May 10, 2013

Earthquake and Tsunami Countermeasures in Japan

The Committee for Technical Investigation on Countermeasures for Earthquakes and Tsunamis Based on The Lessons Learned from The “2011 Off The Pacific Coast of Tohoku Earthquake”

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Outline of The Disaster

- We lost about 19,000people（Missing: 2,700） and the injured ones 6,100.
- The death rate is about 2% (In Kobe earthquake: 0.1%)
- Only 125 people were killed due to earthquake.
- Every people in damaged area believed firmly that next earthquake will be Miyagiken-Oki earthquake with the magnitude of around 7.5 (Conclusive evidence bias).
- Therefore, people believed that every countermeasures such as tsunami breakwater, coastal dike, river levee, water gate, hazard map, tsunami forest and also local government building are effective against tsunami.
- The reconstruction process will continue more than 10 years.

Our Central Government Efforts in Committee Activities of Disaster Reduction

- Two important committees (C1: Disaster lessons and C2: Reconstruction principle) started in May,2011.
- After the committees, a new comprehensive committee C3 started in Nov. 2011 and final report was proposed in July 2012.
- C3 includes two special working groups (G1:Nankai Trough Gigantic earthquake and G2: Tokyo Metropolitan earthquake). They will be National catastrophe.
- G1 and G2 is now final stage to propose recommendation.
- May 2013, we have another C4 to promote resilient society against natural disasters.

Ryouishi Fishery Harbor、Kamaishi, Iwate Prefecture

(Seismic Intensity 6+、 Huge Tsunami Warning、 Evacuation Advisory)

Number of Victims：43(Population：650)、 Death Rate：6.7%

Tsunami Height：17.7m （1896 Meiji Sanriku Tsunami：11.6m)

Response of the Japanese Government after the Great East Japan Earthquake (Principle for Disaster Management)

- 27 Apr., 2011： Establishment of a new committee was approved by the Central Disaster Management Council.
- 27 May.： The Committee for Technical Investigation on Countermeasures for Earthquake and Tsunamis Based on the Lessons Learned from the “2011 off the Pacific coast of Tohoku Earthquake”
  （17members, Chair: Yoshiaki KAWATA）
- 26 Jun.： Interim Report
- 12 meetings were held in 4 months. Basic principles for earthquake and tsunami measures, and the revision of the “Basic Disaster Management Plan”.
- 28 Sep.： Submission of the report to the Minister of State for Disaster Management HIRANO.
- 11 Oct.：Reported to the Prime Minister NODA at the Central Disaster Management Council.
- 28 Oct.： Establishment of a new committee（”Council for Promotion of Disaster Management Countermeasures”）. The first meeting held.
- 28 Nov.： The second meeting held.（Draft of the revised Basic Disaster Management Plan）

Committees Established by the Japanese Government after the Great East Japan Earthquake

- **Reconstruction Design Council in response to the Great East Japan Earthquake**
  （15 members：a member）

12 meetings (Apr.14 – Jun.25)

25 Jun. : Submission of the proposal to the Prime Minister, KAN.

10 Nov.: The final meeting（the third supplementary budget, budgetary request, and the reconstruction projects)

This council will be reorganized and renamed next year upon the establishment of the Reconstruction Agency, and will continue for the next ten years.

- **Central Disaster Management Council：“ Committee for Technical Investigation on Countermeasures for Earthquake and Tsunamis Based on the Lessons Learned from the “2011 off the Pacific coast of Tohoku Earthquake ”**
  （17members, the Chair）

12 meetings (May.27 – Sep.28)

Oct. 11: Submission of the report to the Prime Minister, NODA.

Oct. 28: First meeting of the Council for Promotion of Disaster Management Countermeasures（consists of 6 cabinet members and 12 academic experts）

