DISASATER MANAGEMENT PERSPECTIVE

From Engineering to Citizen's Participation

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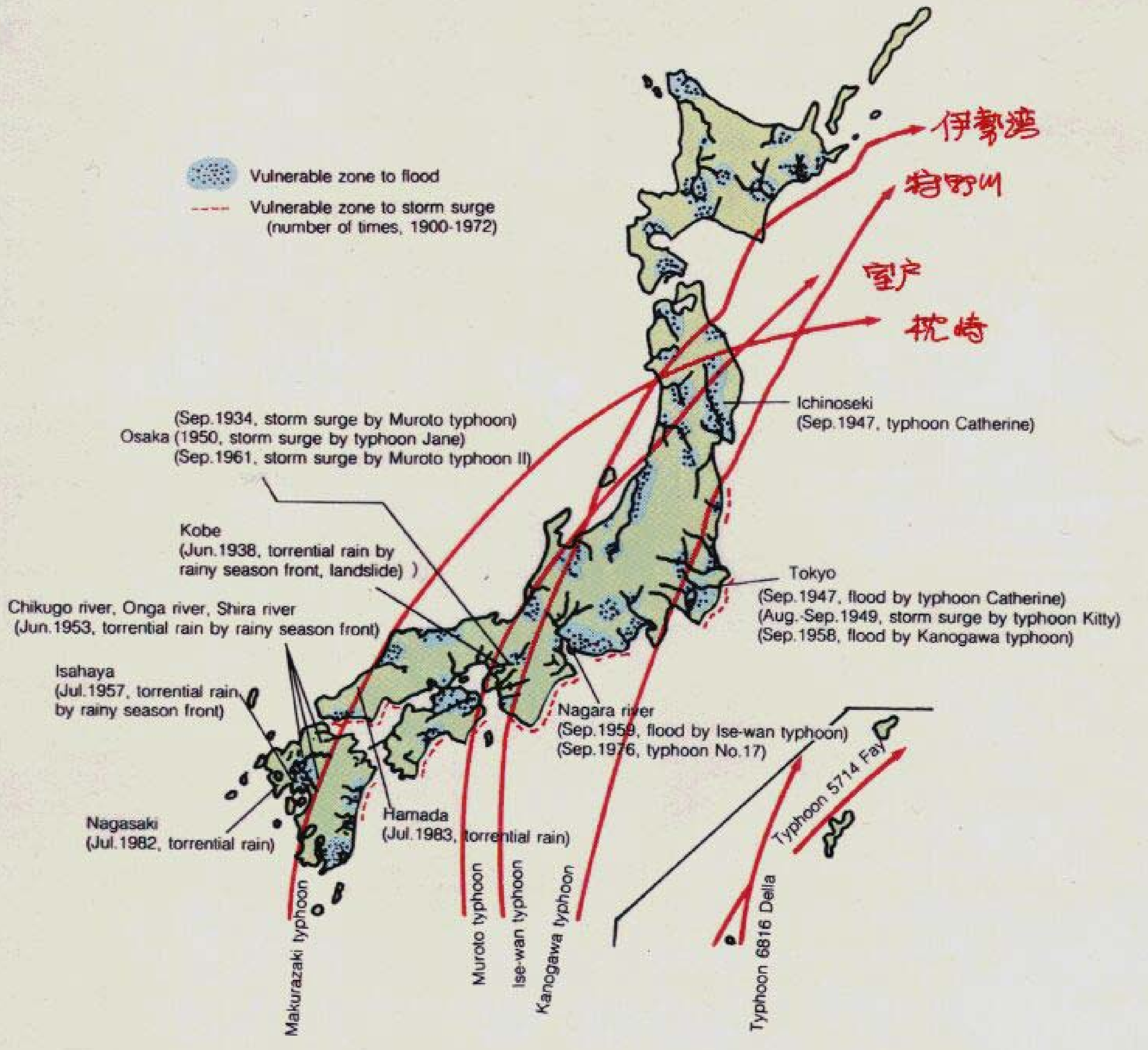
Major Flood in Japan

- Major Flood after WW2
- Big Damage in 1950’ to 1960’
- Less Damage in Last 30 years
- Flood in Urban Area became Major Issue

