

Tsunami Assessment for Nuclear Power Plants in Japan.

Makoto TAKAO, PE

Agenda

1. Tsunami assessment for NPP on the Pacific coast.
2. Operational status of NPP after the Feb. 28, 2010 tsunami from Chile.

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JSCE Method

“Tsunami Assessment Method for Nuclear Power Plants in Japan (2002)”

published by

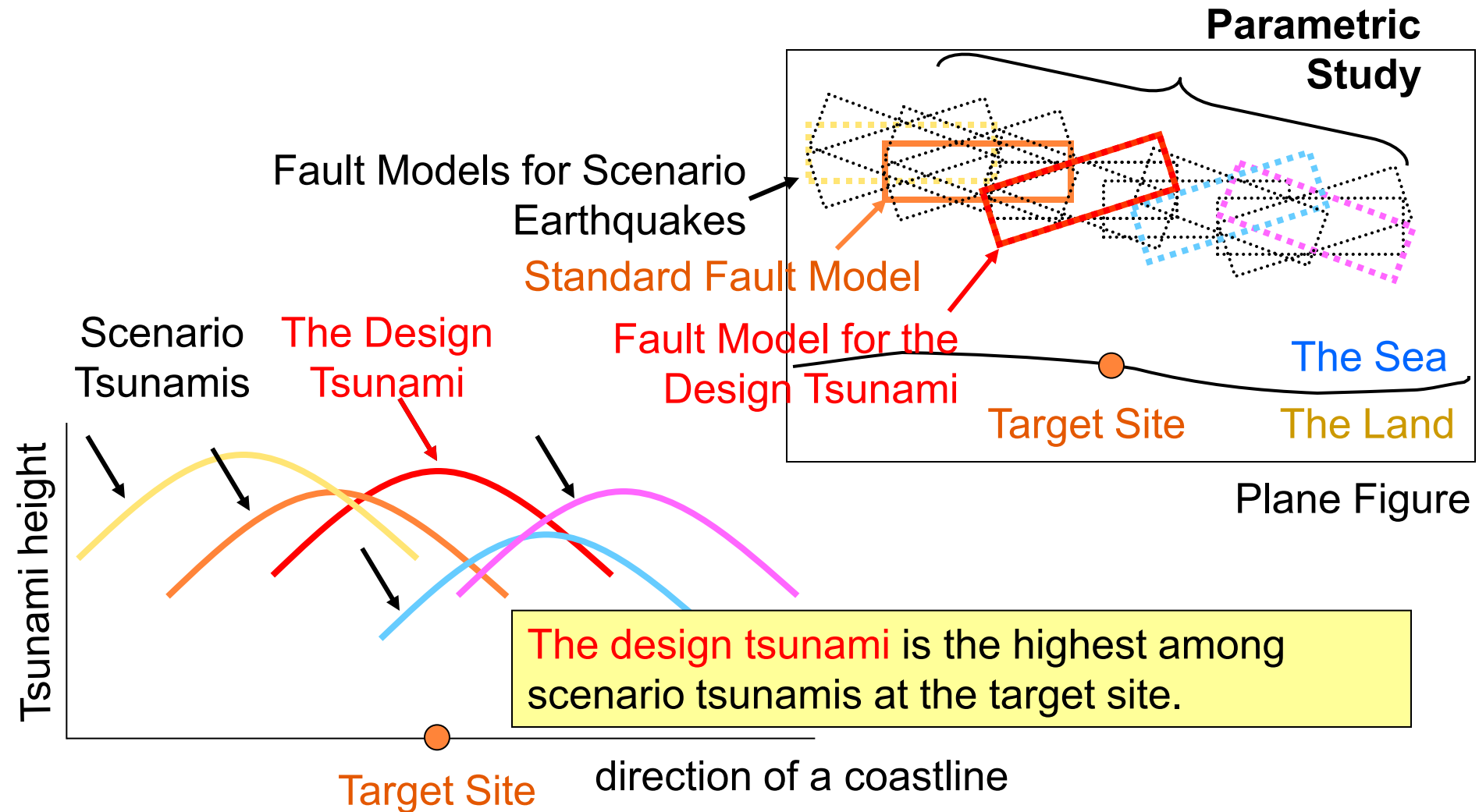
Tsunami Evaluation Subcommittee,
Nuclear Civil Engineering Committee,
JSCE (Japan Society of Civil Engineers)



