Our Basic Recognition of Fukushima Accident

2 years and 2 months have passed since our Fukushima Accident

- The cause of the accident should not be treated merely as a natural disaster due to an enormous tsunami being something difficult to anticipate.

- We believe it is necessary to seriously acknowledge the result that TEPCO failed to avoid an accident which might have been avoided if ample preparations had been made in advance with thorough use of human intellect.

Agenda

1. Lessons Learned from Tsunami Estimation Process
   - Could we predict an enormous Tsunami and take whatever countermeasures?

2. Lessons Learned from Plant Recovery Process
   - Could we respond to the accident better?

3. Challenge for Nuclear Safety Reform

4. Summary
   - For the worldwide operators to avoid such an accident

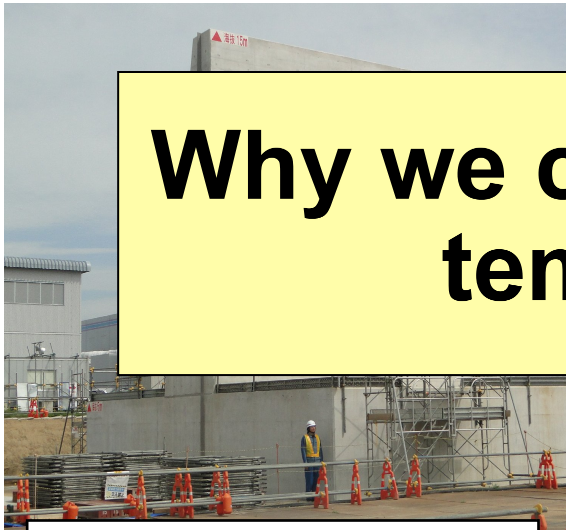
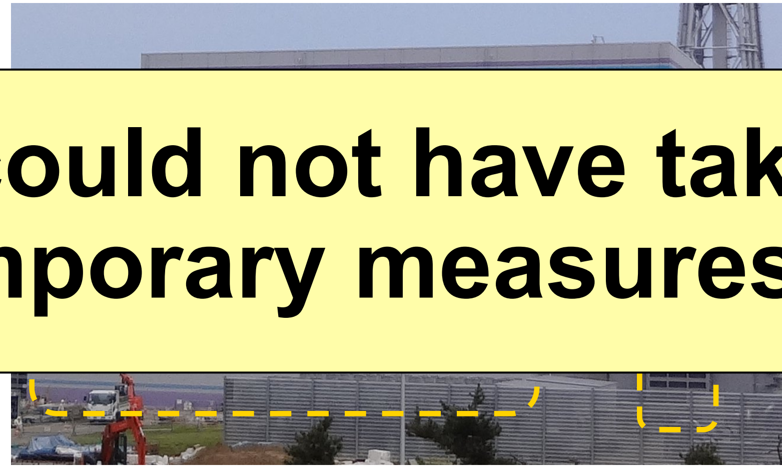
1. Lessons Learned from Tsunami Estimation Process

Facts:

- Underestimated tsunami height for design base.
- Site level was not high enough to prevent inundation of tsunami.
- Equipments as barriers of DiD layer were disabled by tsunami. (common cause failure mode)

Physical protection against Tsunami @KK

The Physical barriers against tsunami are being constructed and the measures which protect power sources and other important apparatus is being taken at Kashiwazaki Kariwa NPS

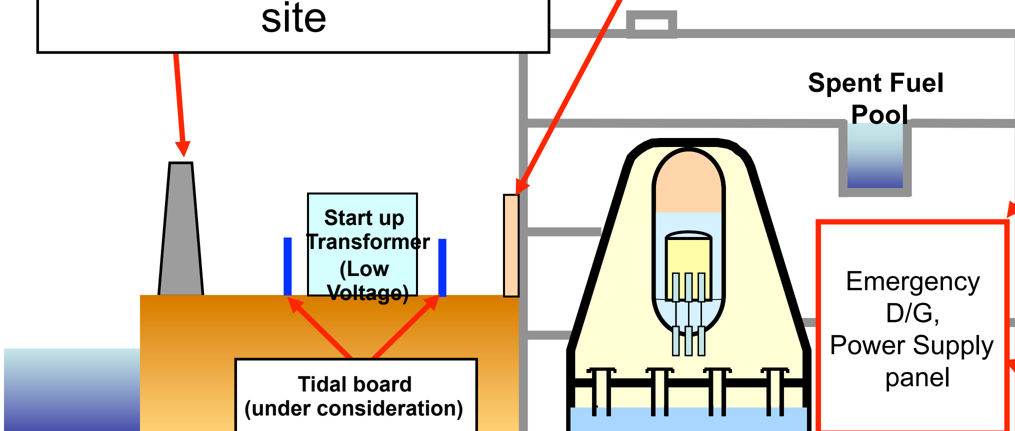




Why we could not have taken even temporary measures?

Embankment : Preventing inundation of site

Tidal wall : Preventing inundation of building

Water-tight door : Preventing flooding of critical areas (~60 places)

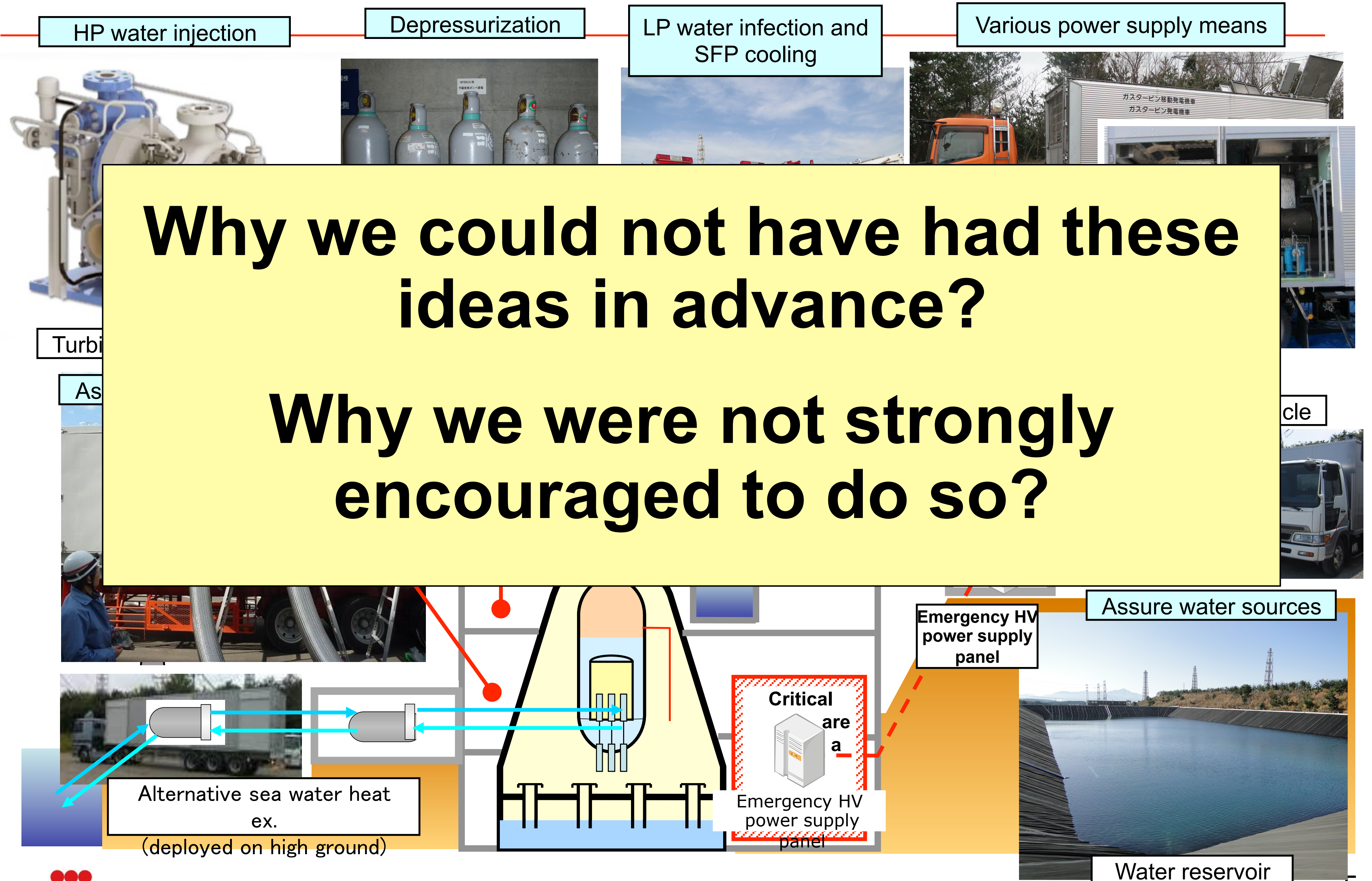


Waterproof treatment at Cable trays

Waterproof treatment at Pipes

Waterproof treatment : Preventing flooding of critical areas (~ 300 places)

Reinforcement for Cooling Function @KK



Why we could not have had these ideas in advance?

Why we were not strongly encouraged to do so?

Could we predict an enormous Tsunami and take whatever countermeasures?

Historical Tsunami before March 11th, 2011

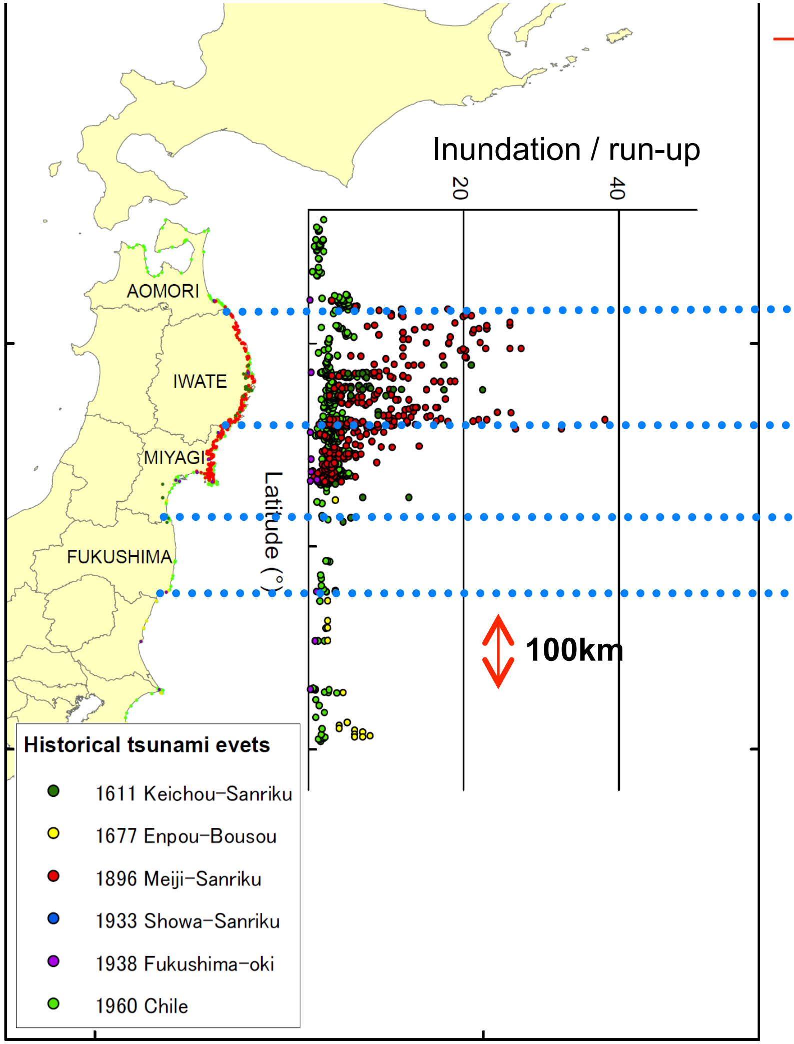
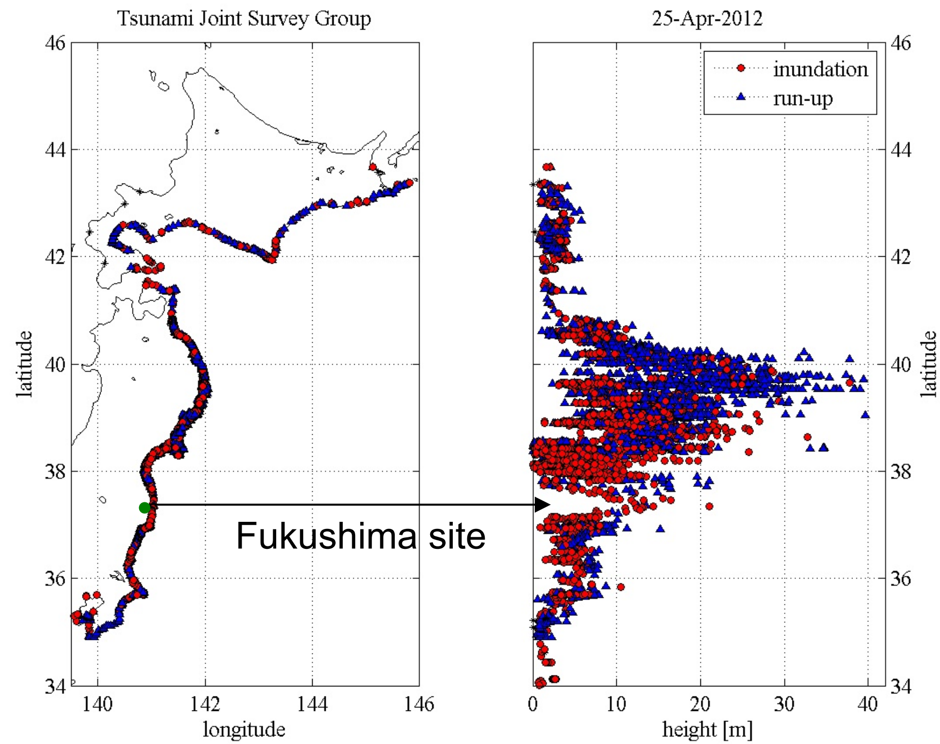


Fig. Tsunami height distribution after Edo era



There was no record of huge tsunami in Fukushima Pref.