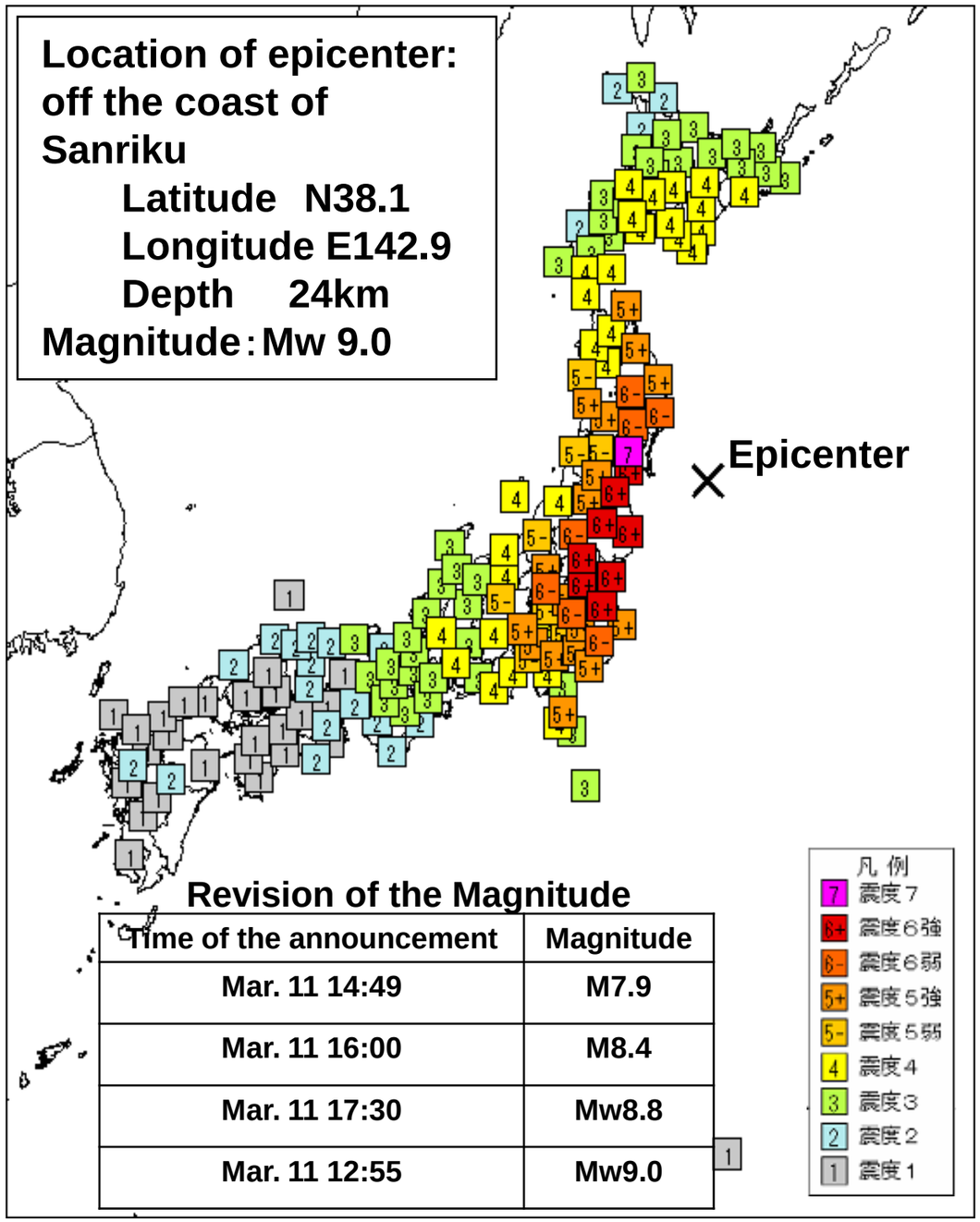
July 31, 2012 Final report

The Overview of the Great East Japan Earthquake 2011

Date and Time : 14:46 March 11, 2011

Observed seismic intensity

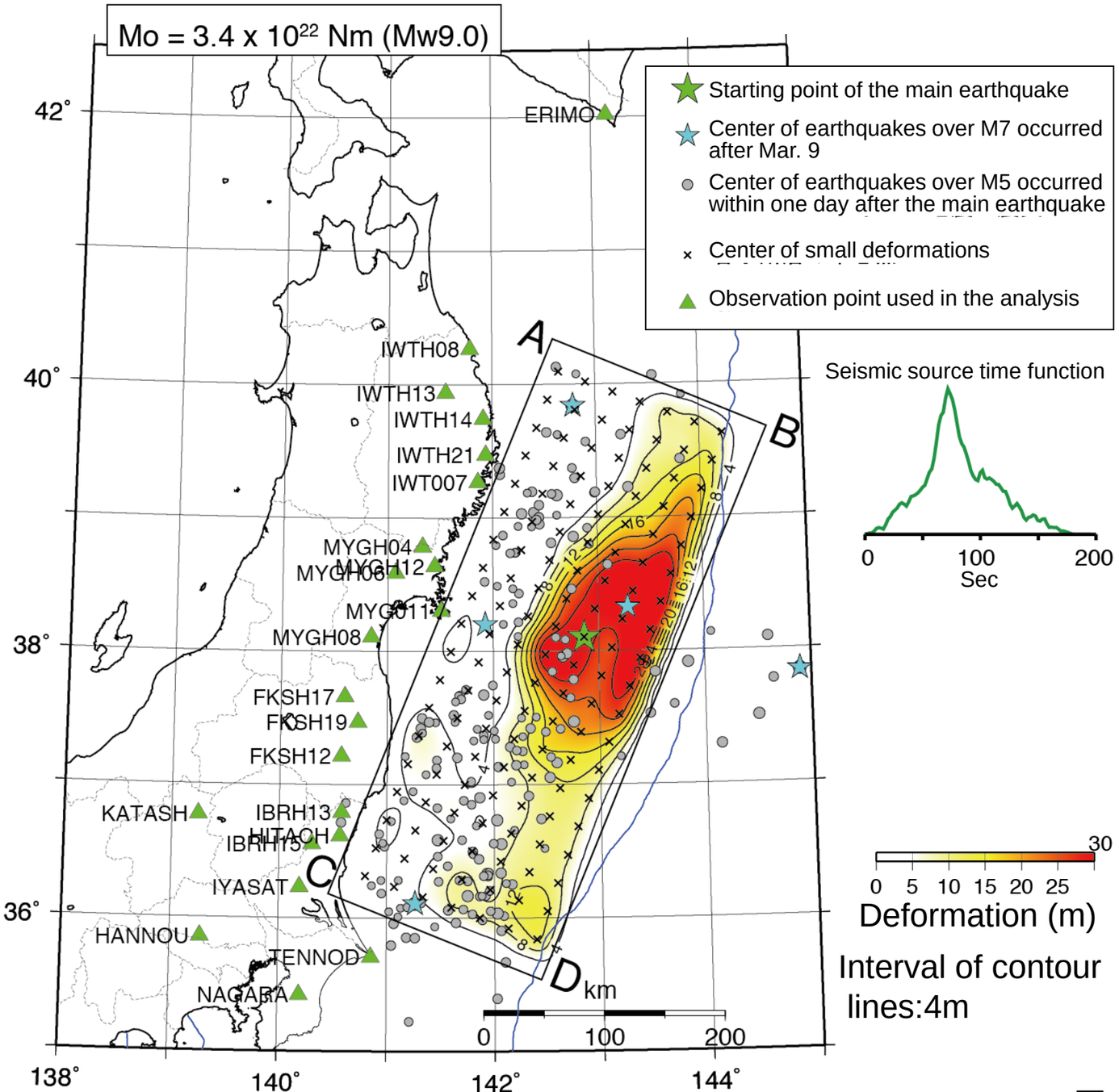
Location of epicenter: off the coast of Sanriku
Latitude N38.1
Longitude E142.9
Depth 24km
Magnitude : Mw 9.0



Revision of the Magnitude

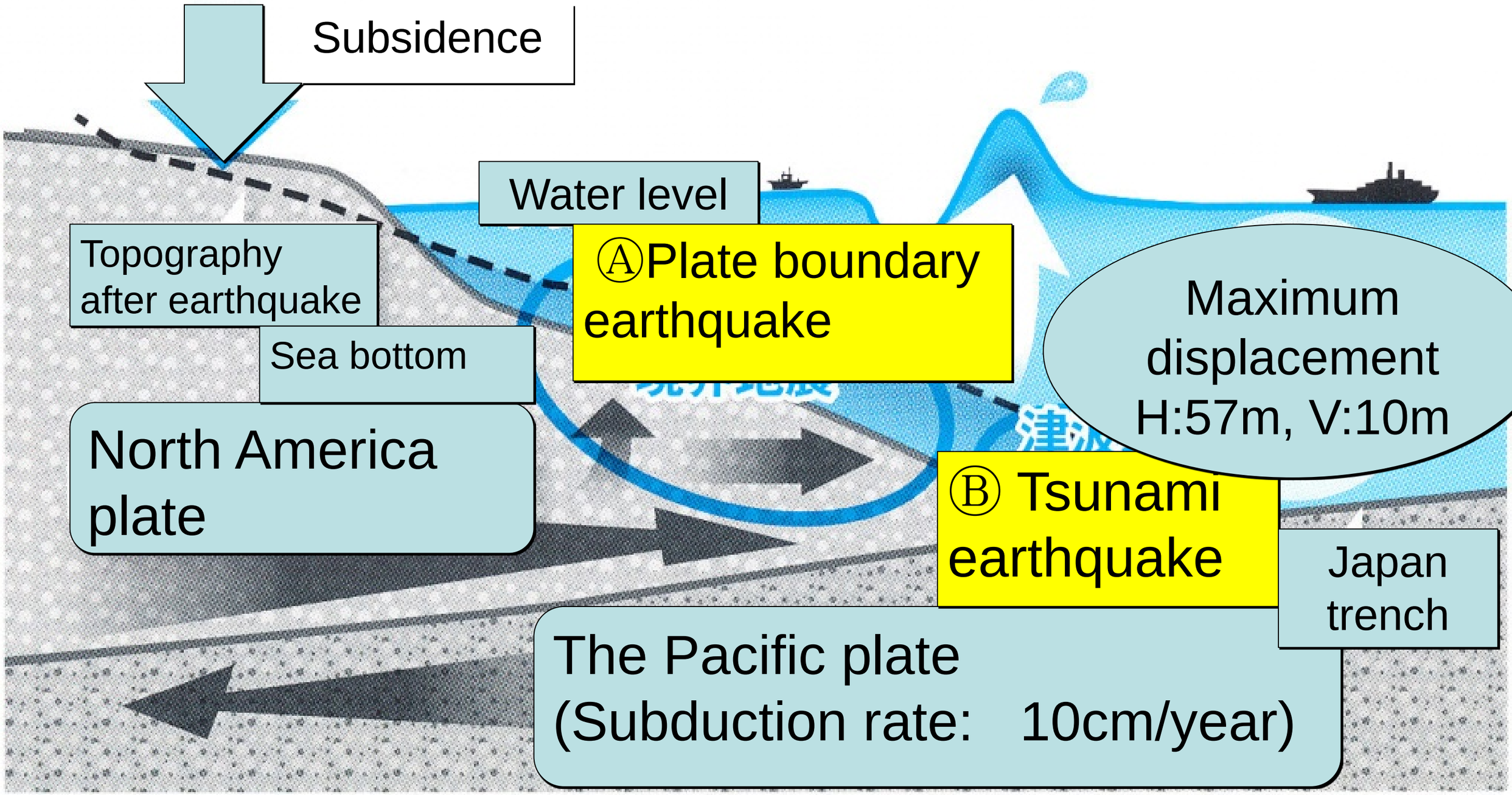
Time of the announcement	Magnitude
Mar. 11 14:49	M7.9
Mar. 11 16:00	M8.4
Mar. 11 17:30	Mw8.8
Mar. 11 12:55	Mw9.0