English version

http://www.jsce.or.jp/committee/ceofnp/Tsunami/eng/tsunami_eng.html

Parametric Study of Tsunami Source



TEPCO's Nuclear Power Stations

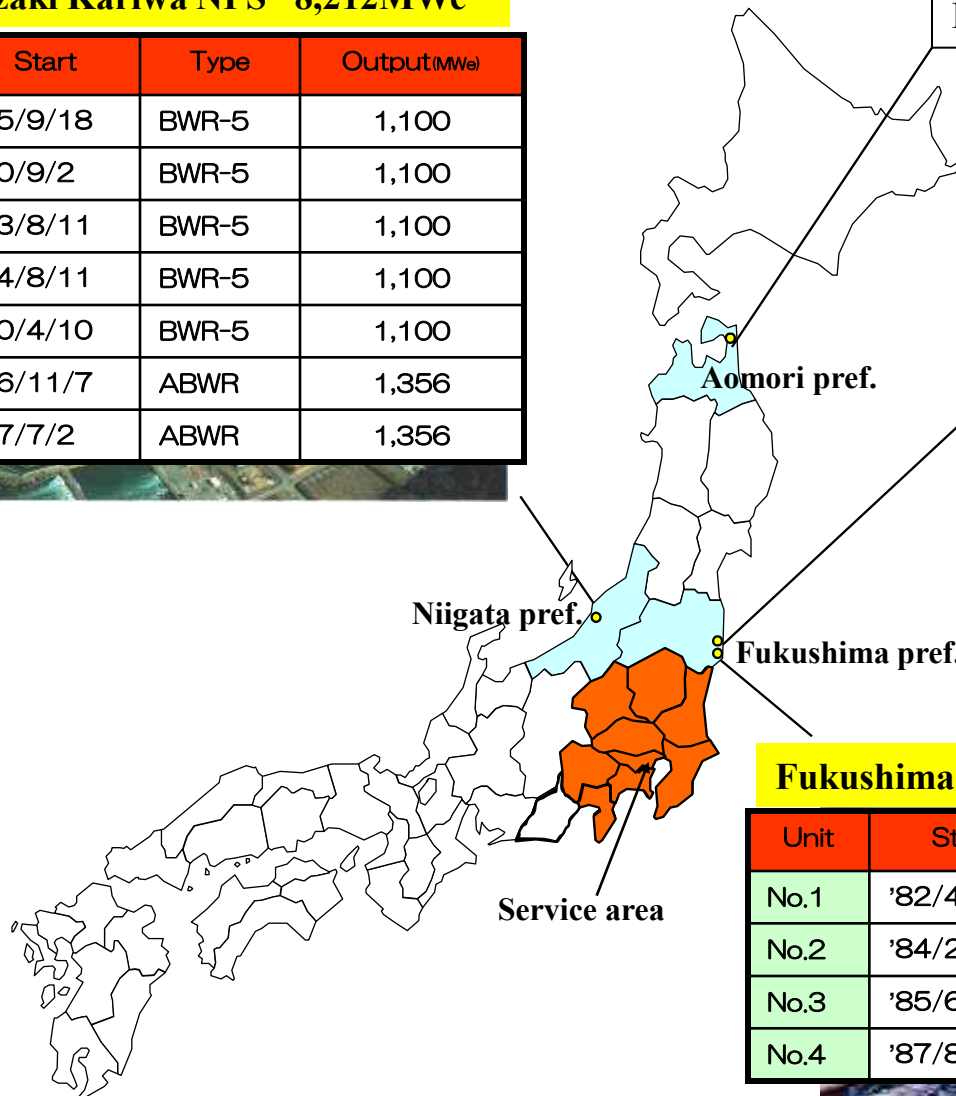
Kashiwazaki Kariwa NPS 8,212MWe

Unit	Start	Type	Output(MWe)
No.1	'85/9/18	BWR-5	1,100
No.2	'90/9/2	BWR-5	1,100
No.3	'93/8/11	BWR-5	1,100
No.4	'94/8/11	BWR-5	1,100
No.5	'90/4/10	BWR-5	1,100
No.6	'96/11/7	ABWR	1,356
No.7	'97/7/2	ABWR	1,356

Higashidori Nuclear Power Construction Preparation Office

Fukushima Daiichi NPS 4,696MWe

Unit	Start	Type	Output(MWe)
No.1	'71/3/26	BWR-3	460
No.2	'74/7/18	BWR-4	784
No.3	'76/3/27	BWR-4	784
No.4	'78/10/12	BWR-4	784
No.5	'78/4/18	BWR-4	784
No.6	'79/10/24	BWR-5	1,100



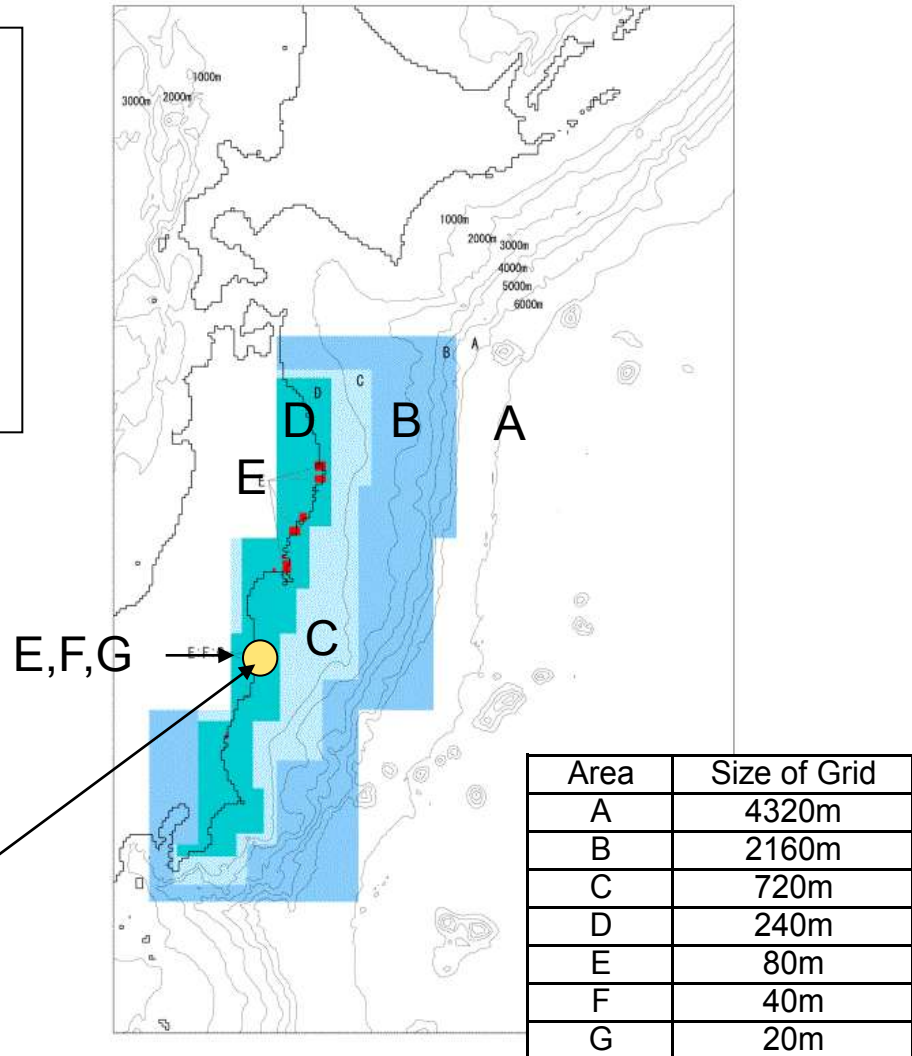
Fukushima Daini NPS 4,400MWe

Unit	Start	Type	Output(MWe)
No.1	'82/4/20	BWR-5	1,100
No.2	'84/2/3	BWR-5	1,100
No.3	'85/6/21	BWR-5	1,100
No.4	'87/8/25	BWR-5	1,100