Factor1 : Location of the tsunami source
Factor2 : Effect by topographic amplification

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Factor1 : Location of the Tsunami Source

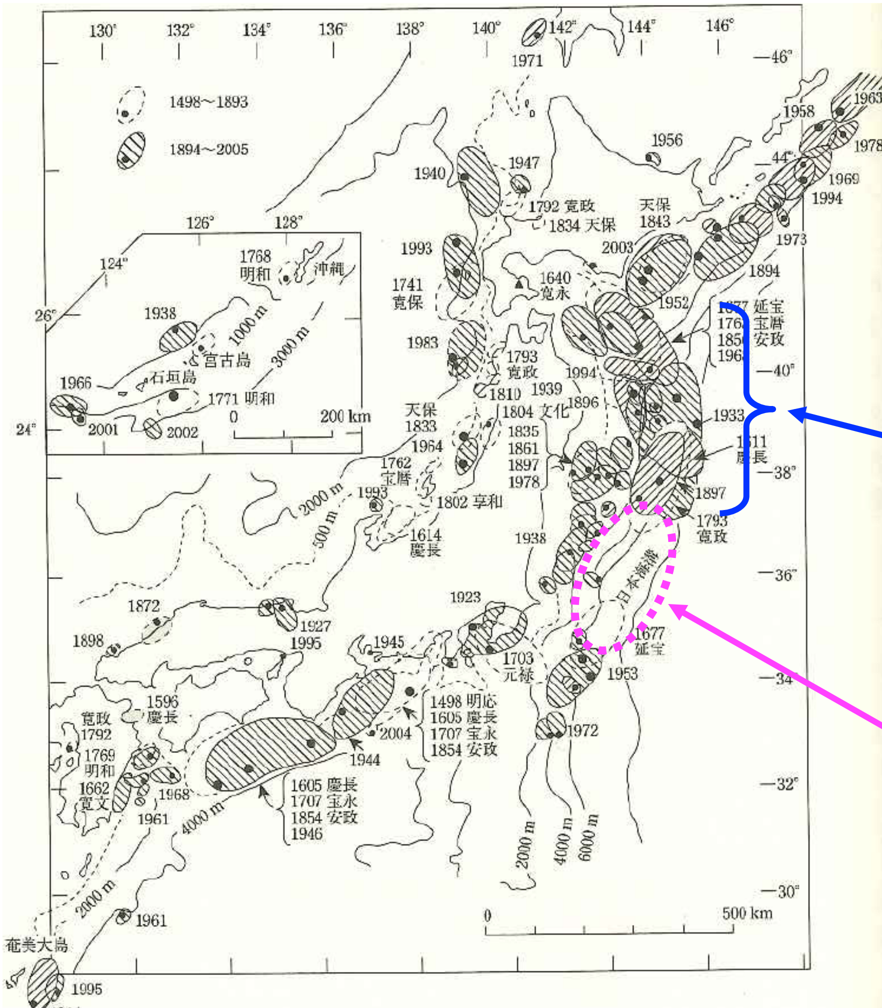

Fig. Location of the tsunami source

Touch in the materials by Shuto et al., 2007

1611	Keityo Sanriku	Mw8.6
1677	Enpou Bousou	Mw8.2
1896	Meiji Sanriku	Mw8.3
1933	Shouwa Sanriku	Mw7.9

- Historical tsunamis, especially over M8 earthquakes, mainly occurred in northern area of northern latitude of 38 degrees.

- There was no record about large earthquake along Japan Trench off the coast of the Fukushima Pref.

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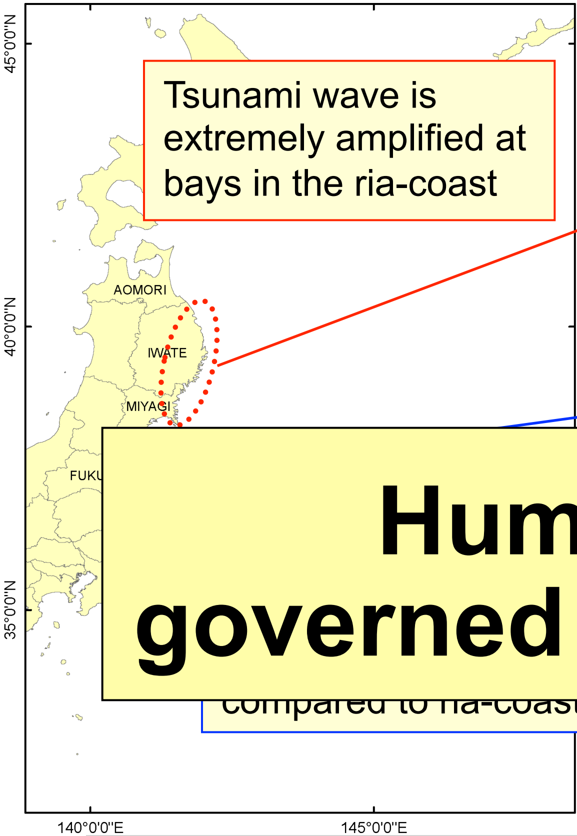
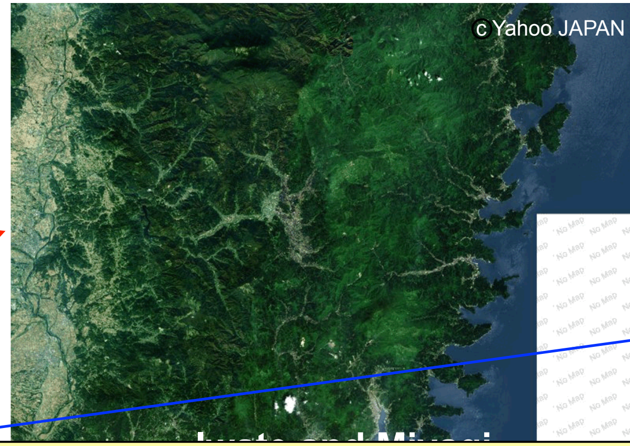
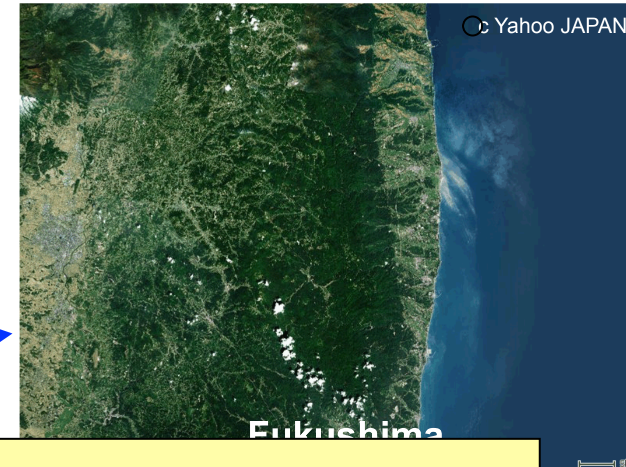
Factor2 : Effect by Topographic Amplification



Tsunami wave is extremely amplified at bays in the ria-coast





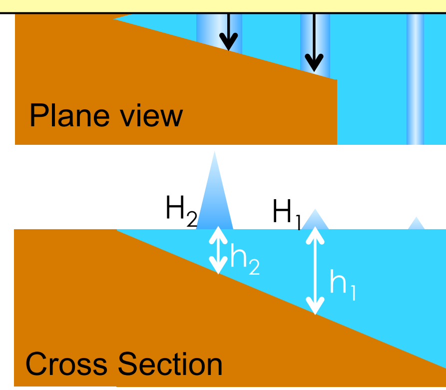
Human beings tend to be governed by their own experiences.

compared to ria-coast.

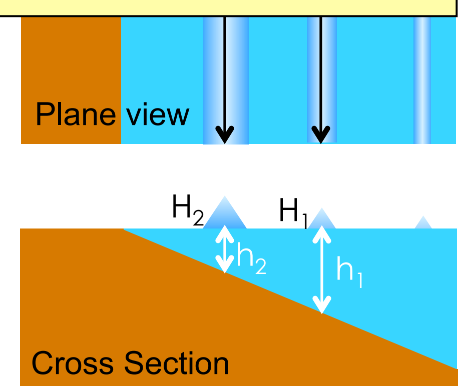
Green's Law

Tsunami height is amplified due to specific topography such as in V-shaped bay. (In this case $b_1 > b_2$)

H_2, H_1 : height、h_1, h_2 : depth、b_1, b_2 : width



Iwate and Miyagi



Fukushima

Fig. Schematic view of tsunami amplification

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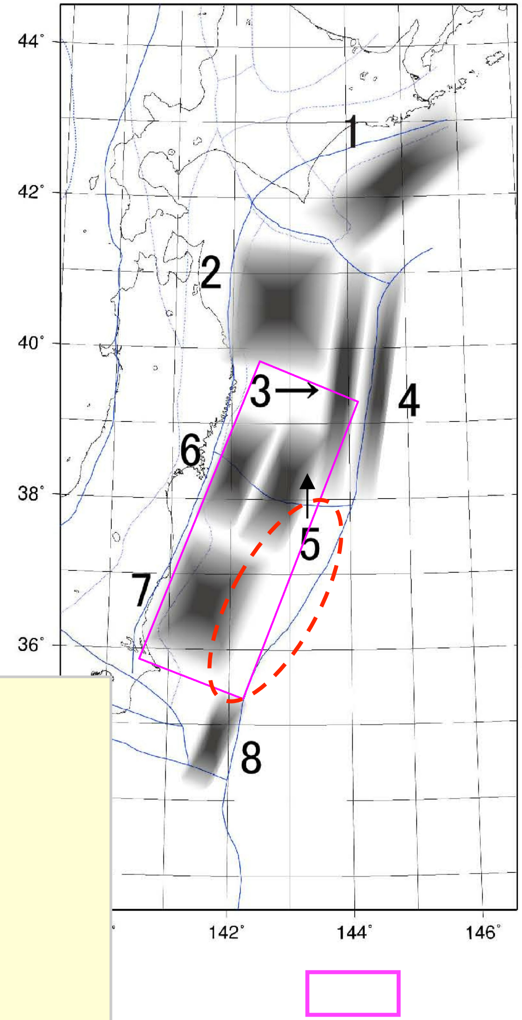
"Tsunami Assessment Method for Nuclear Power Plants in Japan (2002)" by JSCE (Japan Society of Civil Engineers)

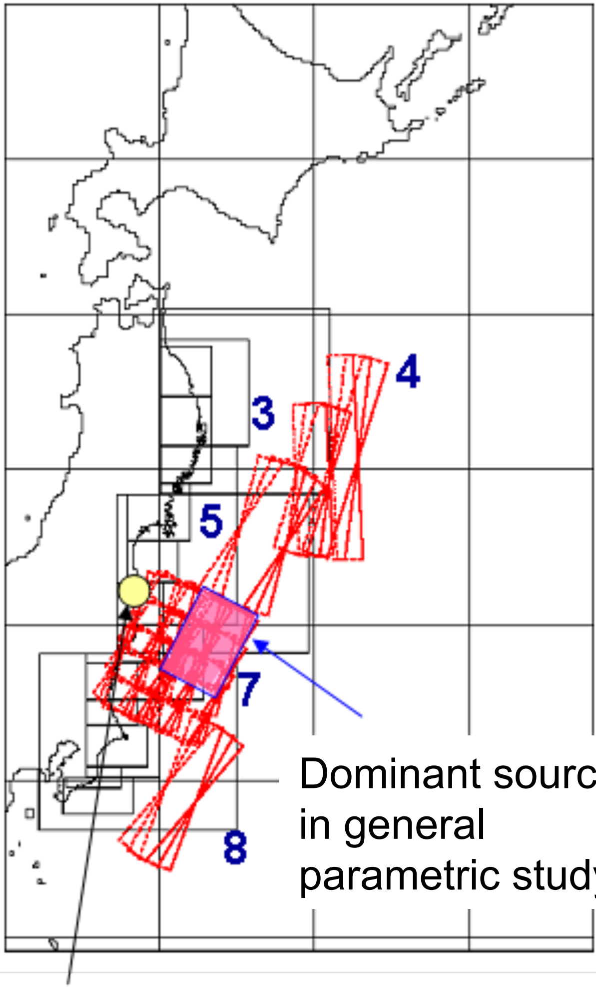
No	Mw	Earthquake
1	8.2	1952 Nemuro-oki
2	8.4	1968 Tokachi-oki
3	8.3	1896 Meiji-Sanriku
4	8.6	1611 Keicho-Sanriku
5	8.2	1793 Miyagi-oki
6	7.7	1978 Miyagi-oki
7	7.9	1938 Fukushima-oki
8	8.1	1677 Enpo-Bousou



2011/3/11
source area

- Uncertainties, such as inexperienced event, are taken into account by **parametric study** of the standard fault model.
- Earthquakes are assumed in **8 areas individually** for numerical simulation **based on the historical tsunamis**.
- Earthquake on March 11th occurred **cross over several areas, that was not predicted by any experts**.
- **JSCE 2002 did not consider the tsunami source in the area along the trench of off the coast of Fukushima prefecture.**

Parametric Study



Dominant source in general parametric study

Fukushima Daiichi NPS
Fukushima Daini NPS

3	Mw 8.3
4	Mw 8.6
5	Mw 8.2
7	Mw 8.0
8	Mw 8.2

General parametric study
- location
- strike

Detailed parametric study
- location - strike
- depth - dip angle
- slip angle

➢TEPCO carried out general parametric study for area 3, 4, 5, 7 and 8.

➢Tsunami from Area 7 was dominant, and detailed parametric study was conducted for this area.

➢This parametric study did not cover the uncertainty on whether Tsunami source exists or not.

Did Tepco's Countermeasures for Tsunami Lag Behind Other Electric Power Utilities?

