Analytical study on multiple defense with use of earth bank against tsunami at industrial complex

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1 Purpose

2 Outline of analysis

3 Analytical result

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Background

Broken sea wall in Sendai plains photographed by TOKIDA

Many infrastructures were damaged destructively by the 2011 Off the Pacific Coast of Tohoku Earthquake.

Background

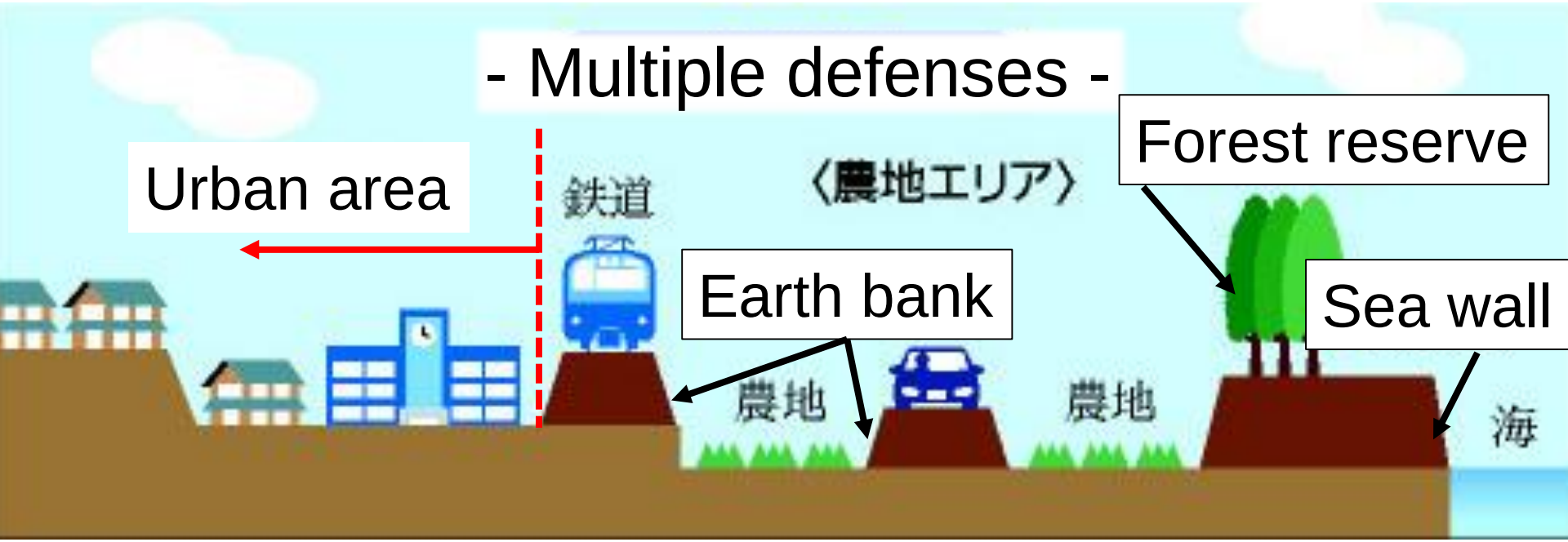
Source: National Research Institute of Fire and disaster

Source: Kahoku Shinpo

Measures against tsunami in industrial complex is important.

Concept of multiple defenses

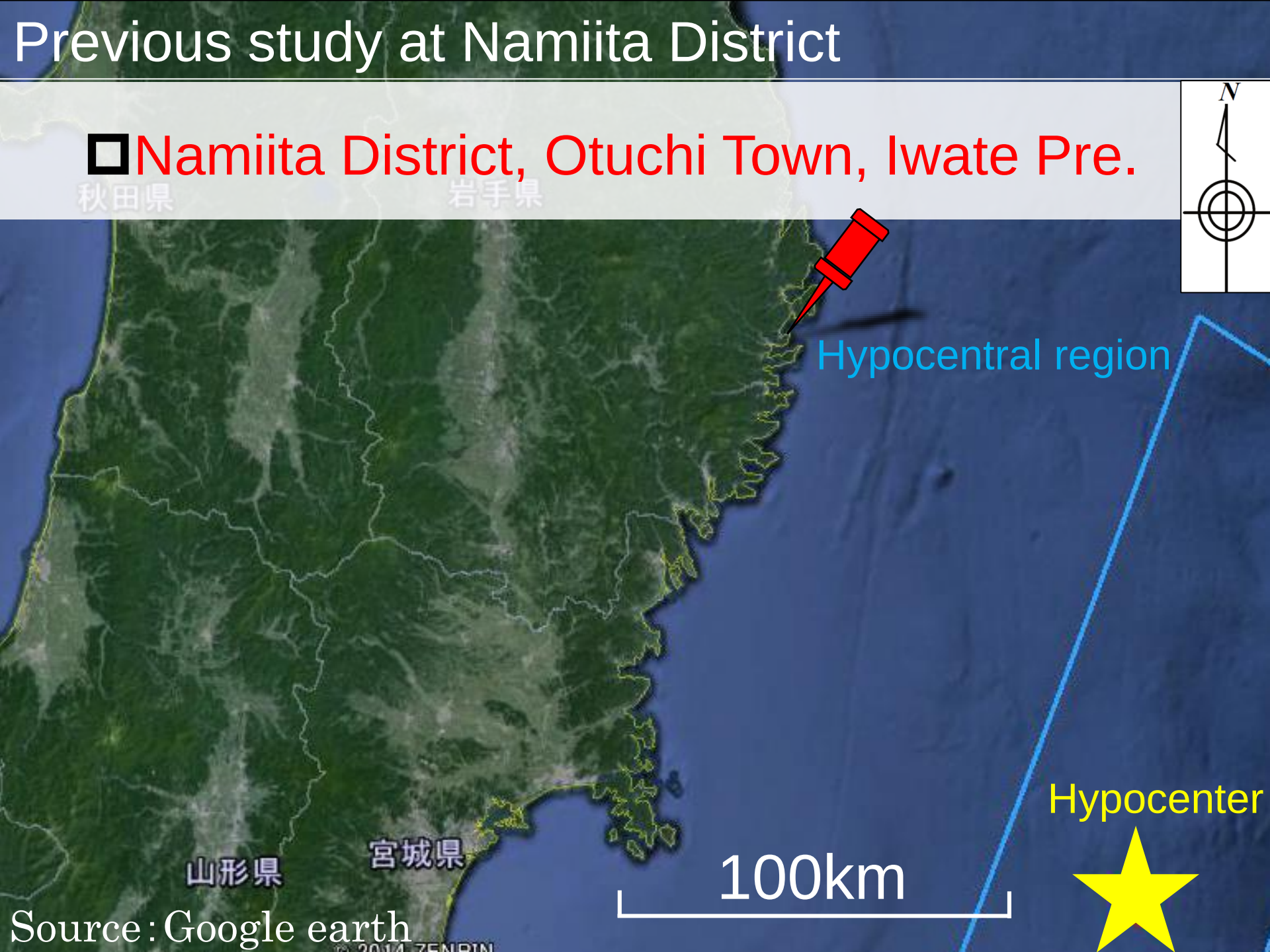
Concept of multiple defenses is to utilize some constructions to reduce the tsunami damage.



