Status of Investigation into the Rise in Temperature of Temperature Measuring Tube 150-7S for the Land-Side Impermeable Wall (frozen-soil wall)

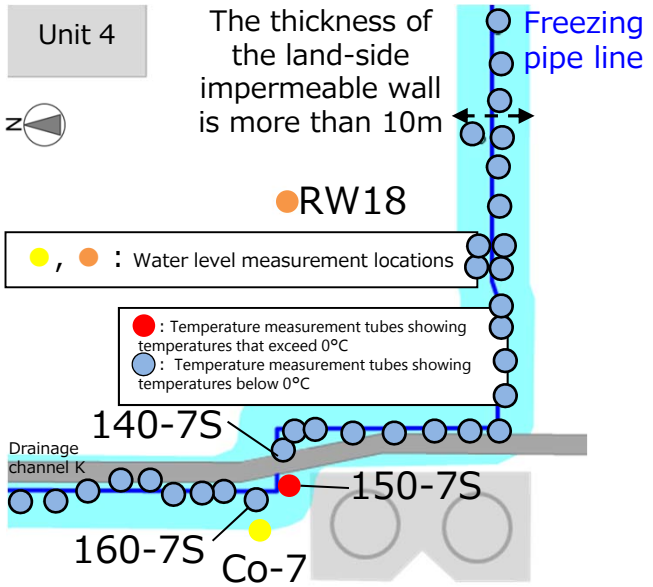
November 25, 2021

TEPCO

Tokyo Electric Power Company
Holdings, Inc.

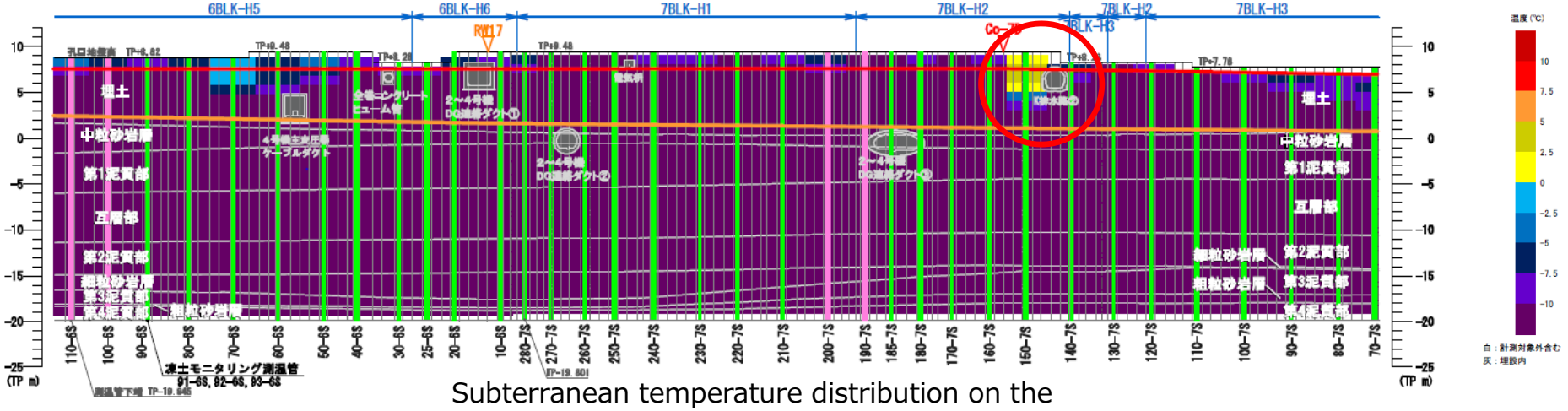
1. Overview

- Brine is being switched on and off to maintain the land-side impermeable wall based on surface and subterranean ground temperatures measured by temperature measuring tubes.
- On October 13, it was observed that in localized areas 3m below the ground (around 1.0m~4.0m below the ground surface) temperatures measured by temperature measurement tube 150-7S near the intersection of drainage channel K (downstream side) continued to exceed 0°C (ground surface temperature was confirmed to be approximately 0°C).
- Since there were no obvious changes in groundwater levels, and the difference in water levels inside and outside the wall were being maintained, it was determined that this would not have an impact on the impermeability of the land-side impermeable wall. (Refer to page 10).



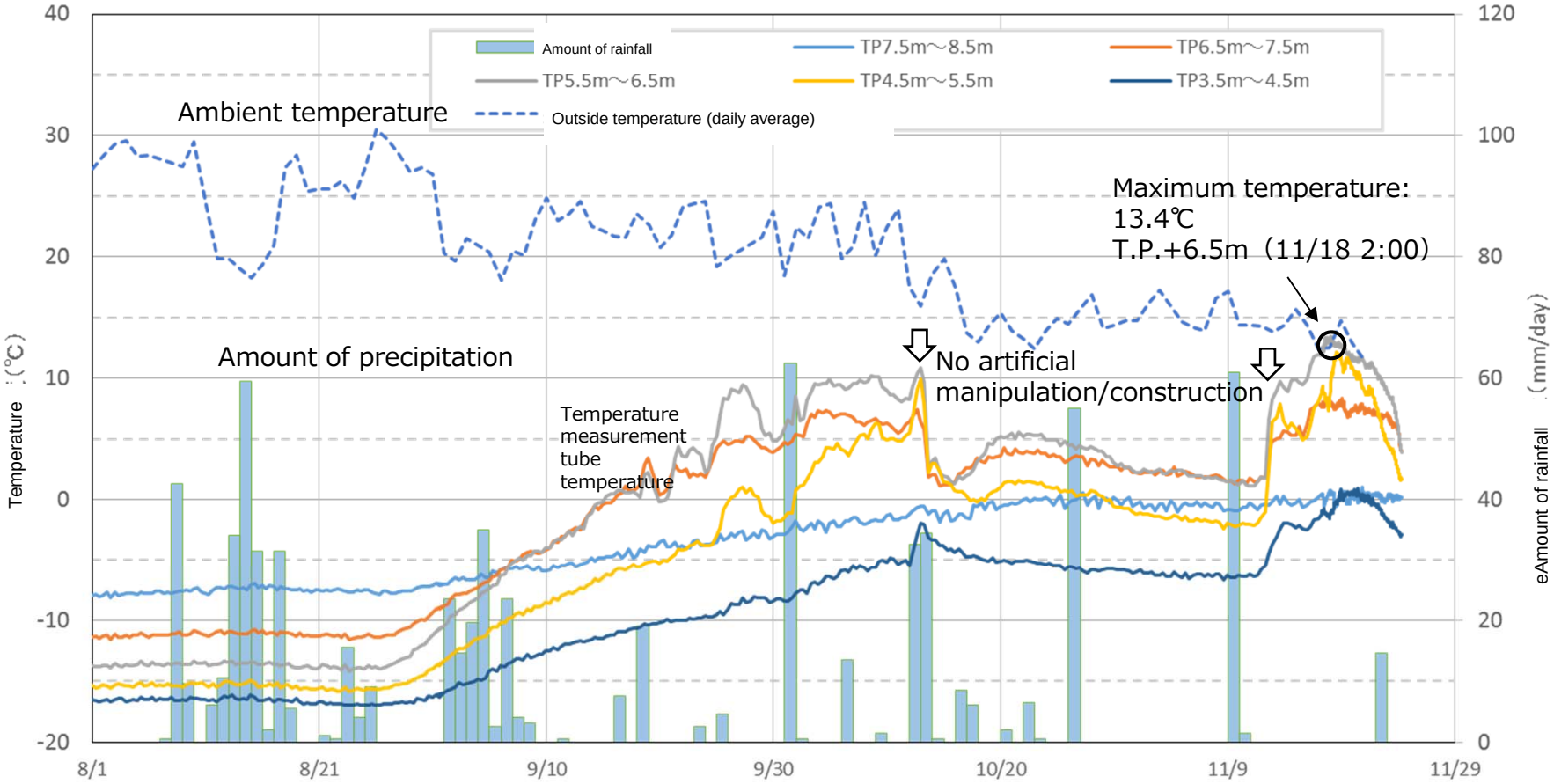
Schematic drawing of area near the drainage channel K intersection

Near the drainage channel K intersection



Subterranean temperature distribution on the mountain side of Units 3 and 4 (As of 7 AM, November 24)