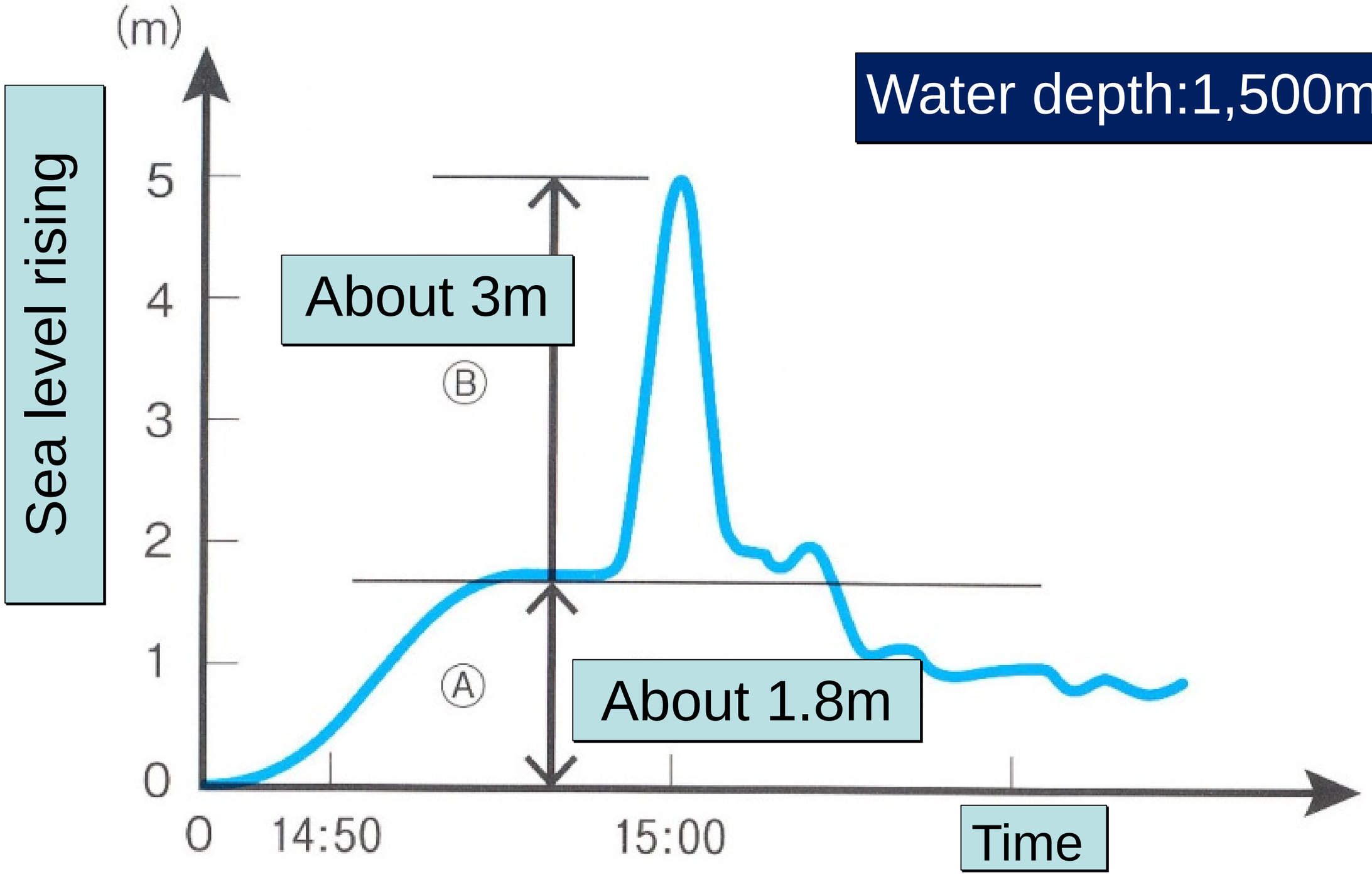
Deformation distribution



（Analysis by Meteorological Research Institute）

Generation Mechanism of Gigantic Tsunami in 2011 East Japan Earthquake



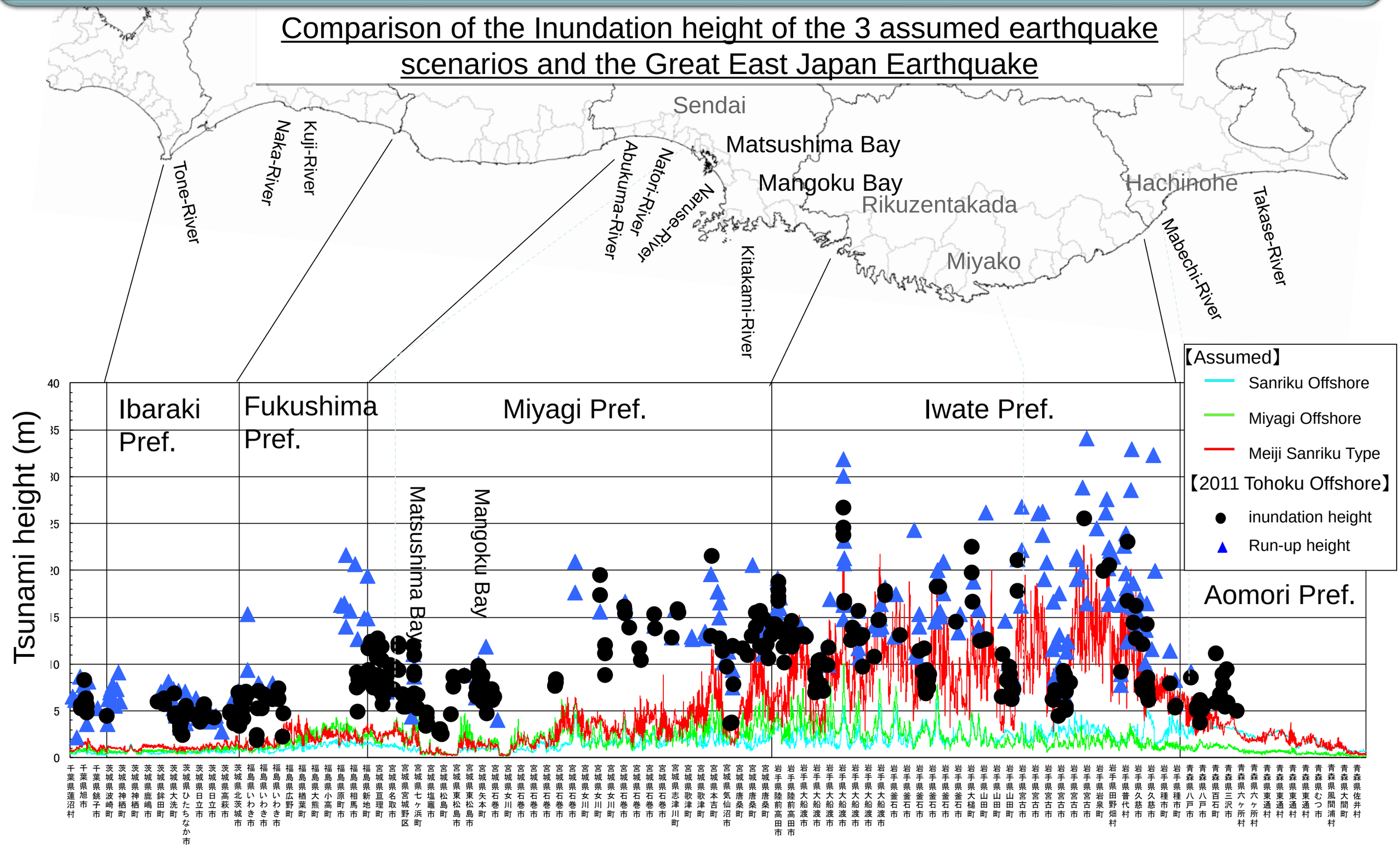


Water depth:1,500m

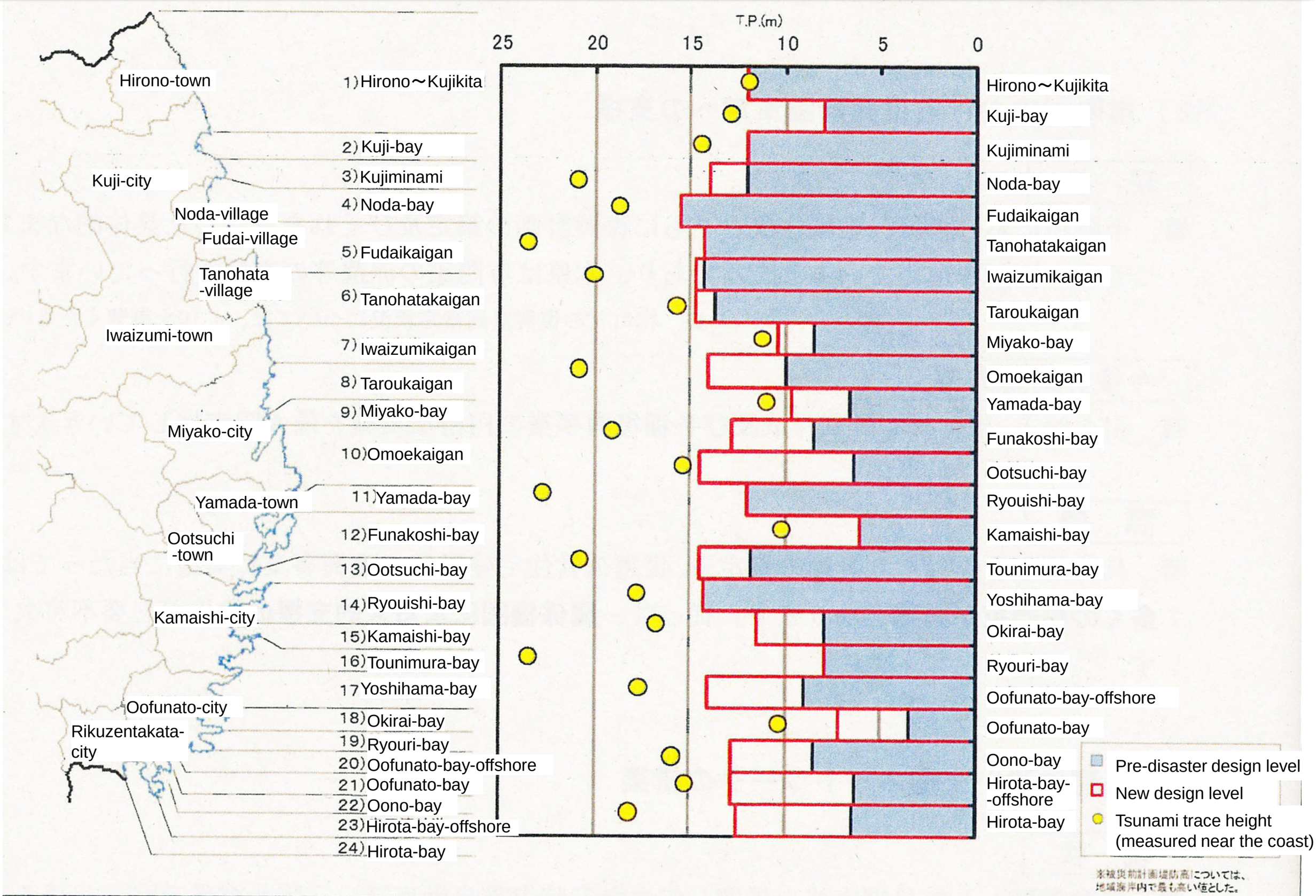
Ⓐ : The first tsunami generated by plate boundary Ear.

Comparison of Former Hazard Assumptions and the Recent Tsunami (Inundation Height and Run-up Height)

Comparison of the Inundation height of the 3 assumed earthquake scenarios and the Great East Japan Earthquake



Height of the coastal protection facilities along the coast of Iwate Pref.

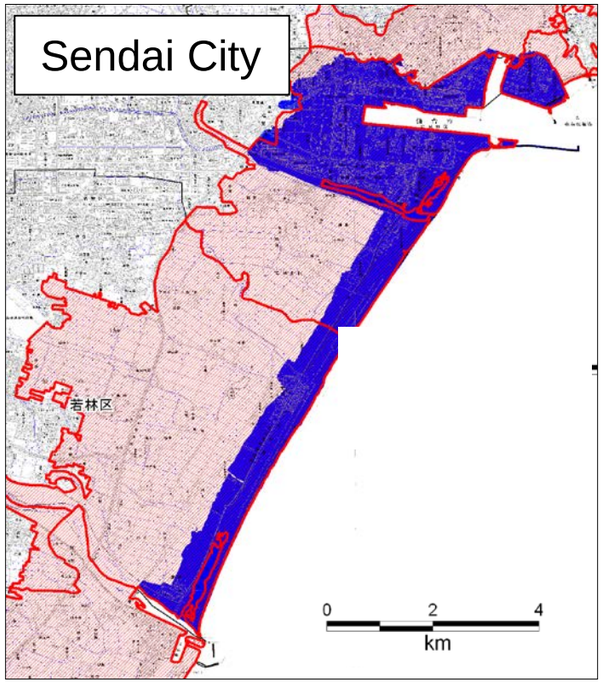


Characteristics and Verification of the Damage Caused by the Recent Earthquake and Tsunami

Characteristics and Verification

- ○ **<u>An enormous earthquake with a magnitude of 9.0, a size that could not be envisaged</u>** from the history of earthquakes in Japan over the last several hundred years.
- ○ The reasons why such enormous tsunamis occurred include the fact that the mechanism causing the tsunami consisted not only of a slipping movement at the deep plate boundaries, but also **<u>a considerable simultaneous slipping movement at the shallow plate boundaries.</u>**
- ○ The enormous tsunami height, extensive inundation area, penetration of inundation area into a considerable distance inland, inundation caused by tsunami run-up along rivers overflowing the river banks, and the widespread occurrence of subsidence all **<u>exceeded any pre-disaster assumptions</u>**. It is **<u>possible that the hazard maps prepared based on the pre-disaster hazard assumptions lead to providing false sense of security to people, and led to an expansion of damage.</u>**
- ○ **<u>The massive tsunami exposed the limitations of disaster management measures that rely to an excessive degree on coastal protection facilities.</u>**
- ○ The estimation of earthquake magnitude and the tsunami height predictions issued by the Japan Meteorological Agency immediately after the earthquake vastly underestimated their true scales, **<u>which possibly blunted the evacuation actions of residents and volunteer fire fighters, leading to expansion of damage incurred.</u>**

Comparison of the inundation area between hazard map and The Great East Japan Earthquake



Inundation Area

- Great East Japan Earthquake
- Hazard map (Sendai City)

（Source）
- inundation area of the Great East Japan Earthquake： drawn from documents from Geospatial information Authority of Japan
- hazard map：Miyako City “Miyako City comprehensive disaster management map”， Ofunato City “Be prepared to the crisis – Tsunami evacuation map to protect our lives”