	TEPCO		JAPC	Tohoku EPCO
Event	Fukushima Daiichi	Fukushima Daini	Tokai Daini	Onagawa
Ground Level of main buildings	O.P.+10 or 13m	O.P.+12m	H.P.+8.9m	O.P.+14.8m
Esta		Unit 1in 1972		Unit 1 in 1970 O.P.+2～3m y) ion)
JSCE				st of t.) as
Scen disaster prevention was published by Ibaraki prefectural government	Countermeasure was unnecessary.	Countermeasure was unnecessary.	Countermeasure such as raise of the wall around seawater pumps was completed.	unexplained
Scenario Tsunami for disaster prevention was published by Fukushima prefectural government	Approx. O.P.+5m Countermeasure was unnecessary.	Approx. O.P.+5m Countermeasure was unnecessary.	unexplained	unexplained
Latest bathymetric and tidal data in 2009	O.P.+.6.1m Countermeasure such as raise of the seawater pumps was completed.	O.P.+.5.0m Countermeasure was unnecessary.	unexplained	unexplained
Tsunami in 2011	O.P.+13.1m (Tsunami height) O.P.+15.5m (Inundation height)	O.P.+9.1m (Tsunami height) O.P.+14.5m (Inundation height)	T.P.+5.4m	O.P.+13.8m

TEPCO was relatively comfortable with the commonly used methodology among all the utilities.

Trial Calculation 1 in the Light of HERP in 2008

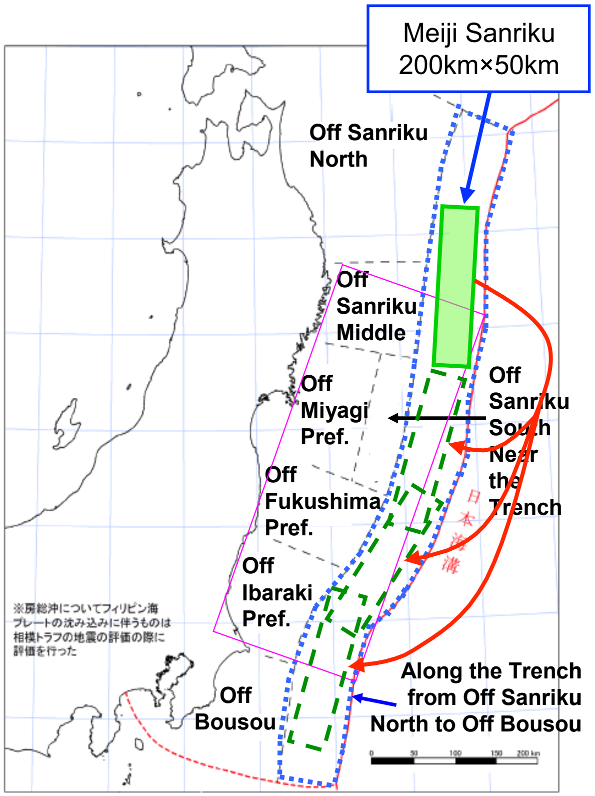


Fig. Earthquake region by the Headquarters for Earthquake Research Promotion (HERP)

Touch in the materials by HERP, 2002

- The Headquarters for Earthquake Research Promotion **(HERP)** proposed in 2002 that **there is a possibility that M8.2 earthquake occur anywhere along the Japan Trench.**
- Prior to antiseismic back-check in the light of the seismic guideline, **TEPCO carried out a trial calculation in deterministic way.**
- HERP showed only the size of fault as 200km×50km and its magnitude as 8.2.
- **HERP** did not carry out tsunami simulation, and also **did not show the parameters which was necessary for tsunami calculation.**
- As tsunami source model had not been determined, **TEPCO hypothetically applied the model of Meiji Sanriku Earthquake Tsunami in 1896.**
- Its magnitude is Mw 8.3, which is larger than the magnitude 8.2 shown by HERP.

	1F							
unit	1	2	3	4	5	6	Northern part (O.P.13m)	Southern part (O.P.10m)
Tsunami Hight [m]	8.7	9.3	8.4	8.4	10.2	10.2	13.7	15.7

	2F				
unit	1	2	3	4	(O.P.12m)
Tsunami Hight [m]	7.6	7.2	7.8	8.2	15.5 (Southern part)

Run-up Height

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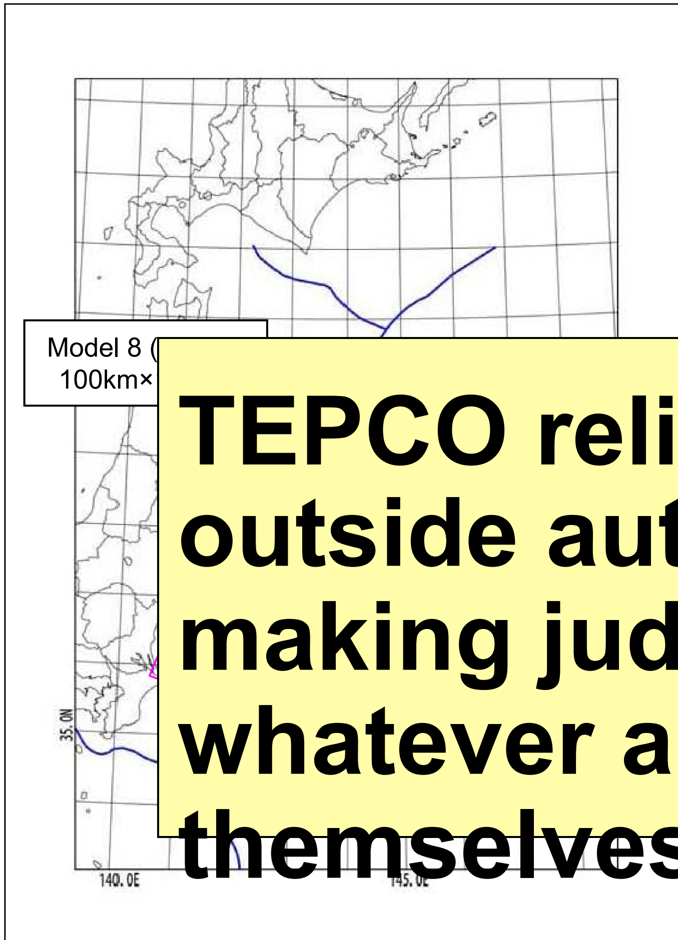
Trial calculation 2 of Jogan Tsunami



➢TEPCO conducted trial calculation of Jogan Tsunami using the model proposed by Satake et al.(2008), that was the first-ever model for tsunami calculation based on tsunami deposit survey results.

➢Satake et al.(2008) pointed out that **they could not determine the fault parameters because of lack of information**, then **they mentioned the additional tsunami deposit survey should be carried out.**

TEPCO relied too much on the outside authority, instead of making judgment and taking whatever actions by themselves.

								Southern part (O.P.10m)
Tsunami height [m]	8.7	8.7	8.7	8.7	9.1	9.2	No inundation	No inundation

	2F				
Unit	1	2	3	4	(O.P.12m)
Tsunami height [m]	8.0	7.8	7.8	7.9	No inundation

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Background of Missed Opportunity

TEPCO did NOT:

✓put more importance on 'consequence' rather than 'probability'

✓actively promote cross-functional discussions among associated organizations

✓improve the process to learn the lessons from operational experiences in the world, such as flooding event at Blayais NPS, France

✓thus take a proactive manner for safety enhancement, even temporarily

That was because:

✓TEPCO believed that severe accident was unlikely then it was not necessary to improve safety measures more, at least immediately (putting off the decision)

2. Lessons Learned from Plant Recovery Process

Facts:

- TEPCO was not sufficiently prepared in responding to such an accident.
- At the Fukushima Daiichi site the command and control structure was degraded in the response to the multi units and also because of external intervention.
- TEPCO management showed distinguished leadership to respond to those unexpected situations, though desirable results did not come out.
- TEPCO employees devoted themselves to save the plants with strong self-accountability, spirit of self-sacrifice and braveness.

Could we respond to the accident better?

Accident Response at 1F
<Challenging Condition in Main Control Room>

Checked instrumentation in near-complete darkness.

Supervised operation wearing full-face mask.

Brought in heavy batteries to restore instrumentations.

- **Lack of:**
  instrumentation, communication means, lighting, food, water, sleep, ...
- **Increase in:**
  radiation level, fatigue, fear, despair, ...

Accident Response at 1F
<Challenging Condition in Field>

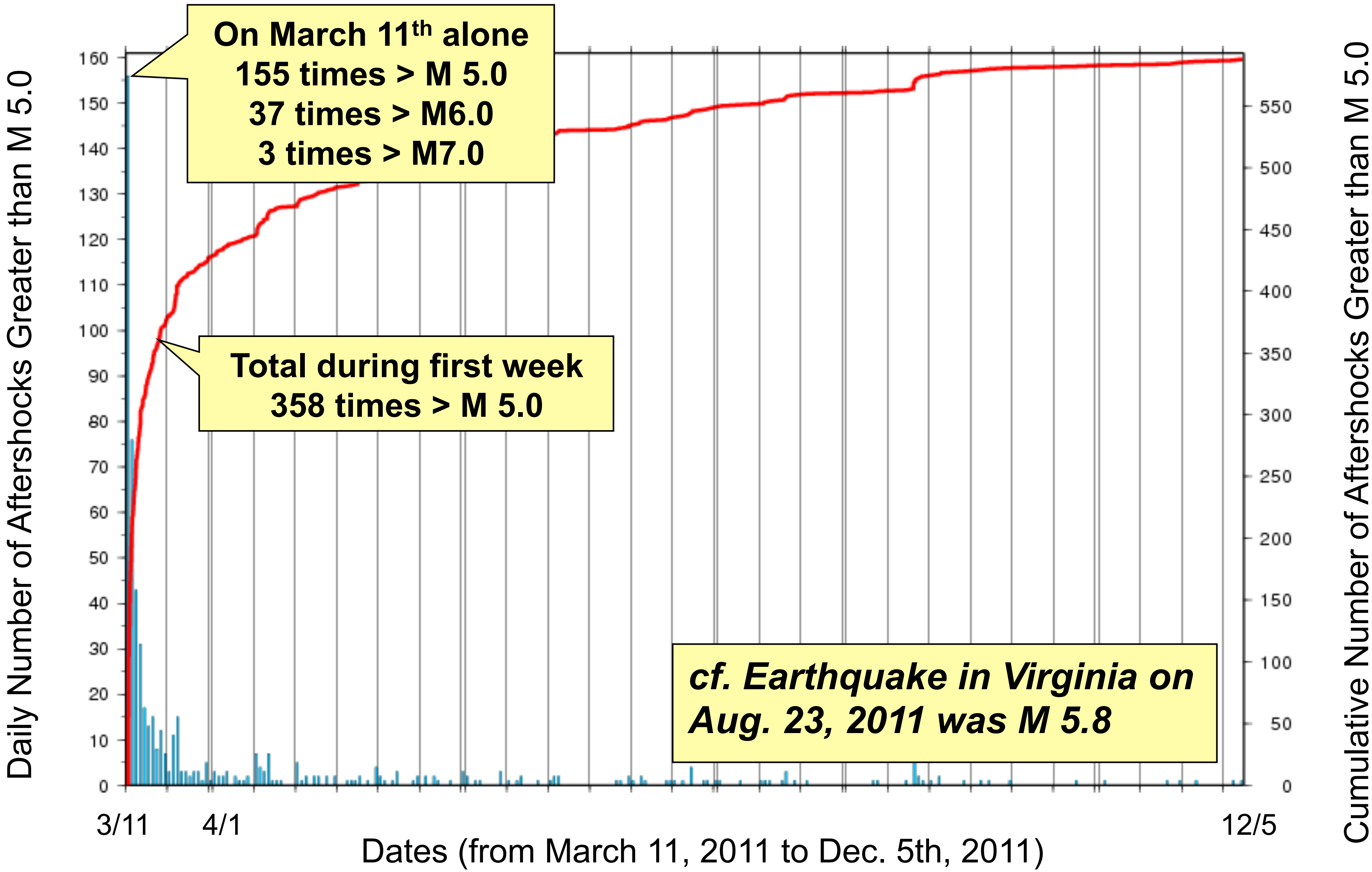
Tsunami-drifted obstacles blocked roads.

Hazardous road conditions.

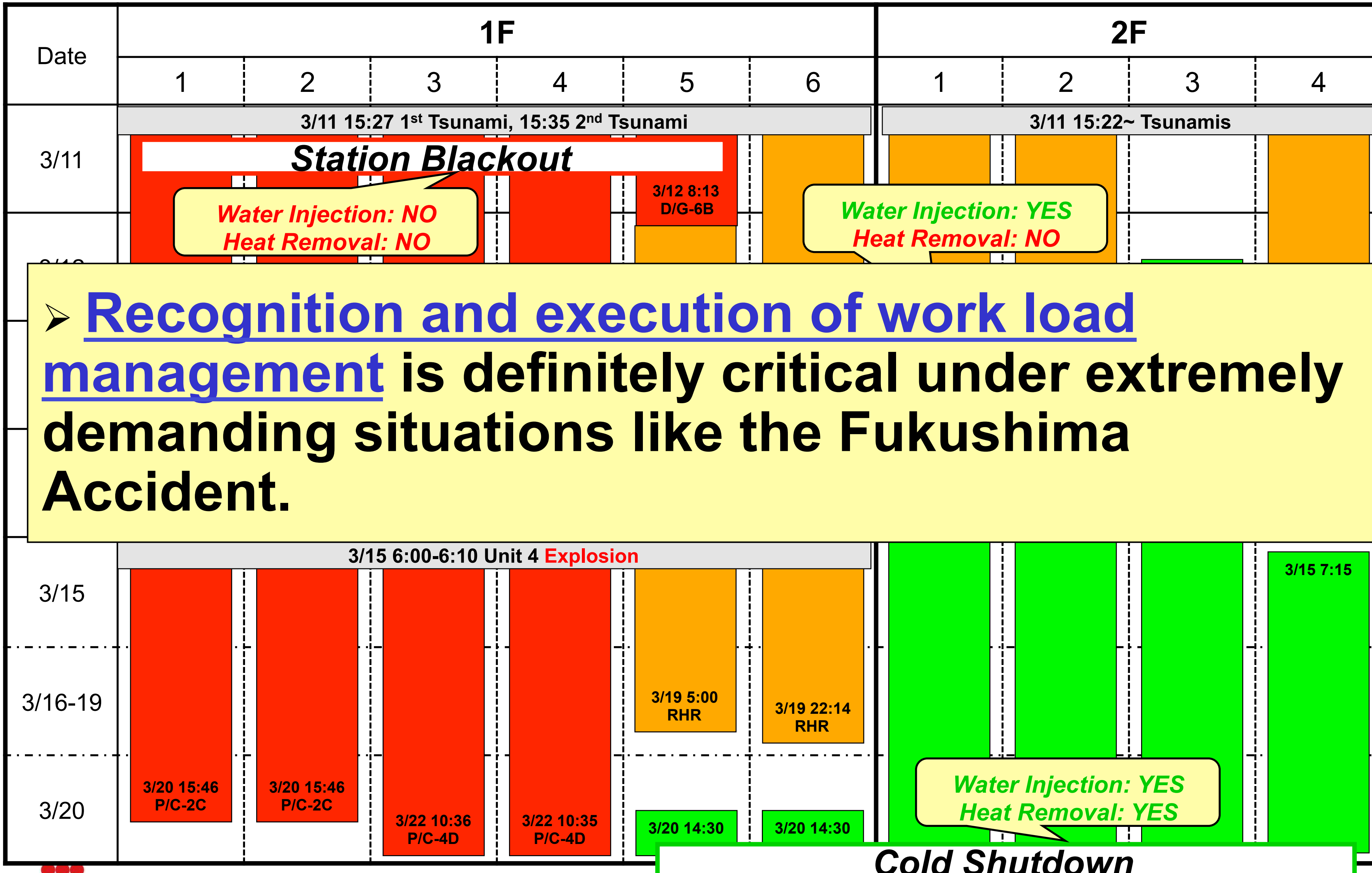
Fire hoses laid for reactor water injection restricted field access by vehicles.