2. Changes in the temperatures measured by temperature measurement to 150-7S

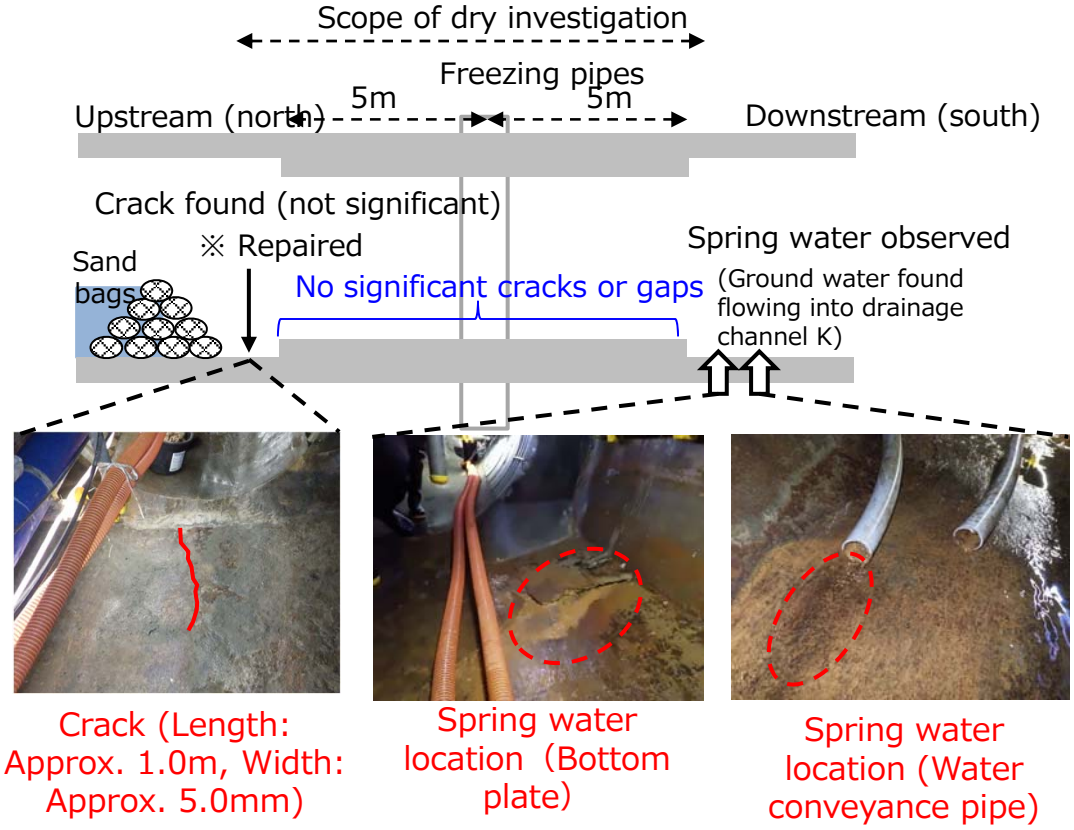


Changes over time in the temperatures measured by temperature measurement to 150-7S (as of 7 AM November 24)

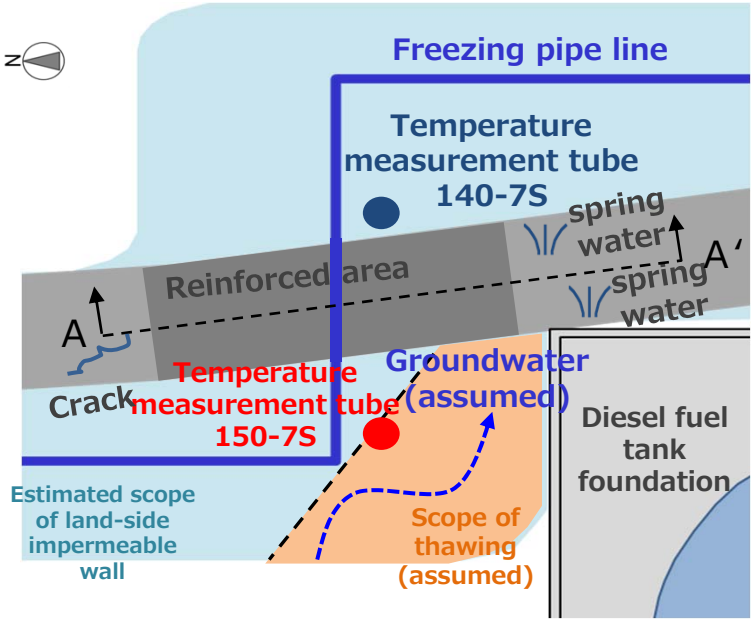
- After the spike in subterranean ground temperature on November 12, the temperature continued to rise until the 18th, and then began to fall after the 19th.
- On November 13, a visual inspection was performed of excavated areas inside the land-side impermeable wall, the inside of drainage channel K, and the surface of the ground around temperature measurement tube 150-7S, but no abnormalities were found.
- Since there were no artificial activities or construction that could cause changes in the flow of groundwater during the period when there were great fluctuations in subterranean temperatures, it is assumed that changes to water pathways in the vicinity caused by rainfall led to the fluctuations in subterranean ground temperatures.

3. Dry investigation results and assumed cause of the rise in temperatures

- From November 1, the reinforced section of drainage channel K was allowed to dry. One crack on the upstream side of the reinforced section was found along with spring water emanating from the channel bottom on the downstream side of the reinforced section. (The inside of drainage channel K was checked as a result of the hypothesis drawn in October)
- According to our hypothesis in October, it was thought that the rise in temperature of temperature measurement tube 150-7S was being caused by water leaking from drainage channel K, however when spring water was found inside drainage channel K, it indicated the possibility that groundwater may be flowing from around temperature measurement tube 150-7S towards drainage channel K, so we excavated shallow areas both inside and outside of the frozen soil wall around temperature measurement tube 150-7S.



A - A' cross-sectional diagram



Estimated scope of thawing of land-side impermeable wall and diagram of the surrounding area

4. Investigation of shallow areas inside of the land-side impermeable wall (frozen-soil wall)

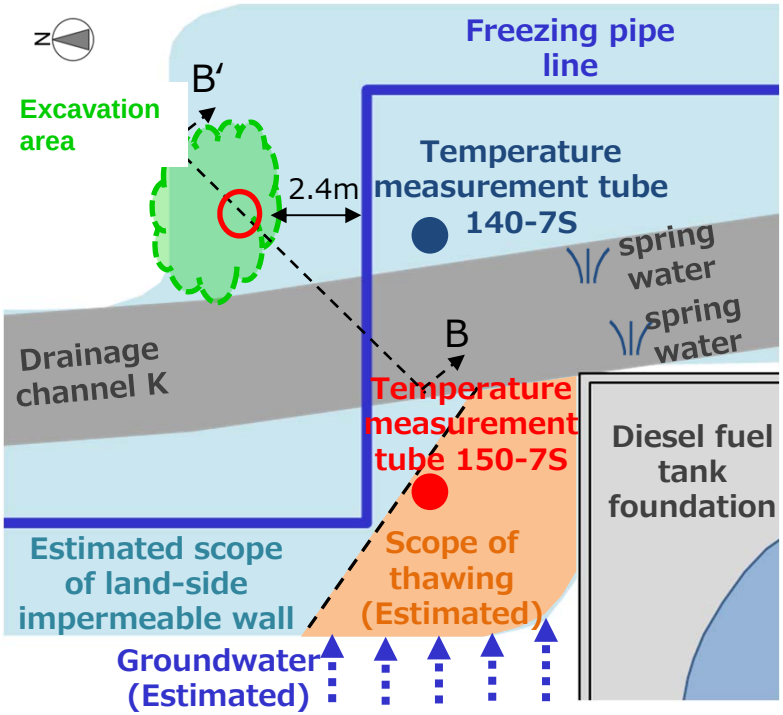
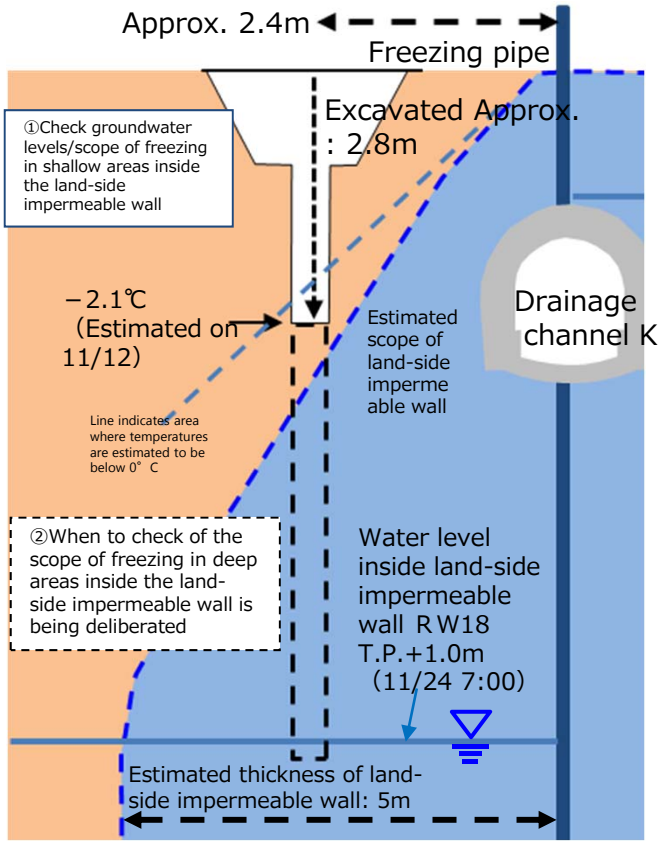