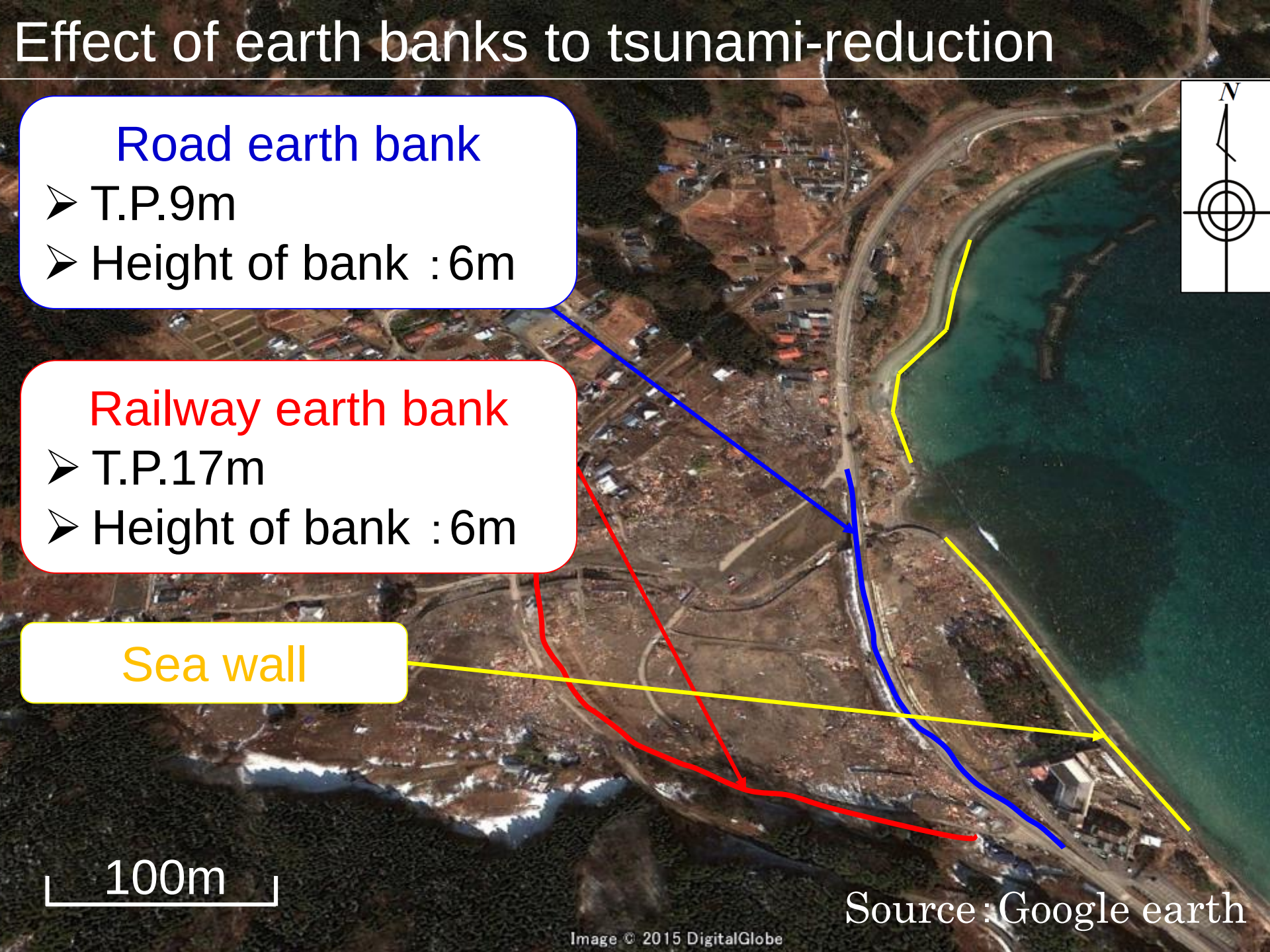
Source：Asahi Shimbun Digital

It is indicated that earth banks is effective to reduce tsunami damage.