Challenging conditions exacerbated by continual aftershocks/tsunami alerts.

Number of Aftershocks Greater than M 5.0



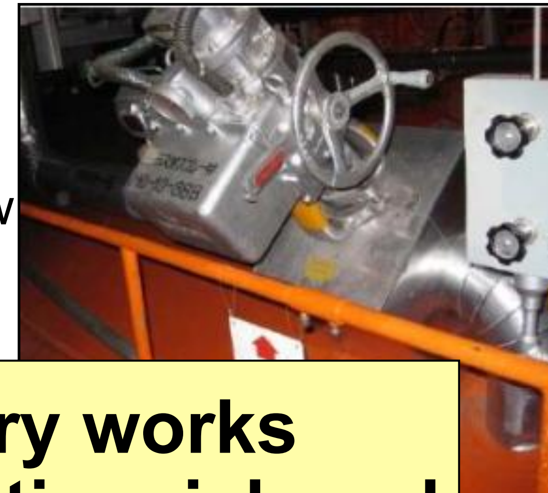
Overview of the 10-Unit Simultaneous Accidents



➢ **Recognition and execution of work load management is definitely critical under extremely demanding situations like the Fukushima Accident.**

Voices from the Field

- “In an attempt to check the status of Unit 4 D/G, I was trapped inside the security gate compartment. Soon the tsunami came and **I was minutes away from being drowned**, when my colleague smash opened the window and saved my life.”



- “In total darkness, I could hear the unearthly sound of SR[…] to o[…] **mel**[…]
- “Th[…] incr[…] cou[…]

> **Implementation of plant recovery works with a lot of physical and radioactive risk and <u>securing safety (life) of workers</u> was the <u>ultimate dilemma for station top management</u>.**

- “I asked for volunteers to manually open the vent valves. **Young operators raised their hands** as well.”
- “Unit 3 could explode anytime soon, but it was my turn to go to the main control room. **I called my dad and asked him to take good care of my wife and kids should I die.**”

Unit 1 Main Control Room

D/G: Diesel Generator
SRV: Safety Relief Valve
S/C: Suppression Chamber

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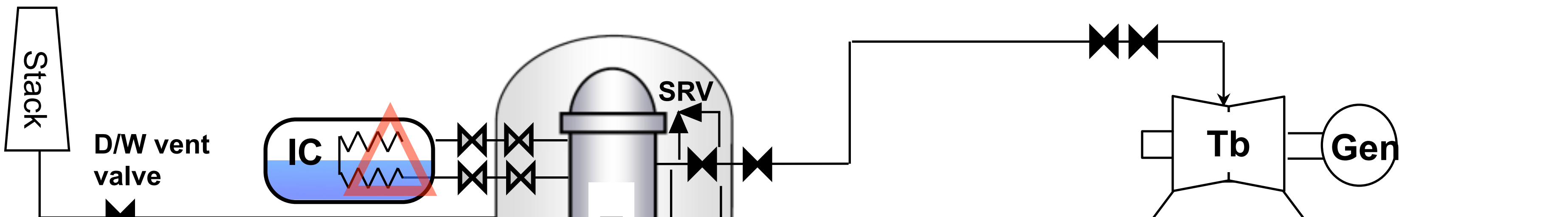
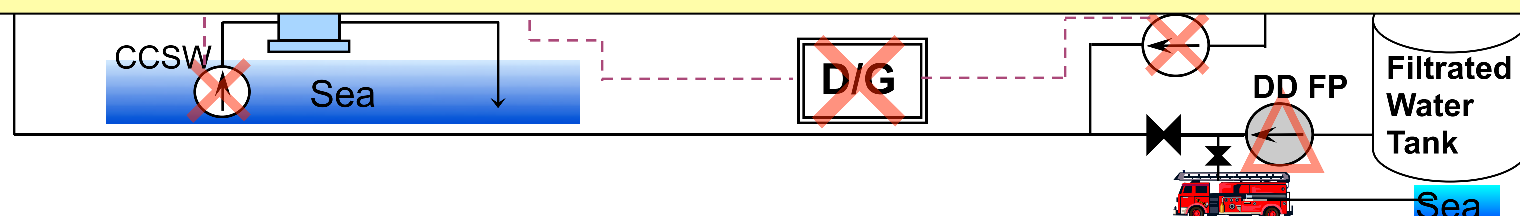
1F Unit 1 Schematic System Diagram (After Tsunami)



- The <u>operational status of IC was not precisely shared</u> between Main Control Room (MCR) and Emergency Response Center (ERC), and ERC decision makers believed that IC was in operation.

- Though the only way to explore the possibility to save Unit 1 was that operators could bravely go up to the 4th floor of Reactor Building and open the valves to start IC, it was <u>given up without any clear communication among key decision makers</u> for confirming the IC operational status.



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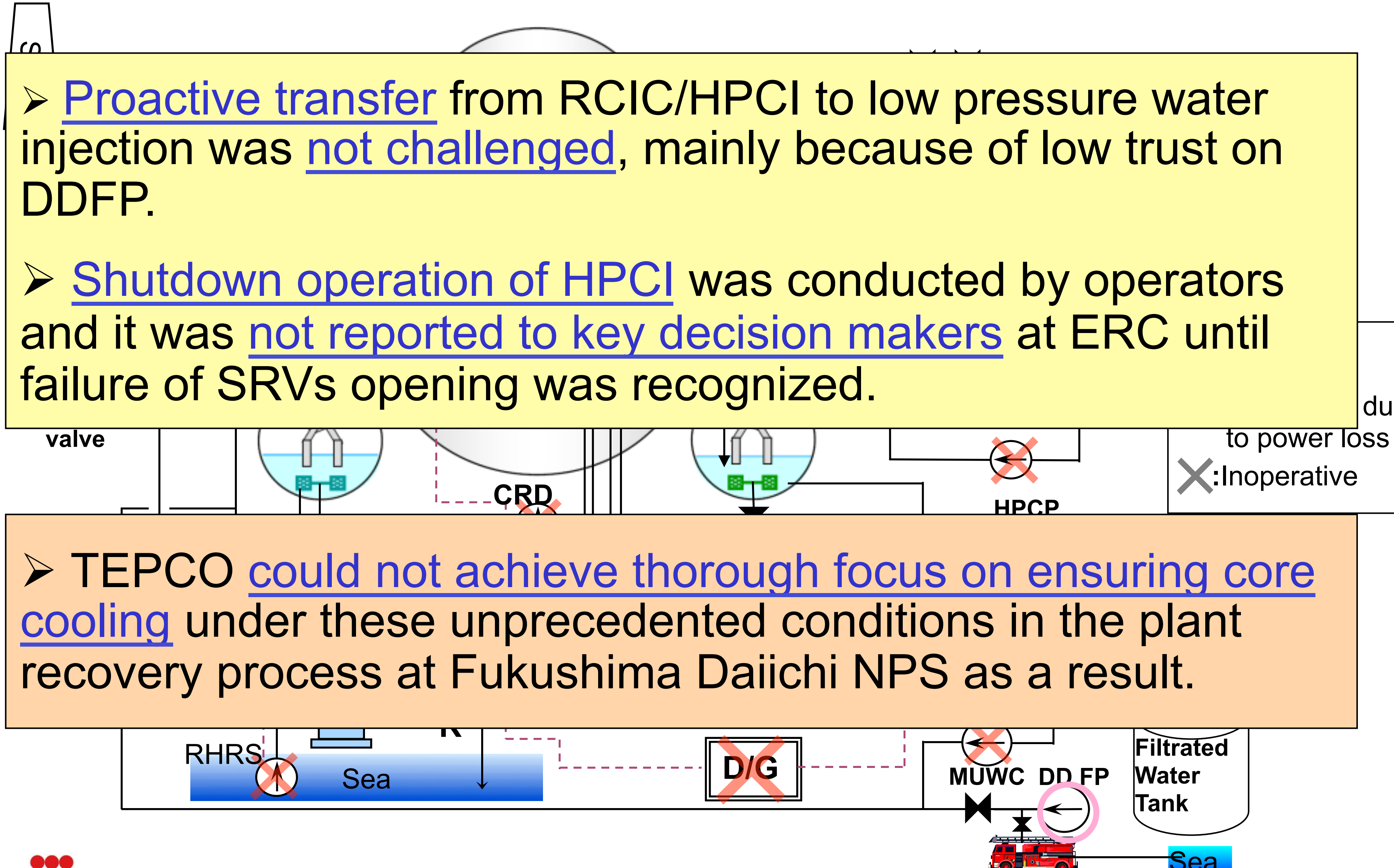
1F Unit 3 Schematic System Diagram (After Tsunami)



- Proactive transfer from RCIC/HPCI to low pressure water injection was not challenged, mainly because of low trust on DDFP.

- Shutdown operation of HPCI was conducted by operators and it was not reported to key decision makers at ERC until failure of SRVs opening was recognized.

- TEPCO could not achieve thorough focus on ensuring core cooling under these unprecedented conditions in the plant recovery process at Fukushima Daiichi NPS as a result.

Reinforcement for Cooling Function @KK

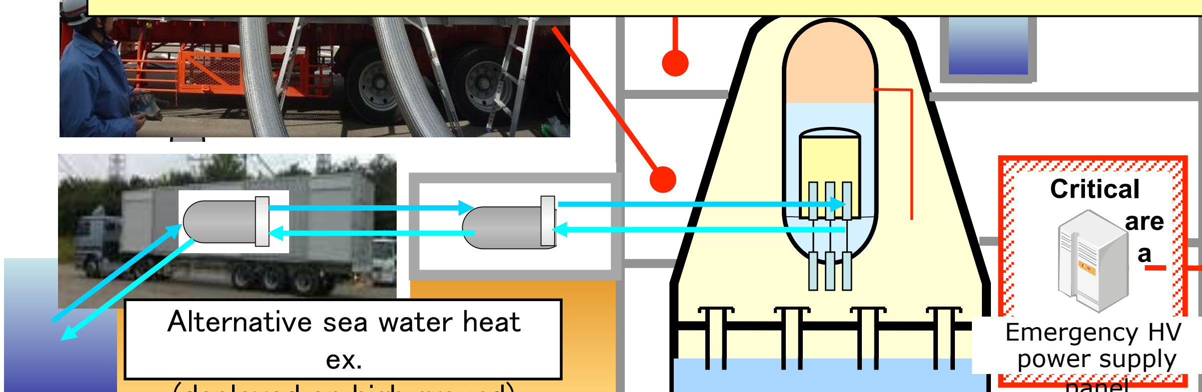
HP water injection

Depressurization

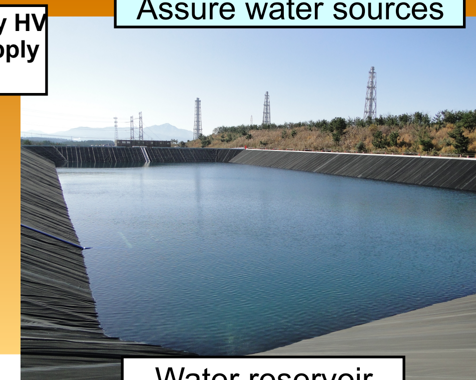
LP water infection and SFP cooling

Various power supply means

➢If TEPCO had prepared these countermeasures with optimum accident management strategies and associated implementing procedures, and people had been well trained and knowledgeable enough to use these tools effectively in advance, we could have had more possibility to save the plants.