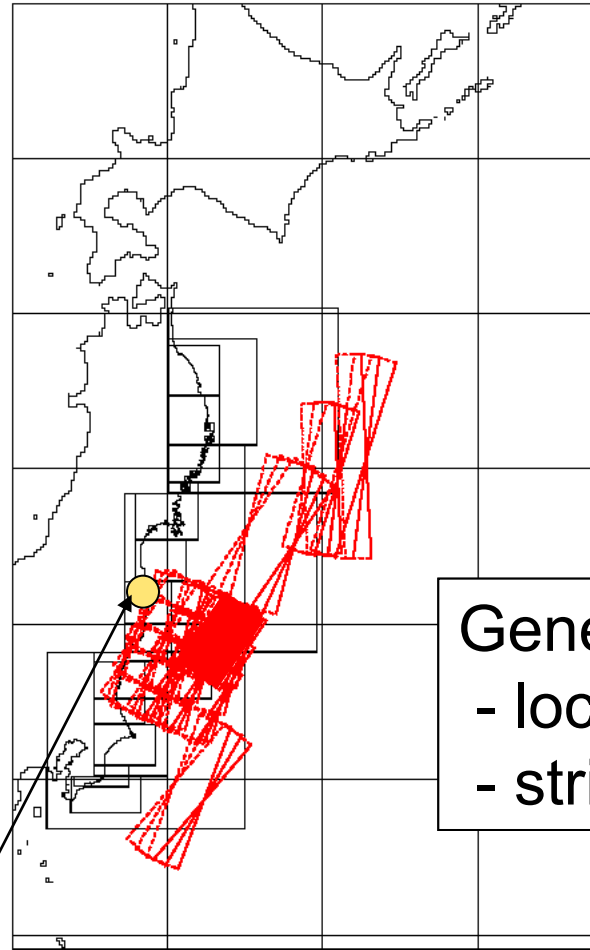
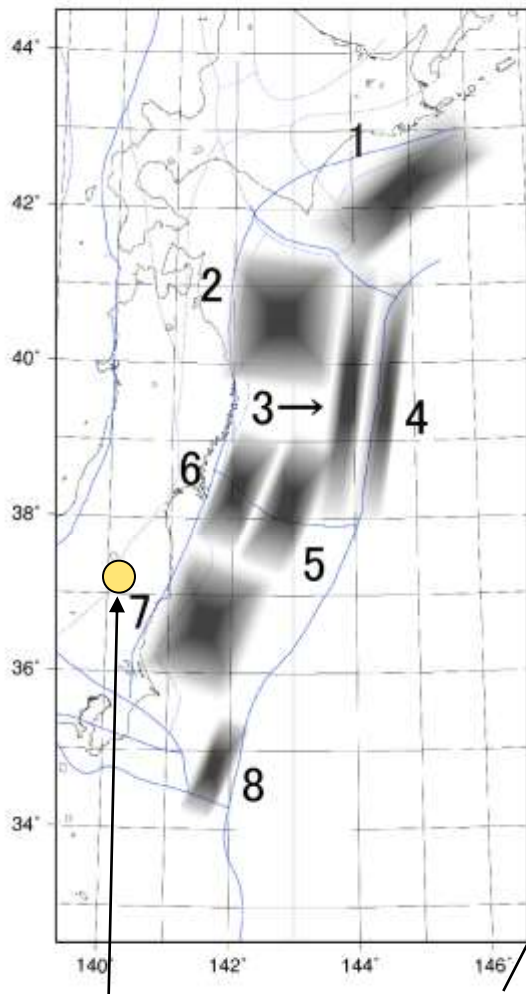
Numerical Model for the near field

- ✓ Non-linear long wave theory (shallow water)
- ✓ Staggered mesh
- ✓ Leap frog method

Fukushima Daiichi NPS



General parametric study in the near field



General parametric study
- location
- strike

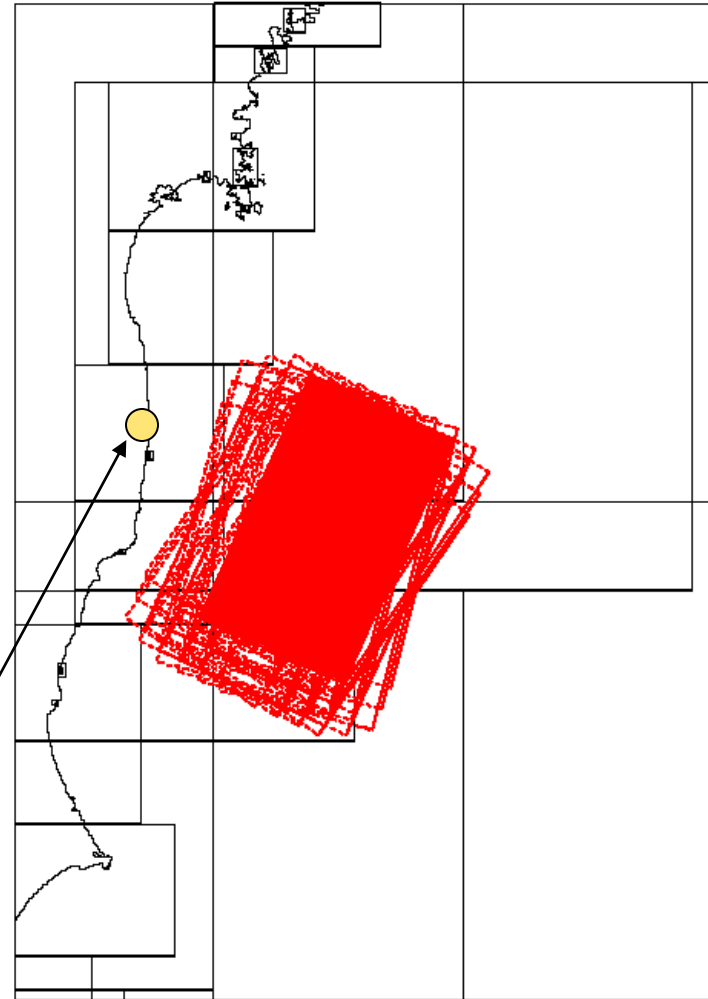
Fukushima Daiichi NPS

Detailed parametric study in the near field

Detailed parametric study

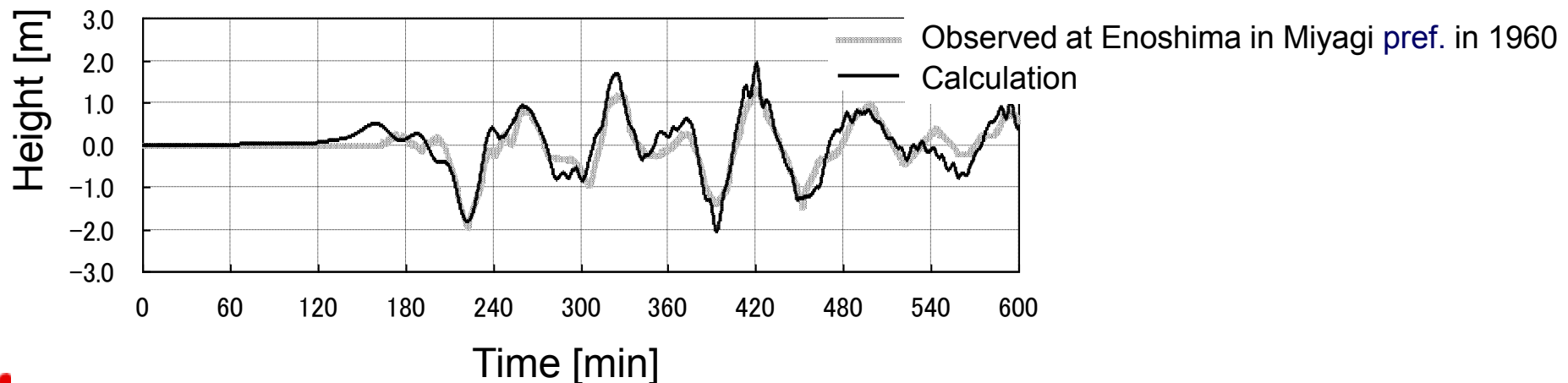
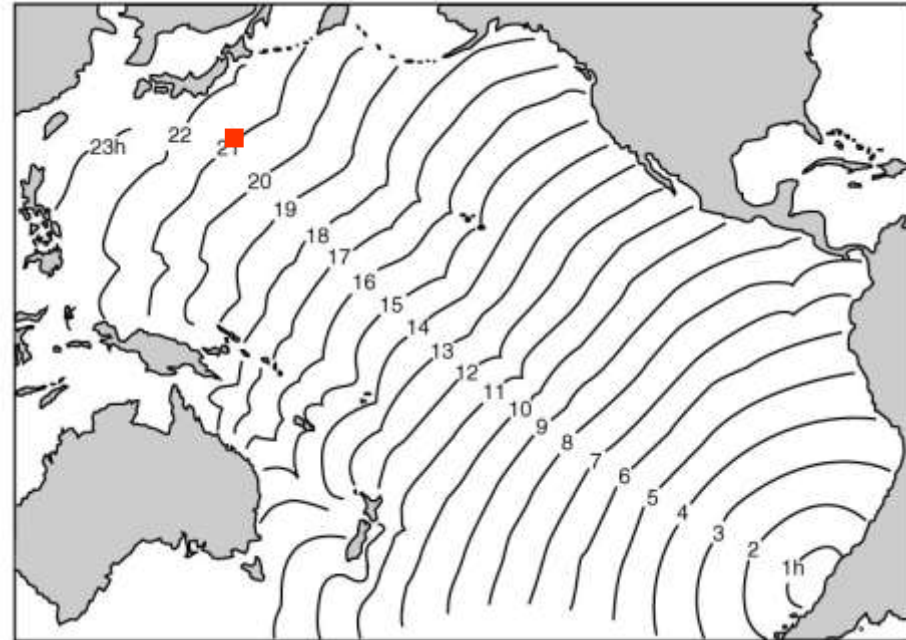
- location
- strike
- depth
- dip angle
- slip angle