Diagram of investigation of shallow areas on the inside of the land-side impermeable wall



B-B' Cross-sectional diagram

【Investigation results】

・No groundwater was found in the excavation area inside the land-side impermeable wall, so it was confirmed that water levels inside and outside the wall are being maintained.

・Subterranean temperatures deeper than around G.L.-2.70m were found to be below 0°C, and fixed point temperature readings confirmed that temperatures are being maintained below 0°C

・In light of the above, we believe that the land-side impermeable wall is functioning normally.

Fixed point temperature measurement results

Date	Subterranean temperature (℃)
11月13日	-0.4
11月17日	-0.7
11月18日	-0.2
11月19日	-0.2
11月20日	-0.3
11月21日	-0.3
11月22日	-0.3
11月23日	-0.4
11月24日	-0.4

Excavated soil (around G.L.-2.6m)

11/10 : Excavation of surface layer commences
11/11 : Excavated to G.L.-1m~-2m
11/12 : Excavated to G.L.-2.8m

Temperature measurements from each excavation depth

Excavation depth (m)	TP (m)	Subterranean temperature (℃)
G.L.+0.00	T.P.+9.50	18
G.L.−1.50	T.P.+8.00	6.1
G.L.−1.80	T.P.+7.70	5.1
G.L.−2.55	T.P.+6.95	0.3
G.L.−2.70	T.P.+6.80	−0.9
G.L.−2.80	T.P.+6.70	−1.6
G.L.−2.84	T.P.+6.66	−2.1

Fixed point subterranean temperature measurements taken by burying temperature gauges in excavated locations

※Temperature readings not taken between November 14 and November 16 because the excavated areas were being prepared

5. Investigation of shallow areas outside of the land-side impermeable wall (frozen-soil wall)

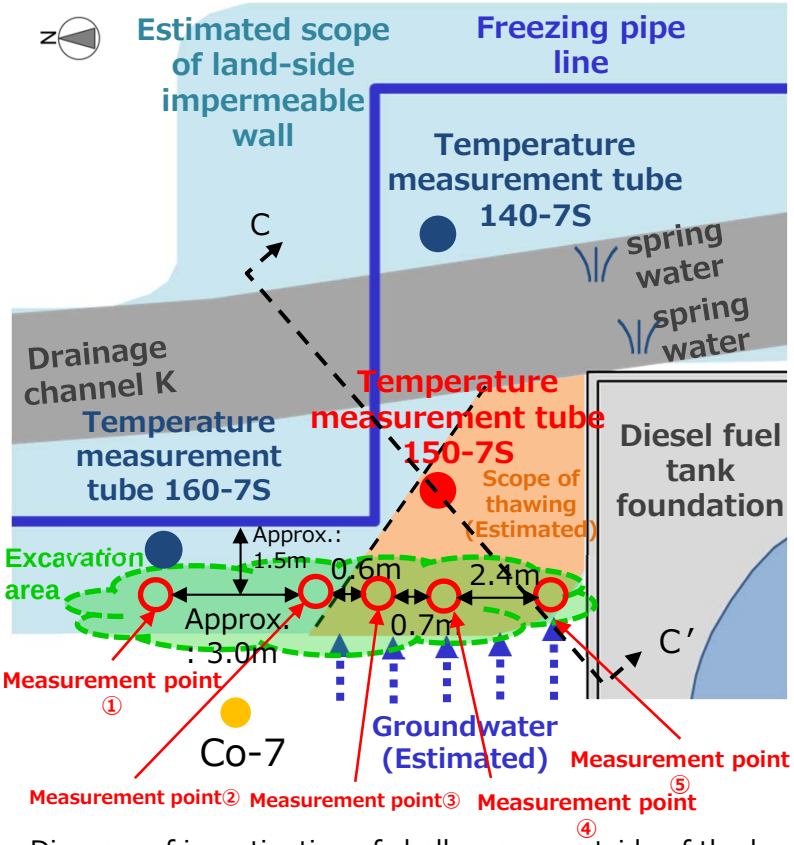
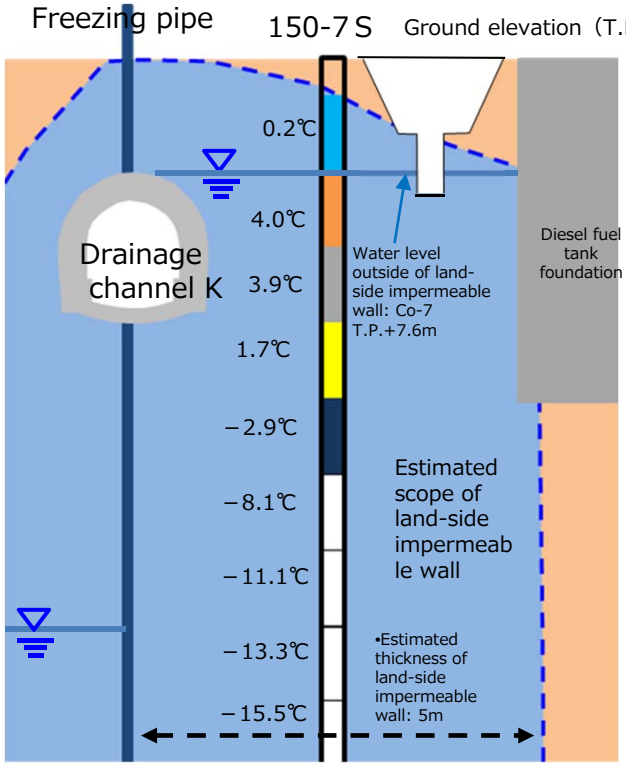


Diagram of investigation of shallow area outside of the land-side impermeable wall



(Temperatures/water level as of 7 AM, November 24)

C - C' Cross-sectional diagram

Excavated soil (Solidified) (Measurement point① Near G.L.-1.3m)

11/15：Excavation commenced
11/16：4.0×1.0 area excavated to Depth of 1.0m
11/17：4.5×1.0 area excavated
11/18：5.8×1.0 area excavated
11/21： Subterranean temperature confirmed to be below 0℃ at Measurement point①G.L.-1.30m and Measurement point②G.L.-1.50m
Surface of groundwater found at Measurement point③G.L-2.50m