Situation of Tsunami Warning Announcement

region \ date and time	11日 14:49	11日 15:14	11日 15:30	11日 16:08	11日 18:47	11日 21:35	11日 22:53	12日 03:20	12日 13:50	12日 20:20	13日 07:30	13日 17:58
青森県太平洋沿岸	1m	3m	8m	10m以上	10m以上	10m以上	10m以上	10m以上		切下げ	切下げ	解除
岩手県	3m	6m	10m以上	10m以上	10m以上	10m以上	10m以上	10m以上		切下げ	切下げ	解除
宮城県	6m	10m以上	10m以上	10m以上	10m以上	10m以上	10m以上	10m以上		切下げ	切下げ	解除
福島県	3m	6m	10m以上	10m以上	10m以上	10m以上	10m以上	10m以上		切下げ	切下げ	解除
茨城県	2m	4m	10m以上	10m以上	10m以上	10m以上	10m以上	10m以上	切下げ	切下げ		解除
千葉県九十九里・外房	2m	3m	10m以上	10m以上	10m以上	10m以上	10m以上	10m以上	切下げ			解除
北海道太平洋沿岸中部	1m	2m	6m	8m	8m	8m	8m	8m	切下げ	切下げ		解除
北海道太平洋沿岸東部	0.5m	1m	3m	6m	6m	6m	6m	6m	切下げ	切下げ		解除
北海道太平洋沿岸西部	0.5m	1m	4m	6m	6m	6m	6m	6m	切下げ	切下げ		解除
伊豆諸島	1m	2m	4m	6m	6m	6m	6m	6m	切下げ			解除
千葉県内房	0.5m	1m	2m	4m	4m	4m	4m	4m	切下げ		解除	
小笠原諸島	0.5m	1m	2m	4m	4m	4m	4m	4m	切下げ			解除
青森県日本海沿岸	0.5m	1m	2m	3m	3m	3m	3m	3m	切下げ	解除		
相模湾・三浦半島	0.5m	0.5m	2m	3m	3m	3m	3m	3m	切下げ	解除		
静岡県	0.5m	0.5m	2m	3m	3m	3m	3m	3m	切下げ		解除	
和歌山県	0.5m	0.5m	2m	3m	3m	3m	3m	3m	切下げ	切下げ		解除
徳島県	0.5m	0.5m	2m	3m	3m	3m	3m	3m	切下げ		解除	
高知県	0.5m	0.5m	2m	2m	2m	2m	3m	3m	切下げ	切下げ		解除

※shows only regions that announced the major tsunami warnings
（source：documents from Japan Meteorological Agency）

- Major tsunami warning
- Tsunami warning
- Tsunami advisory
- No warning or advisory

Based on reflections and lessons learned, the disaster management measures against earthquakes and tsunamis must be rebuilt in their entirety

Selection of Earthquakes and Tsunamis for Hazard Assumption and Disaster Management Measures

Selection of Earthquakes and Tsunamis for Hazard Assumptions

- According to researches based on scientific perception, the largest-possible mega earthquakes and tsunamis should be considered from every possible angle.
- Even in cases in which it would be practically difficult to develop the facilities needed as disaster management measures against the earthquakes and tsunamis based on a hazard assumption, **such assumption must be adopted without hesitation**.

Principles for Future Tsunami Hazard Assumptions and Tsunami Countermeasures

The two levels of assumption of tsunamis in the future.

①The largest-possible tsunamis while the frequency of their occurrence is extremely low, **when they do occur the damage would be enormous**.（“2011 off the Pacific coast of Tohoku Earthquake” belongs to this group.）

Establish **comprehensive tsunami countermeasures embracing every possible instrument,** which place evacuation as the core and combine land use planning, evacuation facilities and disaster management facilities.

②Tsunamis which **occur more frequently than the above mentioned largest-possible tsunamis and cause major damage despite their relatively lower tsunami heights.** **Coastal protection facilities must continued to be constructed** from the point of view of protecting human life and the assets of residents, stabilizing the regional economy and securing efficient industrial bases.

Countermeasures for Mitigating Tsunami Damage (1)

Basic Principles

○It is important to enact countermeasures against largest-possible tsunamis based on a **‘disaster reduction*’ philosophy that focuses on minimizing damage**. In order to do so, tsunami damage should be mitigated as much as possible not only through **structural measures such as coastal protection facilities**, but also through **non-structural measures centring on evacuation**, such as thorough disaster education and preparation of hazard maps, in order to prepare for tsunamis that exceed the protection levels of the structural facilities.

○In order to achieve swift and assured evacuation from tsunamis, **community development should allow evacuation within the shortest possible timeframe, around five minutes in the case of communities where tsunamis arrive quickly**, while placing evacuation on foot as the basic principle and in due response to local circumstances. **In communities where topographical conditions or the state of land use make such responses difficult, it is essential that measures for tsunami evacuation are thoroughly examined with consideration to factors such as the tsunami arrival time**.

○The fundamental step in protecting human life from a tsunami is **evacuating to higher ground without hesitation, swiftly and autonomously, as soon as a strong or extended shaking is felt.**

*‘disaster reduction’ does not prevent damage due to natural disaster entirely but rather focuses on minimizing damage.

Countermeasures for Mitigating Tsunami Damage (2)

Preparation of Systems & Development of Rules for Efficient Evacuation

○Improve tsunami warning announcements

- The content to be conveyed as tsunami warnings be examined from the point of view of the warnings' recipients.
- Disaster response activities and evacuation actions in accordance with the levels of tsunami warnings or expected tsunami height should be examined.

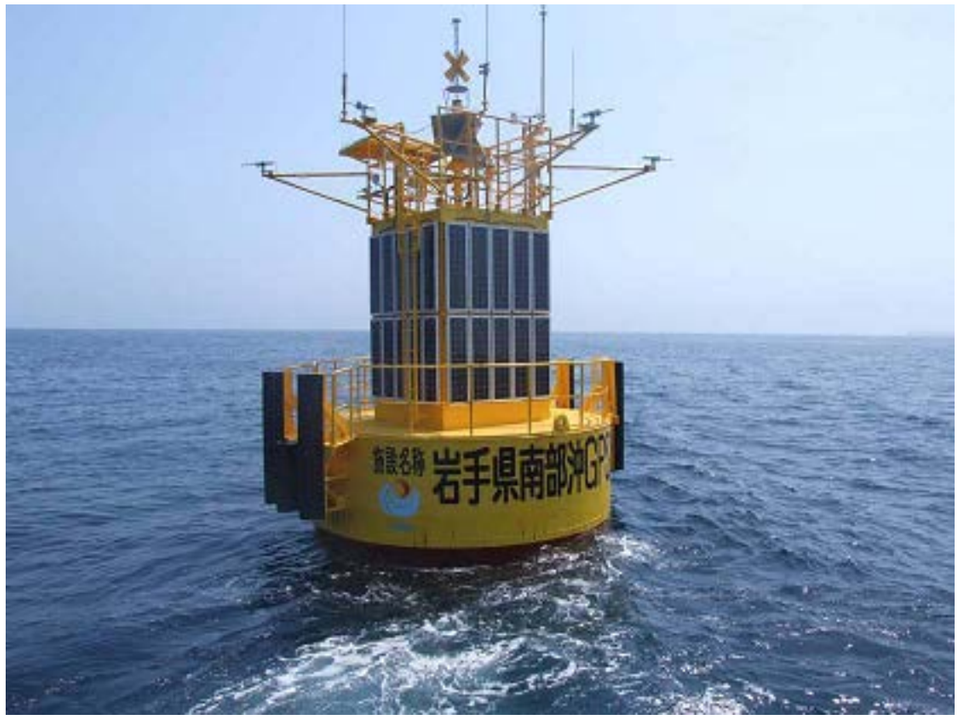
○Improve and strengthen tsunami warnings and information delivery systems

- Local disaster management radio communication systems, J-ALERT (a satellite based system that allows authorities to quickly broadcast alerts to local media and to citizens directly via system of speakers), television, radio, mobile phones, 1-Seg (a mobile terrestrial digital audio/video and data broadcasting service), etc should be utilized.