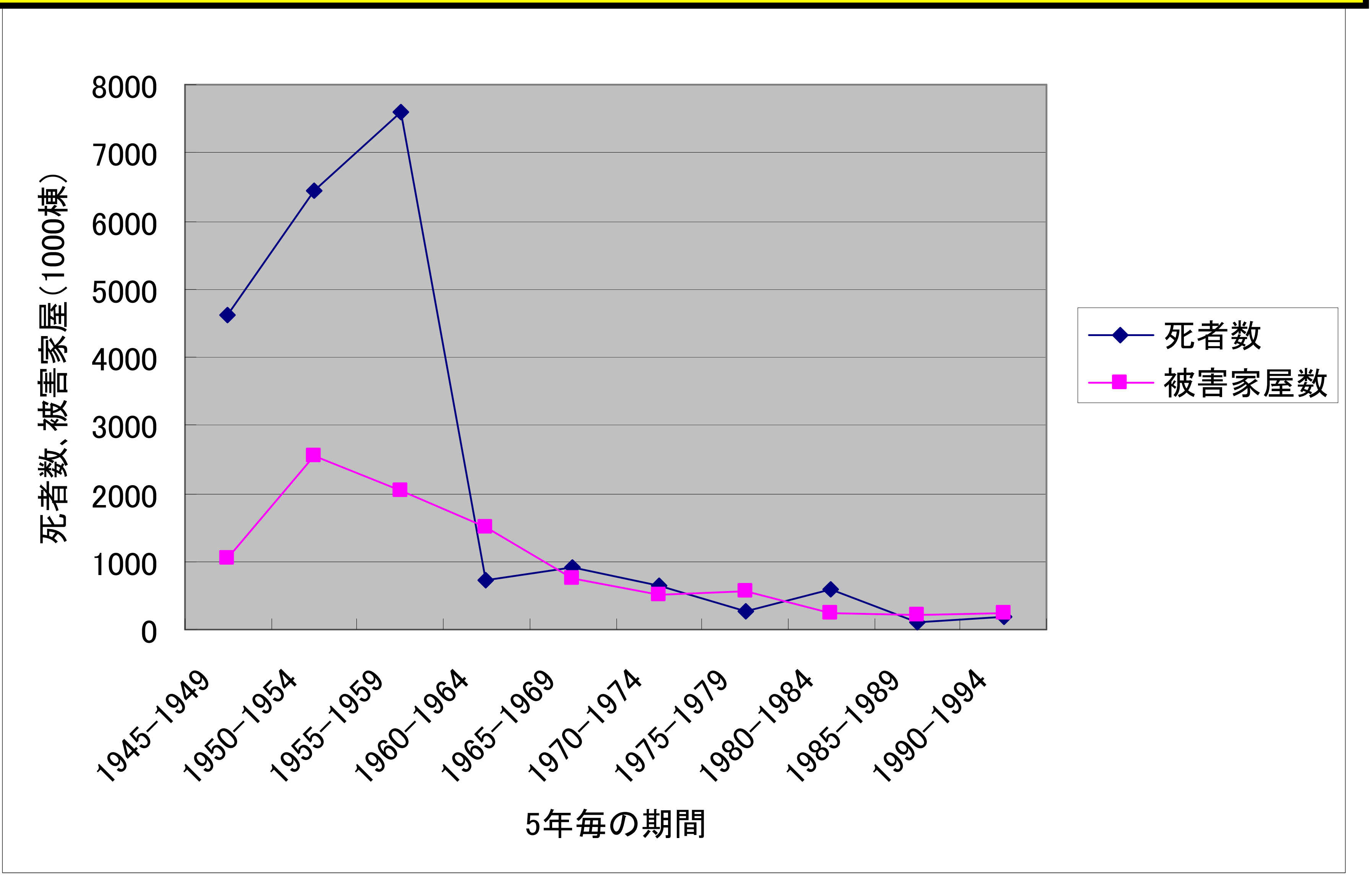
Major Flood Disaster in Japan

Name	Date	Death	Houses Damaged	Affected Area in Japan
枕崎台風	1945.9	1,700	361,321	九州～東北
カスリーン台風	1947.9	1,930	394,041	東海以北
アイオン台風	1948.9	838	138,052	四国～東北（特に岩手）
キティ台風	1949.8	160	161,263	中部～北海道
ジェーン台風	1950.9	508	222,736	四国以北（特に大阪）
大雨（前線）	1951.7	306	104,883	中部以西（特に京都）
ルース台風	1952.10	973	359,391	全国（特に山口）
大雨（前線）	1952.7	140	161,691	中国～東海
大雨（前線）	1953.6	1,013	489,298	九州～中国（特に熊本）
南紀豪雨	1953.7	1,124	97,368	全国
台風第13号	1953.9	478	582,273	全国（特に近畿）
台風第12号	1954.9	146	221,235	関東以西
洞爺丸台風	1954.9	1,761	311,075	全国
諫早台風	1957.7	992	79,376	九州（特に長崎）
狩野川台風	1958.9	1,269	538,458	近畿以北（特に静岡）
台風第７号・前線	1959.8	235	224,806	近畿～東海（特に甲信）
伊勢湾台風	1959.9	5,098	1,197,576	全国（九州を除く）
Ｓ36梅雨前線	1961.6	357	422,826	全国（北海道を除く）
第２室戸台風	1961.9	202	883,564	全国（特に近畿）
大雨（前線）	1962.7	102	91,999	九州・東海
台風第20号	1964.9	56	116,020	九州～東北
台風第24号・前線	1965.9	107	259,925	全国
台風第24・26号	1966.9	318	126,767	全国（特に山梨）
Ｓ42.7月豪雨	1967.7	371	305,201	九州北部～関東

Areas damaged by wind and water disasters in Japan



Death and Damage by Major Flood in Each 5 Years

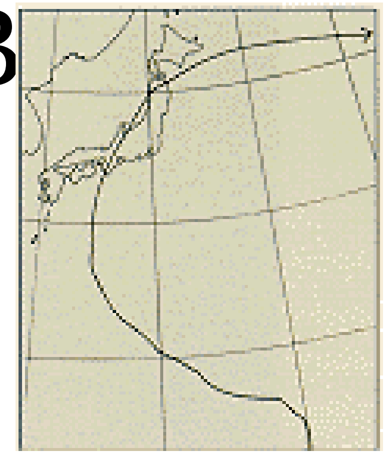


都市水害Urban Flood

- Flood in Urban Area
  - Ise Bay Typhoon（1959）
  - Nagasaki Flood　(1982)
  - Under Ground Shopping Mall in Fukuoka（1999）

- Private House Underground Flood in Tokyo(1999)

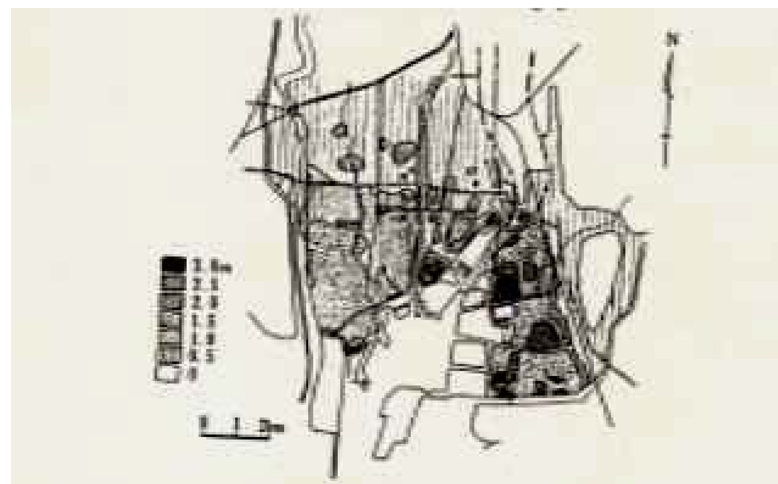
伊勢湾台風(Ise B



- **1959年9月**

死者	4,759人
行方不明者	282人
負傷者	38,921人
家屋全壊	36,135戸
家屋流失	4,703戸
家屋半壊	113,052戸
床上浸水	157,858戸
床下浸水	205,758戸
破堤	5,760カ所
田の流失	8,969ha
畑の流失	21,795ha
船舶流失	2,431隻