Temperature measurements from each excavation depth

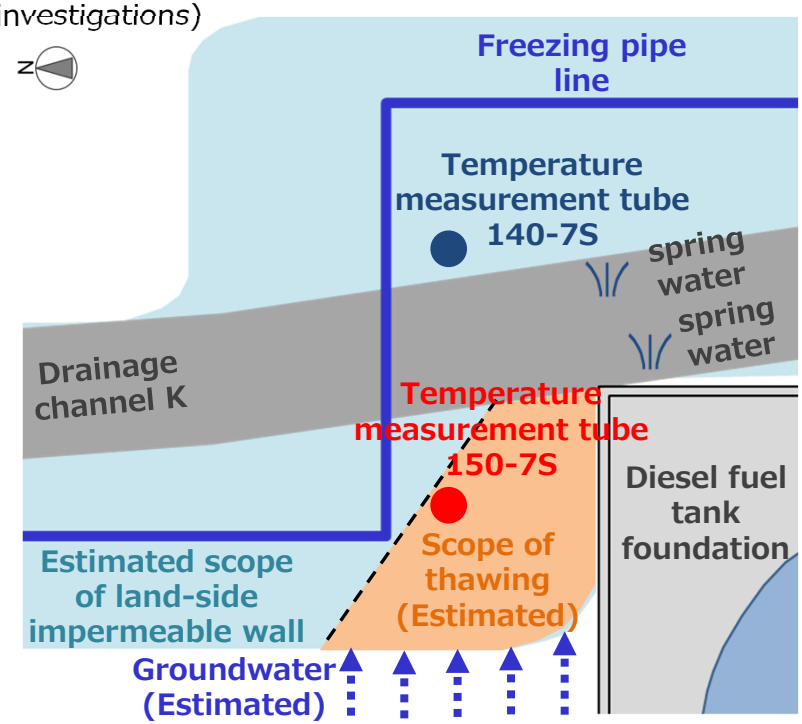
Excavation depth	T. P. (m)	Measurement point 1	Measurement point 2	Measurement point 3	Measurement point 4	Measurement point 5
		Subterranean temperature (℃)				
G.L. −0.50	T.P +9.00	7.2	6.3	6.3	6.3	8.0
G.L. −1.00	T.P +8.50	0.3	2.9	4.3	5.4	9.3
G.L. −1.30	T.P +8.20	−1.6	0.2	2.6	6.6	11.4
G.L. −1.50	T.P +8.00		−1.5	2.8	6.6	12.9
G.L. −2.00	T.P +7.50			5.0	9.8	13.9
G.L. −2.40	T.P +7.10			5.1	12.8	15.5
G.L. −2.50	T.P +7.00					16.0

: Frozen
: Groundwater

【 Investigation results 】
・Measurement point①G.L.-1.30m found to be frozen (solid)
・ Subterranean temperature at around Measurement point ②G.L.-1.50m Confirmed to be below 0°C
・Groundwater surface found at around Measurement points ③, ④, ⑤G.L.-2.50m
・ The land-side impermeable wall is functioning around temperature measurement tube 160-7S, but some shallow areas outside of the land-side impermeable wall near the diesel fuel tank foundation are not frozen

6. Scope of test waterproofing

- Since spring water was found during the visual inspection of drainage channel K, it is assumed that the rise in temperature measured by temperature measurement tube 150-7S was caused by the thawing of a portion of the frozen wall caused by ground water flowing from the land-side impermeable wall to the downstream side of drainage channel K.
- The area outside of temperature measurement tube 150-7S shall be waterproofed to see if the flow of groundwater can be stopped and to measure subsequent changes in temperatures measured by temperature measurement tube 150-7S as well as changes in the amount of spring water flowing into drainage channel K. (Waterproofing has been given priority since the area is very narrow and it would be difficult to simultaneously implement groundwater flow direction investigations)



Estimated scope of thawing of the land-side impermeable wall

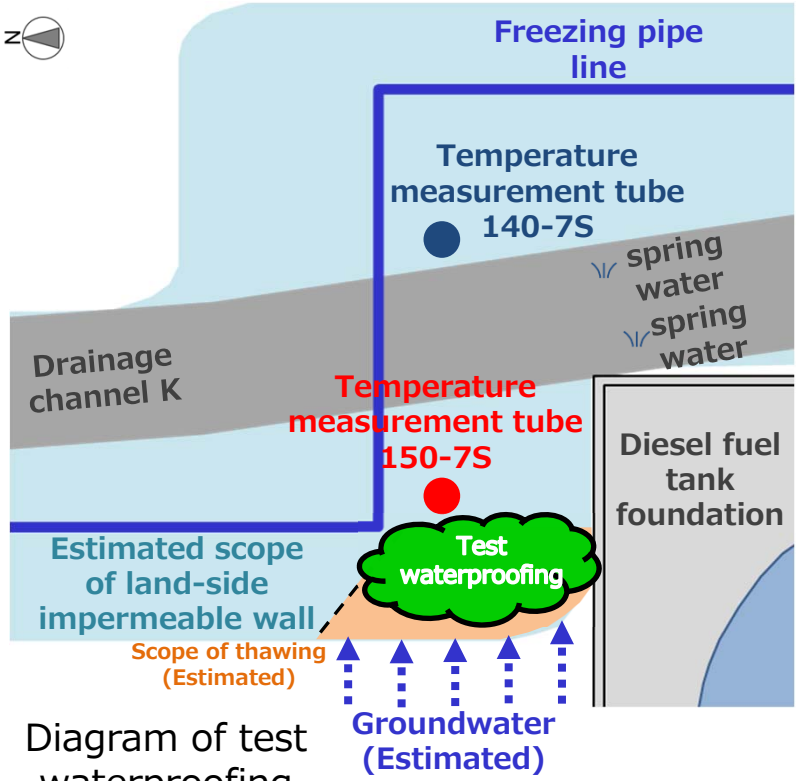
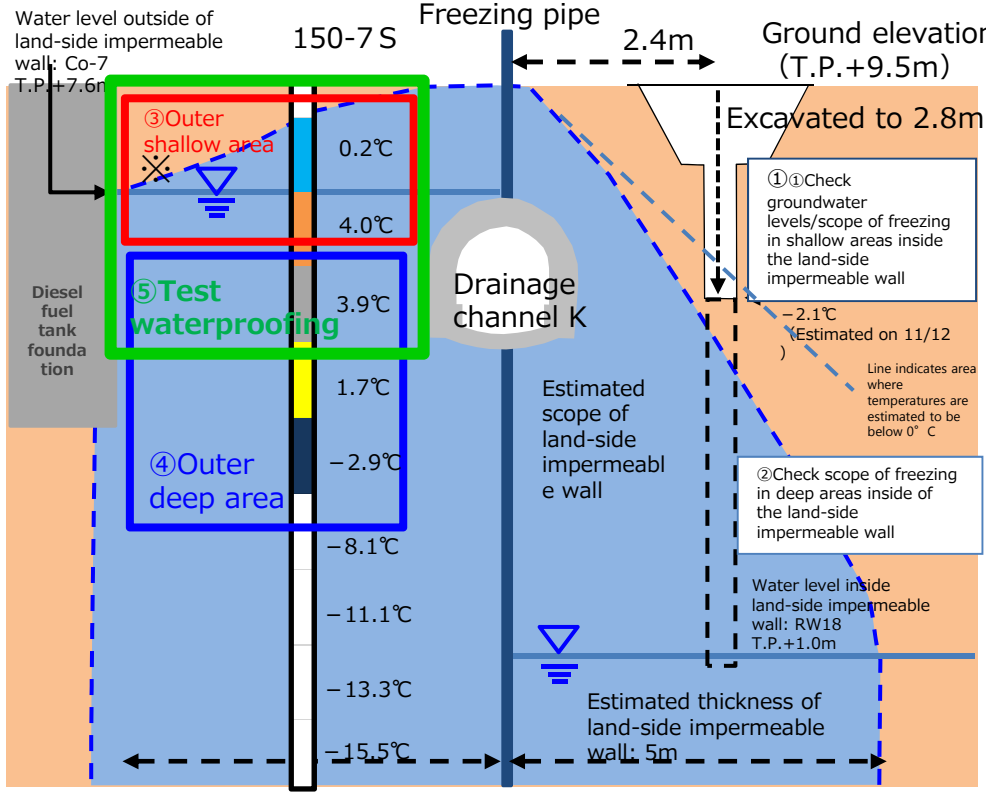


Diagram of test waterproofing

7. Flow of the investigation into the cause of the temperature rise

【Investigation objectives】

- To assess the integrity of the wall based upon the soil from inside the land-side permeable wall and groundwater conditions 【① (Finished) ② (Period being deliberated) 】
- Waterproof on a trial basis in order to ascertain the suitability of the assumed cause of the temperature rise recorded by temperature measurement tube 150-7S. Conduct an investigation by excavating areas outside of the wall in order to deliberate the scope of waterproofing and waterproofing methods, as well as soil and groundwater conditions outside the land-side impermeable wall. 【③ (Finished) , ④ (To be implemented if needed) 】
- Implement test waterproofing in areas assumes to have excellent groundwater flow 【⑤ (To be implemented) 】



Minimum separation between diesel fuel tank foundation and freezing pipes: 4.1m

(Temperatures and water levels as of 7 AM on November 24)

Investigation flow
(May change in accordance with investigation conditions)

① Shallow area inside the land-side impermeable wall (Finished)
・ The area inside of the land-side impermeable wall will be excavated by hand as much as possible
・ Temp. at 2.8m from the surface is-2.1℃
・ Groundwater: None
・ solidification status: Not solid

② Deep area inside the land-side impermeable wall
Depths found sufficiently solid on the inside checked
(Implementation period under deliberation)

Additional investigation

③Shallow area outside the land-side impermeable wall
(Approximately one week from November 15)
The area outside of the land-side impermeable wall will be excavated by hand as much as possible

④Deep area outside the land-side impermeable wall
Depths found sufficiently solid on the outside checked
(To be implemented if needed)

⑤Test waterproofing
Performed on estimated scope of thawing
(Steel tubes and steel sheet piles used so that the waterproofing can be reversed. Preparations are underway to commence waterproofing at the beginning of December at the earliest)

Countermeasure construction
Countermeasures to be deliberated based on changes in temperature and spring water amounts after test waterproofing

※ The area in the green box around 150-7 may have thawed, but readings from temperature measurement tubes in the vicinity indicate that the area around the land-side impermeable wall is below 0°C

8. Overview of test waterproofing (steel tube/steel sheet piles, etc.)

- Steel tubes ※ will be installed on the west side of temperature measurement tube 150-7S from the diesel fuel tank foundation (estimated scope of following of the land-side impermeable wall) in order to quickly commence test waterproofing. After installation of the steel tubes, conditions, such as temperature readings from the temperature measurement tubes, etc., shall be watched, and if necessary steel sheet piles will be installed on the west side of the steel tubes for additional waterproofing.