○Improve and strengthen earthquake and tsunami observation systems using ocean bottom seismographs, cable-type offshore hydraulic gauges and GPS wave gauges etc.

○The designation requirements, structural and location criteria for tsunami evacuation buildings etc. should be reviewed.

○Rules of conduct needs to be stipulated concerning disaster management responses and evacuation guidance within the time that tsunamis arrive in order to avoid placing volunteer fire fighters and police officers in danger.



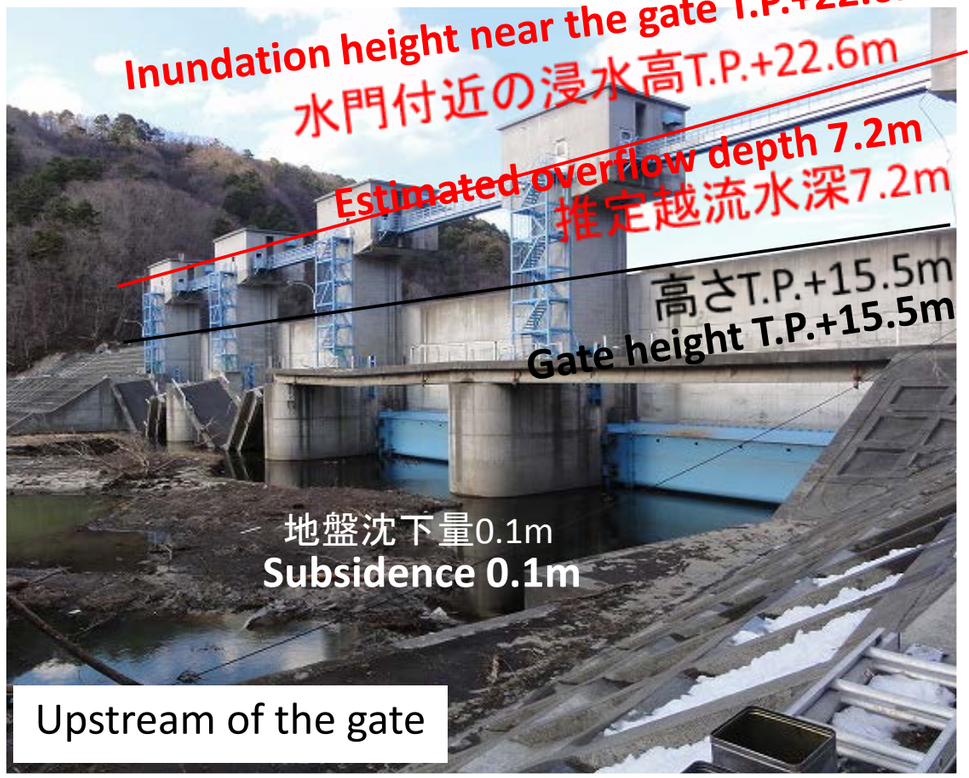
GPS wave gauge at Kamaishi offshore, Iwate Pref.
（Photo：Ministry of Land, Infrastructure, Transport and Tourism）

Tsunami evacuation building（Kesennuma central community center）
（Photo：Tokyo Fire and Disaster Management Agency（3/12））

Countermeasures to Mitigate Tsunami Damage (3)

Development of Communities Resilient to Earthquakes and Tsunamis

○Community development to consider the risk of tsunami inundation.
○Development of highly resilient coastal protection facilities and multi-layer protection incorporating secondary barriers utilizing transportation infrastructure such as raised roads.
○ Development of evacuation sites, tsunami evacuation buildings, evacuation routes and stairs.
○The government-related facilities and welfare facilities constructed in areas where there is no risk of tsunami inundation or where the risk is at least minimal.
○ Organic coordination of local disaster management plans for municipalities and city planning.



Fudai Gate (Fudai, Iwate Pref.)
（Photo: Ministry of Land, Infrastructure, Transport and Tourism)

Raising Disaster Awareness on Tsunamis

○Enhance hazard maps
・Clarify the relationships of hazard map information with tsunami warnings, evacuation advisories and instructions
・Use hazard maps in the explanation of important matters in building lots or buildings transactions
・Indicate inundation areas and heights within town,　etc.
○ Maintain evacuation on foot to be the principle method for tsunami evacuation. Measures for safe and assured automobile evacuation of evacuees should adequately examined in case they have no choice but to evacuate in cars.
○Implement disaster education and improve community disaster management capability.

Use of evacuation stairs during a drill
（Photo：Ministry of Land, Infrastructure, Transport and Tourism）

Measures to Reduce Damage Caused by Shaking

Measures to Reduce Damage Caused by Shaking

○Continue systematic efforts to make buildings resistant to earthquakes, raise awareness to promote measures for preventing ceilings falling and anchoring furniture.
○Countermeasures against long-period ground motion and liquefaction.

Ceilings and lights fallen in school gymnasium (Hitachi City, Ibaragi Pref.)
(Photo: National Institute for Land and Infrastructure Management, Building Research Institute)

Buildings damaged by liquefaction (Abiko City, Chiba Pref.)
(Photo: Abiko City Homepage)

Future Damage Scenario

○Review the methods and content of damage scenario in response to the colossal damage caused by the Great East Japan Earthquake
○Examine multiple damage scenarios under different seasonal conditions, or different time of day or under different meteorological circumstances.

Preparations for a large-scale earthquake

○ Full preparations need to be made on the basis that an earthquake or tsunami can occur anywhere in Japan.

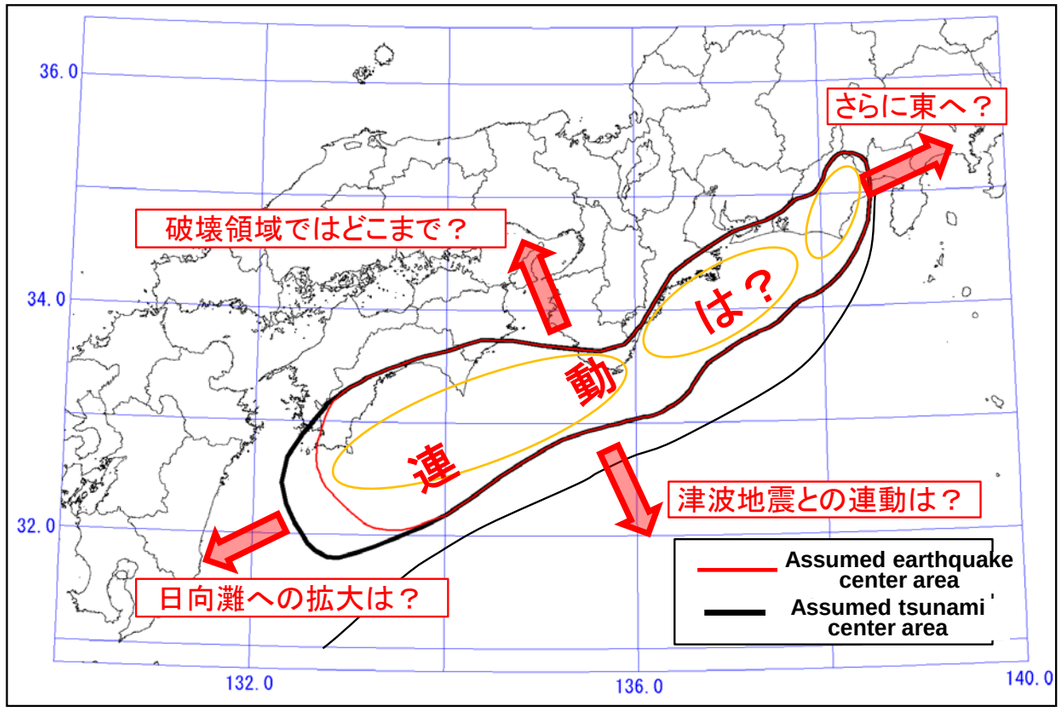
○Countermeasures against a mega ocean trench earthquake occurs in the Nankai trough need to be considered from the view point of creating a national grand design.