- 災害対策基本法の制定
- 災害危険地域
  - 地盤のかさ上げ
  - H2年に高床でも可



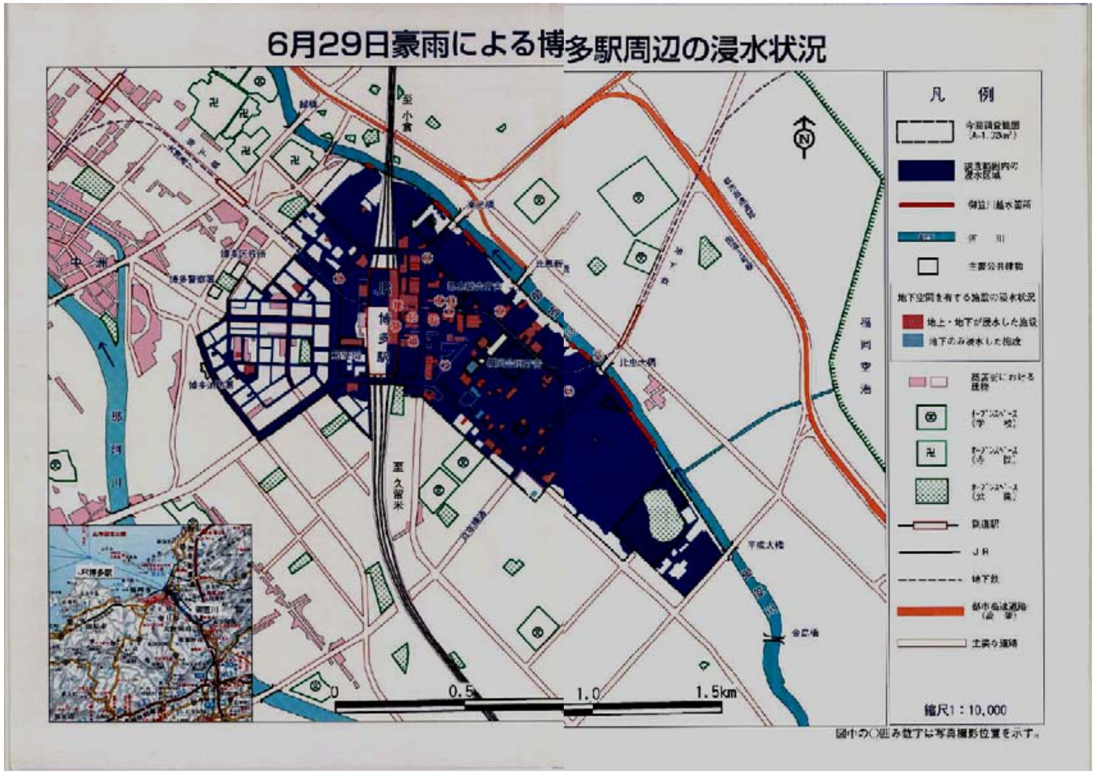
長崎水害(Nagasaki Flood)

- **Flooding to Underground Restaurant**
- **Flooding to Underground Parking**
- **Flooding to Hospital Underground Floor**
  - **Expensive Medical Equipments**
  - **Emergency Generators**

Flooding to Fukuoka Underground Shopping Mall

June 29,1999

JR Hakata Station
Low Level Land
1m Flood
Electricity of Undregroud Shopping Mall
1 person death

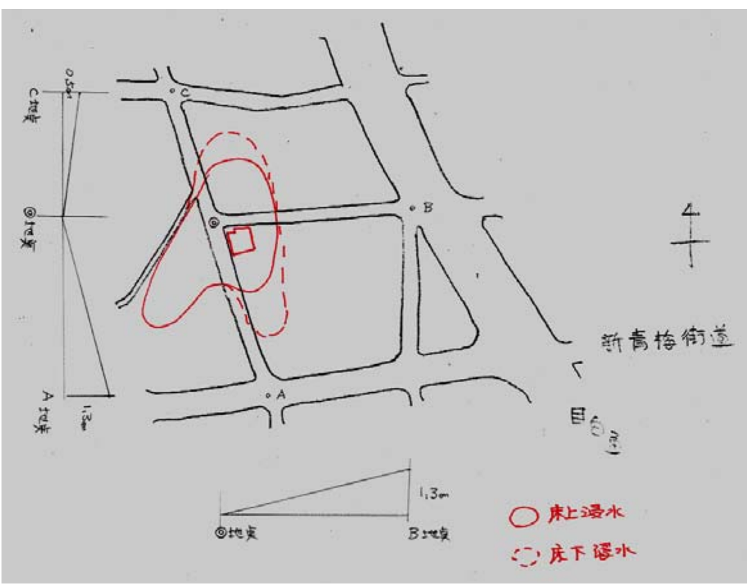


Flooding to Fukuoka Underground Shopping Mall

地下鉄博多駅出口より流れ込む濁流
（地下鉄博多駅15番出口）

Private House Basement Flood in Tokyo(1999)

- **July 21, 1999   Heavy Rain in Western Part of Tokyo**
- **Flooding to Private House Underground**
- **House Owner who go down to Underground Floor was killed**
- **Elevator for Private House**



Problems in case of t he Private House Basement

- Resident recognized that small flooding occurred in past several times
- Flooding from outside of underground floor
- Hole for air fan on the wall of basement
- Exit from Basement are only for outside and Elevator and no step for first floor
- No emergency exit from elevator

Lessons learned from Private house basement flooding

- Basement space for Private housing
- Water protection in Basement
- Evacuation Exit in Private House Basement

- Risk of Private House Basement
  - Residents should know the risk
  - Designer should know the risk
  - Risk should be transmitted to public