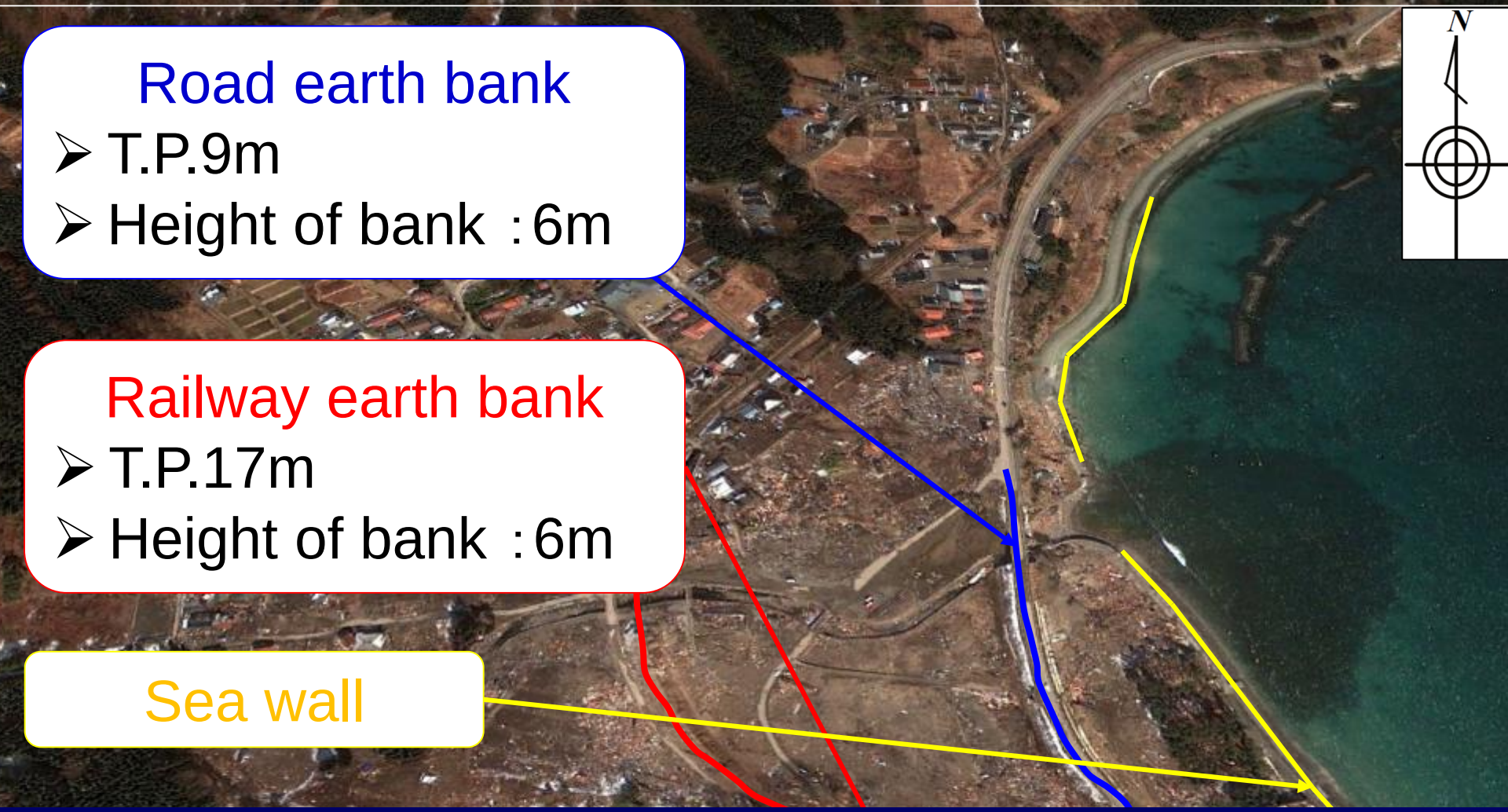
Previous study at Namiita District



Effect of earth banks to tsunami-reduction

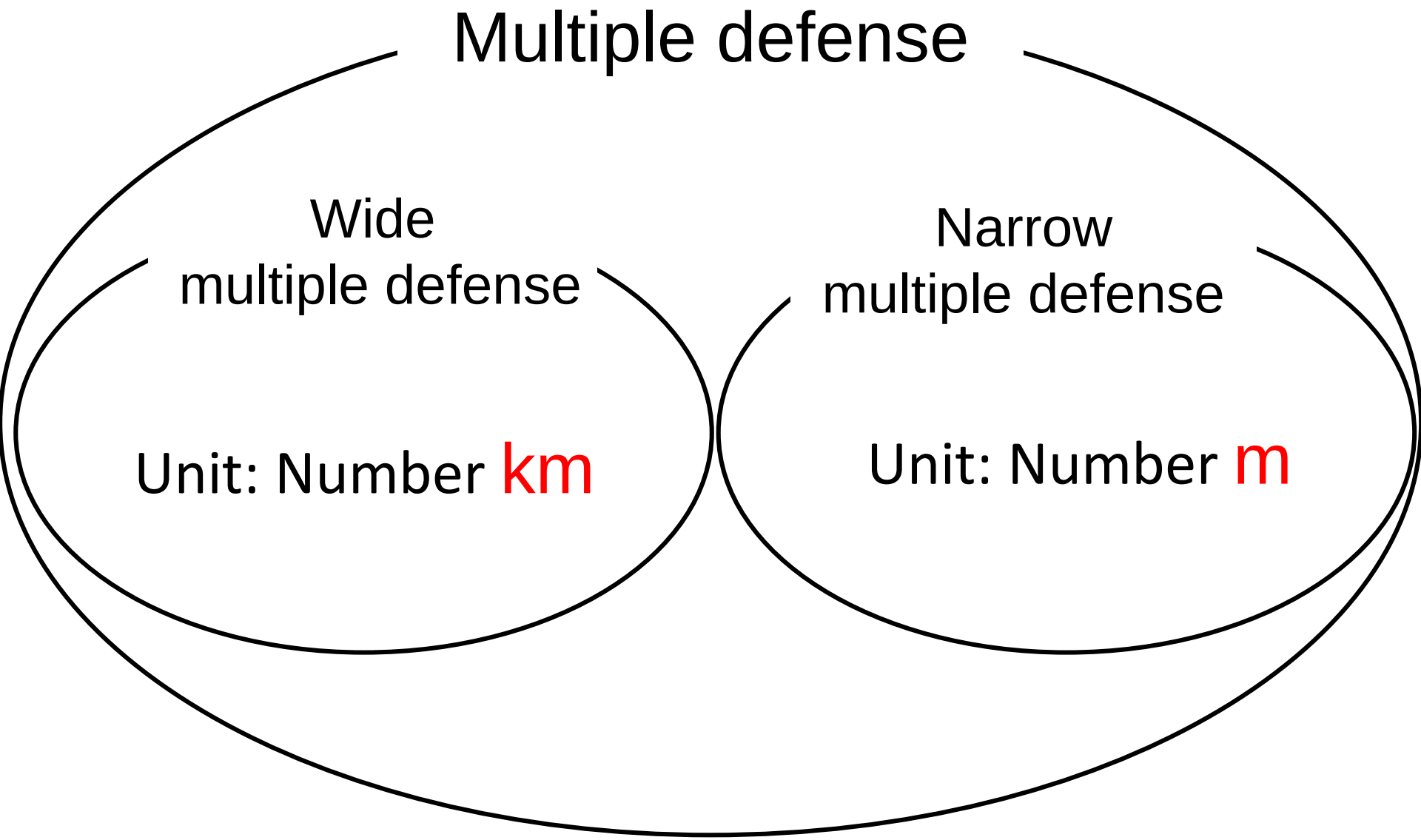


Effect of earth banks to tsunami-reduction

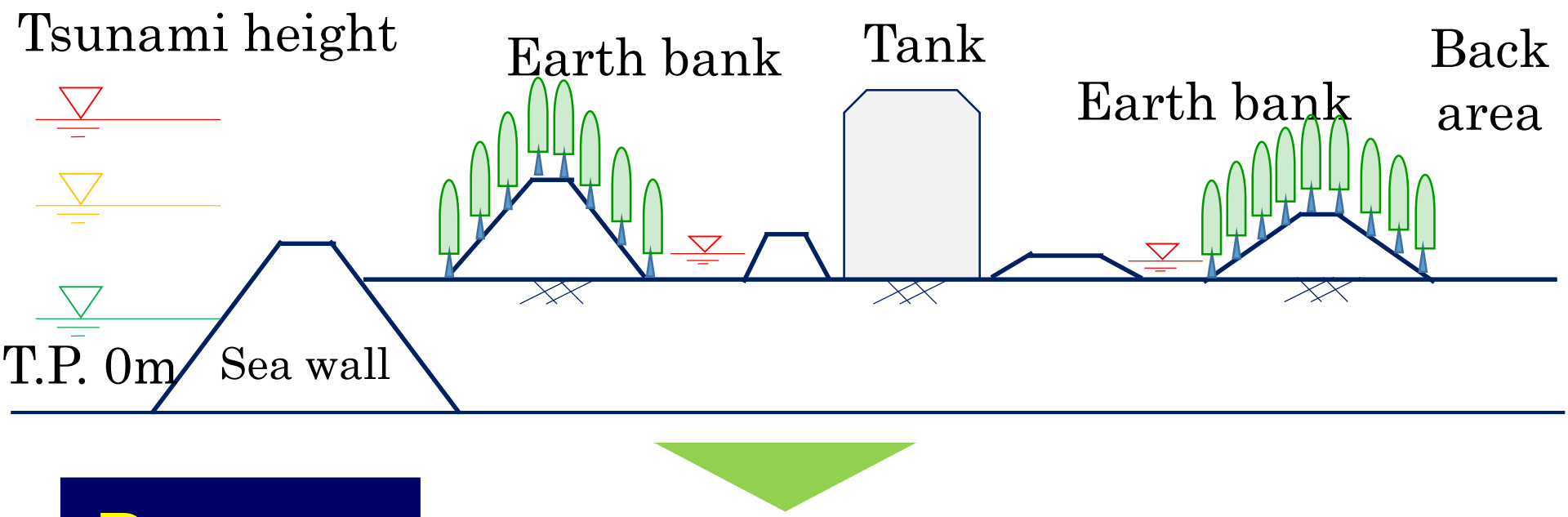


Lower 3m inundation depth,
delay tsunami arrival 10–60s by two earth banks.

Classification of multiple defense



Possibility of earth bank in industrial complex



Purpose

Investigating tsunami-reduction characteristics with multiple defense by earth banks.