○Need to consider not only Tokai, Tonankai, and Nankai earthquakes all occurring at the same time, but also these earthquakes occurring at different times, and compound disasters such as coastal earthquakes occurred at the same time as an inland earthquake, typhoon, or other natural disasters.

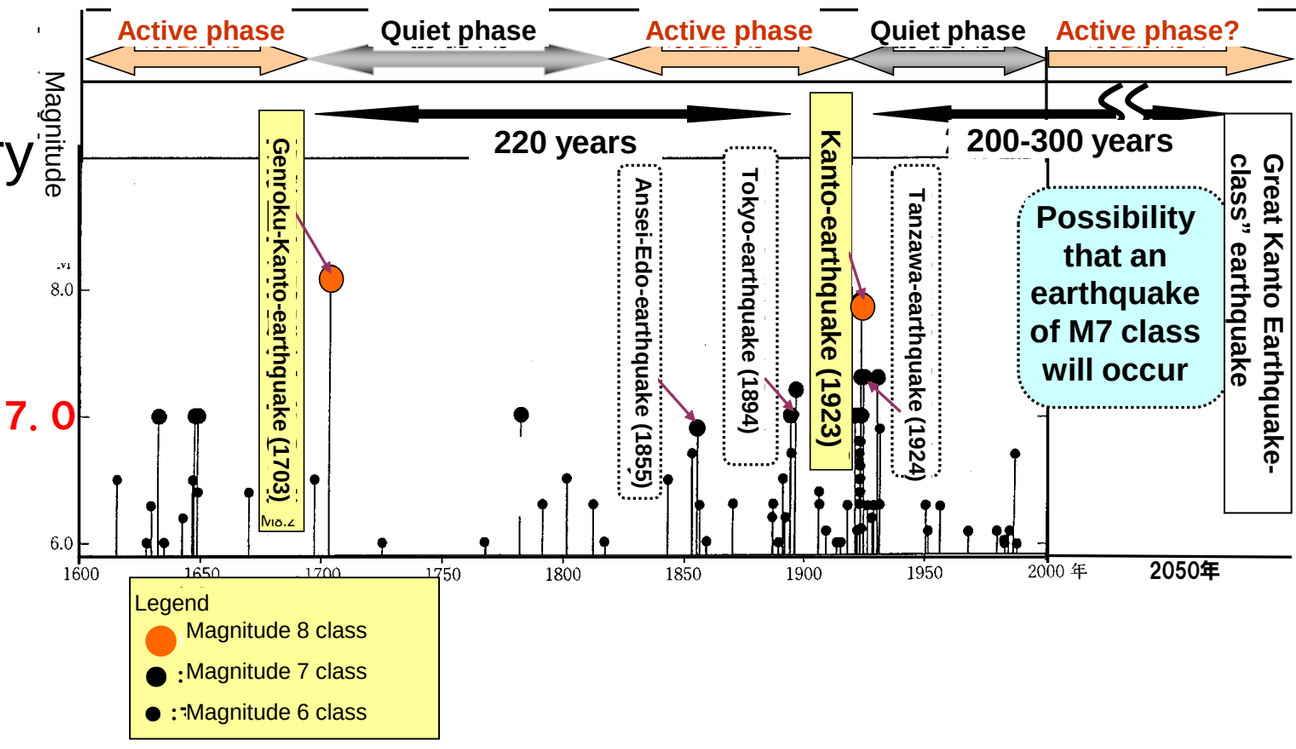
○Business continuity plans (BCP) are necessary to avoid stagnation of domestic economic activity due to the damage of key industries.

○ With regard to Tokyo Inland Earthquakes, consideration should also be given to a so-called “Great Kanto Earthquake-class” earthquake.

Consideration of Tokai-Tonankai-Nankai Earthquake’s Assumed Epicentral Area and Tsunami Source Area



Historical earthquakes in Southern Kanto Area （over M6, after 1600）



Expectations to the proposal document

○The bitter experiences and tough lessons must be permanently passed on as a testament linking the past, the present and the future, and as wisdom for the building of disaster-resilient nation and communities.

○Based on the report of the Committee, the national government is expected to perform necessary revisions of Japan’s overall earthquake and tsunami countermeasures and pour every effort into enhancing disaster management measures for the future, thus liberally fulfilling the fundamental role of the government to protect the lives and property of the nation’s

Objectives of tsunami disaster education

- Learn the preciousness of life and the importance of living.
- To do this:

1. How is tsunami created, and what are the characteristics?
2. What would the damage be if tsunami comes?
3. What should we do to avoid damage?

Learn to make your own judgment to avoid danger. If time permits evacuate to safer place.

Ishinomaki City Okawa Elementary School
（74 students and 10 teachers lost their lives）

Disaster management education

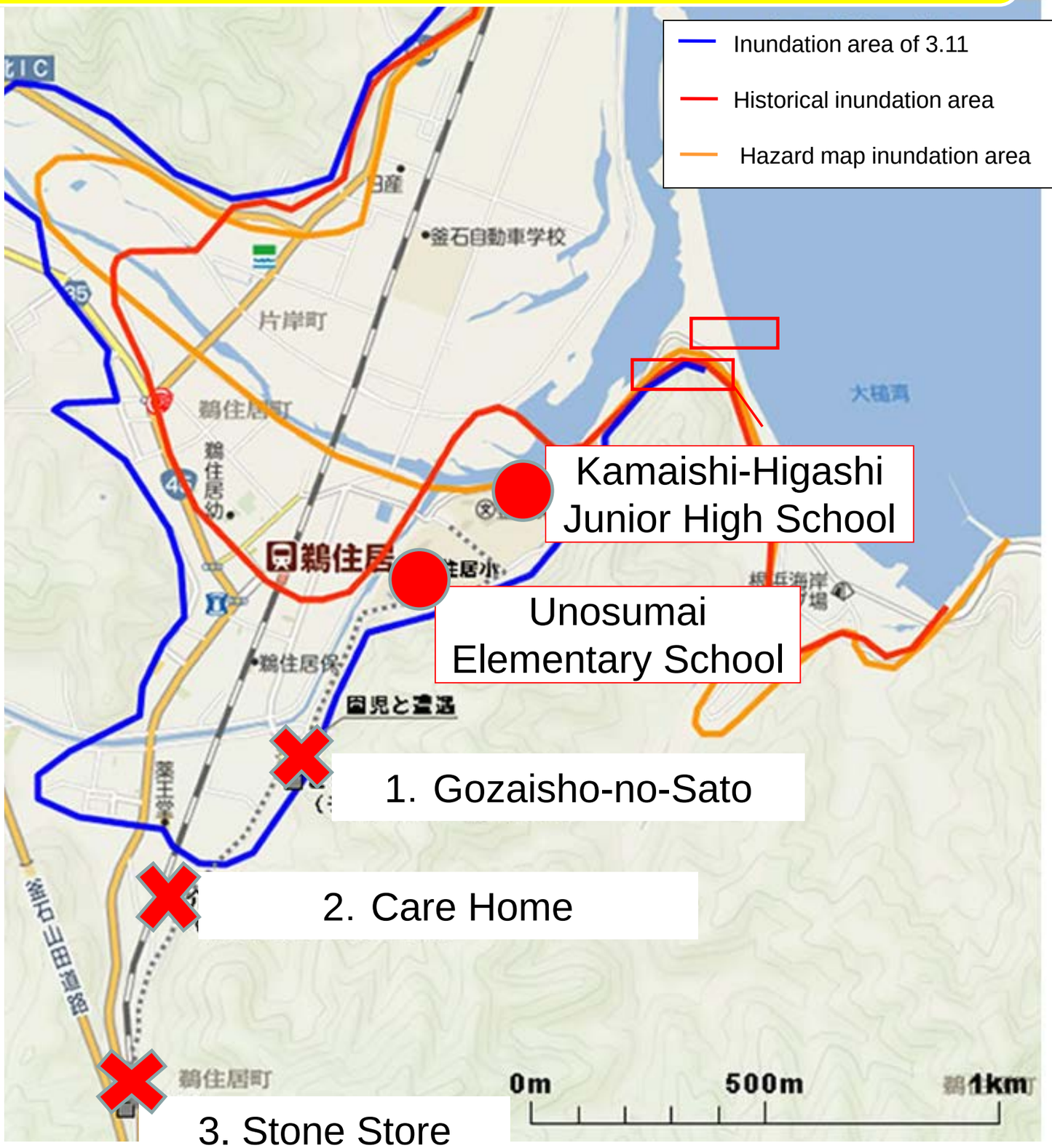
Unosumai region, Kamaishi City （Unosumai-Elementary School, and Kamaishi East Junior High School）