Fukushima Daiichi NPS

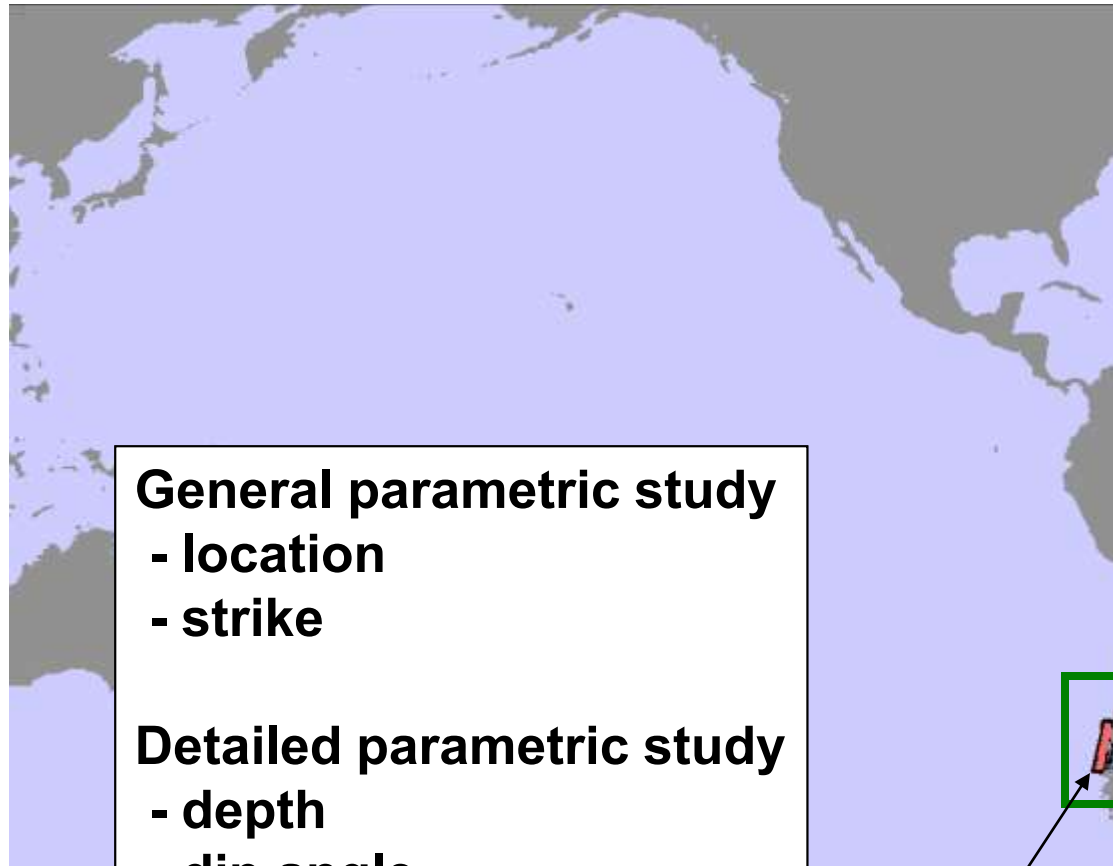


Tsunami from far field

- ✓ Linear dispersive theory for far field (spherical-coordinate system)
- ✓ Non-linear long wave theory for near field (Cartesian coordinate system)
- ✓ Staggered mesh
- ✓ Leap frog method