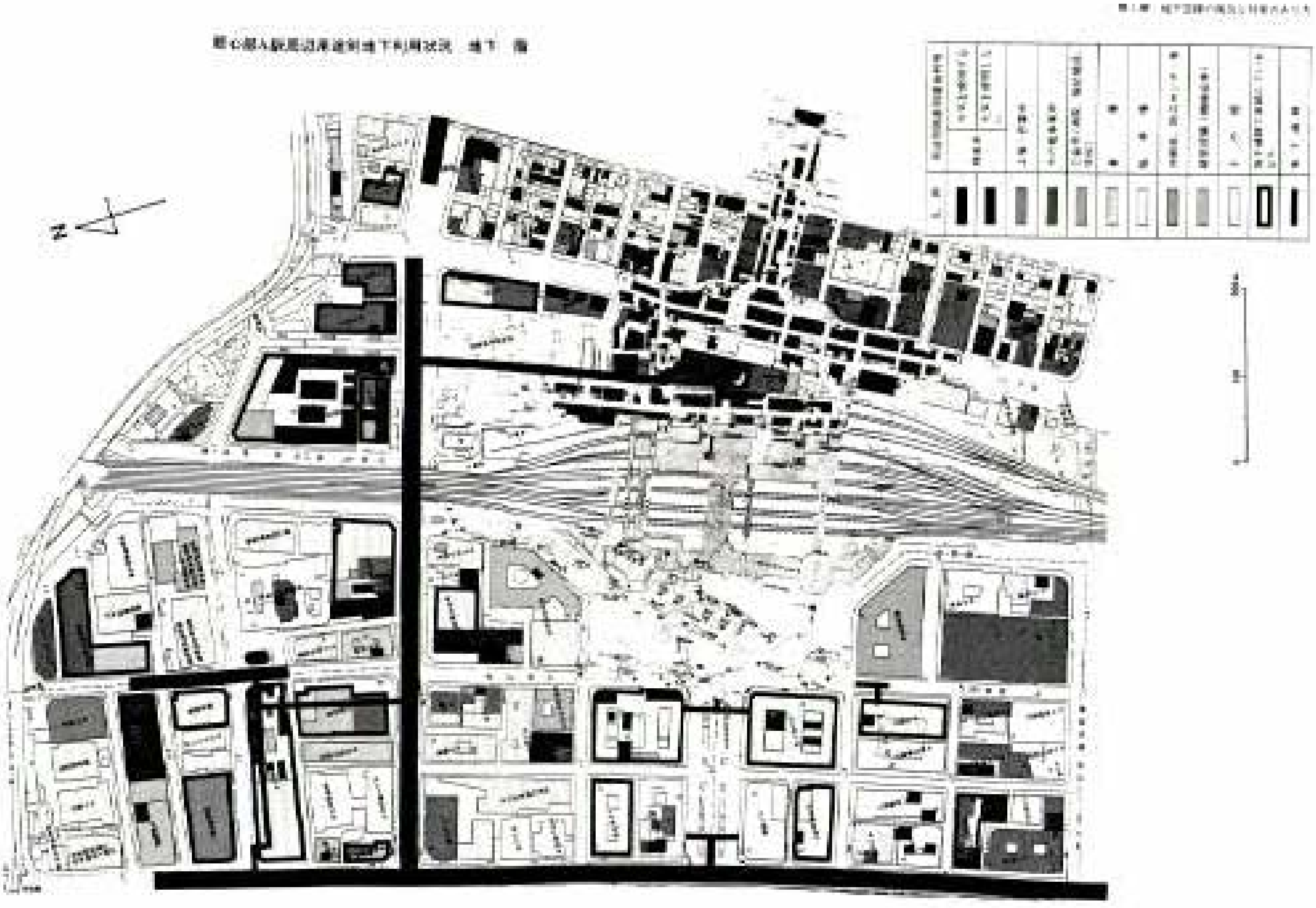
Urbanization and Urban Flood

Rapid Urbanization in 20 century

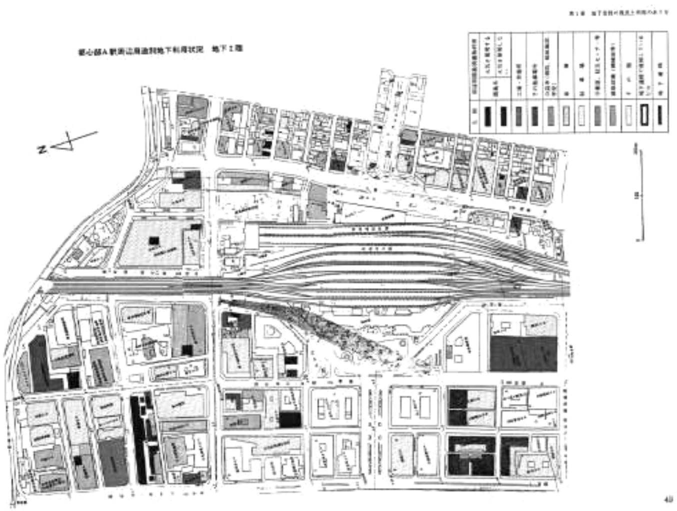
- Tsurumi River in Kanagawa Prefecture
  - Frequent flooding in urban area
- Depth of Subway in Tokyo
  - Asakusa line : Just under ground surface
  - Chiyoda line : 50m to 70m under surface