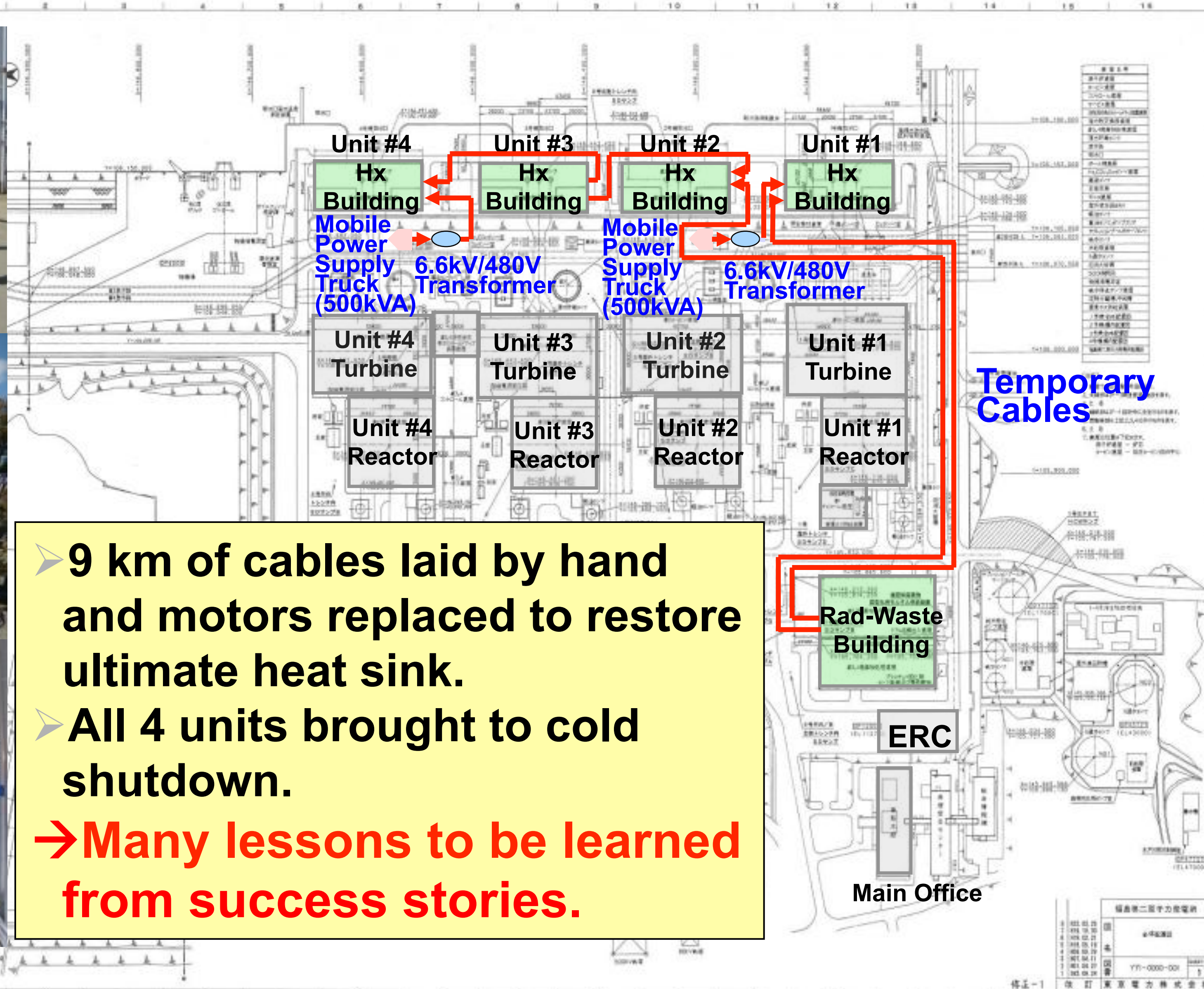
Assure water sources



Water reservoir

Accident Response at 2F

<Temporary Power Supply and Motor Replacement>



- 9 km of cables laid by hand and motors replaced to restore ultimate heat sink.
- All 4 units brought to cold shutdown.

→Many lessons to be learned from success stories.

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Key Success Factors (1/2)

Availability of plant parameters with DC power supply and back-up cooling function (MUWC) with off-site power supply made 2F recovery process different from 1F.

➢ **Leadership** was shown to establish a well-prioritized strategy by station management

✓ A **well-prioritized restoration strategy to repair and replacement for restoration** was established after field walk down in the ERC as follows:

To recover RHR (B) cooling systems by replacing motors and supplying power from survived electrical buses and mobile power vehicles through temporary cable

✓ **The strategy on recovery operation was also well established in the MCR**, that was Ex. the focus on the uninterrupted water injection by RCIC & MUWC based on the symptom basis EOP.

✓ This **clear strategy was communicated to and shared** among operators, ERC personnel, all other TEPCO employees, and affiliated companies.

✓ **The organization and the personnel could move straight forward to the goal** of this strategy well.

Key Success Factors (2/2)

- Prompt restoration with emergency procurement of materials and equipment
  - ✓ **Coordinated activities of ERC and the headquarters** were important.
- Logistics and emotional cares for continuous response activities (mid- to long-term)
  - ✓ Emergency response personnel continued to work in a **tense atmosphere for a long period while some of their family members were suffered in disaster**.
  - ✓ Some responders were diagnosed as **Post-Traumatic Stress Disorder**.
  - ✓ **Periodical examination** was conducted to minimize stress-related illness.
- **Organizational integrity** during crisis
  - ✓ **Command and control structure to deal with simultaneous damage of multiple units was maintained.**
  - ✓ ERC leaders **had to manage conflicts**, **fears** and **worries** in response staff including those temporarily dispatched to the site.
  - ✓ **Good teamwork** had been already developed prior to the accident.

3. Challenge for Nuclear Safety Reform

Before the Account

➢**How successful and effective (or not) the challenges for organizational and cultural changes and to enhance nuclear safety were before the Accident?**

Exs.

✓ Nuclear Renaissance Activities

✓ Lessons Learned from Niigata Cyuetsuoki Earthquake @KK site

Initial Recognition on 2002 Scandal & Countermeasures taken

TEPCO has been making changes required in:

1. Organizational Culture
   - Safety first not yet permeated
   - Vertical silo based on complacency
   - Lack of learning/questioning attitude
   - Need to improve business ethics
2. Work Process
   - Safety culture not built into the processes
   - Unclear accountability and authority in the work processes
   - Ambiguous roles between TEPCO and manufacturer/subsidiaries, as well as between the Headquarters and sites
3. Quality Assurance
   - Ineffective oversight by experienced and knowledgeable people
4. External Interface – METI, Local Government, Local Community, etc.
   - Insufficient opportunities to have reasonable discussion for pursuit of excellence

Initial Recognition & Countermeasures taken (cont.)

Remedial Actions taken:

1. Oversight committee, in-house oversight group & corporate ethics committee
2. Organizational change: implemented and plans discussed by Managing Board

   (ex. Quality & Safety Group at each site, New Maintenance Department – responsible for all of planning, management, supervision and engineering)
3. Procedure/manual development meeting new QA structure
4. Ethics education and ethics hotline (in house): functional
5. CAP (Corrective Action Program): functional and "Passport" has been applied
6. Modernization of Maintenance Practices: RCM/CBM implemented on a part of equipments and evaluated (at 1F site)

↓ further improvement for pursuit of excellence

Nuclear Renaissance Activities

Nuclear Renaissance Activities for pursuit of Excellence

Since the TEPCO scandal in 2002

Benchmark Activities (Learning from the Best Practices)

Process Improvement (Core Activities: Implementation)

The reason why this activity was not fully successful was that:

- Sponsorship had not been shown continuously by top management
- Thorough focus on safety was not clearly demonstrated by top management

activities

Developing Leadership (Establishing a Foundation for Core Activities: Training)

- LDE - LDE Overview

Assessment to Renaissance Activities (Assessment – Self & External)

Learning and assessment for making changes

Implementing changes

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TEPCO

Improvement of Crisis Management

Emergency Response Center was unavailable immediately after the quake; plant staffs had to collect information outside of the office building. *(@KK site)*

Newly built Seismic-Isolated Building

Without this newly built Seismic-Isolated Building (Incl. Emergency Response Center), the post-accident activities could not have been carried out.

Improvement of Crisis Management

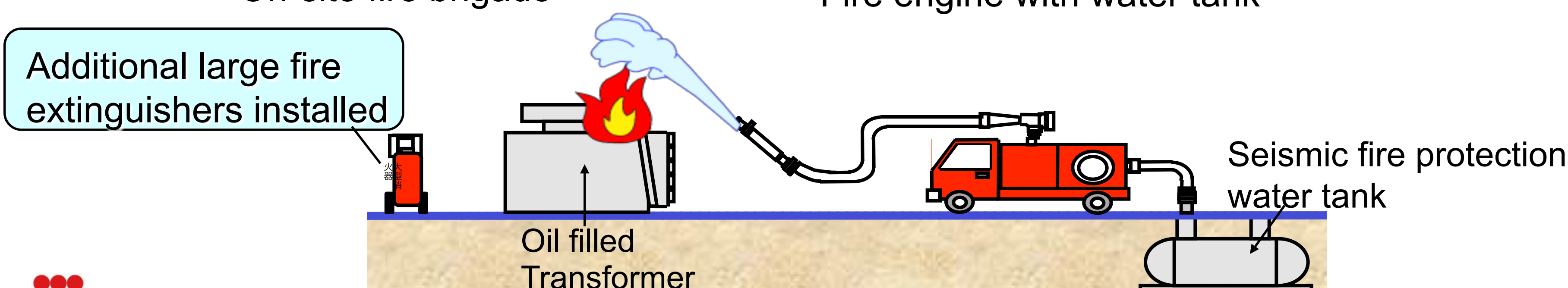
Reinforcement of Emergency Preparedness

- **TEPCO Team for immediate fire fighting**
  - ✓ **On-site fire brigade on around-the-clock standby**
  - ✓ **Deployment of chemical fire engine and fire pump truck with a water tank**

On-site fire brigade

Fire engine with water tank

These equipments and trained personnel contributed the post-accident activities, especially for core/SFP cooling.



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Reflecting Fukushima Accident

- During the design stage and afterward, ample consideration was not given to common cause failures originating in external events, which led to a severe situation where almost all the power supplies and safety system functions were lost.
- Continuous efforts to reduce risks were not ample, including the collection, analysis and utilization of information on safety enhancement measures and operational experiences in other countries and/or the consideration of new technical knowledge.
- Preparation for a severe accident was somewhat deficient in terms of facility and personnel deployment.

Challenge for Nuclear Safety Reform

Objective: Strengthen Safety Culture in TEPCO.

Root cause analyses: Reviewed safety activities in the 2000s and identified deficiency in safety awareness, engineering and communication ability.

Safety Awareness

- Lack of awareness that it was important to improve safety continuously
- Reluctant to improve safety measures beyond regulatory requirements
- Overestimate current safety features reliability

Engineering Ability

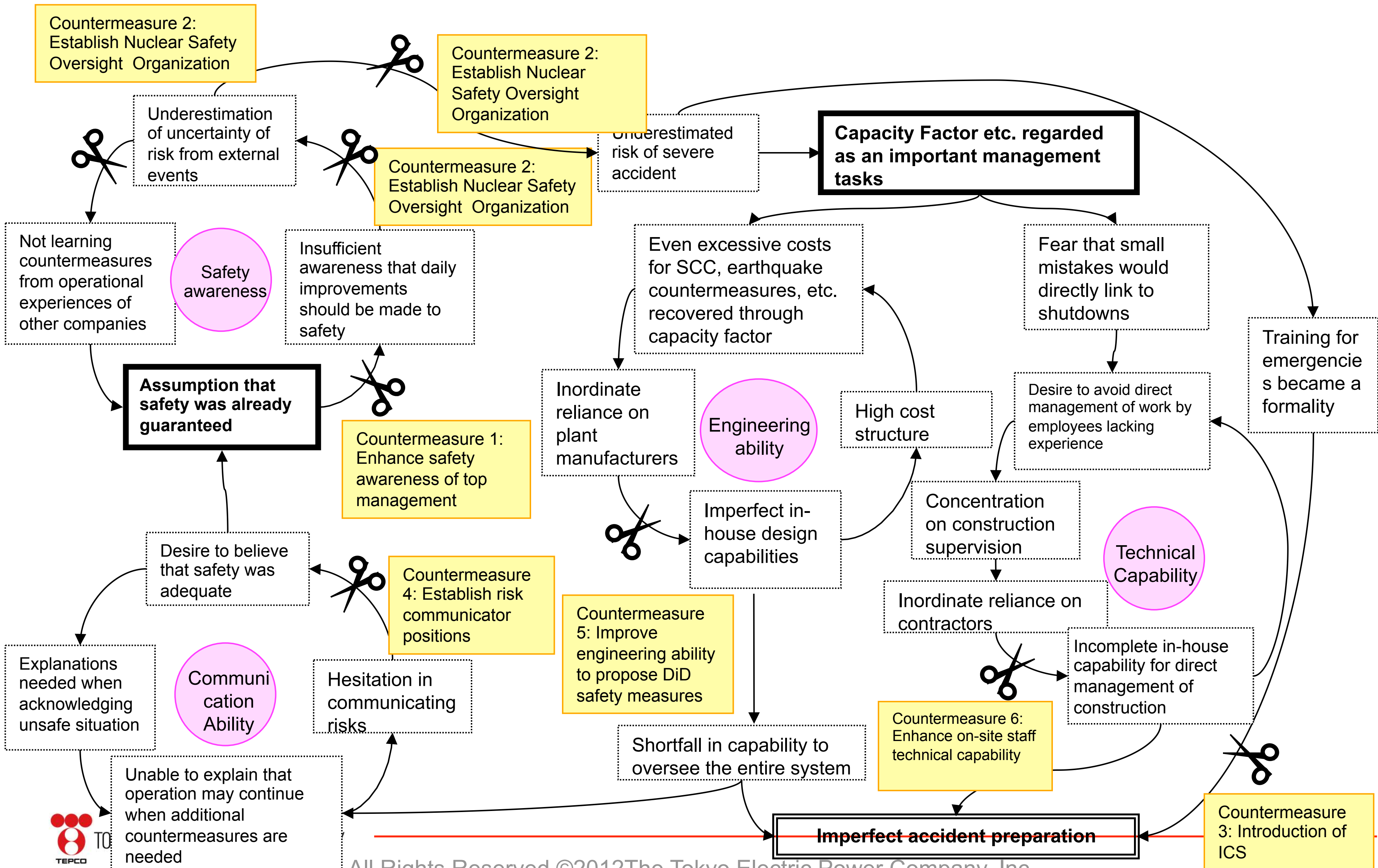
- Lack of awareness that external events cause SBO, which is highly likely to lead to severe accidents
- Lack of ability to develop effective safety measures with limited resources in short period.
- Cannot use information effectively from overseas or other power stations.

Communication Ability

- Reluctant to acknowledge required improvements for fear of losing public confidence in nuclear safety

Negative Spiral of Insufficient Accident Preparation

We believed safety had been established and concerned capacity factor mainly then reluctant to improve safety measures.



