings that needs to be confirmed in the long-term before debris retrieval completion will be assessed through investigations of the building inside, trend analysis using seismometers, etc.

  (Challenges)

  - Measures other than seawall as tsunami countermeasures (protecting the freezing brine transfer pipes, etc.)
  - Study of safety measures to be taken with regard to remote recovery, dewaterability evaluation, and handling of decontamination system high radiation sludge
  - Study of methods to investigate integrity inside high dose buildings
- **Analysis facilities**
  - Facilities that has the analysis capability to be required as decommissioning progresses will be installed.
  - An analysis system, etc. will be established in order to flexibly handle changes with demand for analysis.
- **Other**
  - In order to improve work efficiency, partner companies' building within the controlled area will be renovated so that it can be used as a resting place, etc.

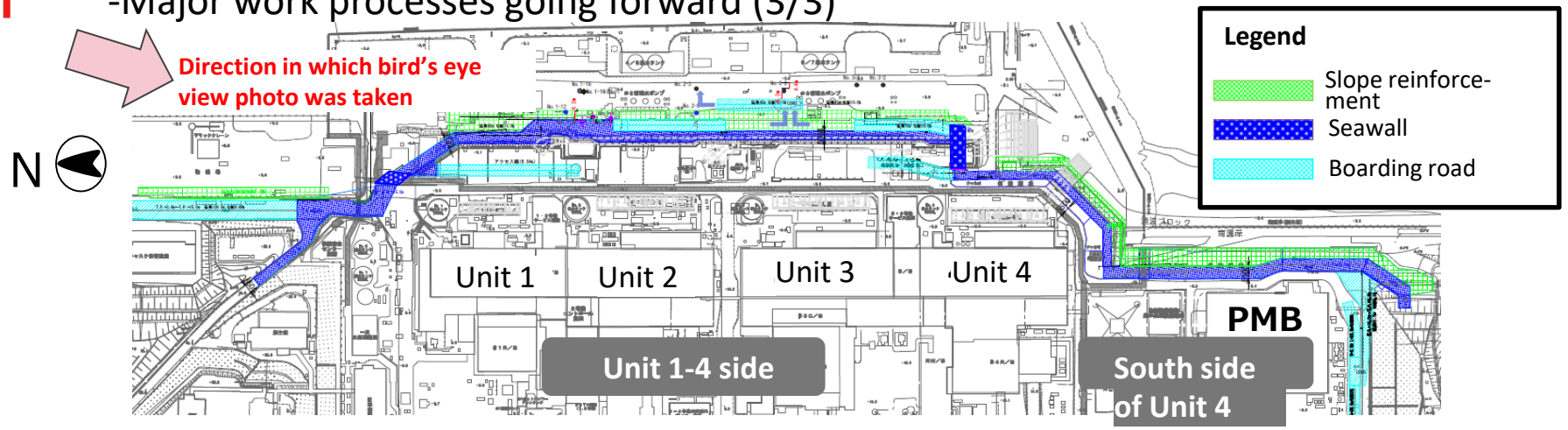
Other measures

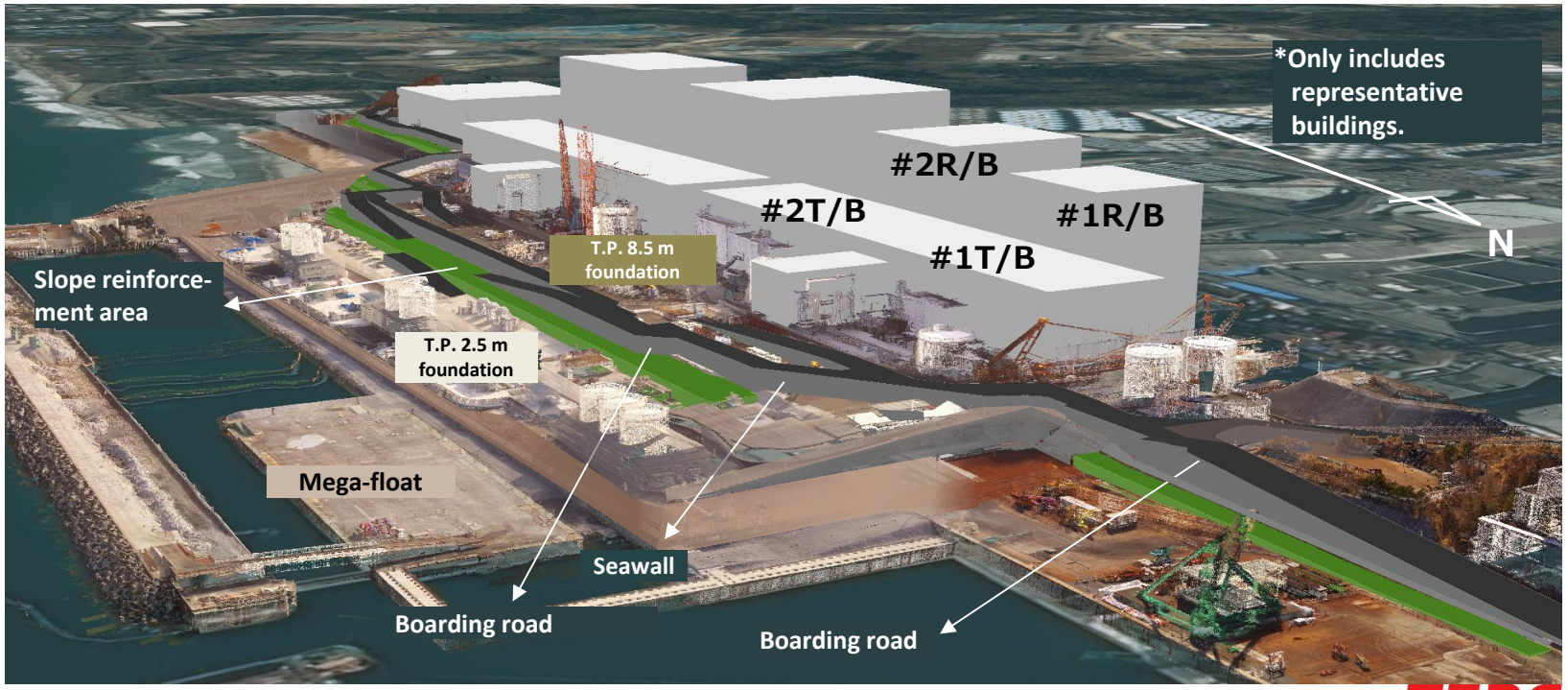
-Major work processes going forward (2/3)



Other measures

-Major work processes going forward (3/3)