Use of Underground Space

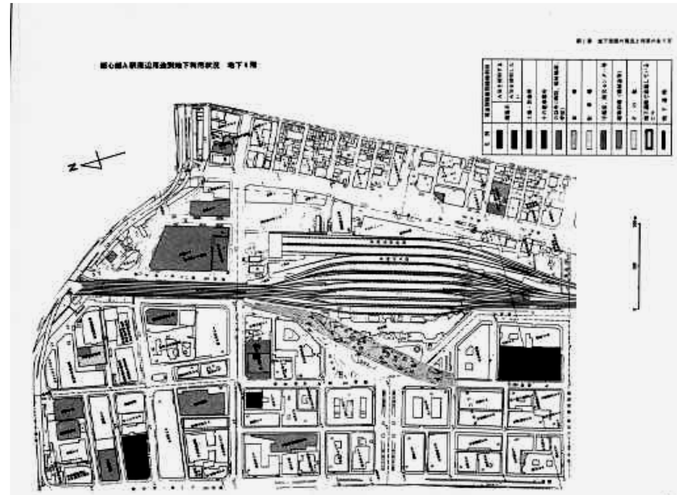
- Underground Use in Marunouchi-aria



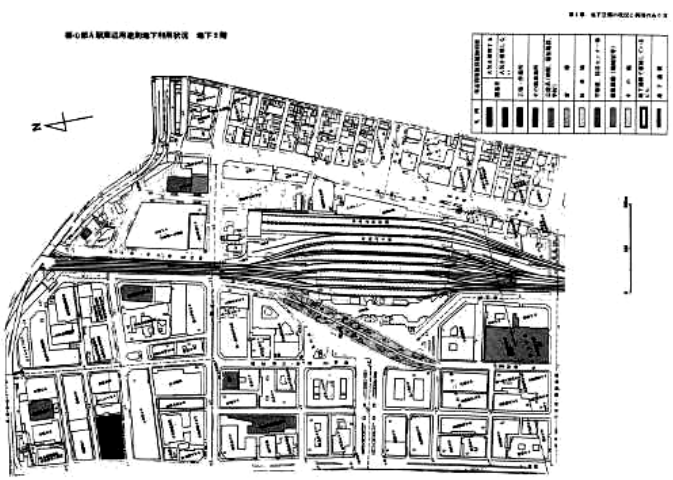
東京駅周辺地下1階



地下2階



地下3階



地下4階

地下5階

Six approaches for Urban Flooding

Information Sheering

Citizen's Capacity Building for Flooding

Enforcement of Disaster Response

Countermeasures for protection of flooding

Evacuation System

Urban Planning for Disaster Mitigation

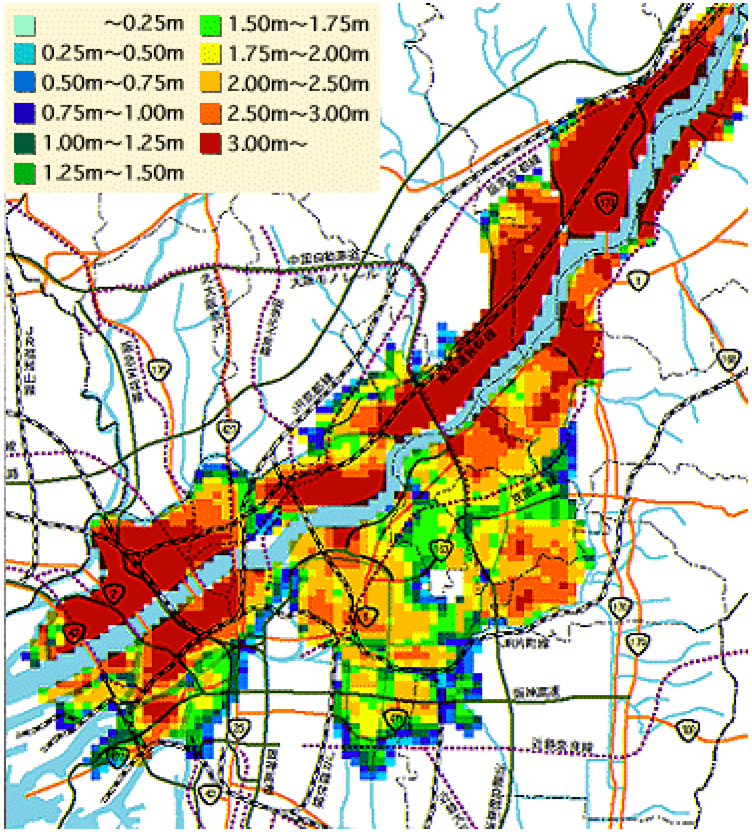
Citizen’s Capacity Building for Flooding

- **Information Dissemination**
- **Citizen’s Awareness**
- **Flood Information Sharing**
- **Disaster Education**
- **Volunteer Organization**

Hazard Map

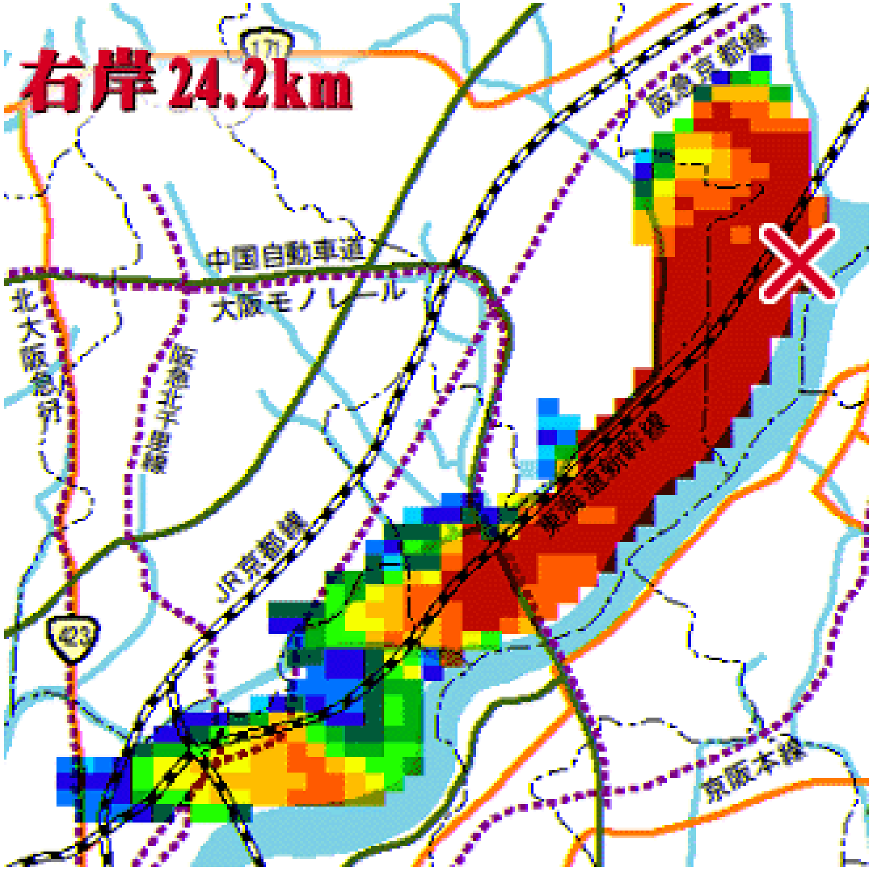
Flooding Simulation

Information Dissemination

- 

Yodo River in Osaka

We can see from Internet anytime



~0.25m	1.50m~1.75m
0.25m~0.50m	1.75m~2.00m
0.50m~0.75m	2.00m~2.50m
0.75m~1.00m	2.50m~3.00m
1.00m~1.25m	3.00m~
1.25m~1.50m	