- With tsunami simulation analysis
- Considering the best-arrangement of banks

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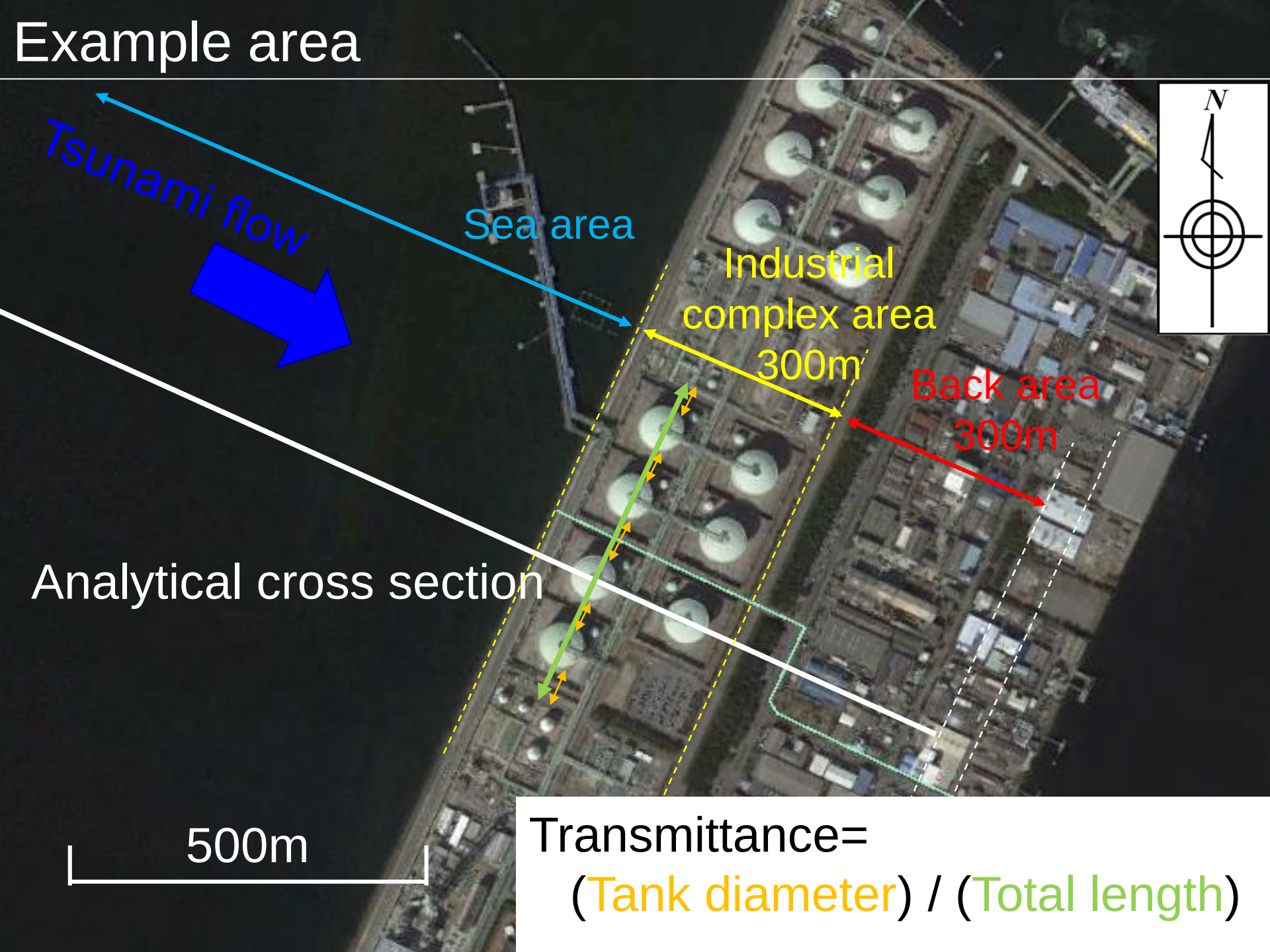
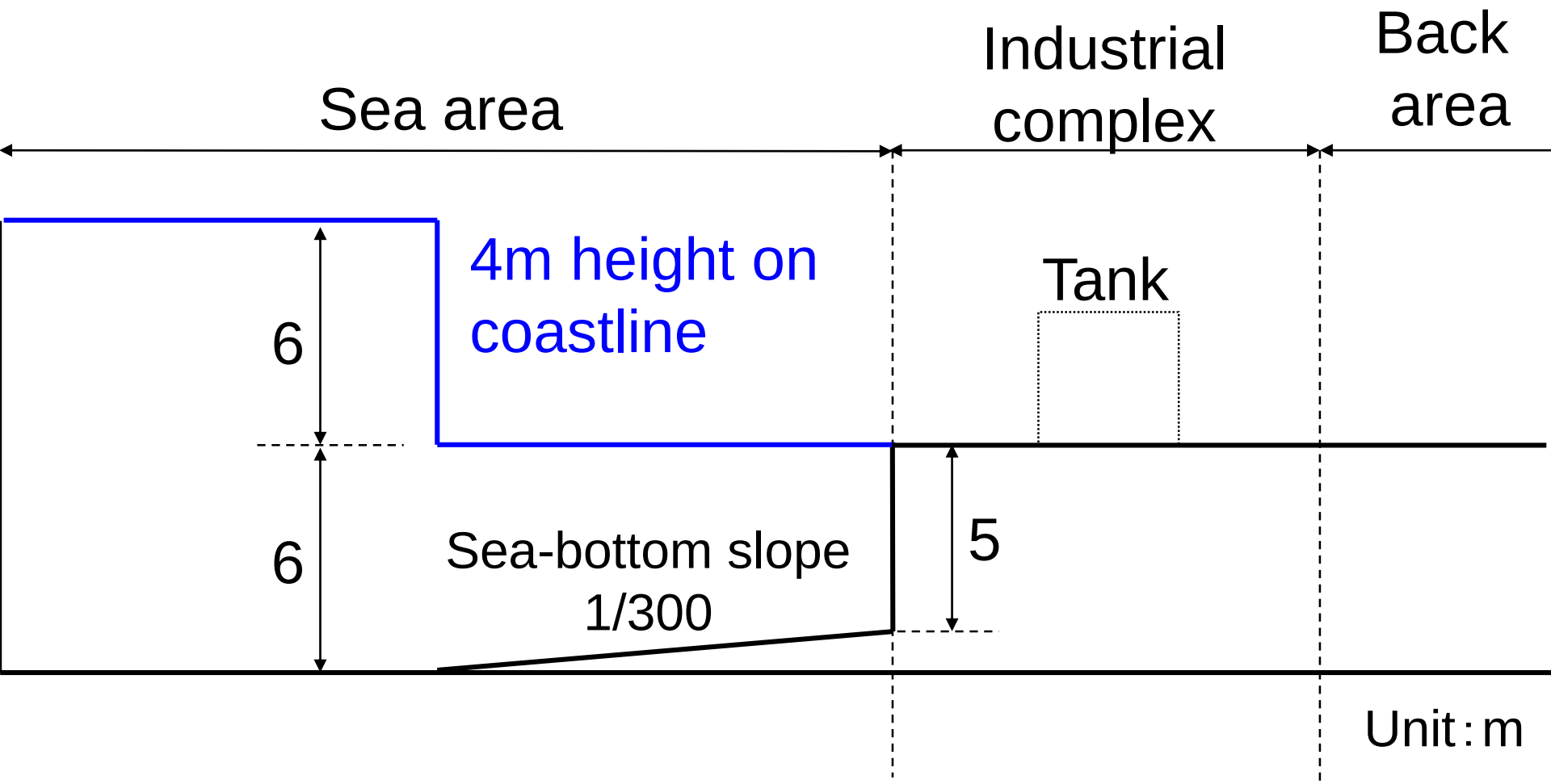
Example area
兵庫県
大阪府
N
20km
17.2 km
Image Landsat
© 2015 ZENRIN
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Source : Google earth