Action Plan

1. Enhance safety awareness of top management

   *IAEA Senior Management Workshop on Safety Culture under consideration

2. Establishment of Nuclear Safety Oversight Organization (NSOO)

3. Reorganize emergency response team based on Incident Command System (ICS)

4. Improve engineering ability to propose Defense in Depth (DiD) safety measures

5. Establish risk communicator positions and Social Communication Office to build trust with local community and public

6. Enhance on-site staff technical capabilities

4. Summary

- Nuclear operators must recognize that even the most superior engineers cannot be perfect enough to cover all the aspects for safety enhancement in a timely manner.
- Nuclear operators should assume that something unexpected could happen in the nuclear business even tomorrow, being much more aware of the risk existing in this business than the people in the other industries, and continuously learn the lessons from any others in a modest manner. Self-complacence could hamper these challenges.
- In order to achieve the above it is definitely necessary for nuclear operators to routinely collaborate with other people, other groups, other companies and other countries as if they were their neighbors.

4. Summary (Continued)

- Communication skills and understandings of behavior science and organization dynamics at a certain level are critical for nuclear operators, that could be essential factors for robust safety culture to be developed.

- Though unique efforts like blind training to improve the capability to respond to the unexpected might be valuable for nuclear operators in parallel with efforts for making the experience basis more robust, the ultimate measures might be to continuously improve their own fundamental engineering capabilities and firsthand technical skills.

Thanks for your attention !

&

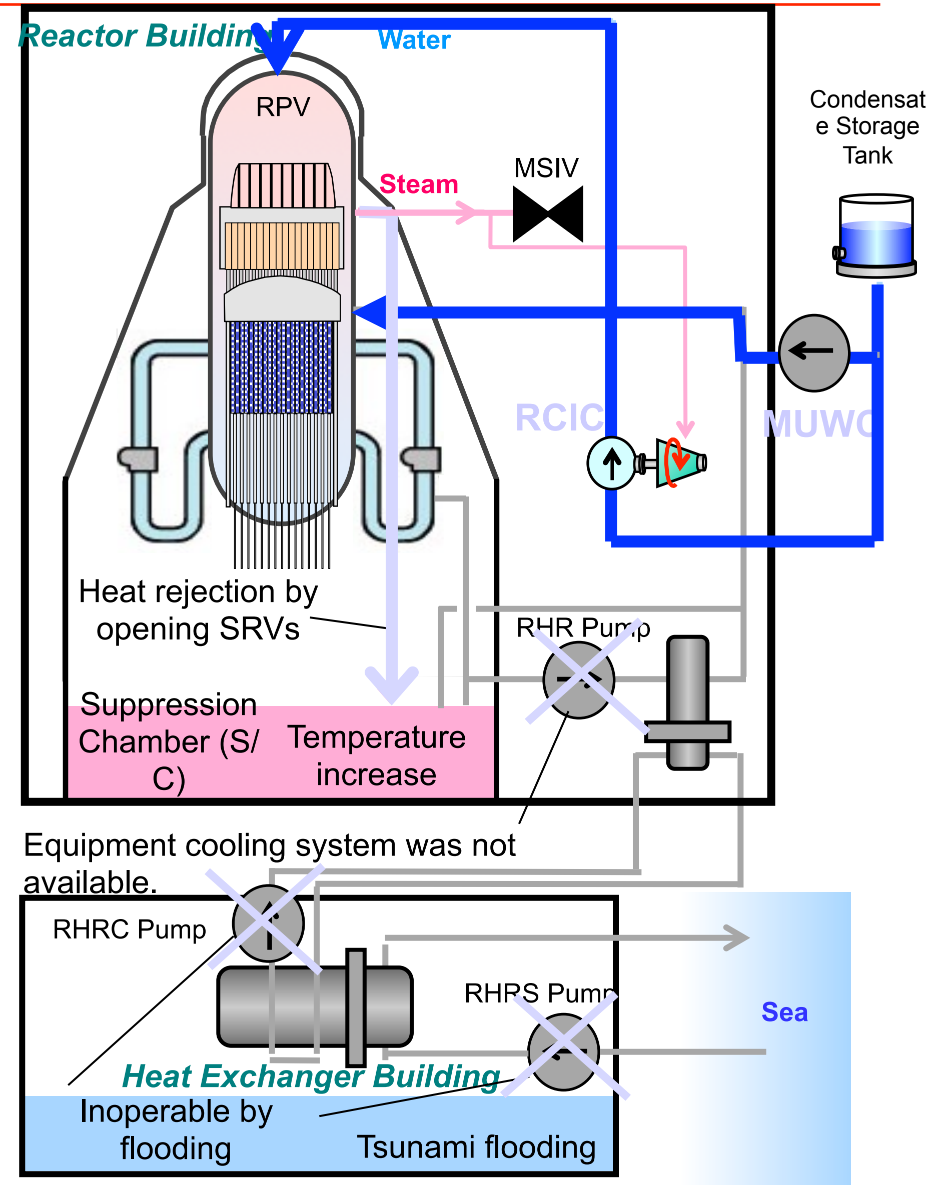
Thank you so much for all of your supports you have already provided us and in anticipation of your continuous supports in future !

Reference

2F Recovery Process

Response at Main Control Room and TSC

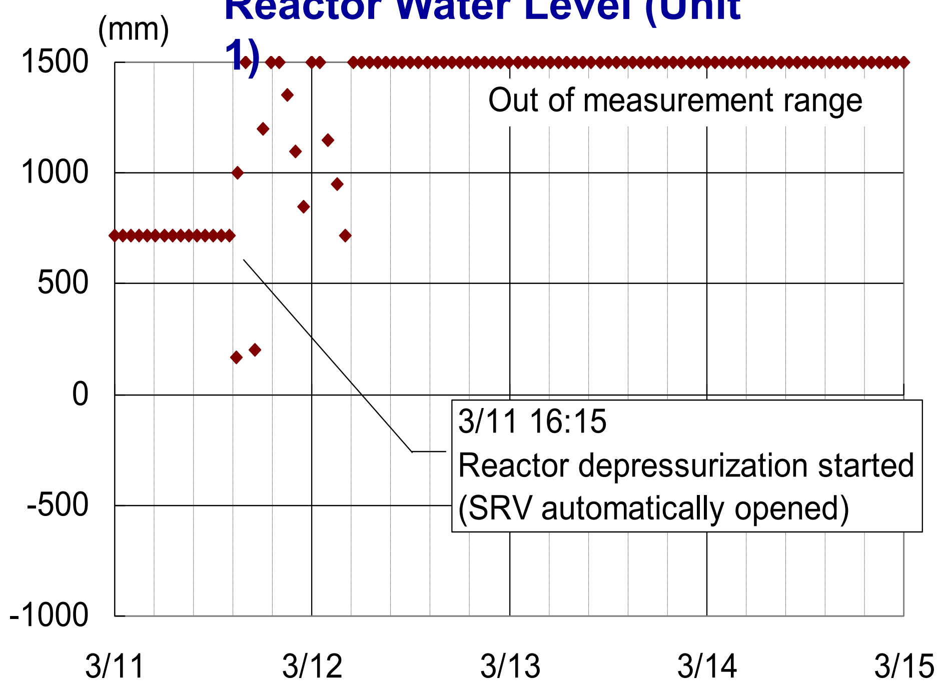
- Operator's initial response
  - MSIVs closed manually, and reactor pressure controlled by SRVs.
  - RCIC actuated manually to maintain reactor water level. RCIC repeated automatic trip due to high water level signal and manual restart.
  - MUWC actuated for alternative water injection measure introduced for Accident Management, as stated in EOP manual for seamless water injection.
  - Reactor depressurized and RCIC stopped due to steam pressure decrease.
  - Water level maintained by MUWC.



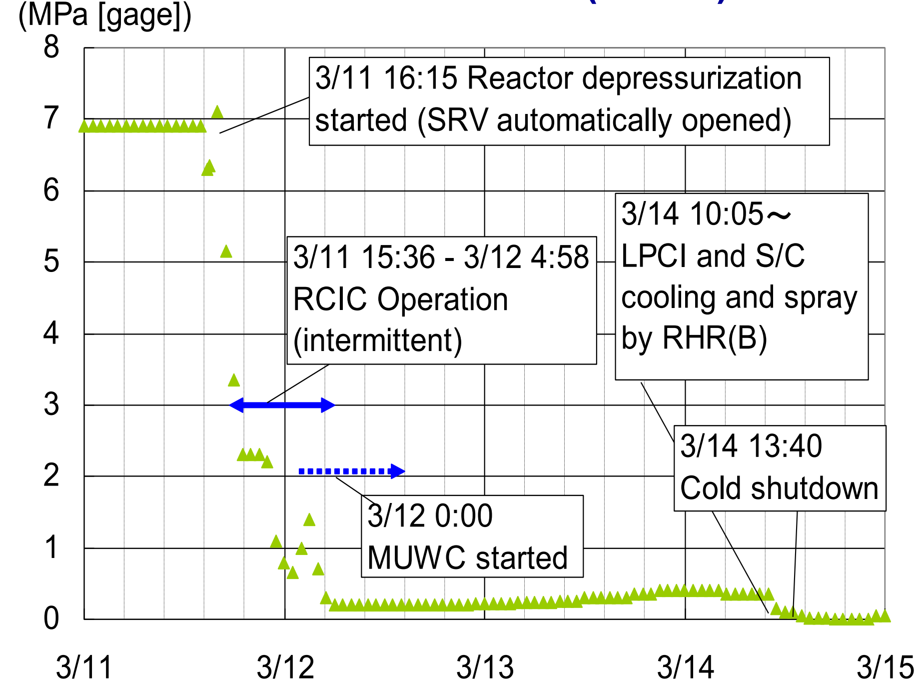
Successful Reactor Cooling during Transient

Securing uninterrupted water injection throughout the depressurization process with RCIC at high pressure condition and MUWC at low pressure condition was a critical factor for successful reactor cooling.

Reactor Water Level (Unit 1)



Reactor Pressure (Unit 1)



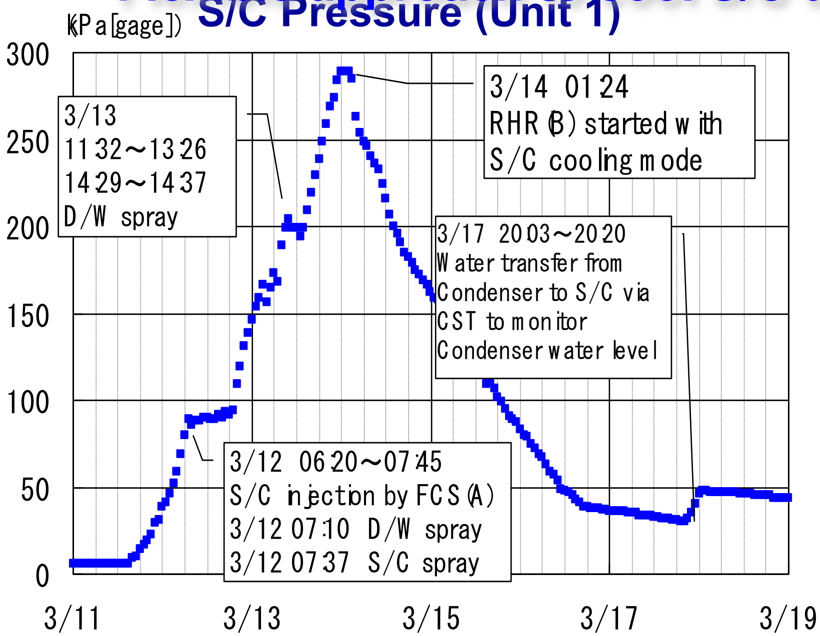
Efforts to Control Temperature and Pressure in PCV

- S/C water temperature reached 100ºC (212F).
  → It eventually increased up to about 130ºC (266F).
- Water injected to S/C through Hydrogen Recombiner cooler discharge line in order to mitigate temperature and pressure increases.
- Alternative injection to reactor using MUWC switched to D/W spray, then S/C spray.
- S/C temperature decreased after restoration of RHR.

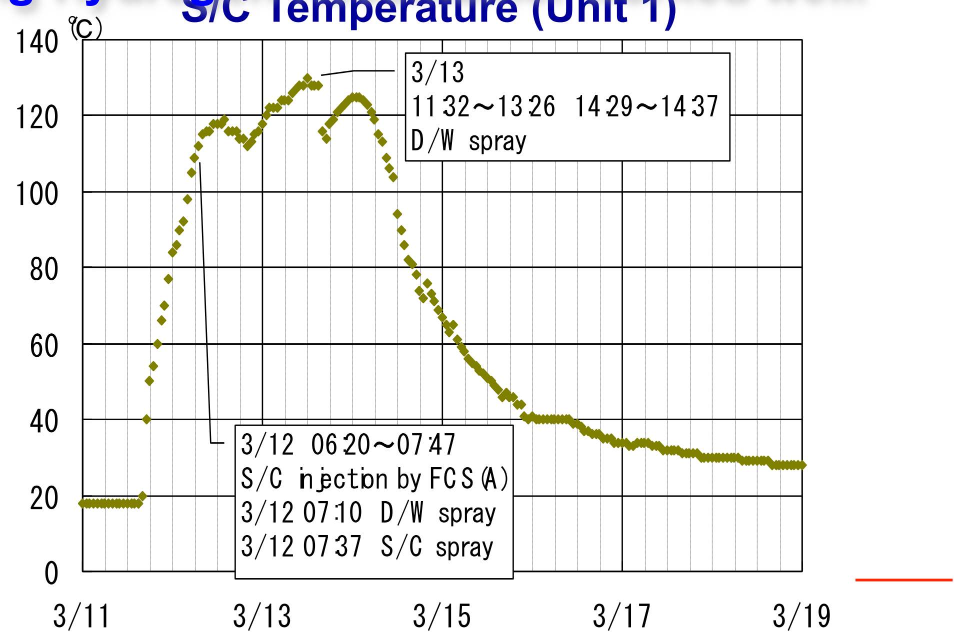
EOP includes an alternative water injection measures employing MUWC .

Flexible approach to cool S/C using Hydrogen Recombiner worked well.