※ Kept on-site to divert water pathways and can be used quickly. However, since separate holes will be needed for each tube, they may only be able to be installed every 5 to 10cm.

- The scope of steel sheet pile installation will be up to the west side of temperature measurement to 160-7S from the diesel fuel tank foundation out of concern that diverted groundwater may impact temperature measurement tubes in the surrounding area.

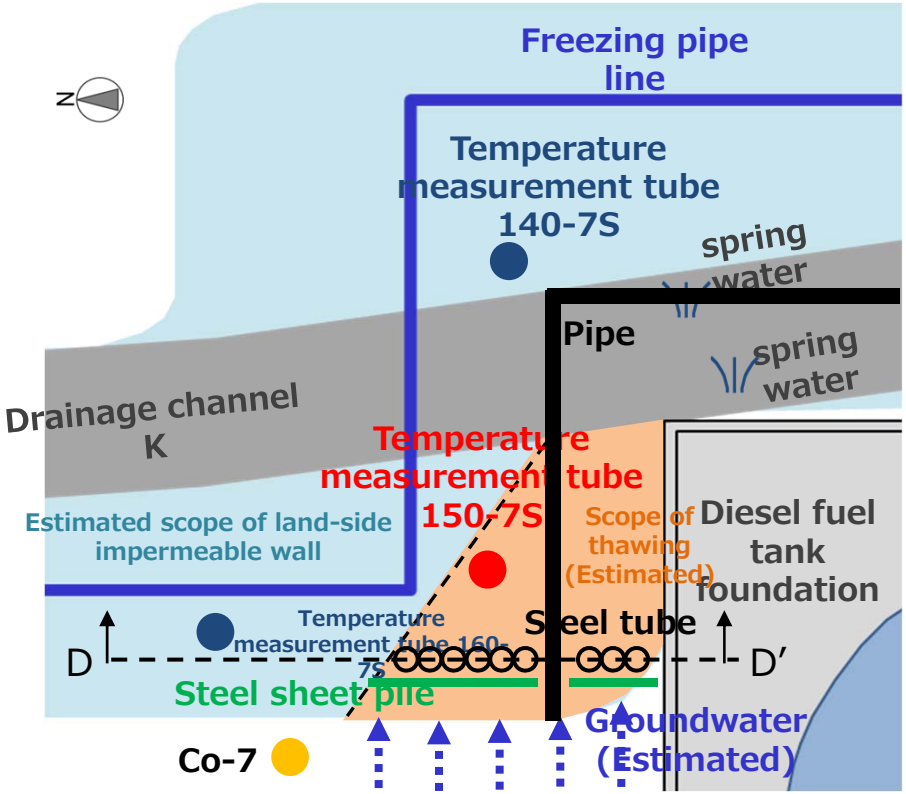
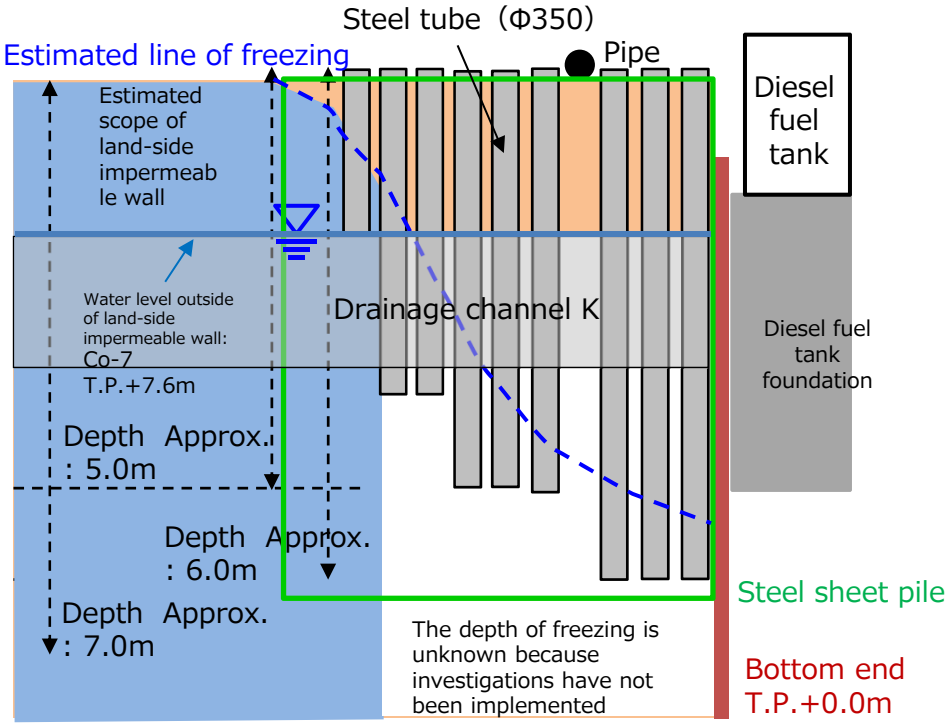


Diagram of test waterproofing



※ The depth of steel tube installation shall be adjusted in accordance with frozen conditions of the land-side impermeable wall. Penetration depth shall fundamentally be approximately 1 m from the freezer