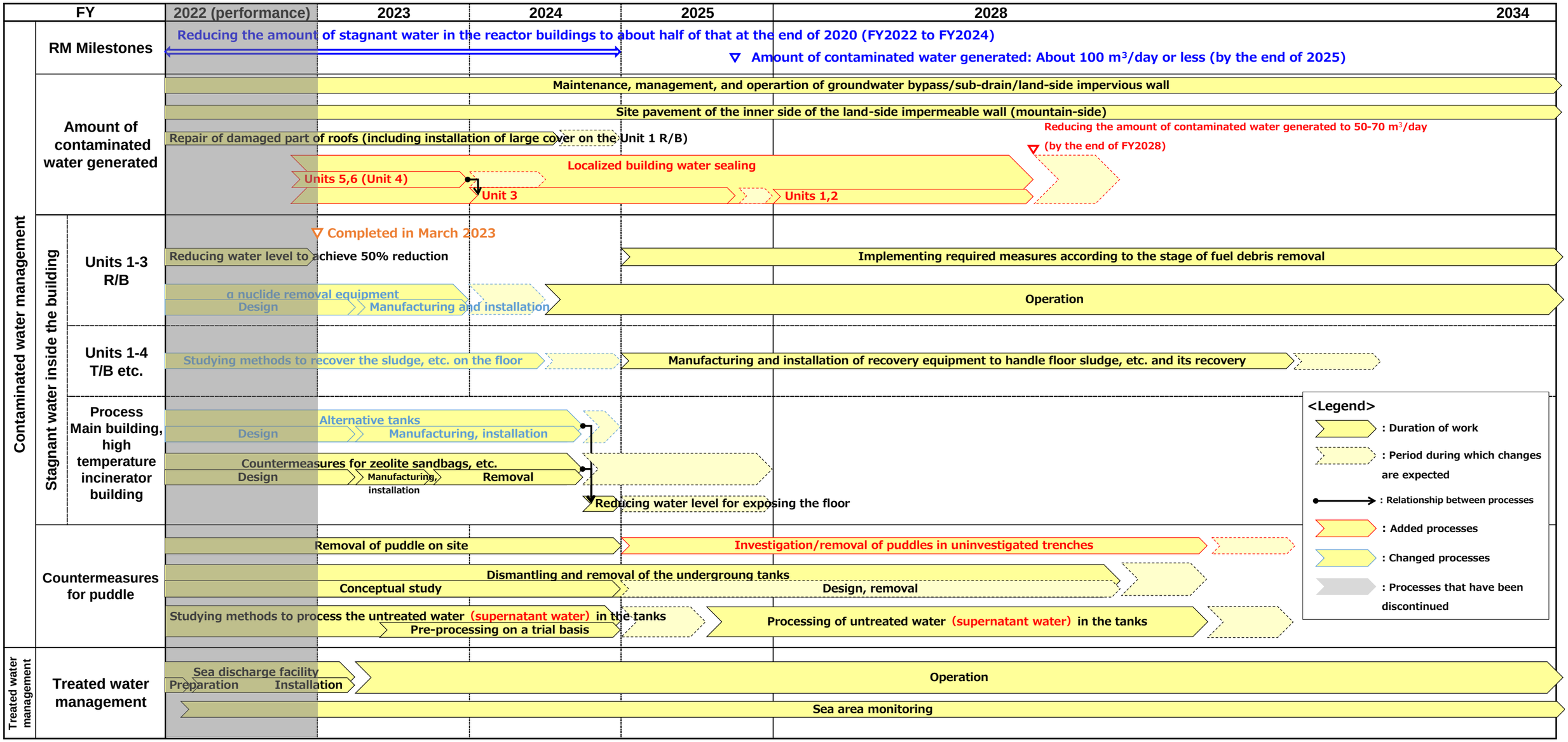




Ground plan and bird's eye view plan of the Japan Trench tsunami seawall