S/C Pressure (Unit 1)



S/C Temperature (Unit 1)



System Status after the Tsunami at 2F

System		Unit 1		Unit 2		Unit 3		Unit 4	
RHR(A) including cooling systems	RHR(A)	×	inoperable due to the loss of power source and cooling system	△	inoperable due to the loss of cooling system	△	inoperable due to the loss of cooling system	△	inoperable due to the loss of cooling system
	RHRC/RCRS(A,C)	×	inoperable due to the submerge of power source and motor	×	inoperable due to the submerge of power source and motor	×	inoperable due to the submerge of power source and motor	×	inoperable due to the submerge of power source and motor
	EECW(A)	×	inoperable due to the submerge of power source and motor	×	inoperable due to the submerge of power source and motor	×	inoperable due to the submerge of power source and motor	×	inoperable due to the submerge of power source and motor
LPCS		×	inoperable due to the loss of power source and cooling system	△	inoperable due to the loss of cooling system	△	inoperable due to the loss of cooling system	△	inoperable due to the loss of cooling system
EDG(A)		×	inoperable due to submerge	△	inoperable due to the loss of cooling system	△	inoperable due to the loss of cooling system	△	inoperable due to the loss of cooling system
RHR(B) including cooling systems	RHR(B)	△	inoperable due to the loss of cooling system	△	inoperable due to the loss of cooling system	○	stand-by	△	inoperable due to the loss of cooling system
	RHRC/RCRS(B,D)	×	inoperable due to the submerge of power source and motor	×	inoperable due to the submerge of power source	○	stand-by	×	inoperable due to the submerge of power source and motor
	EECW(B)	×	inoperable due to the submerge of power source and motor	×	inoperable due to the submerge of power source	○	operation	×	inoperable due to the submerge of power source
RHR(C)		△	inoperable due to the loss of cooling system	△	inoperable due to the loss of cooling system	○	stand-by	△	inoperable due to the loss of cooling system
EDG(B)		×	inoperable due to submerge	△	inoperable due to the loss of cooling system	○	operation	△	inoperable due to the loss of cooling system
RWCU		△	inoperable due to the loss of cooling system	△	inoperable due to the loss of cooling system	△	inoperable due to the loss of cooling system	△	inoperable due to the loss of cooling system
MUWC (alternative water injection)	MUWC(B)	○	stand-by	○	stand-by	○	stand-by	○	stand-by
RCIC		○	stand-by	○	stand-by	○	stand-by	○	stand-by

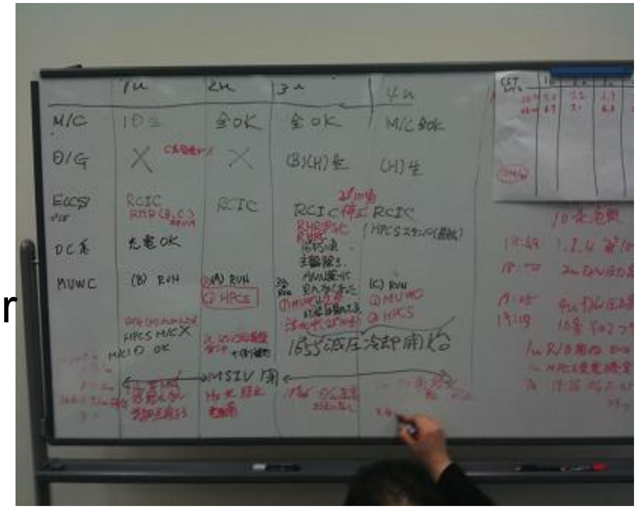
○ ; secure (power, pump and motor all working) △ ; malfunction (inoperable due to factor other than power, pump or motor)

× ; loss of function (power, pump or motor inoperable)

Field Walkdown

In order to establish a well-prioritized restoration strategy, degree of damage and possibility of short-term restoration must be understood through walkdown.

- Challenges in conducting field walkdown
  - Under continuous tsunami alerts, walkdown must be done in the field where a lot of debris, openings and flooding areas existed in the dark.
  - Preparation for emergency evacuation in case of further tsunami and other safety measures for personnel going out to the field.
  - Successful access to the field was 6 hours after the tsunami flooding.
- Field walkdown after the tsunami
  - Plant equipment status checked / component functionality verified.
  - Results were summarized and shared at TSC.
  - TSC set priorities on recovery of RHR (B) cooling systems by replacing motors and supplying power from survived electrical buses and mobile power vehicles through temporary cable.



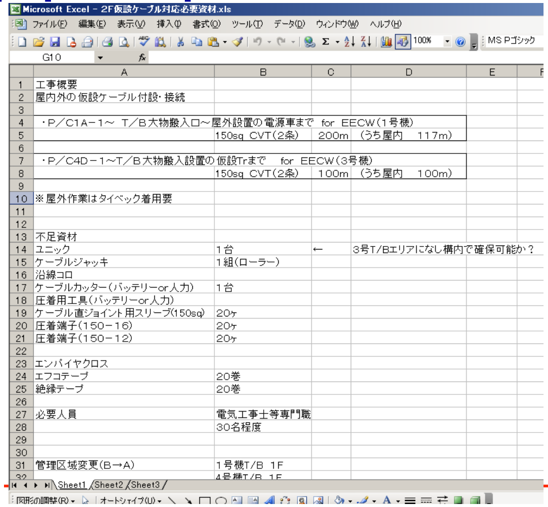
Logistics in Emergency Situation

- Procurement and transportation of Materials and Equipment
  - Emergency procurement of motors, cable, mobile power vehicles, fuel oil and mobile transformers with close cooperation between site TSC and corporate ERC.
  - Rated output of some motors were not the same as that of the original motors.

  →TSC determined to install them based on the evaluation of actual load conditions.
- Difficulties experienced in logistics
  - Motors were transported from Toshiba by a chopper of SDF and from Kashiwazaki Kariwa NPP by trucks.
  - Securing redundant communication measures were critically important when major highway was damaged and public cell phone services were disrupted.

Mobile Power Vehicles

Necessary materials and equipment prioritized and listed



Microsoft Excel – 2F仮設ケーブル対応必要資材.xls

	A	B	C	D
1	工事概要			
2	屋内外の仮設ケーブル付設・接続			
3				
4	・P／C1A−1〜 T／B大物搬入口〜屋外設置の電源車まで for EECW（1号機）			
5		150sq CVT（2条）	200m	（うち屋内 117m）
6				
7	・P／C4D−1〜T／B大物搬入設置の仮設Trまで for EECW（3号機）			
8		150sq CVT（2条）	100m	（うち屋内 100m）
9				
10	※屋外作業はタイベック着用要			
11				
12				
13	不足資材			
14	ユニック	1台	←	3号T/Bエリアになし構内で確保可能か？
15	ケーブルジャッキ	1組（ローラー）		
16	沿線コロ			
17	ケーブルカッター（バッテリーor人力）	1台		
18	圧着用工具（バッテリーor人力）			
19	ケーブル直ジョイント用スリーブ(150sq)	20ヶ		
20	圧着端子（150−16）	20ヶ		
21	圧着端子（150−12）	20ヶ		
22				
23	エンバイヤクロス			
24	エフコテープ	20巻		
25	絶縁テープ	20巻		
26				
27	必要人員	電気工事士等専門職		
28		30名程度		
29				
30				
31	管理区域変更（B→A）	1号機T/B 1F		
32		4号機T/B 1F		

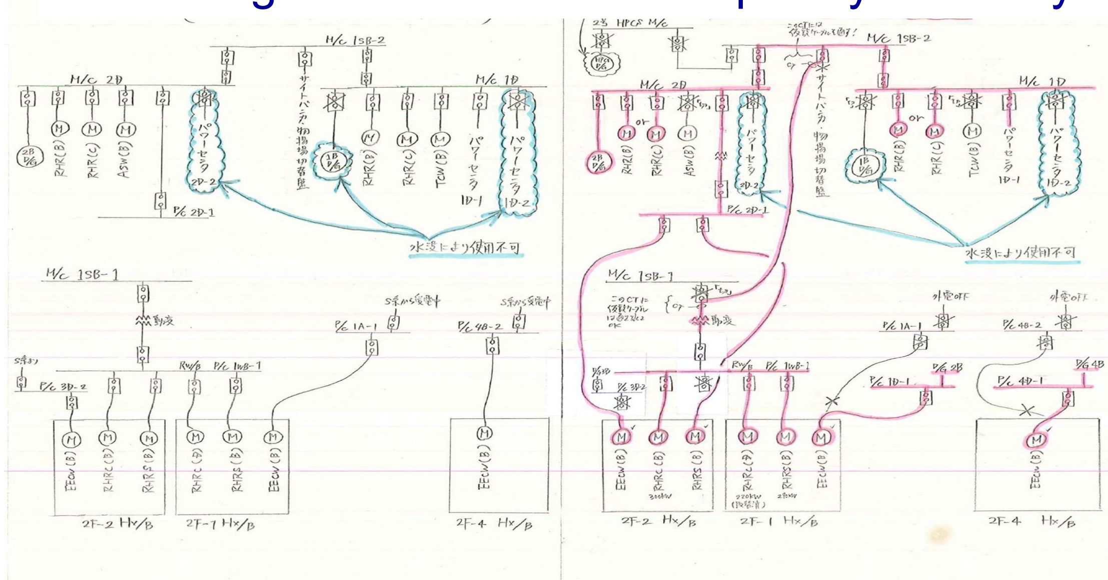
Fuel oil delivery to the site

Emergency Restoration Efforts in the Field

- Pumps of RHR cooling systems (RHRC, RHRS, EECW) were inspected.
- Motors were replaced for pumps in RHRC and EECW.
- In order to restore the inundated electrical buses, temporary cable and high voltage mobile power vehicles were deployed.
- Temporary cable was laid from survived power cubicles in Rad-Waste Building and Unit 3 H

Motor replacement

Drawing made at TSC for temporary cable laying



System Status after Emergency Restoration at 2F

System		Unit 1		Unit 2		Unit 3		Unit 4	
RHR(A) including cooling systems	RHR(A)	×	inoperable due to loss of power source and cooling system	△	inoperable due to loss of cooling system	△	inoperable due to loss of cooling system	△	inoperable due to loss of cooling system
	RHRC/RCRS(A,C)	×	inoperable due to submerge of power source and motor	×	inoperable due to submerge of power source and motor	×	inoperable due to submerge of power source and motor	×	inoperable due to submerge of power source and motor
	EECW(A)	×	inoperable due to submerge of power source and motor	×	inoperable due to submerge of power source and motor	×	inoperable due to submerge of power source and motor	×	inoperable due to submerge of power source and motor
LPCS		×	inoperable due to loss of power source and cooling system	△	inoperable due to loss of cooling system	△	inoperable due to loss of cooling system	△	inoperable due to loss of cooling system
EDG(A)		×	inoperable due to submerge	△	inoperable due to loss of cooling system	△	inoperable due to loss of cooling system	△	inoperable due to loss of cooling system
RHR(B) including cooling systems	RHR(B)	○	operation	○	operation	○	operation	○	operation
	RHRC/RCRS(B,D)	○	operation	○	operation	○	operation	○	operation
	EECW(B)	○	operation	○	operation	○	operation	○	operation
RHR(C)		○	stand-by	○	stand-by	○	stand-by	○	stand-by
EDG(B)		△	operable using tie-line from unit #2	○	stand-by	○	stand-by	○	stand-by
RWCU		△	inoperable due to the loss of purge line	△	inoperable due to the loss of purge line	△	inoperable due to the loss of purge line	△	inoperable due to the loss of purge line
MUWC (alternative water injection)	MUWC(B)	○	stand-by	○	stand-by	○	stand-by	○	operation
RCIC		×	inoperable for loss of core pressure	×	inoperable for loss of core pressure	×	inoperable for loss of core pressure	×	inoperable for loss of core pressure

○ ; secure (power, pump and motor all working) △ ; malfunction (inoperable due to factor other than power, pump or motor)

× ; loss of function (power, pump or motor inoperable)

2F Key Success Factors

Organization and Management Features

- Accident mitigation by applying EOP and AMG
- Prioritized restoration strategy based on Field Walkdown
- Prompt restoration with success of emergency procurement for materials and equipment
- Logistics for long term emergency response
- Organizational integrity: Leadership, Communication, Accountability, Professionalism

Design/Engineering Features

- Availability of most of M/C, P/C and Battery
- Availability of off-site power

Details on Action Plan

Countermeasures 1～6

Countermeasure 1: Reform Starting from Management

[Main Points]

*The management must be strongly conscious of the special risks inherent in nuclear power, be aware that nuclear power operators bear responsibility for safety, and demonstrate leadership in order to raise safety awareness throughout the organization.

*Nuclear leaders (executive officers, site superintendents, corporate general managers) must personify appropriate behavior, be evaluated, and work to improve their own abilities.

*Management needs to take the initiative to imbue a safety culture throughout the organization.

[Countermeasures]

*Increase knowledge about the safety required for nuclear power, and implement our own nuclear safety reforms to disseminate a safety culture throughout the organization.

* Conduct quarterly 360-degree evaluation (comprising evaluations from superiors, peers, subordinates, as well as the opinions of contractors and people in siting communities) of nuclear power leaders and provide feedback to the leaders evaluated.

[**Management** (all executive officers)]
* Study examples of management reform successes and failures at other companies
* Basic principles of nuclear safety design and safety culture
* Causes of Fukushima nuclear accident and countermeasures
* Other topics

[**Nuclear Leaders** (executive officers, site superintendents, corporate general managers)]
In addition to the items listed on the left,
* Refresh plant operational knowledge through upper level courses at operation training center, etc.
* Acquire the latest knowledge, conduct plant walkdowns, etc.