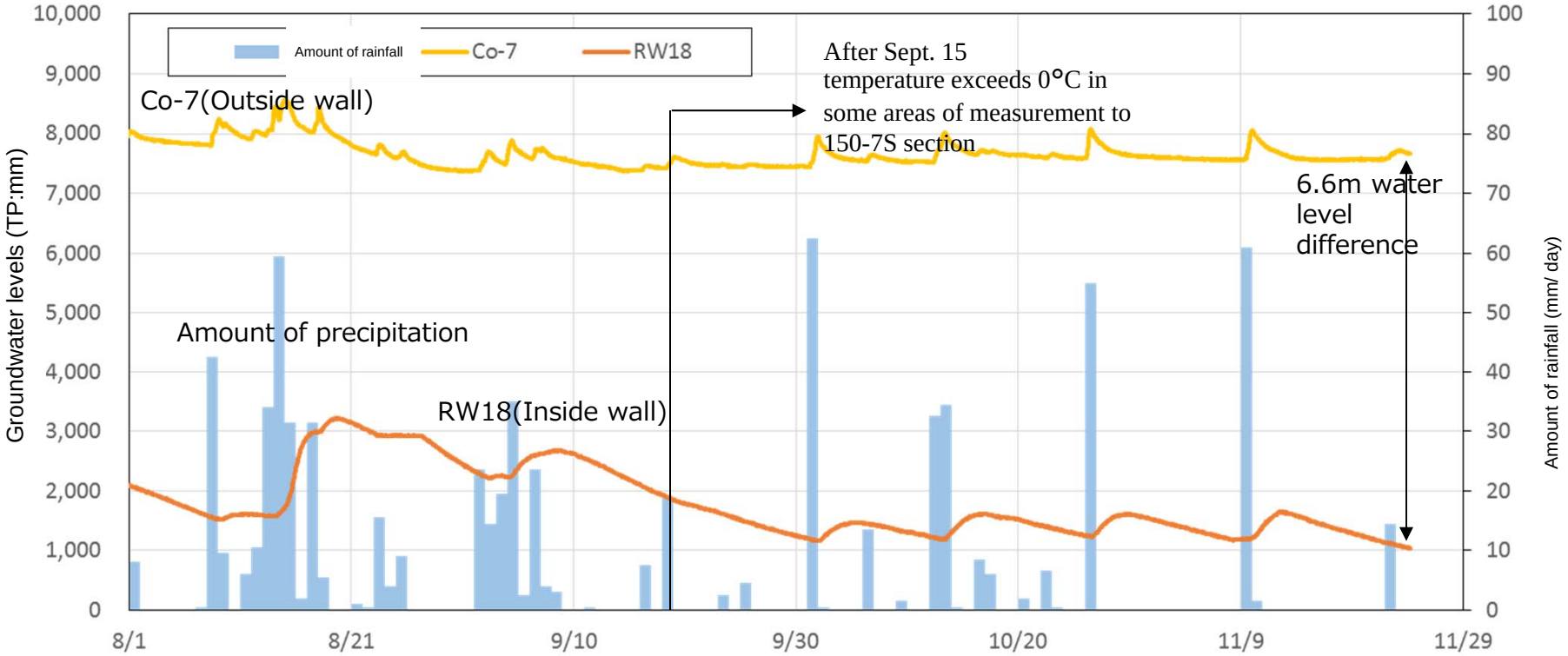
D-D' Cross-sectional diagram

9. Monitoring targets during the waterproofing period

- During the waterproofing period the following items shall be monitored in order to ascertain the impact of waterproofing

Targeted facilities	Targets	Monitoring method	Monitoring frequency※
temperature measurement tube 140-7S, 150-7S, 160-7S	Subterranean temperature	Measurement value	Twice a day
Observation holes Co-7, RW18	Groundwater level	Measurement value	Twice a day
Relay tanks No.4, No.5	Pumped volume	Measurement value	Once a day
Drainage channel K (Inside)	Outer view	Visual check at location	Once a day
	Spring water volume Temperature Muddiness	Measurement taken at location	Twice a day
Investigation excavation area (inside)	Ground conditions	Visual check at location	Once a day
	Subterranean temperature	Measurement taken at location	Once a day
Diesel fuel tank foundation/oil dike	Outer view	Visual check at location	Once a day
	Displacement	Measurement taken at location	Once a week
Ground around the common pool	Outer view	Visual check at location	Once a day

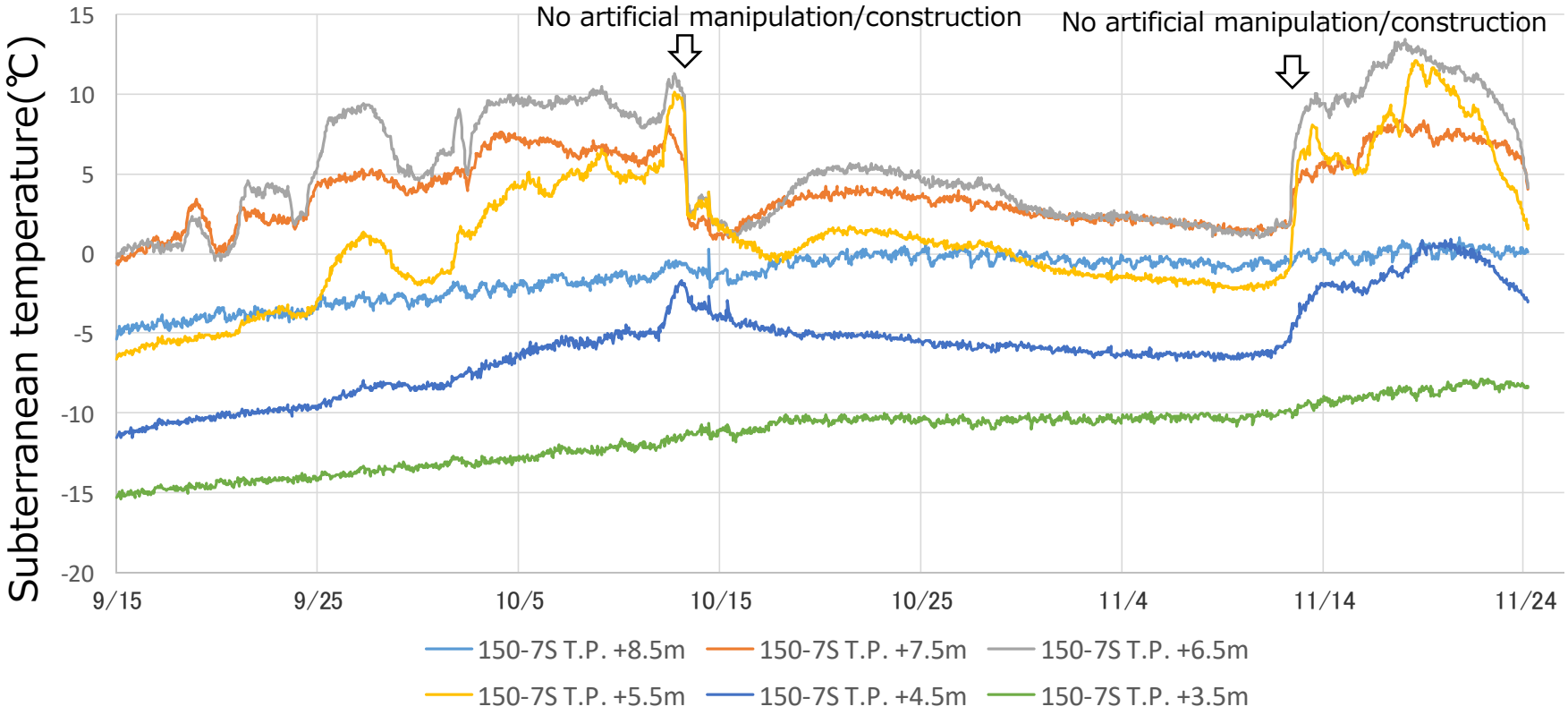
(Reference) Changes in water levels inside/outside the land-side impermeable wall and rainfall over time



Changes in water levels inside/outside of the land-side impermeable wall over time (as of 7 AM, November 24)

- Water levels inside the land-side impermeable wall temporarily increase with rainfall and decrease as water is pumped up regardless of fluctuations in subterranean temperature.
- Water levels inside the land-side impermeable wall continue to decrease after September 15 even when some temperatures within section 4 temperature measurement tube 150-7S exceeded 0°C. As of November 24, a difference in water levels inside and outside the wall of 6.6m has been maintained, so it is our assessment that the overall impermeability of the land-side impermeable wall has remained intact.

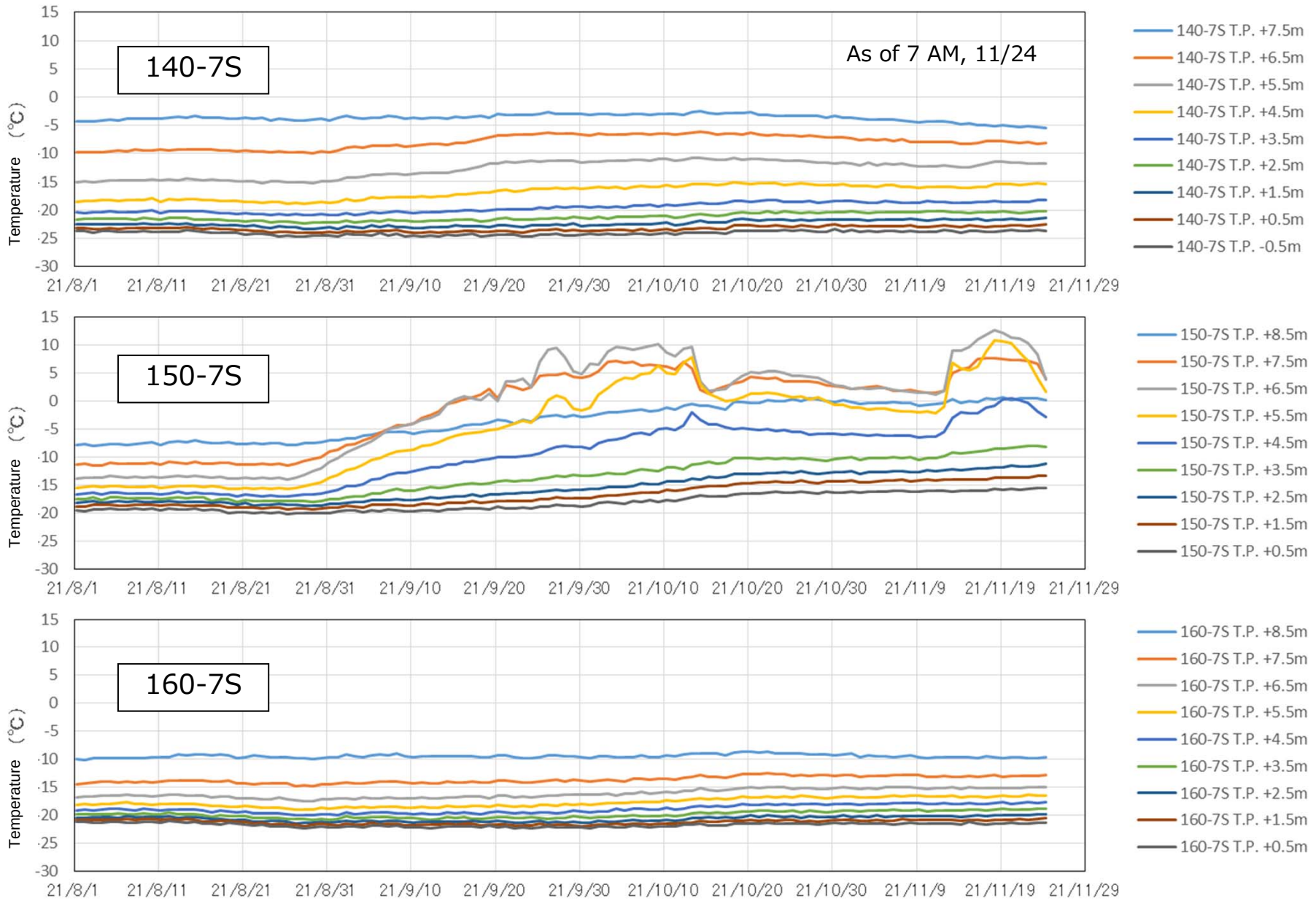
(Reference) Changes in temperature after October 23