※.×=破堤点

Flooding Simulation

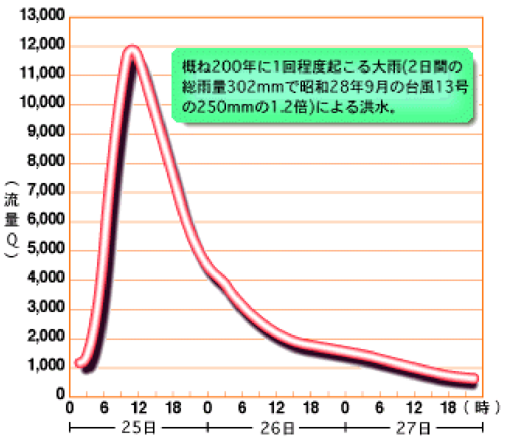
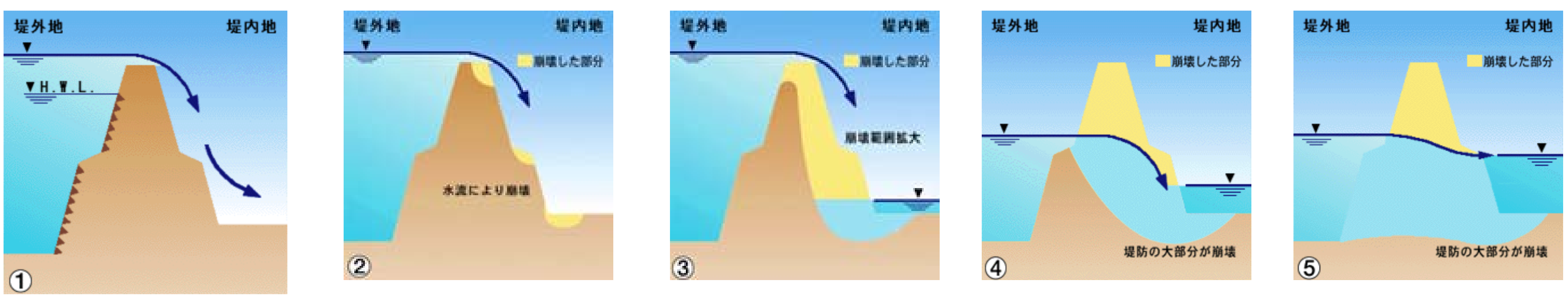