Countermeasure 2: Enhancement of Oversight and Support for Management

[Main Points]

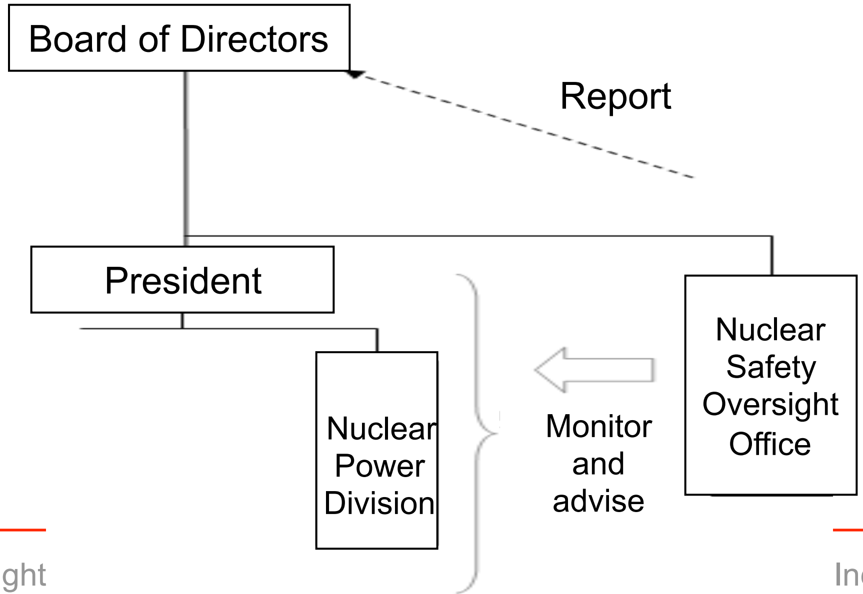
＊ The Board of Directors of a nuclear operator is obliged to oversee nuclear safety. For that purpose, the required support organizations will be established, which will report the necessary information to the Board of Directors.

[Countermeasures]

＊ Establish a "Nuclear Safety Oversight Office" to assist the TEPCO directors in decision making.

＊ The Nuclear Safety Oversight Office will invite its personnel in charge from outside the company to evaluate activities related to nuclear safety from a position independent of those implementing such activities, and to both monitor and advise those doing the implementation while also reporting to the TEPCO Board of Directors.

＊ Additionally, efforts will be made to enhance the roles of middle management and Chief Reactor Engineer.



Countermeasure 3: Reform of Emergency Response Organizations at the Power Stations and Headquarter

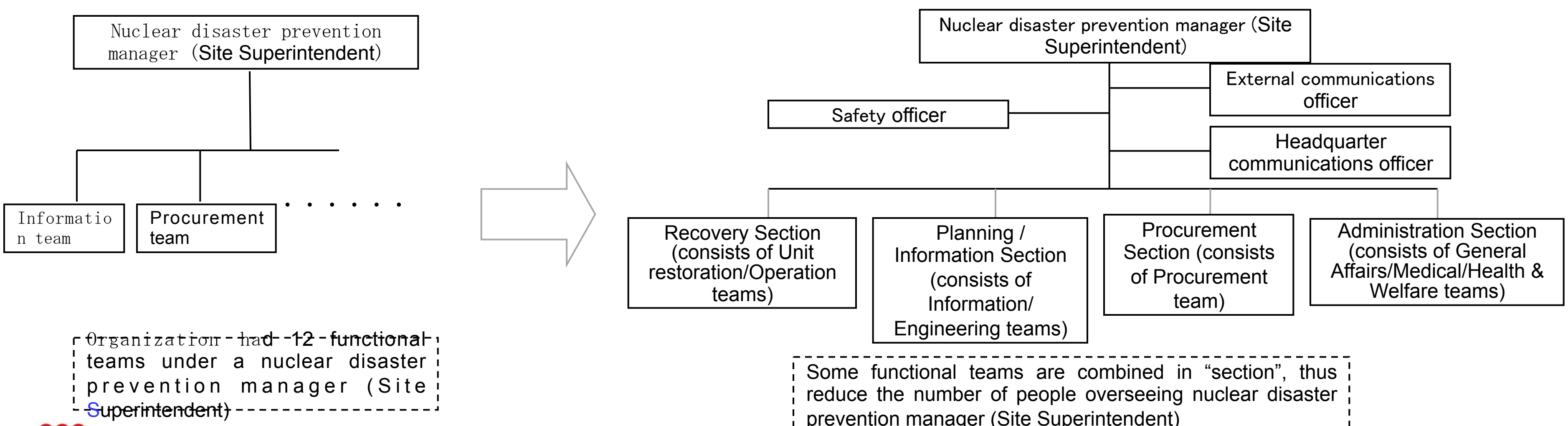
[Main Points]

∗ After the disaster, the activities at the site was in disarray because "the chain of command system was unclear" and "information was not fully shared" as well as other factors.

[Countermeasures]

In emulation of the Incident Command System (ICS) as characterized below that serves as a standardized emergency response structure in the U.S. , reorganize the emergency response organizations at TEPCO power stations and the Headquarter.

- Limit the number of people a single manager oversees to 7 at most
- Clarify division of responsibilities chain of command system (follow only the instructions of direct superiors)
- Clarify the division of roles (decision-making authority should be given to the commander in the field)
- Flexible organizational structure that can expand or contract depending on the scale of a disaster
- Prepare and put into use modalities and tools for sharing information efficiently throughout the organization
- Clarify skills and requisites, and provide thorough and going education and training



Countermeasure 4: Enhancement of Risk Communication Activities (1) Establishment of Risk Communicator Positions

[Main Points]

＊We need to extricate ourselves from "thought-stopping patterns" which are based on the assumption that, if risks are announced, requests for excessive countermeasures will be demanded by regulators and siting communities, necessitating a reactor shutdown.

＊TEPCO, as a company that caused a severe accident, has the duty to make risks known and convey countermeasures broadly to the general public.

Given the above challenges, we will **establish the specialist position of "risk communicator"** for handling risk-related communications from a position close to management and nuclear power leaders.

[Countermeasures]

＊ Risk communicators will make proposals to management and nuclear power leaders, from society's perspective, regarding strategies for explaining risk awareness, formulation of countermeasures in keeping with public announcements, and the limits thereof. They will also undertake risk communications based on the policies developed.

＊ Risk Communicators will regularly engage in dialogue with others and solicit advice and suggestions from outside experts while developing skills for carrying out fruitful dialogues with site communities as well as the public more generally.

Countermeasure 4: Enhancement of Risk Communication Activities (2)
Establishment of Social Communication Office

[Main points]

We did not have an accurate understanding of the present situation around us, and our sensitivity to the feelings of people in siting communities and the general public was obtuse, which inflamed public anxiety (response to loss of power supply accident at Fukushima Daiichi Nuclear Power Station, etc.).

Also, we received severe comments from the Third-Party Investigation Committee on TEPCO's Response to the National Diet of Japan Nuclear Accident Independent Investigation Commission (NAIIC), which indicated that our company has communication problems.

Based on such facts, we must urgently make improvements by delving into corporate culture problems with the Nuclear Power Division playing a central role in order to appropriately communicate with society.

Reflecting on the fact that previous improvement activities could not delve into deep-rooted corporate culture problems, we will invite people outside the company, thereby bridging the gap between our way of thinking and judgment and the standards accepted by society at large, and, at the same time, we will put a framework in place to prevent aggravation of risk.

[Countermeasures]

・Invite a person from outside the company to become the "SC General Manager", establish the organization (SC Office) which is directly responsible to the President, and implement the following;

<Internal educational activities>

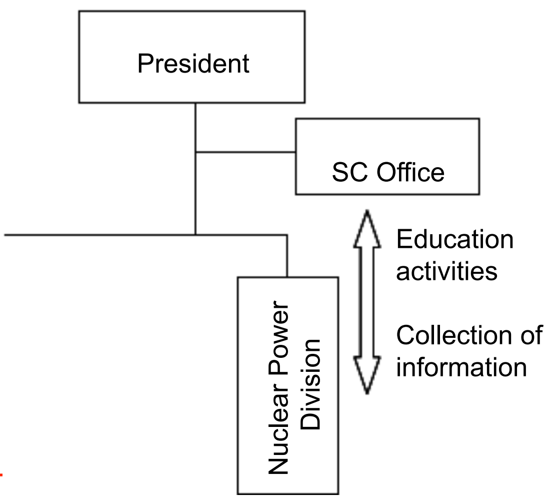
- By utilizing a nuclear power risk communicator, we will collect information on risks beforehand by being involved in the substance of operations, and will simultaneously conduct education activities about the importance of sensitivity to the perspective of people in society.

<Collection of information on the status of activities, instructions for improvement>

- Analyze collected risk information and give instructions on necessary improvement measures for each obvious or latent risk in keeping with the standards of society at large.

<Internal sharing of examples of instructions for improvement>

- Extensively share instruction specifics internally to provide risk management and internal reform throughout the company



<Ref.> Regarding Comments [*1] by the Third-Party Investigation Committee on TEPCO's Response to NAIIC

* As for misleading explanations given to the National Diet Nuclear Accident Independent Investigation Commission (NAIIC), TEPCO received the following three improvement requests from the Third-Party Investigation Committee:

- Enhance employee education in regard to negotiations with external organizations
- Organize a cooperative framework and a support framework among employees
- In regard to the need for showing the attitude of TEPCO as a whole to the external organizations, build an organizational structure in which the directives from the top management spread down among all employees, and the employees are able to consult top management at an early stage.

We think implementation of Countermeasure "Establishment of Social Communication Office," in addition to the aforementioned Countermeasure 1 "Reform Starting from Management" and Countermeasure 4 (1) "Establishment of Risk Communicator Positions," will prompt a revamping of the organization through educational activities for the company, which will result in solution to the request by the Third-Party Investigation Committee.

*1: Third Party Investigation Committee on TEPCO's Response to NAIIC's "Report of Verified Results (March 13, 2013)"

<Ref.> Roles of the SC Office and Nuclear Power Risk Communicators

* The SC Office will utilize nuclear power risk communicators (“RC”) as the pivotal points for risk management in responding to external organizations on behalf of the entire Nuclear Power Division.

Input from RCs to SC Office

* Demonstrate the faculty to pick up information about nuclear power risks
  - Make proposals about risks to be administered by management in regard to risks considered to have a significant influence on management as based on information provided by the Nuclear Power Division and in responding to external organizations on a daily basis.
  - RC will engage in the management of cases on a daily basis (time limit control) about the risks faced by the Nuclear Power Division and the matters of concern when responding to external organizations, thereby sharing information on a timely basis.

Output by RCs (Implementation of risk communication)

* Implement external communication activities concerning nuclear power risks
  - In response to SC Office’s proposal of the policy to publically announce important cases, RCs will create talking points and implement risk communication personally at each site.
  - RCs will acquire the perspective of society through daily communication about nuclear power, and, at the same time, will play some role in educational activities for the Nuclear Power Division.

Countermeasure 5: Enhancement of Ability to Propose Defense in Depth Safety Measures

[Main Points]

In order to decrease residual risks to a socially permissible level, it is necessary to continuously make an effort to enhance safety improvement measures. For this reason, we will construct a system for developing the technological capability for promptly proposing the enhancement of highly cost-effective measures to improve safety in accordance with defense in depth. Also, we will organize our working environment in keeping with enhanced technological capability.

[Countermeasures]

* From a standpoint of accumulating defense in depth, we will reassess operational processes.
  - Promote cross-organizational proposals so that planning and implementation of safety measures will take root as routine work, and we will accumulate a series of successes which realize outstanding proposals for improvement (safety improvement competition)
  - From a standpoint of building a defense-in-depth structure, draw lessons from operational experiences information from both Japan and other countries
  - Conduct hazard analyses of external events causing rare though severe situations
  - Frequently conduct reviews of activities related to nuclear safety (safety review activities)
* We will improve our working environment in order to effectively promote improvement of the processes described above.
  - Improve performance evaluation related to nuclear safety
  - Reassess operations focused heavily on evidence
  - Improve cross-organizational capability for solving problems
  - Reassess personnel exchanges between divisions

TOKYO ELECTRIC POWER COMPANY
TEPCO

Countermeasure 6: Reassessment of Non-Emergency Power Station Organization and Enhancement of On-Site Staff Technical Capability for Direct Maintenance Work

[Main Points]

Reassess power plant organization under normal conditions with the goal of bolstering capability to take a comprehensive view of nuclear safety. Also, strengthen operator's ability and reform the organization to enable maintenance work to be directly performed by maintenance sections so that TEPCO employees can carry out the first response after an accident, and also foster the applied skills for dealing with unanticipated situations.

[Countermeasures]

* Reassess organization under normal conditions

- **Site Superintendent**
  - **GM of Nuclear Power Planning Dept.**
    - * Planning and management of operations/ projects, investments/expenditures
    - * Manages personnel rotations
    - * Staff development/skill training
  - **GM of Administration Dept.**
    - * General affairs
    - * Labor/personnel
    - * Procurement/accounts
    - * Computer systems
  - **GM of Public Relations Dept.**
    - Risk Communicator
    - * Public dialogue-related activities --Localities where plants are sited, central and local governments, media
  - **Unit Superintendent**
    - **GM of Operation Dept.**
      - * Facility operations (including waste treatment)
      - * Systems testing
      - * Plant data diagnostics
      - * Troubleshooting
      - * Fuel and reactor core management
    - **GM of Maintenance Dept.**
      - * All current maintenance operations
      - * Manages work directly
      - * System engineering
      - * Power transmission and transformation
      - * Data communications
      - * Civil engineering
      - * Architectural engineering
  - **Director of Nuclear Safety Management Center**
    - **GM of Safety Management Dept.**
      - * Safety culture
      - * Administrates QMS
      - * Nuclear safety
      - * Nonconformance issue control
      - * Regulatory Assurance
      - * Administrates review of safety management
      - * Fire prevention (equipment)
    - **GM of Disaster & Industrial Accident Prevention Dept.**
      - * Disaster prevention
      - * Fire prevention (operation)
      - * Personnel safety
      - * Security
    - **GM of Radiation Safety Dept.**
      - * Radiation safety (including radiation exposure management)
      - * Radiation control
      - * Radiation chemistry

* Bolster Abilities to perform direct works

- Operators: Train in how to connect power-supply vehicles that the recovery units undertake and conduct regular maintenance work and equipment diagnostics (data collection, simple diagnoses, etc.)

-Maintenance personnel: Develop applied skills by direct maintenance work so as to be able to, when necessary, inject water into a reactor and install or replace temporary equipment.