Example area

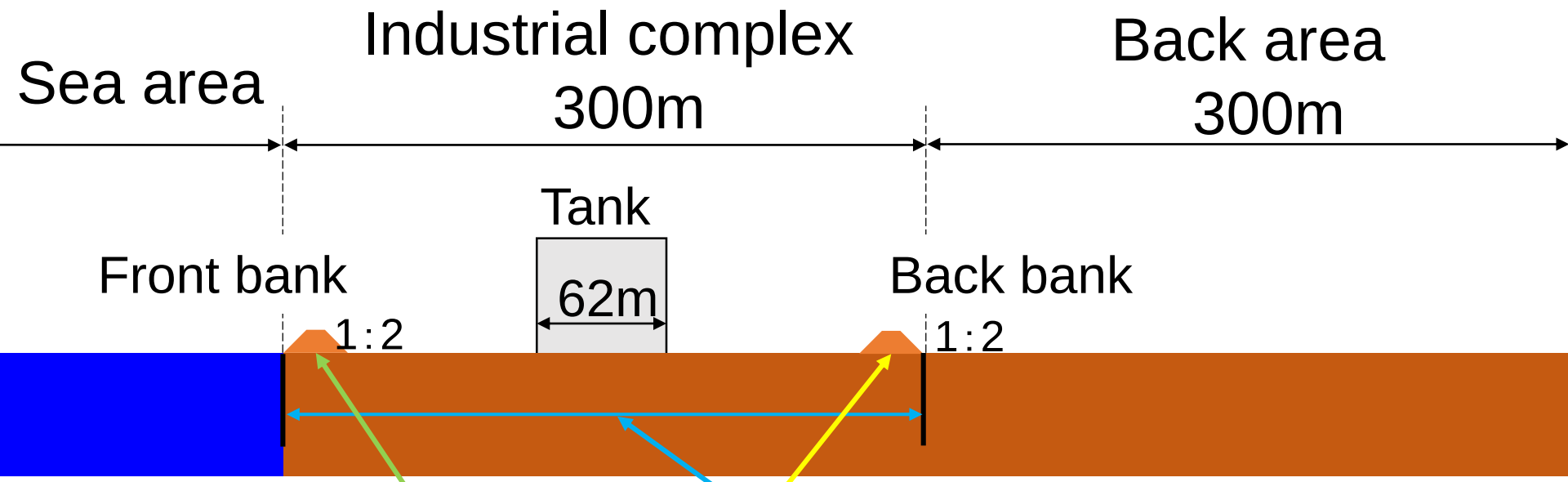

Example area
Tsunami flow
Sea area
Industrial complex area 300m
Back area 300m
N
Analytical cross section
500m
Transmittance=
(Tank diameter) / (Total length)

Analytical model

Simulation program：CADMAS-SURF 2D

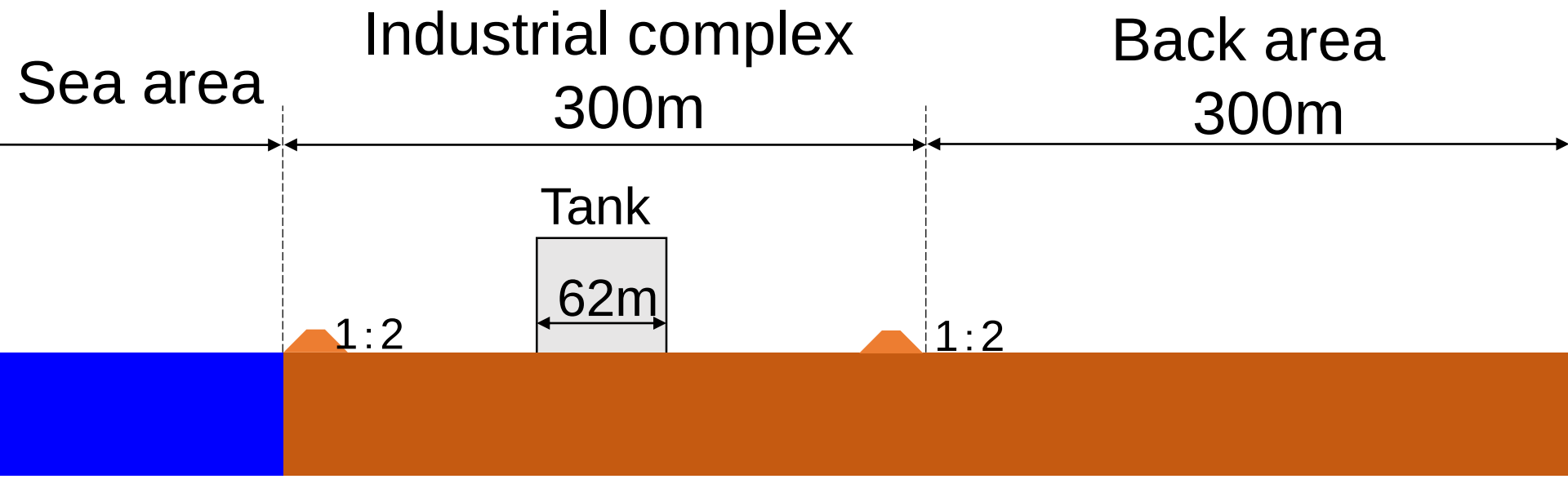


Analytical cases



Case No.	Height of bank (m)		Distance of each bank (m)
	Front	Back	
Case1	0		300
Case2	1		
Case3	2		
Case4	3		
Case5	2	0	
Case6	3		
Case7	0	2	
Case8		3	
Case9	2		100
Case10			200