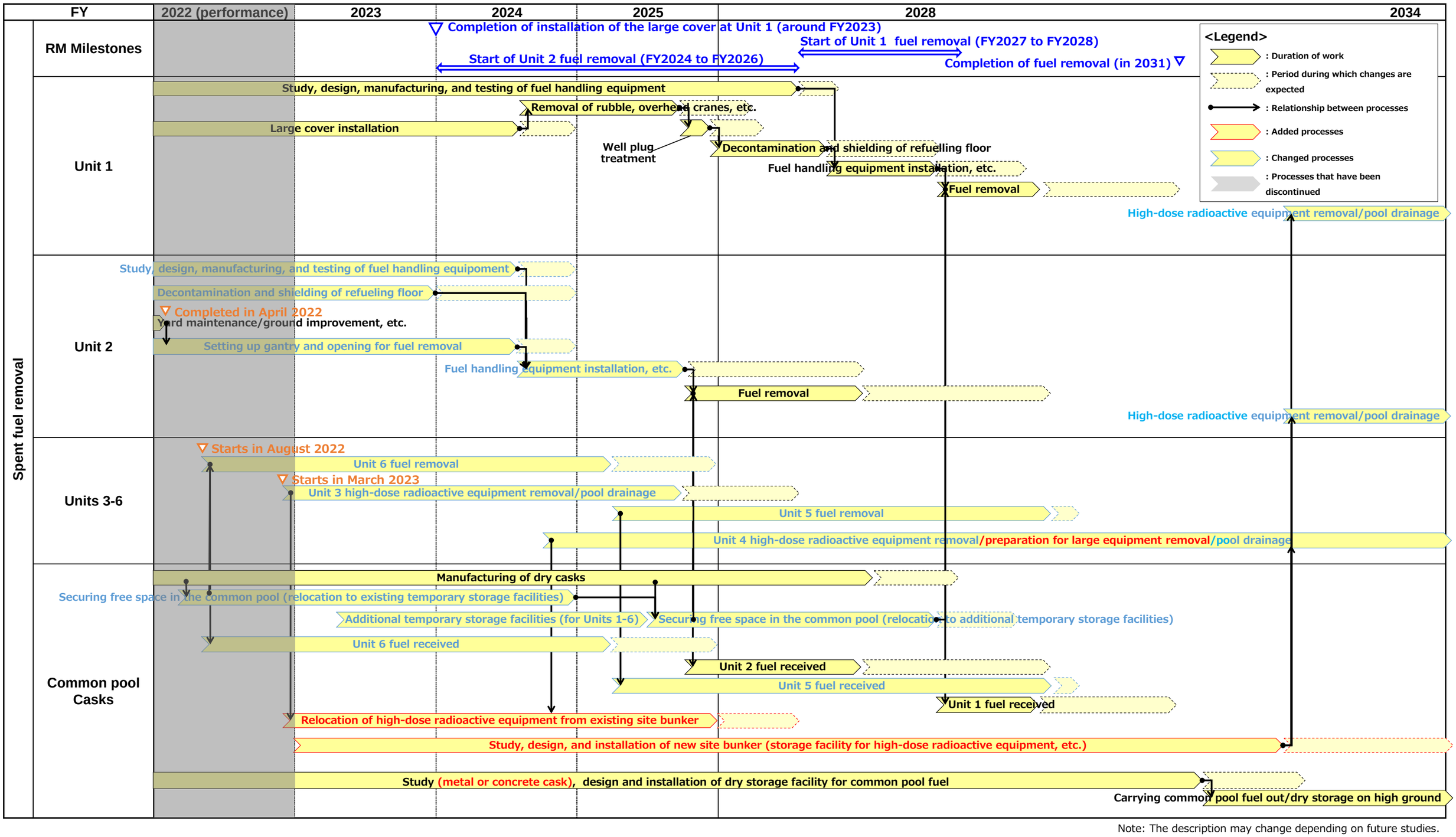
TEPCO

Mid-and-Long-Term Decommissioning Action Plan 2023