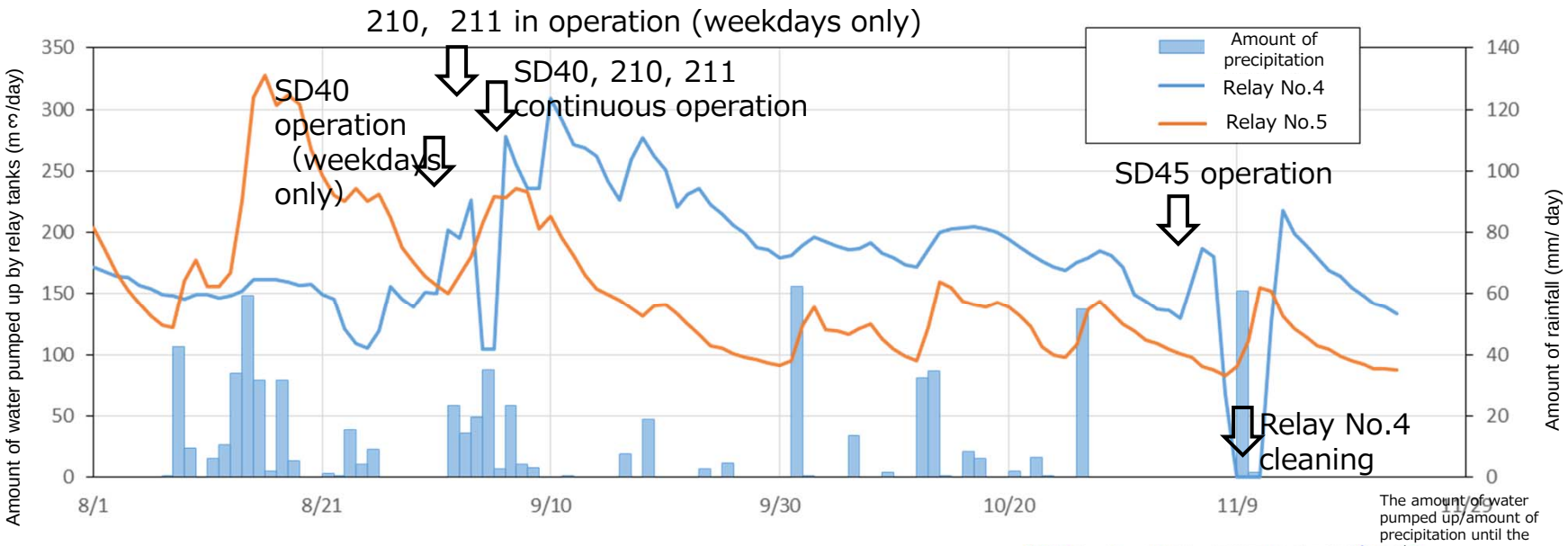
Changes over time for temperature measurement tube 150-7S (as of 7 AM, November 24)

- After spiking on November 12, subterranean temperature continued to rise until the 18th but is now either steady or decreasing.
- On November 13 a visual inspection was performed of excavated areas inside the land-side impermeable wall, the inside of drainage channel K, and the surface of the ground around temperature measurement tube 150-7S, but no abnormalities were found
- Since there were no artificial activities or construction that could cause changes in the flow of groundwater during the period when there were great fluctuations in subterranean temperatures, it is assumed that changes to water pathways in the vicinity caused by rainfall led to the fluctuations in subterranean ground temperatures.

(Reference) Changes over time in the temperature of temperature measurement tubes 140-7S, 150-7S, 160-7S (Surface layer excerpt)



(Reference) The relationship between the amount of water pumped up by subdrains No. 4, No.5 relay tanks and the amount of precipitation



The amount of water pumped up/amount of precipitation until the 16th

- The amount of water pumped up near the location where the temperature rise was observed fluctuates in accordance with the amount of precipitation and the operation of SD40, etc., however there is a gradual decrease as rainfall drops off.
- At this point in time it is not clear if the amount of water being pumped up is increasing in conjunction with the increase in temperature of temperature measurement tube 150-7S, so monitoring will continue

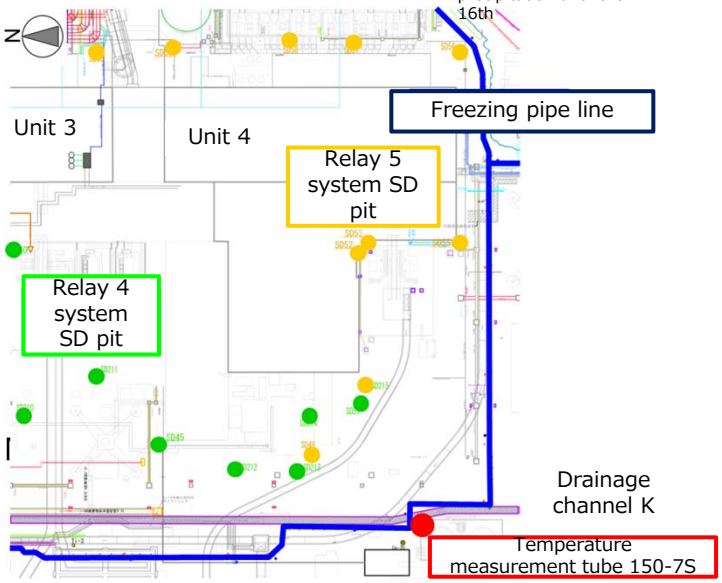
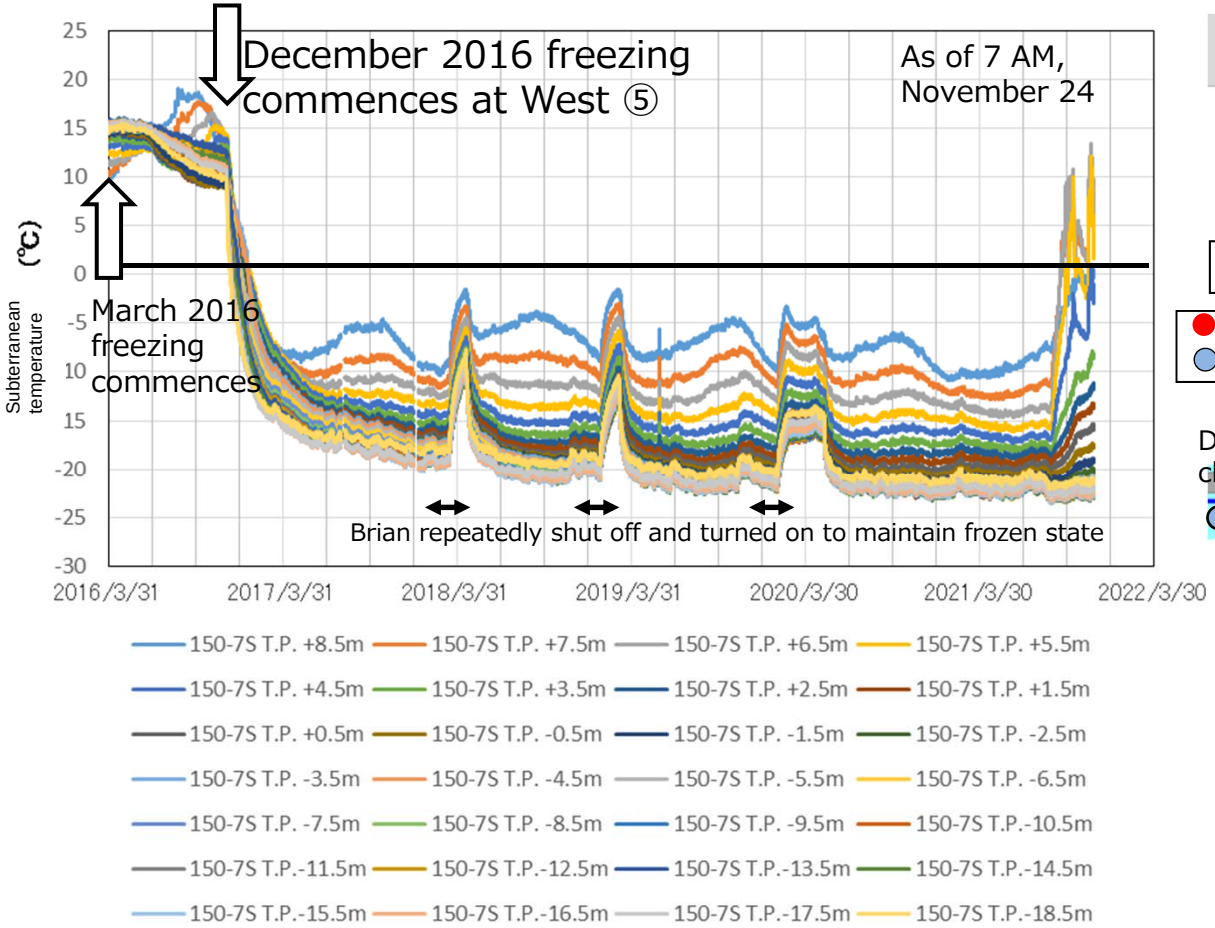