Evaluation on tsunami-reduction effect



Compared result

Distribution of

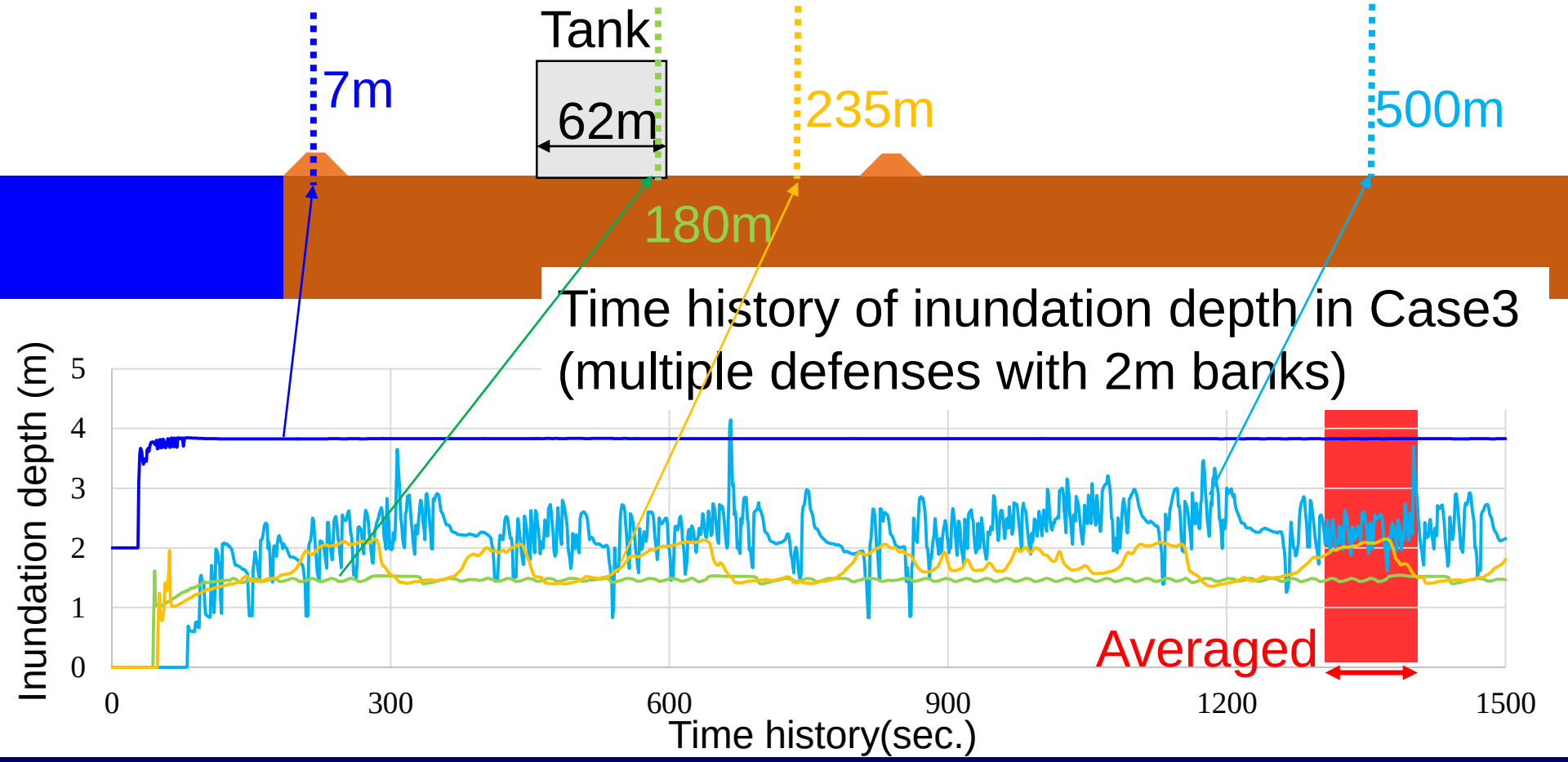
①Inundation depth h

②Horizontal flow velocity v

③Drag force $D = 1/2 \rho v^2 h C_D$

in industrial complex and back area

Evaluation on tsunami-reduction effect



Averaging values in each point within certain time

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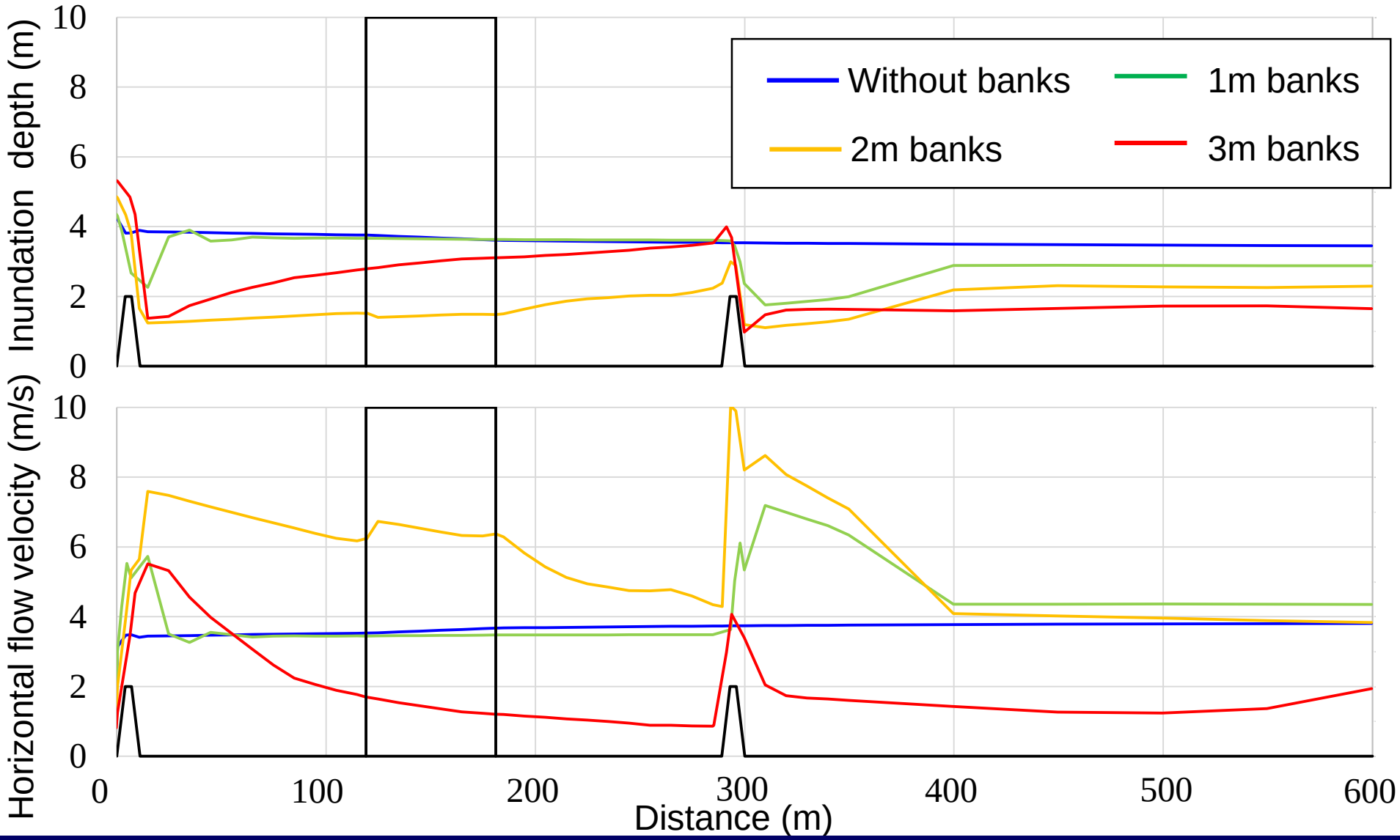
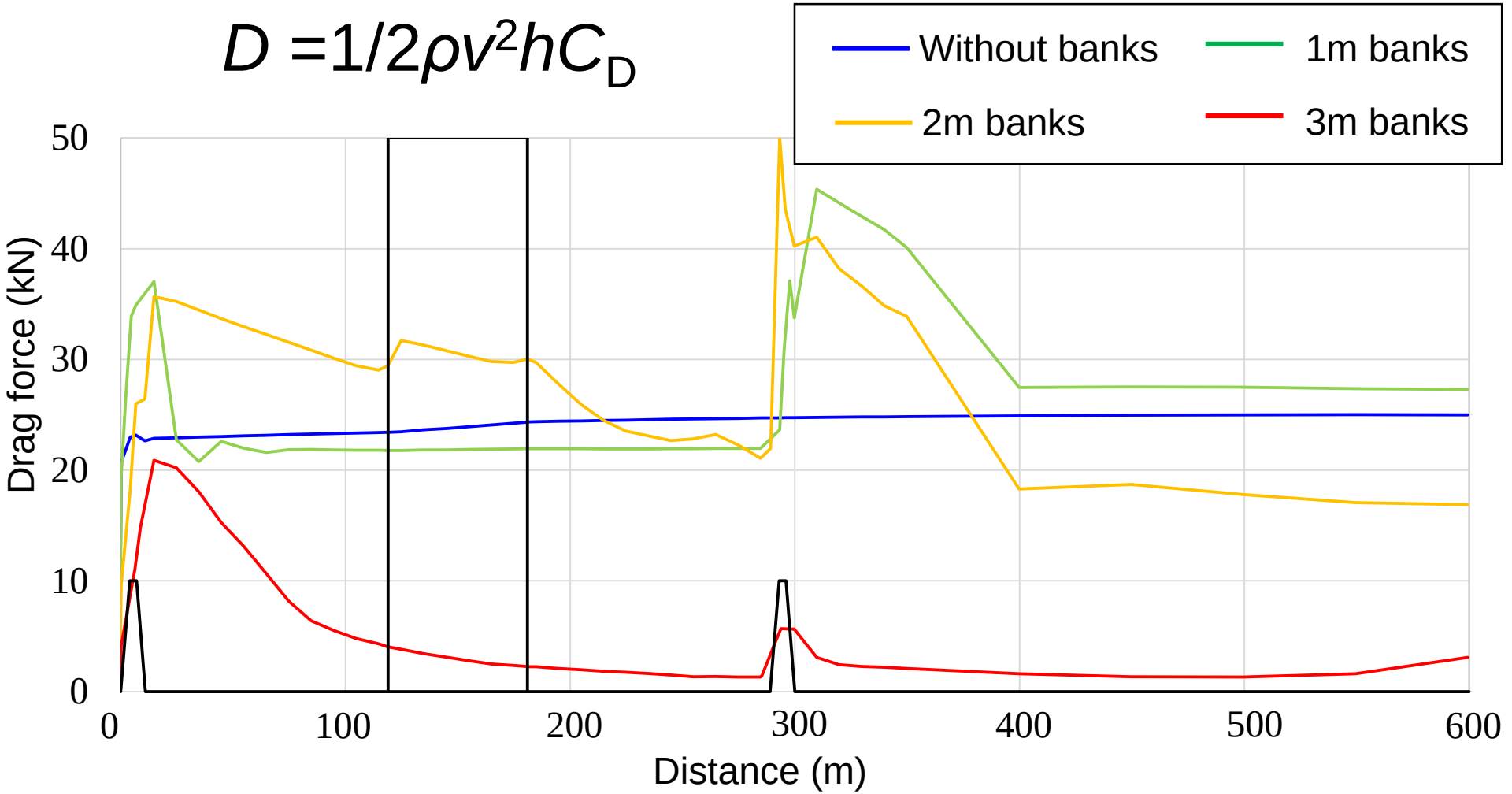
Investigating height of earth banks (Case1-4)