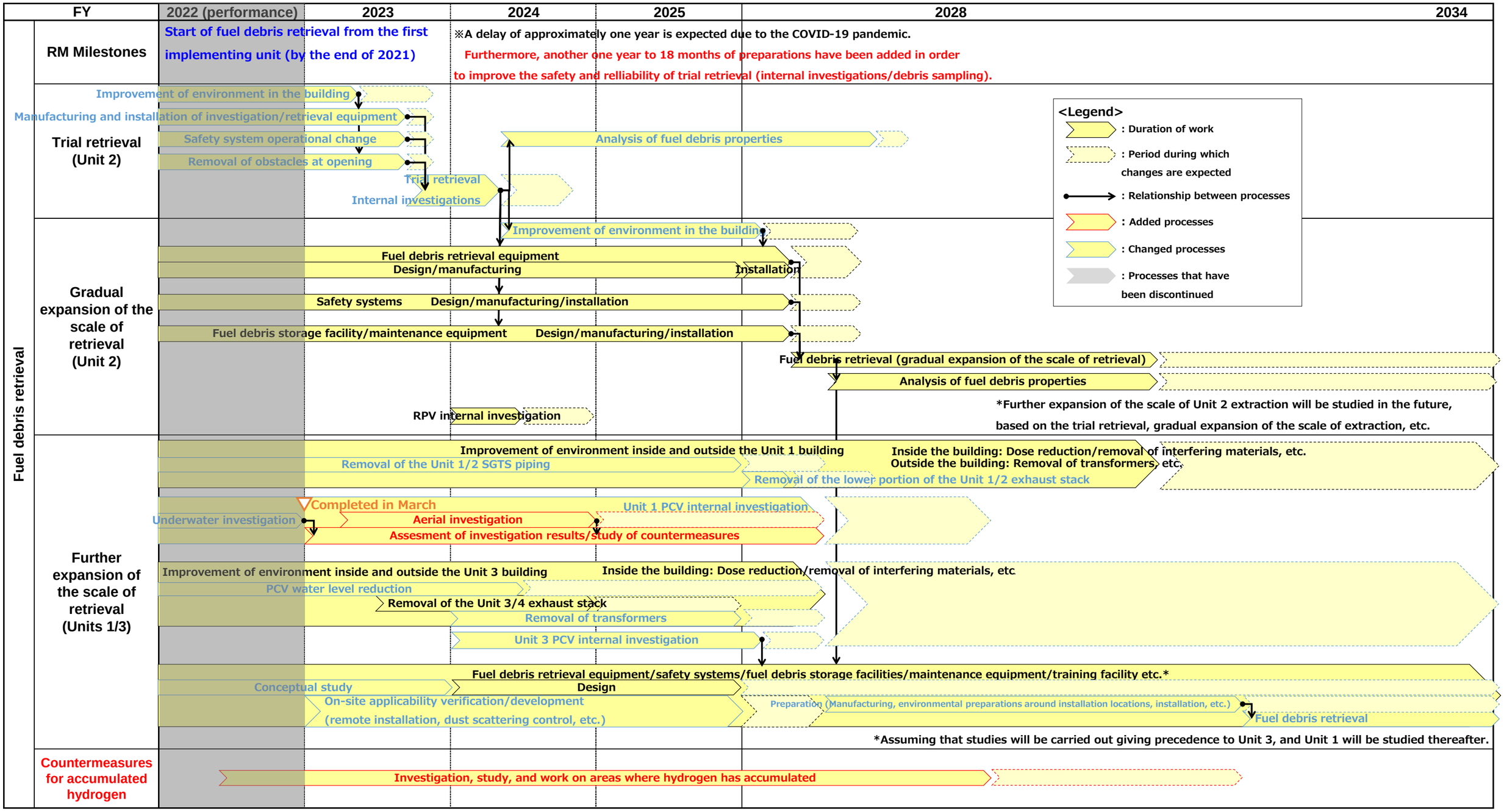
Note: The description may change depending on future studies.