At Kamaishi-Higashi Junior High School, as a teacher screamed “Run away!”, all the students started running toward the evacuation site selected prior to the earthquake, Gozaisho-no-Sato, lead by the students belonging to sports clubs.

On the other hand, at Unosumai Elementary School, all the students were evacuated to the 3rd floor of the school building. But they saw the junior high school students evacuating, and immediately decided to evacuate outside of school.

When students evacuated to Gozaisho-no-Sato, they again start running to another higher ground. junior high school students took hands of elementary school students to assist evacuation as they have done in the drills. During evacuation, they saw staffs of a nursery school. Here, the students carried the children of the nursery school together with the nursery staffs, pushed strollers and became “the person who can save people” as they had been taught.

When the leading junior high school students arrived the care home and began a roll call, they heard the scream of firefighters and residents, “The tsunami went over the seawall!”. “Run away!” The students ran up to a stone store located along the national route 45 higher than the care home. This is how around 570 students of Unosumai elementary school and Kamaishi East Junior High School survived through the tsunami.



Survivors of the Great East Japan Earthquake

- Evacuated soon after the earthquake come to a stop (immediate evacuation)：57%
- Did not evacuate immediately, and evacuated after completing other action (after action evacuation)：31%
- Evacuated only after tsunami came approaching (urgent evacuation)：11%
- Was in a safe place where evacuation was not necessary : 1%

Importance of evacuation drills

- When I got to the evacuation site, there were only the ones who always participate in the evacuation drills. (Those who had not participated in the drills did not evacuate even under the evacuation advisory.)
- On the way to the evacuation site, I saw an old woman doing washes in front of her house. (Even though the earthquake had come, she did not think tsunami would come.)
- The half of the bodies found were found with their belongings such as bags. (They tried to evacuate with their belongings.)
- Some parents came to elementary schools and kindergartens by car to pick up their children, and were attacked by tsunami on their way home. (They rejected the urging of schools.)

Why did people not evacuate?

- At the time of the Chilean earthquake in 2010, even though a major tsunami warning was announced, 35.6% of the residents in the coastal region in Iwate Pref. did not evacuate.

Reason：1. Thought they did not need to evacuate (58.7%)

: Selfish decision based on nothing

2. Decided after checking out the situation of other areas (18.8%)

:There was no such time

3. Was in a situation* that prohibited evacuation actions (16.7%)

:They do not understand it will result losses of lives

*Reason：1. Had to work (30.6%) ：there will be no more work if they die

2. Had sick or old person in their family (18.5%) ：no need for excuses

3. Was sick or old（15.3%)：no excuse

4. No answer (34.4%) ：They were not seriously thinking about surviving

Principle for Tsunami Disaster Management Measures “2 Tsunami Levels”

■Tsunami disaster management Level (Tsunami Level 1)

•Consider the earthquakes whose frequency of occurrence is between several decades to 100-150 years.

Protect human lives and the assets of residents by constructing coastal protection facilities.

•The design of coastal protection facilities should be based on the tsunami protection level (Tsunami Level 1).

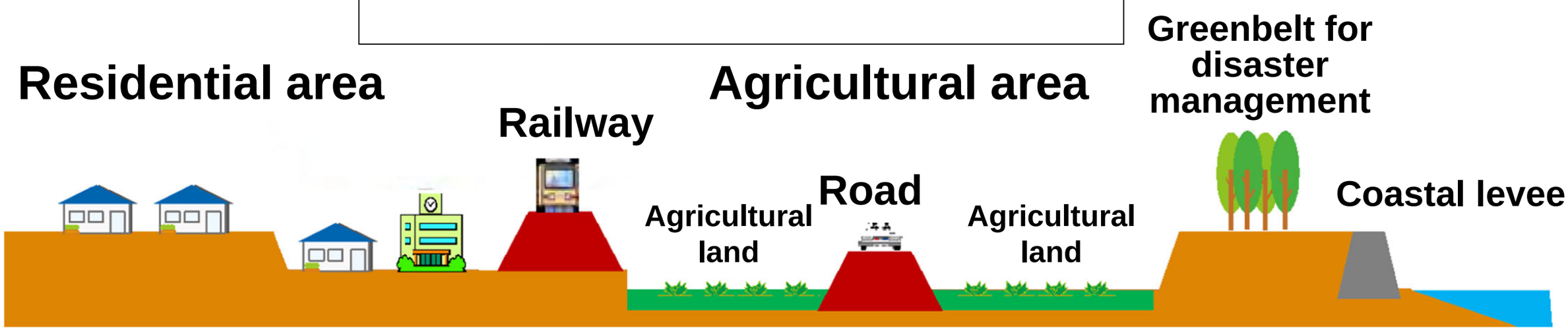
■Tsunami disaster reduction Level (Tsunami Level 2)

•For tsunamis whose scale go far beyond the tsunami protection level and exceed the maximum possible protection level by structural measures, conduct maximum tsunami countermeasures embracing every possible instrument needed to protect human lives.

Principle of Multi-Layer Protection

■Protect with multiple lines which consist of inland embankment of roads and railways, together with the coastal levee, greenbelts for disaster management as the front line of protection.

Multi-Layer Protection (image)



Private Remarks for not to experience “beyond the assumption” again (1)

- “The balancing of disaster management, utilization, and environment in the existing River Law and Seacoast Law” has failed due to occurrence of extreme phenomena. Once an external force of a mega scale occurs, it can cause catastrophic damages.

  The principle of disaster reduction must be extended to the field of utilization and environment. The current River and Seacoast Planning that only targets small or medium sized hazard (ex. the biggest flood after the WWII) need to be revised.

Private Remarks for not to experience “beyond the assumption” again (2)

- In the case of tsunami, the conventional methodology of 1) earthquake experts indicate the fault model, 2) tsunami experts simulate, should be reversed. It should be 1) tsunami experts simulate the tsunami wave height and the distribution of wave length by altering the 7 fault parameters systematically, and 2) earthquake experts evaluate if such an earthquake can occur based on the knowledge of geophysics.
- We must introduce probabilistic approach to tsunami warnings and massive tsunami warning. (The public would not understand?)