Flow velocity increases behind earth banks.

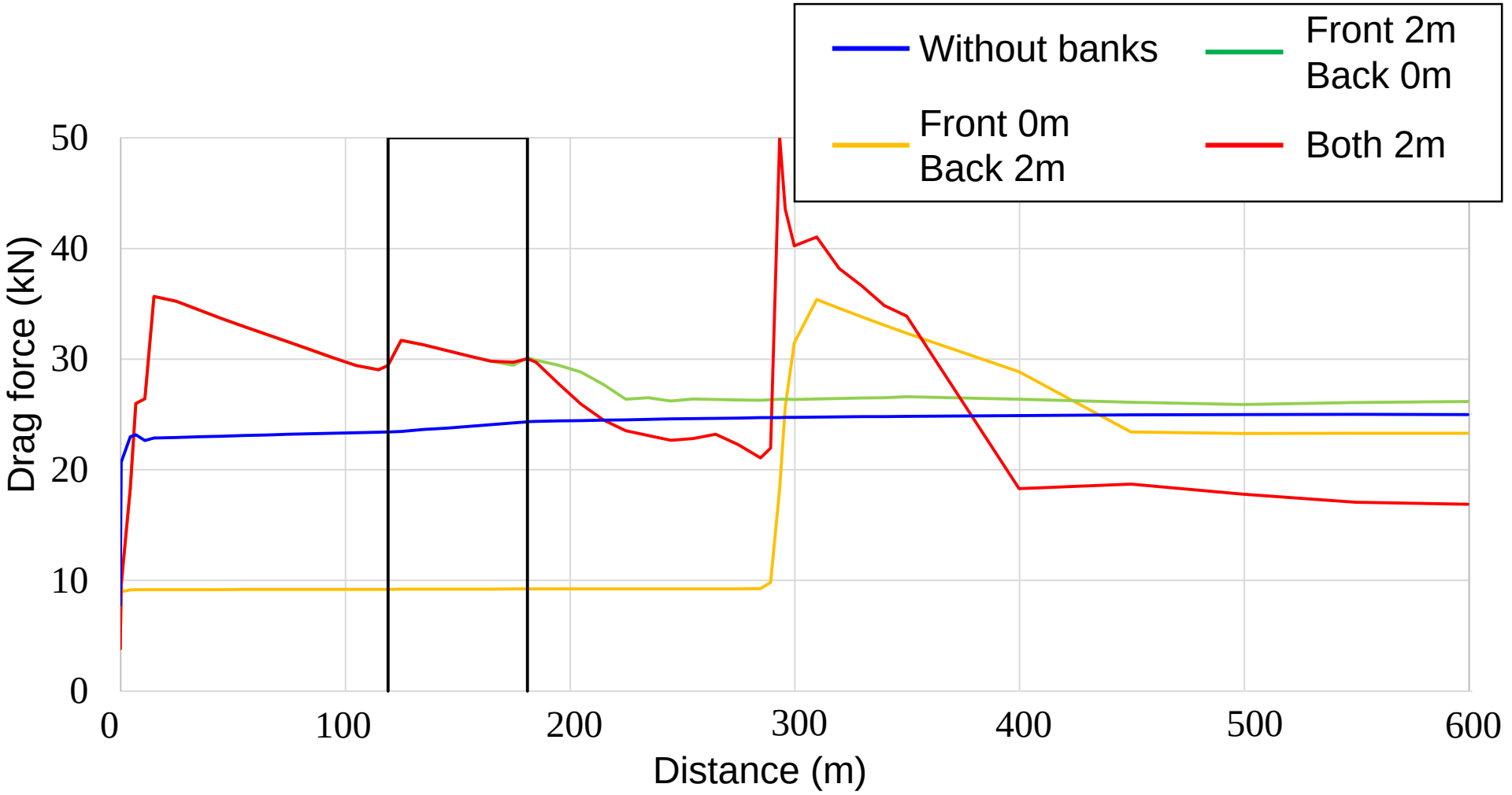
Investigating height of earth banks (Case1-4)