図-1 枚方地点計画流量ハイドログラフ



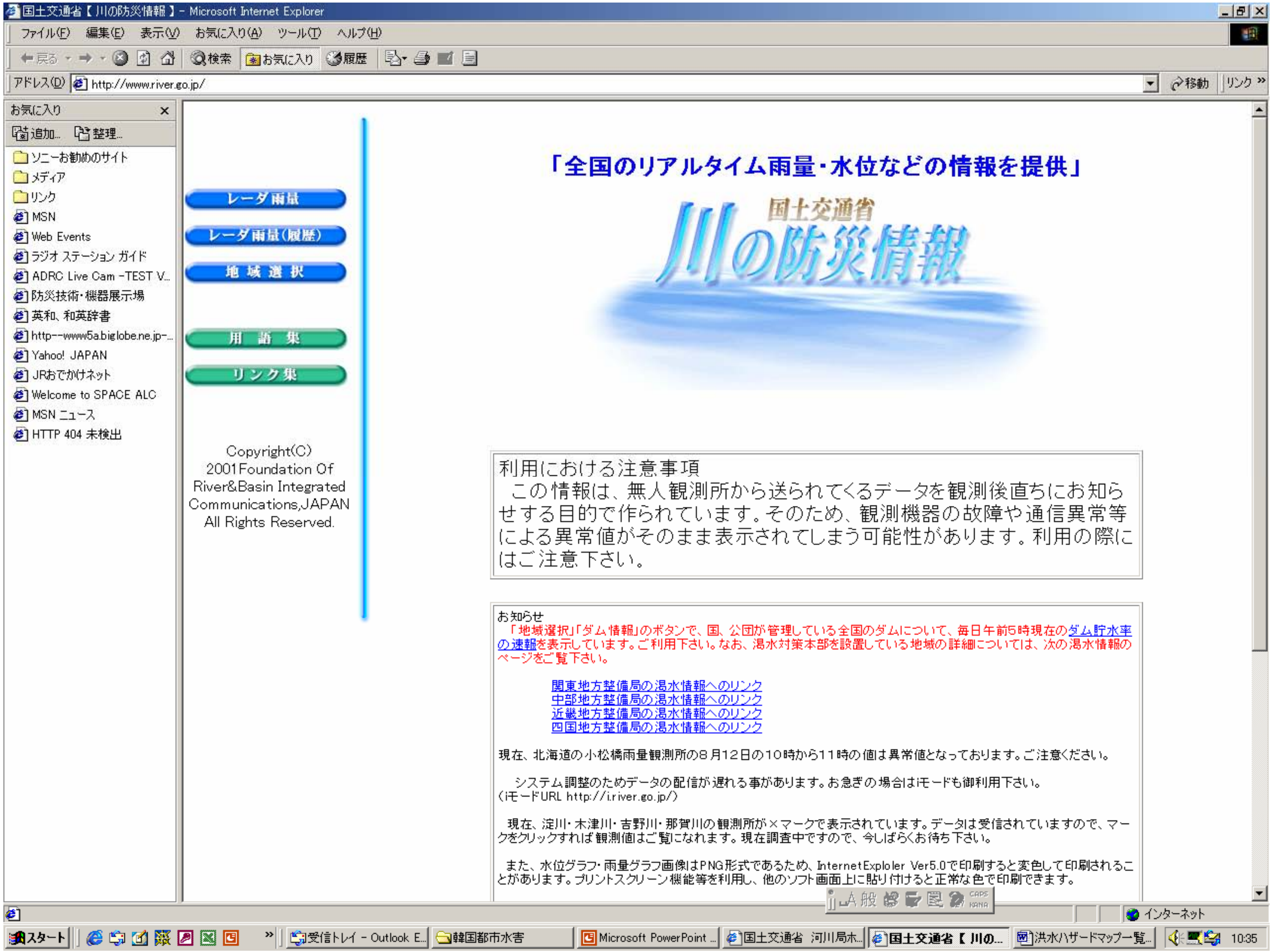
Information Sharing

- 防災関係機関相互
- 住民への情報提供
- 洪水警報
- マスコミとの連携

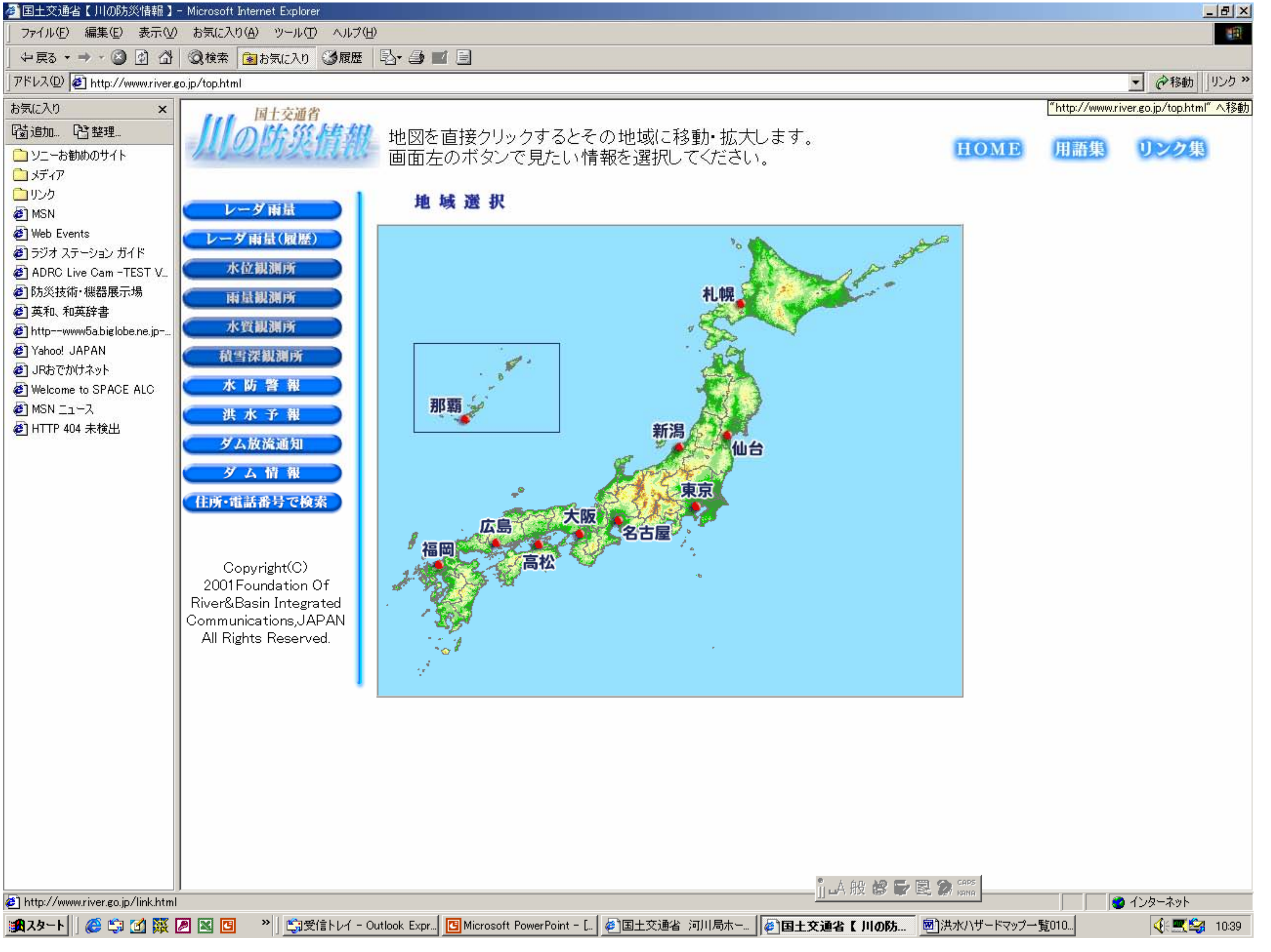
- 最近の情報公開の傾向