Parametric study in the far field

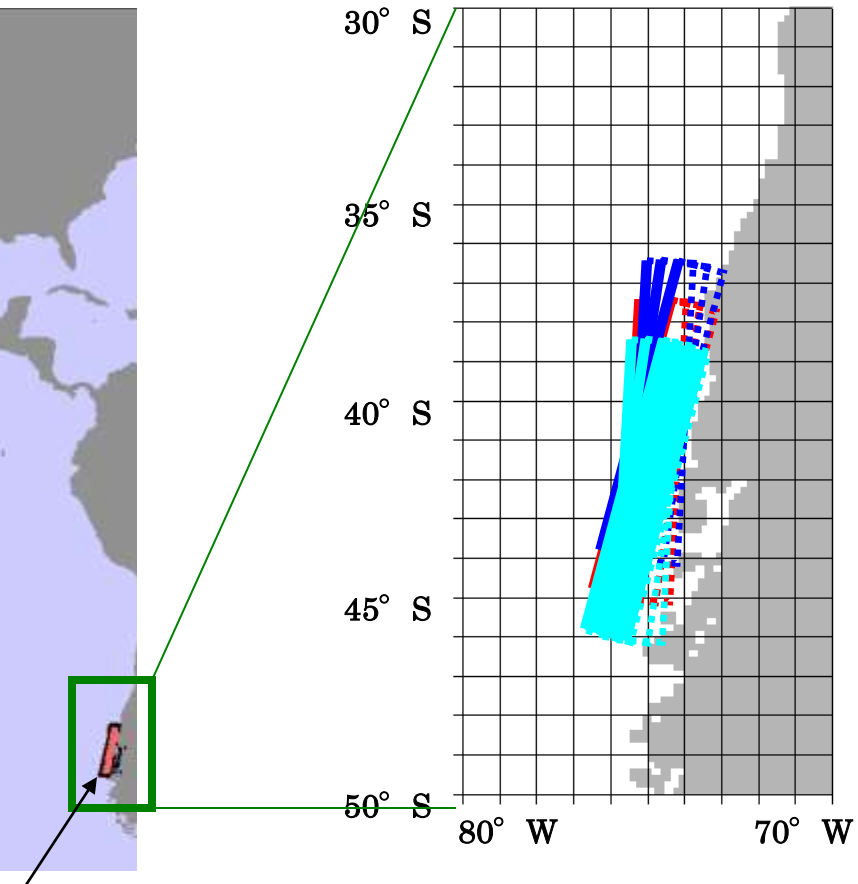


General parametric study

- location
- strike

Detailed parametric study

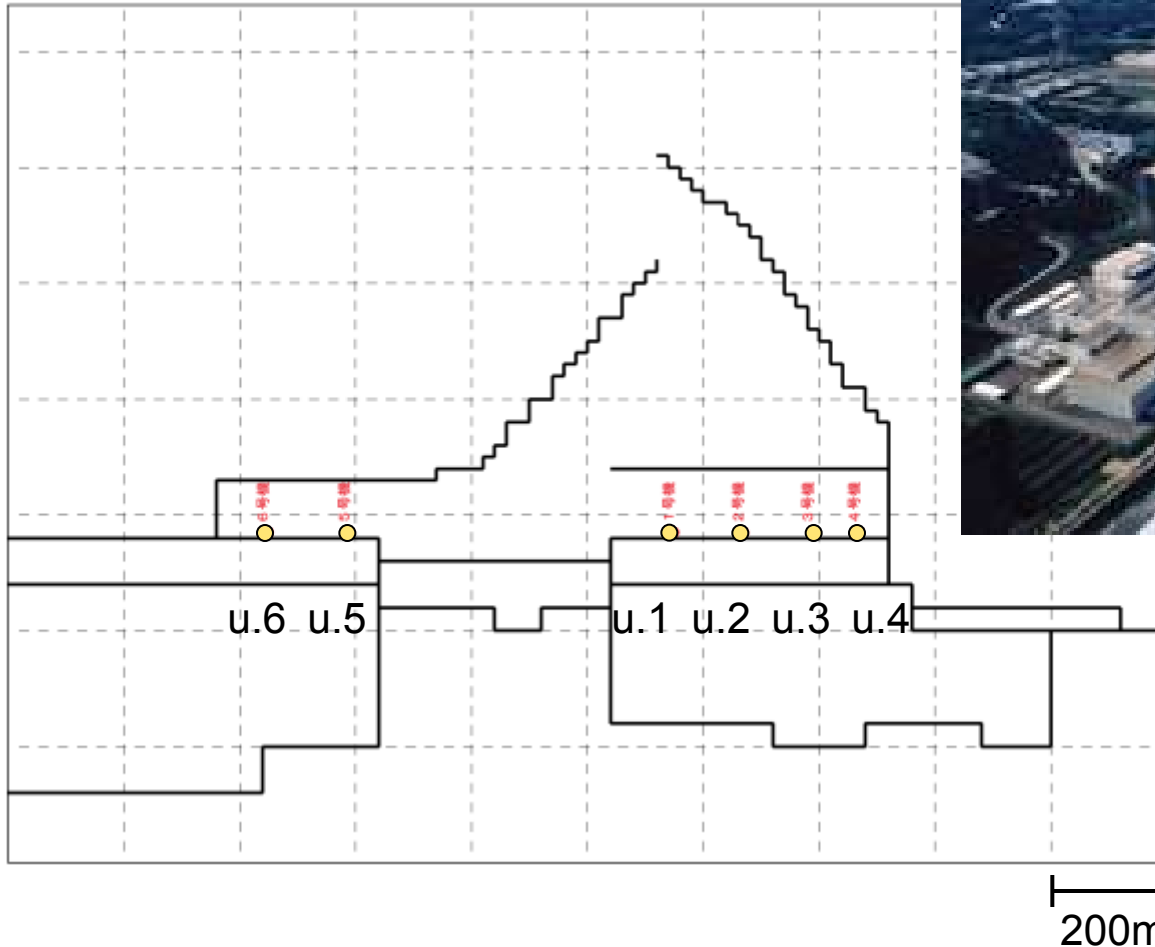
- depth
- dip angle
- slip angle



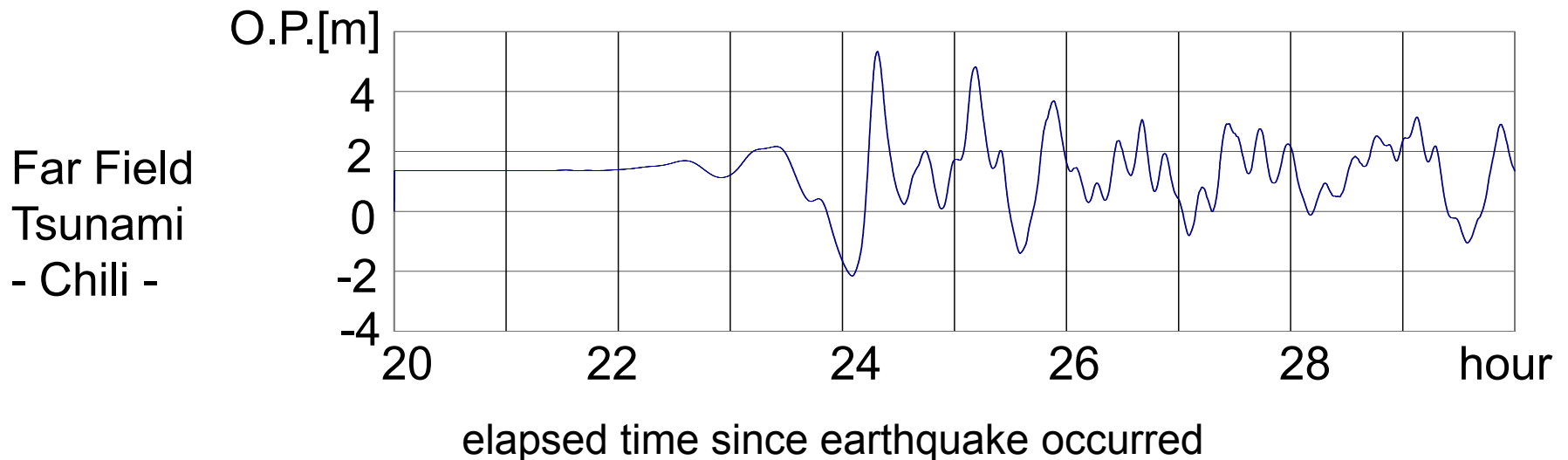
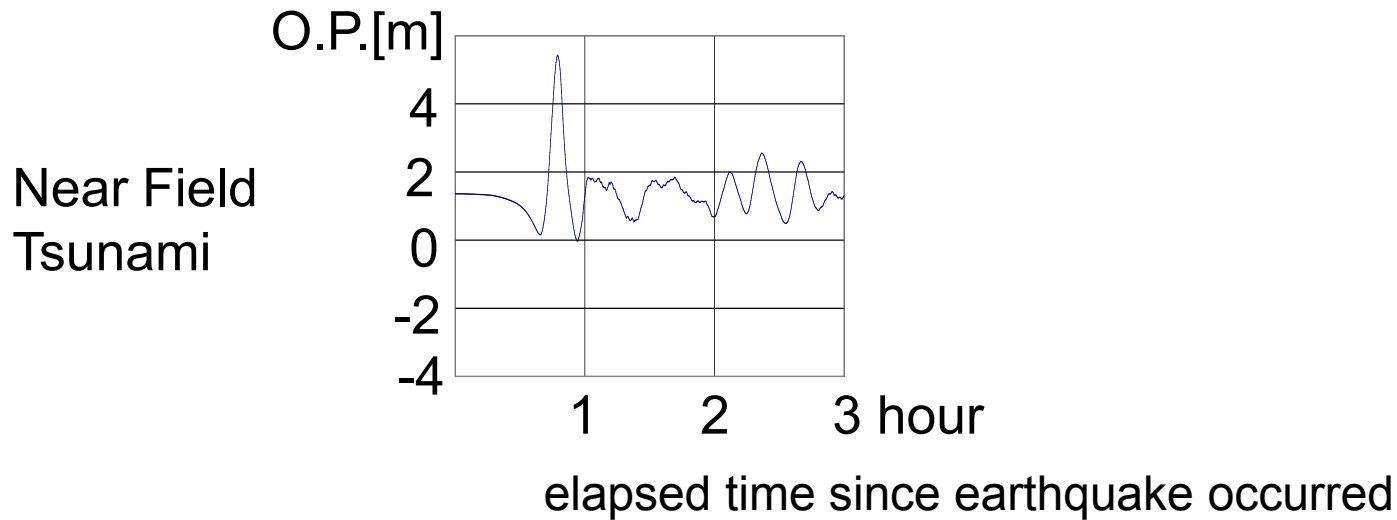
Standard fault model
1960 Chilean earthquake