$$D = 1/2 \rho v^2 h C_D$$

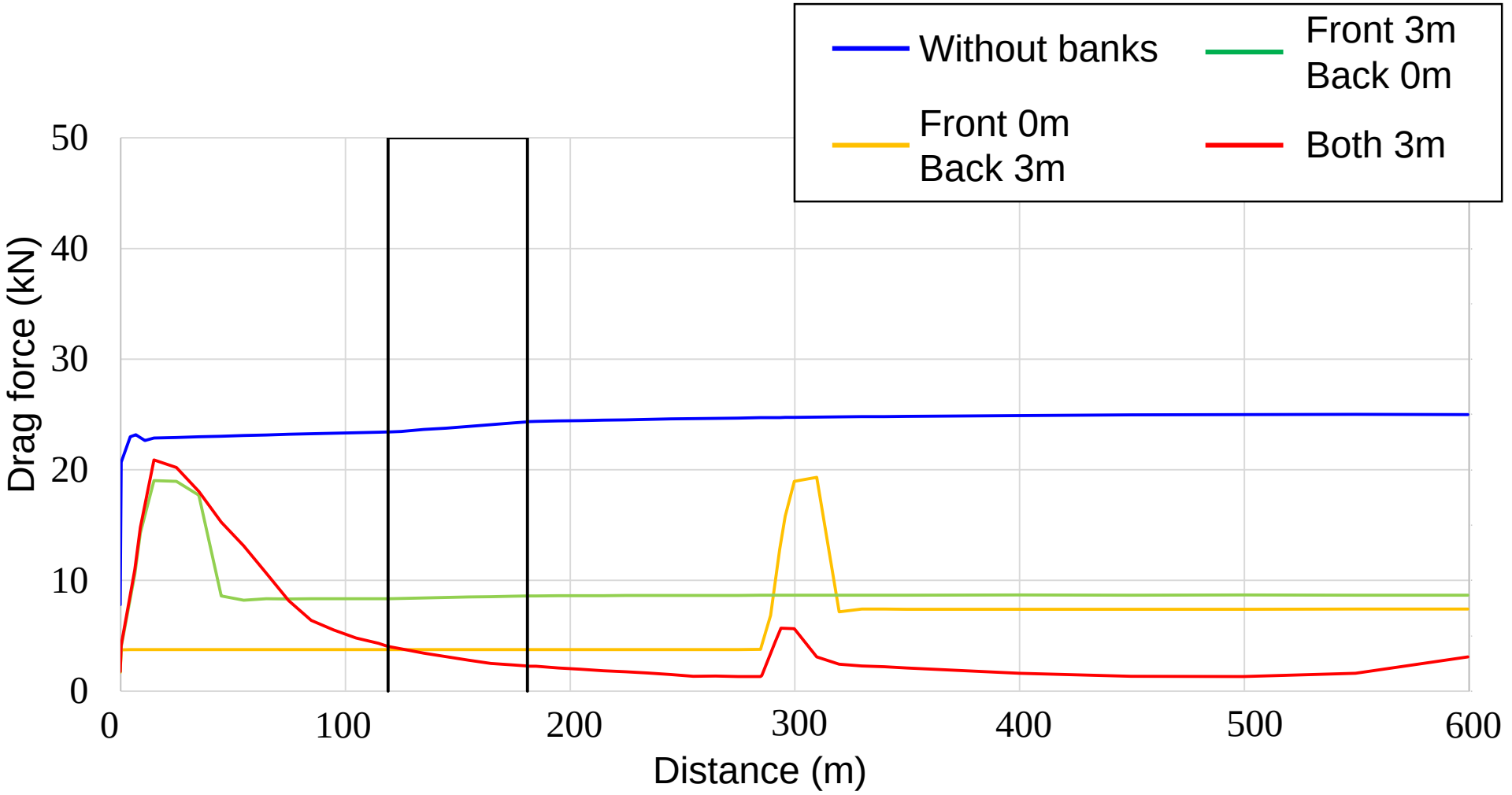


1m and 2m banks increase, 3m banks decrease drag compared with case without bank.

Investigating number of 2m banks (Case1,3,5,6)

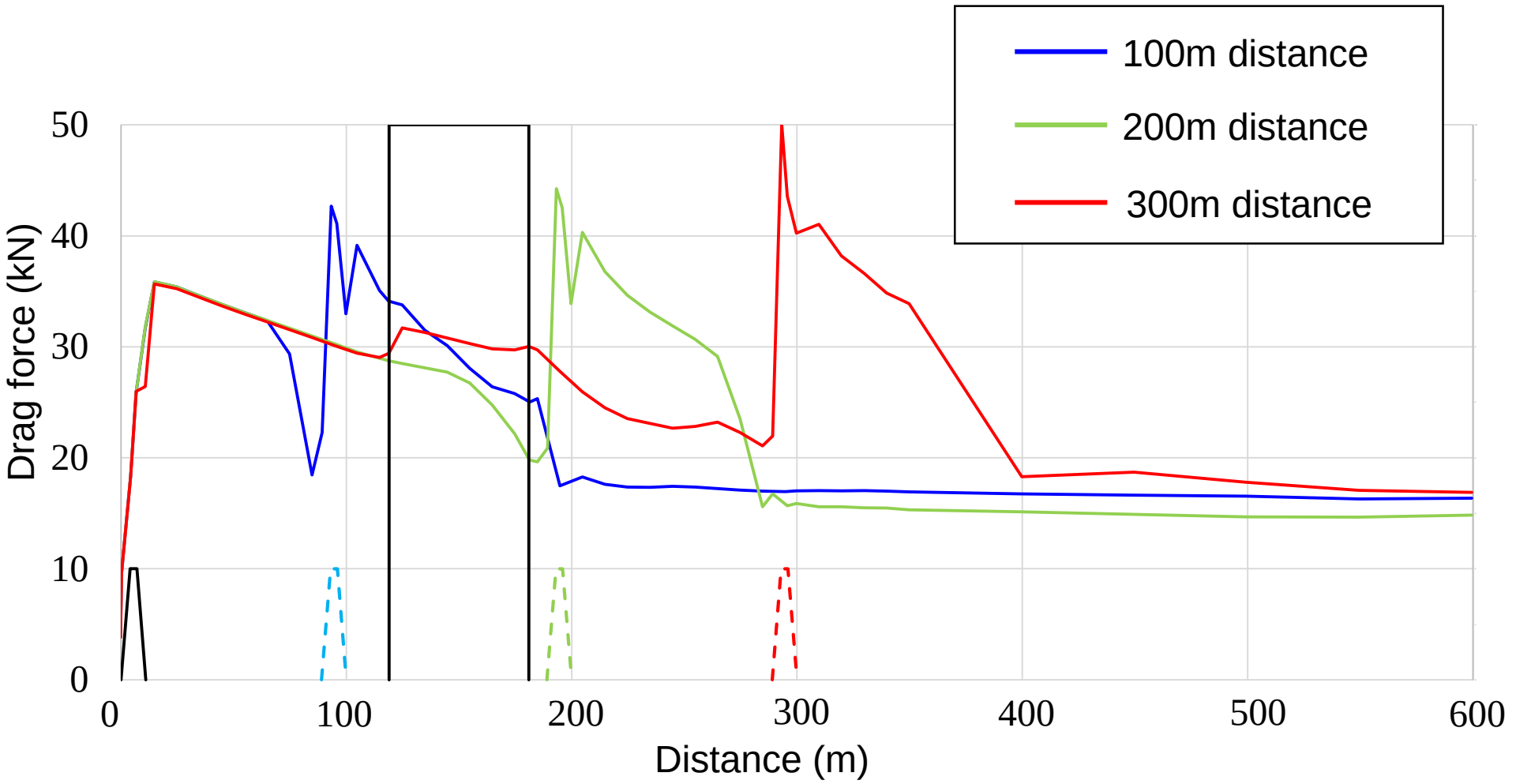


Investigating number of 3m banks (Case1,4,7,8)



It is indicated that multiple defenses reduce tsunami damage gradually.

Investigating distance between each bank (Case3,9,10)



Distance between each banks is not effective for decreasing drag force.

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Conclusion

Investigating tsunami-reduction characteristics with multiple defenses by earth banks.

Height of earth bank

- Height of bank is important to reduce drag force. (More than 3m bank is effective to 4m tsunami.)

Multiple defenses

- Multi banks reduce drag force gradually.

Distance between each banks

- Distance between each banks is not effective.

Multiple defenses with more than 3m earth banks is effective to reduce 4m tsunami damage.

In the future

Height of tsunami

Investigating the tsunami-reduction effect of earth bank in case of higher tsunami

Design method

Proposing design method to apply earth banks for narrow multiple defense
against future tsunami

Thank you for kind attention