Diagram of mountain side of Units 3, 4

(Reference) 150-7S changes over time



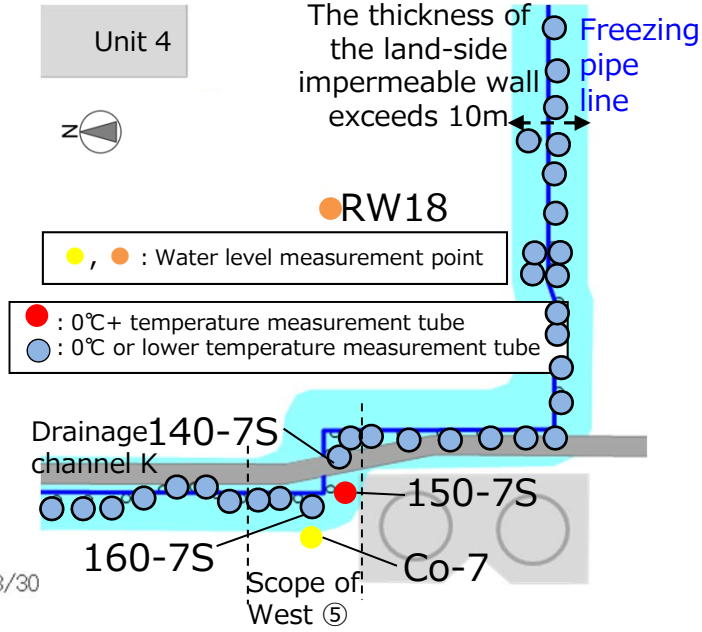
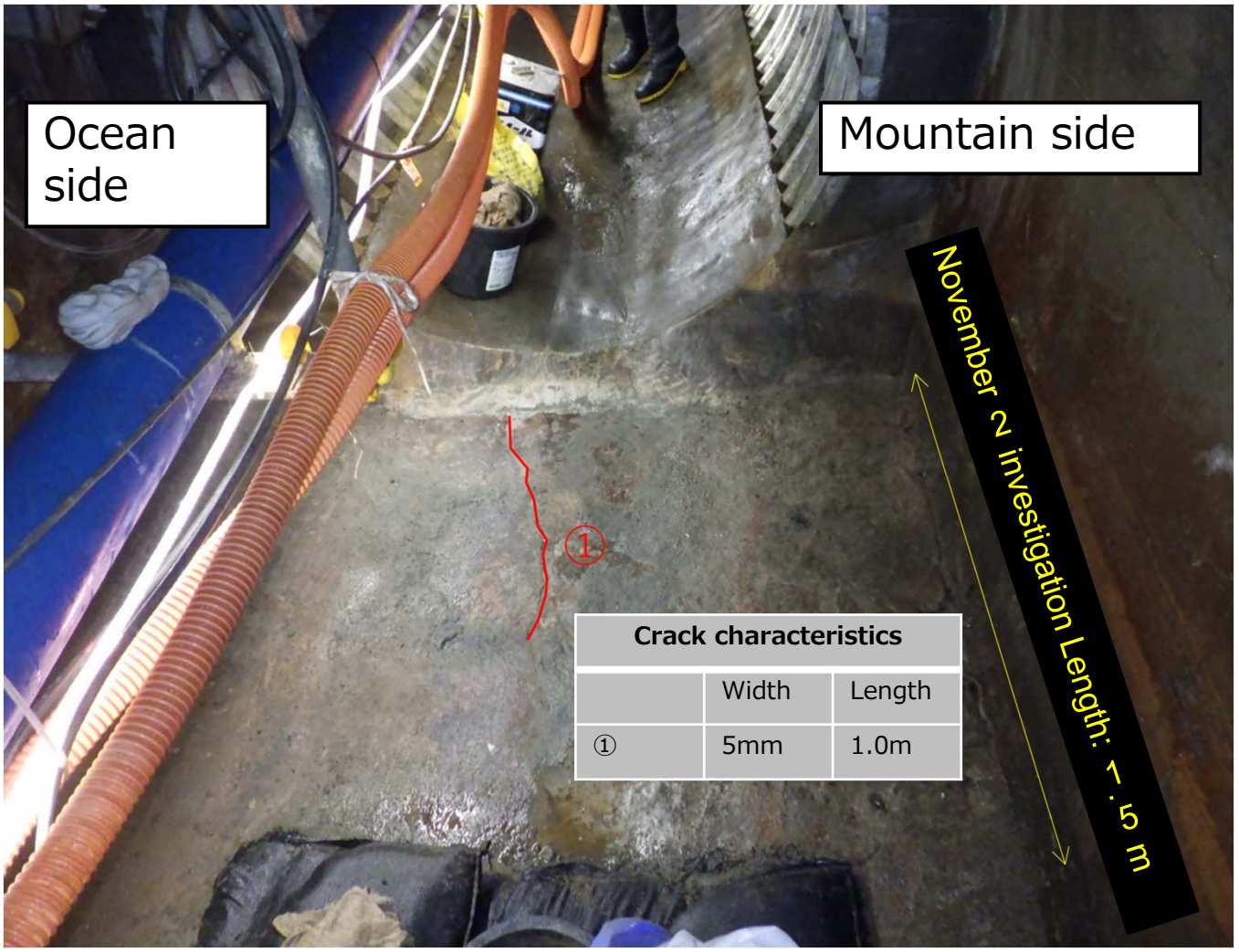


Diagram of area near drainage channel K intersection

- Freezing of the land-side impermeable wall commenced in March 2016
- Several locations were kept unfrozen in order to check for dramatic changes in groundwater levels around the buildings, after which each of these locations was gradually frozen with the freezing of West ⑤ beginning in December 2016

(Reference) Drainage channel K reinforced area upstream investigation (one crack found)



Crack characteristics		
	Width	Length
①	5mm	1.0m

Results of crack investigation in dried out section of drainage channel K

Enlarged photo of crack

(Reference) Drainage channel K reinforced area downstream investigation (two locations of spring water found)

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Water conveyance

Spring water locations