Location of assessment points

Fukushima Daiichi NPS

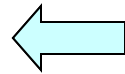
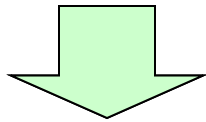


Time History of the design tsunamis



Consideration of tide and safety evaluation

The Design Tsunami



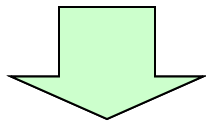
Tidal Conditions

Design High Water Level

= Maximum water rise + Mean of high tides

Design Low Water Level

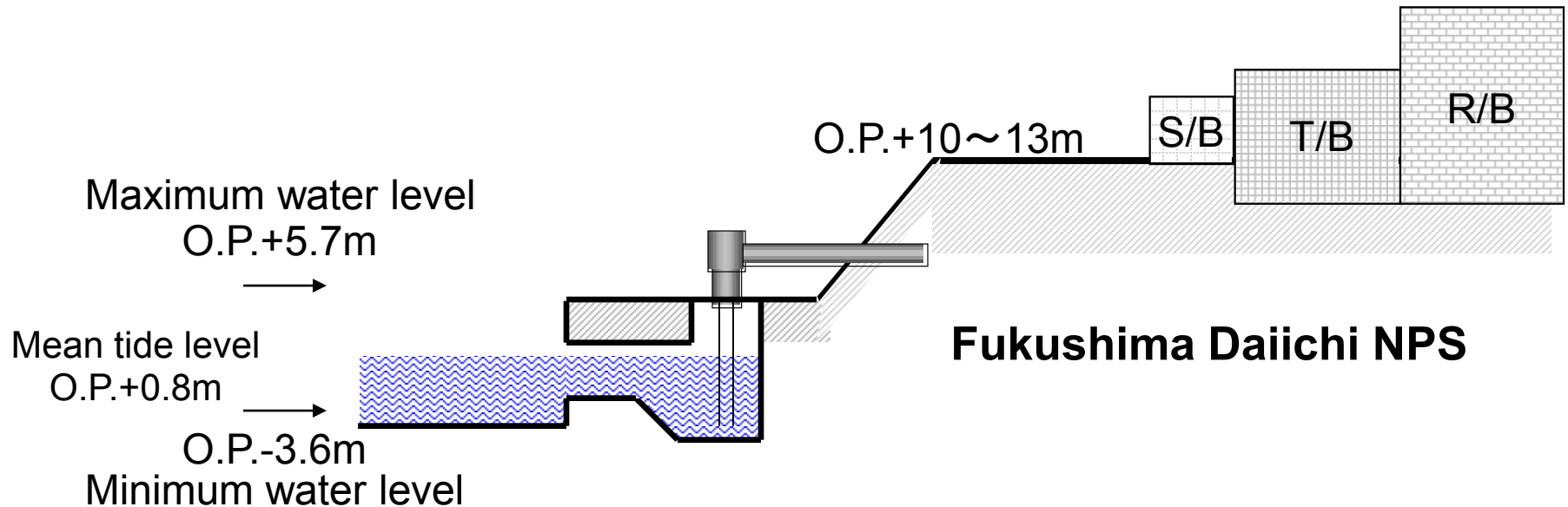
= Maximum water fall + Mean of low tides



Evaluation of the safety of NPP

Summary of Evaluation

Maximum water level = $4.4\text{m} + \text{O.P.} + 1.3\text{m} = \text{O.P.} + 5.7\text{m}$
Minimum water level = $-3.6\text{m} - \text{O.P.} \pm 0.0\text{m} = \text{O.P.} - 3.6\text{m}$



We assessed and confirmed the safety of the nuclear plants based on the JSCE method which was published in 2002.

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1. Tsunami assessment for NPP on the Pacific coast.
2. Operational status of NPP after the Feb. 28, 2010 tsunami from Chile.

Operational status of NPP on Feb.28

Fukushima Daiichi NPS

unit 1	in operation	459 MWe
unit 2	in operation	786 MWe
unit 3	in operation	789 MWe
unit 4	in operation	789 MWe
unit 5	in operation	823 MWe
unit 6	in operation	1,152 MWe



Fukushima Daini NPS

unit 1	in operation	1,113 MWe
unit 2	in operation	1,116 MWe
unit 3	regular maintenance	
unit 4	in operation	1,117 MWe



Feb. 28th NPS Correspondence (1/2)

A manual containing emergency and restoration protocol in the event of a major disaster has been created.

In the event that the Japan Meteorological Agency (JMA) issues a “Tsunami Warning” for the coastline near the NPS, the following measures are to be executed:

1. The Central Control Room Operators are to maintain vigilance in monitoring plant operations.
2. The Site Superintendent is to contact employees who are on standby in a separate office room or at home.
3. If necessary, an emergency headquarter is to be set up.