Mid-and-Long-Term Decommissioning Action Plan 2023



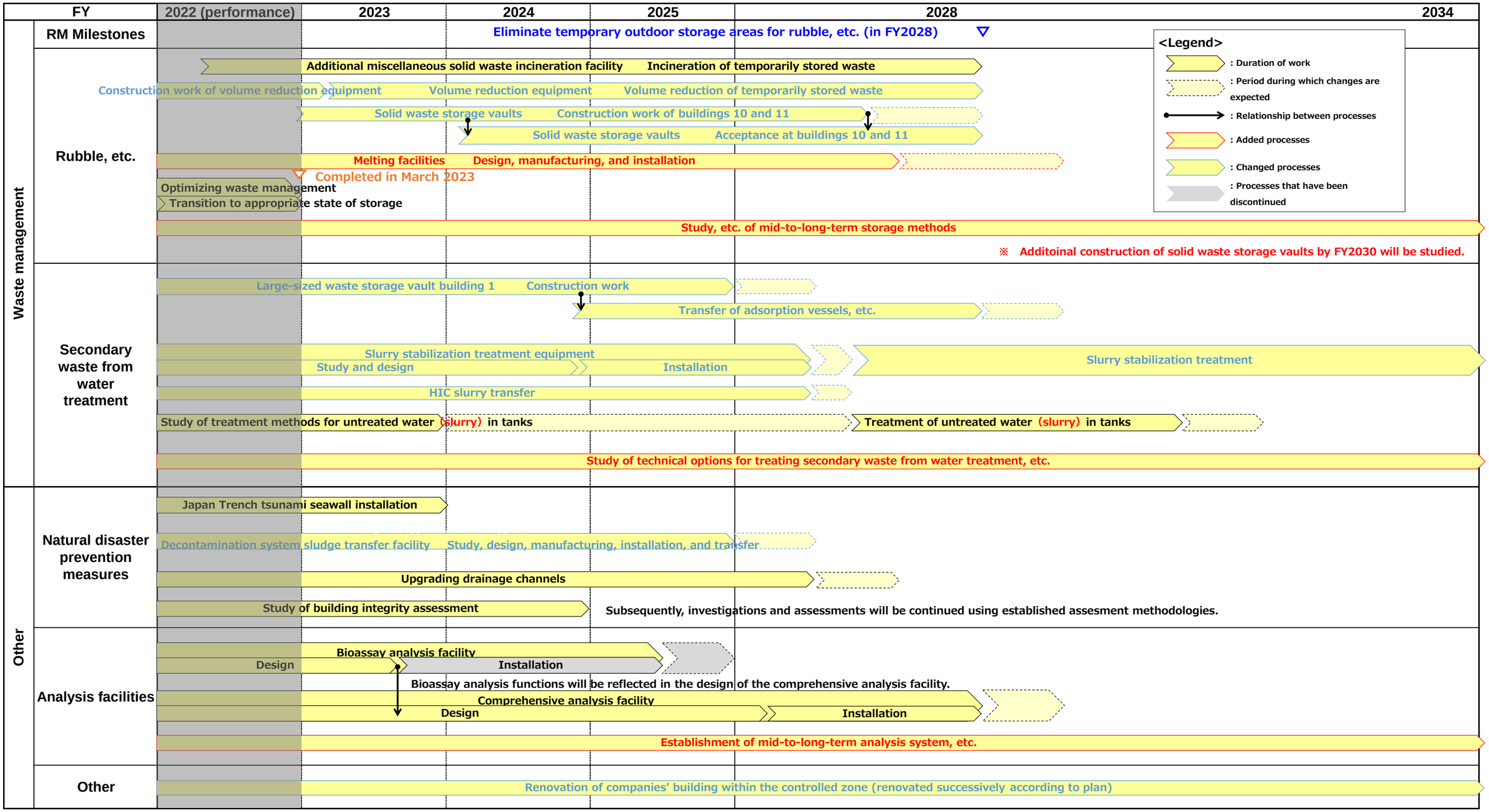
Note: The description may change depending on future studies.

Mid-and-Long-Term Decommissioning Action Plan 2023



Note: The description may change depending on future studies.

Mid-and-Long-Term Decommissioning Action Plan 2023



Note: The description may change depending on future studies.