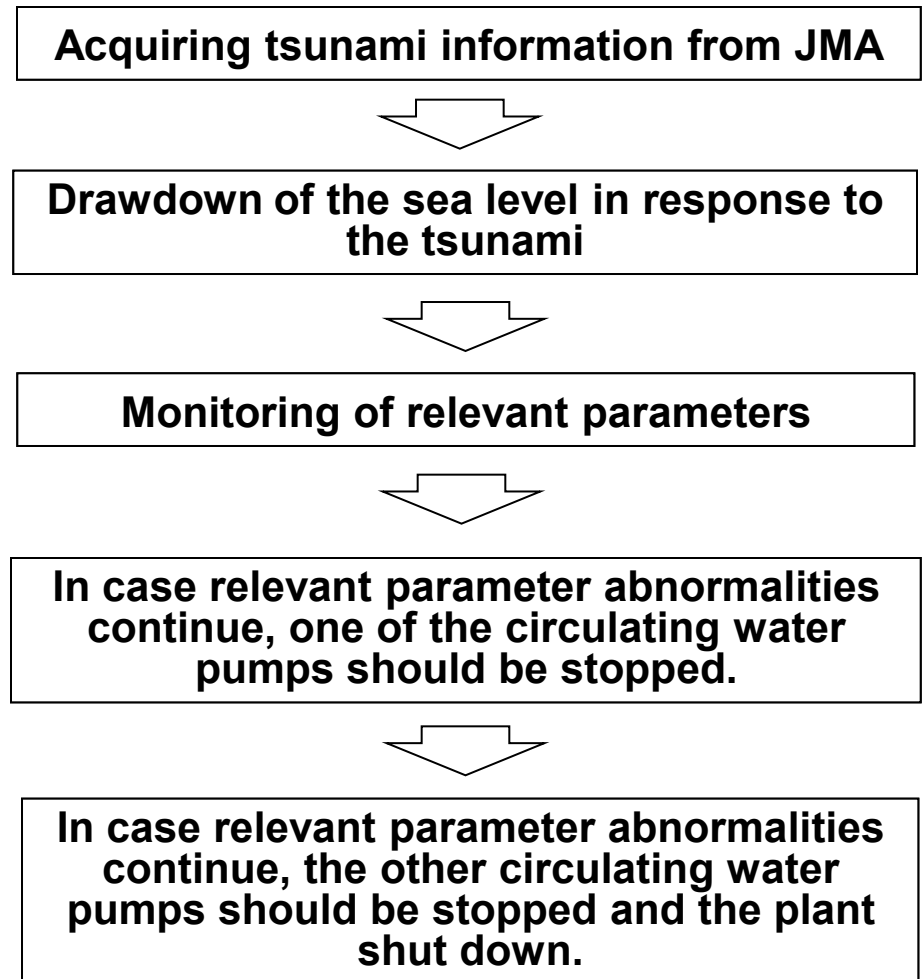
Feb. 28th NPS Correspondence (2/2)

Both Fukushima Daiichi NPS and Fukushima Daini NPS executed the below measures in response to a “Tsunami warning” issued by JMA on Feb.28.

- ✓ Discontinued the work and inspection of the area facing the ocean.
- ✓ Measured the sea level utilizing a tide gauge and via several installed TV cameras monitored the ocean conditions .
- ✓ Contacted employees to ready them for the execution of emergency disaster measures.

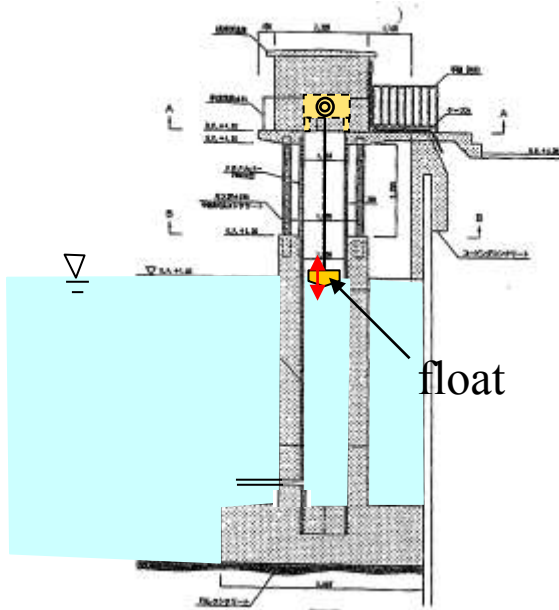
Correspondence based on Sea Level Measurements

- ✓ Utilizing the JSCE method, we assessed the ability of the NPP to withstand potential tsunamis.
- ✓ Based on the assessment results, the level of the seawater pumps was improved.
- ✓ "Accident Operating Procedure (AOP)" for tsunamis was established.



Flowchart on the basis of AOP

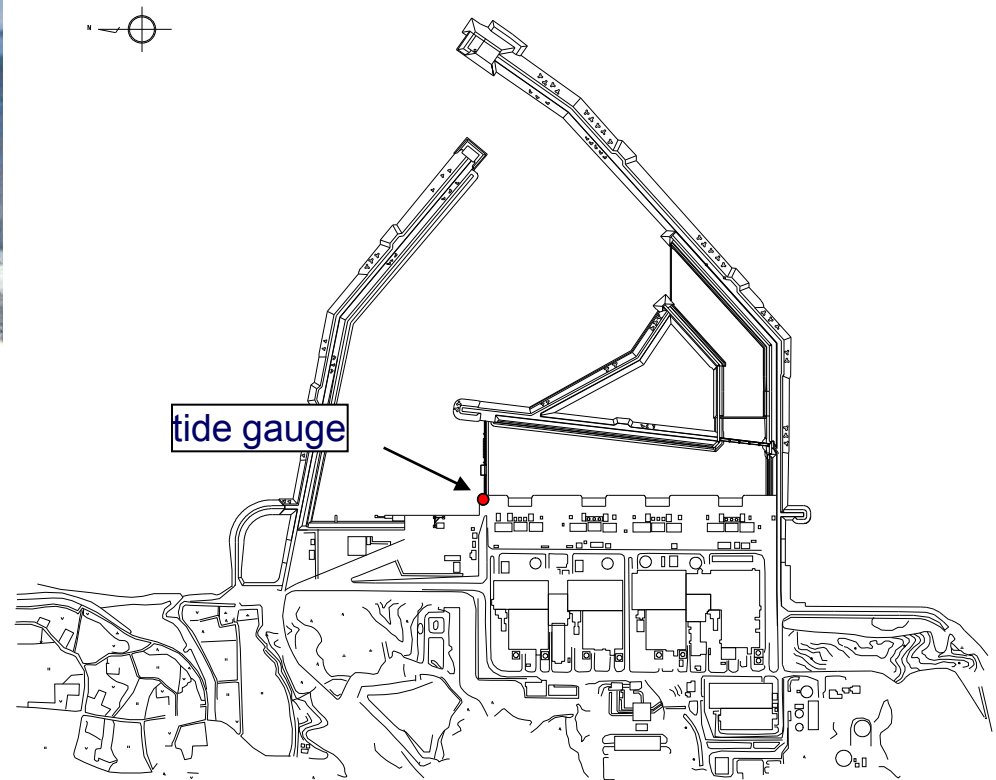
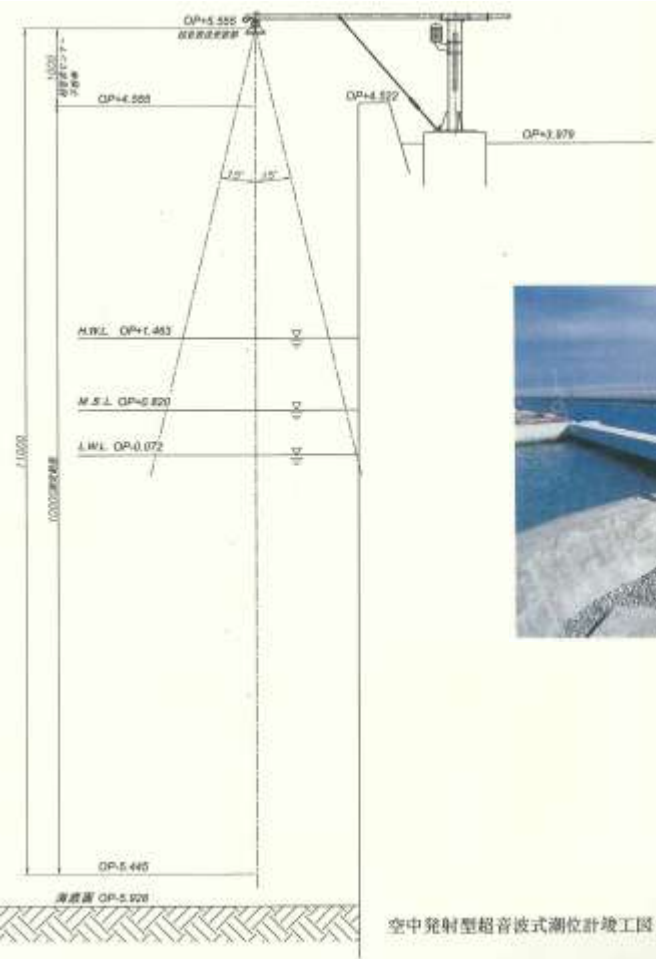
Tide gauge at Fukushima Daiichi NPS



A float-type tide gauge is set up inside the harbor of the NPP.

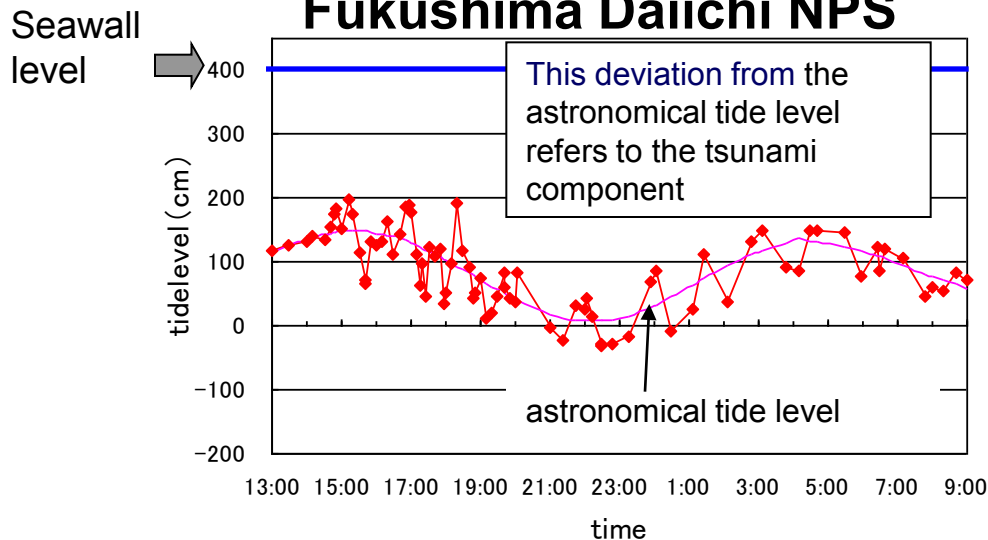
Wave gauge at Fukushima Daini NPS

An ultrasonic-type tide gauge is installed inside the harbor of the NPP.



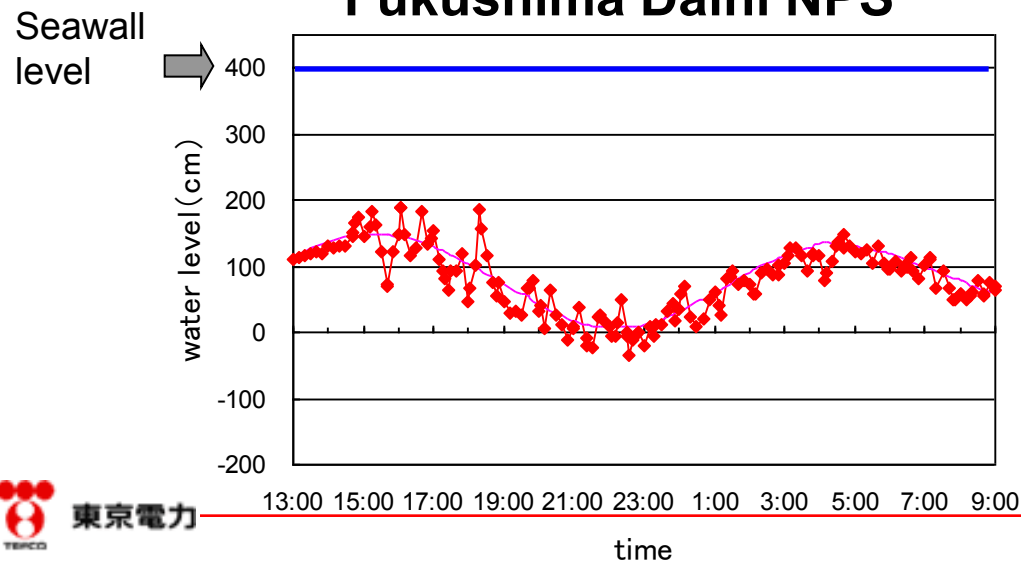
Observational result of Chile tsunami on Feb.28

Fukushima Daiichi NPS



- ✓ Deviation from the astronomical tide was observed.
- ✓ The highest sea level did not reach the seawall level.
- ✓ The lowest sea level did not fall below the intake water level of the circulating pumps.
- ✓ Normal operations were not impacted.

Fukushima Daini NPS



	Tsunami component	
	rising	drawdown
Fukushima Daiichi	+ 0.6m	- 0.8m
Fukushima Daini	+ 1.0m	- 0.8m

Summary

- ✓ **We assessed and confirmed the safety of the nuclear power plants based on the JSCE method which was published in 2002.**
- ✓ **On Feb. 28, in response to the “Tsunami warning” issued by the Japan Meteorological Agency, appropriate measures in accordance with “Accident Operating Procedures (AOP) ” were executed.**
- ✓ **Daily operations were NOT impacted.**

Thank you very much for your kind attention.



ANDOU Hiroshige