- 知らせることによる共同の防災への努力

河川水位の常時公開

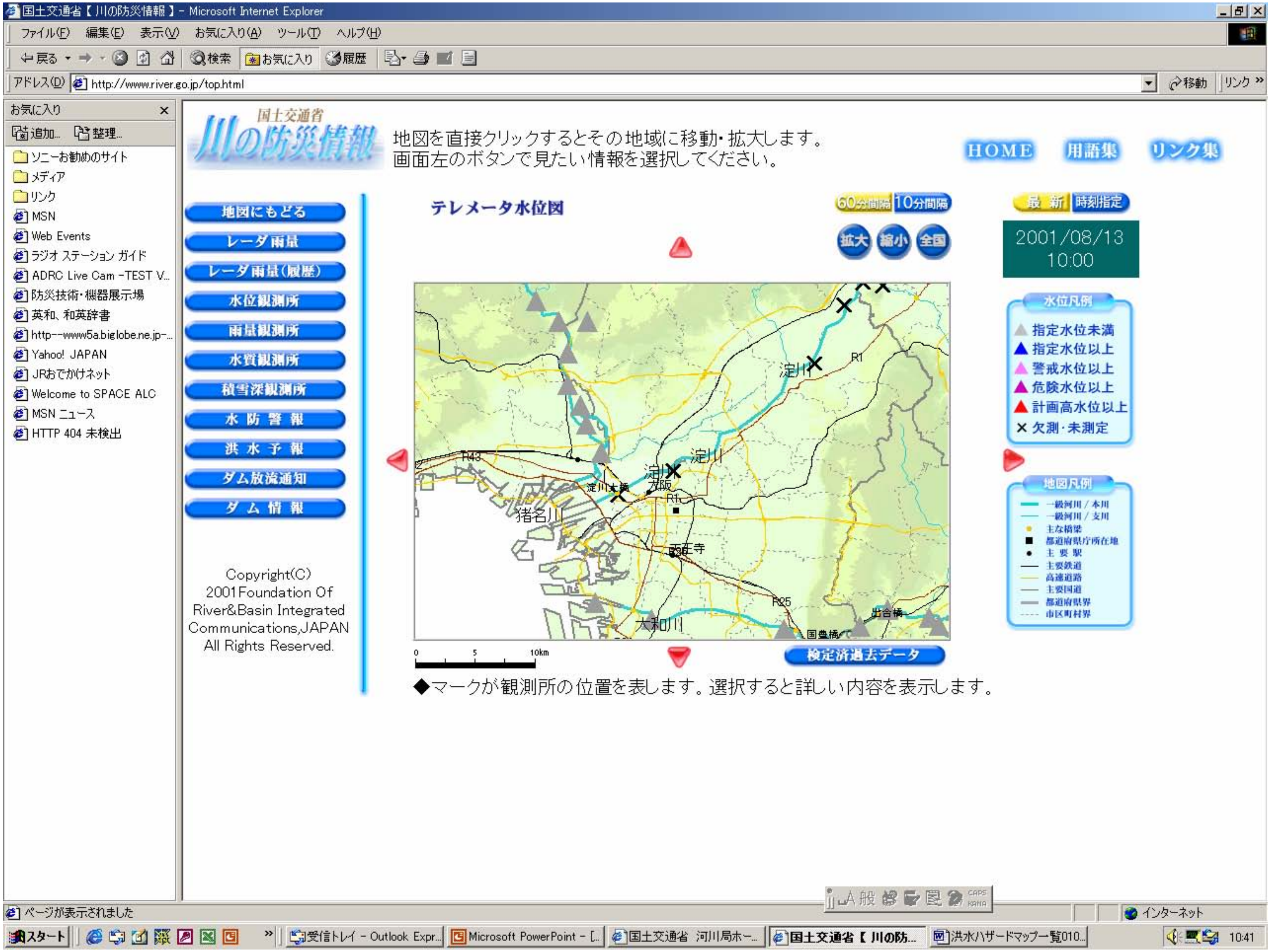
Information Sharing
“Real Time Water Level “



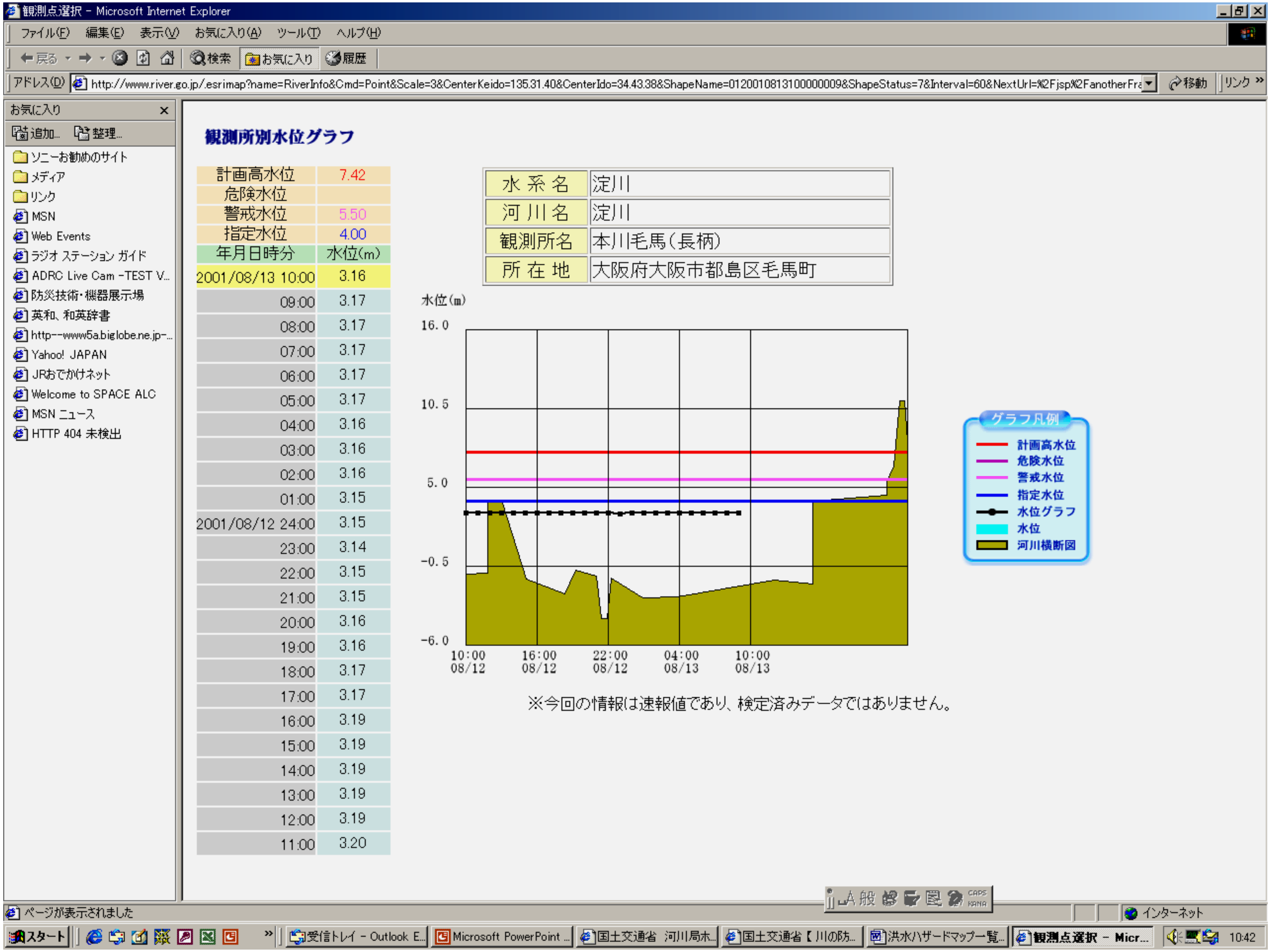
Select Region



Select River



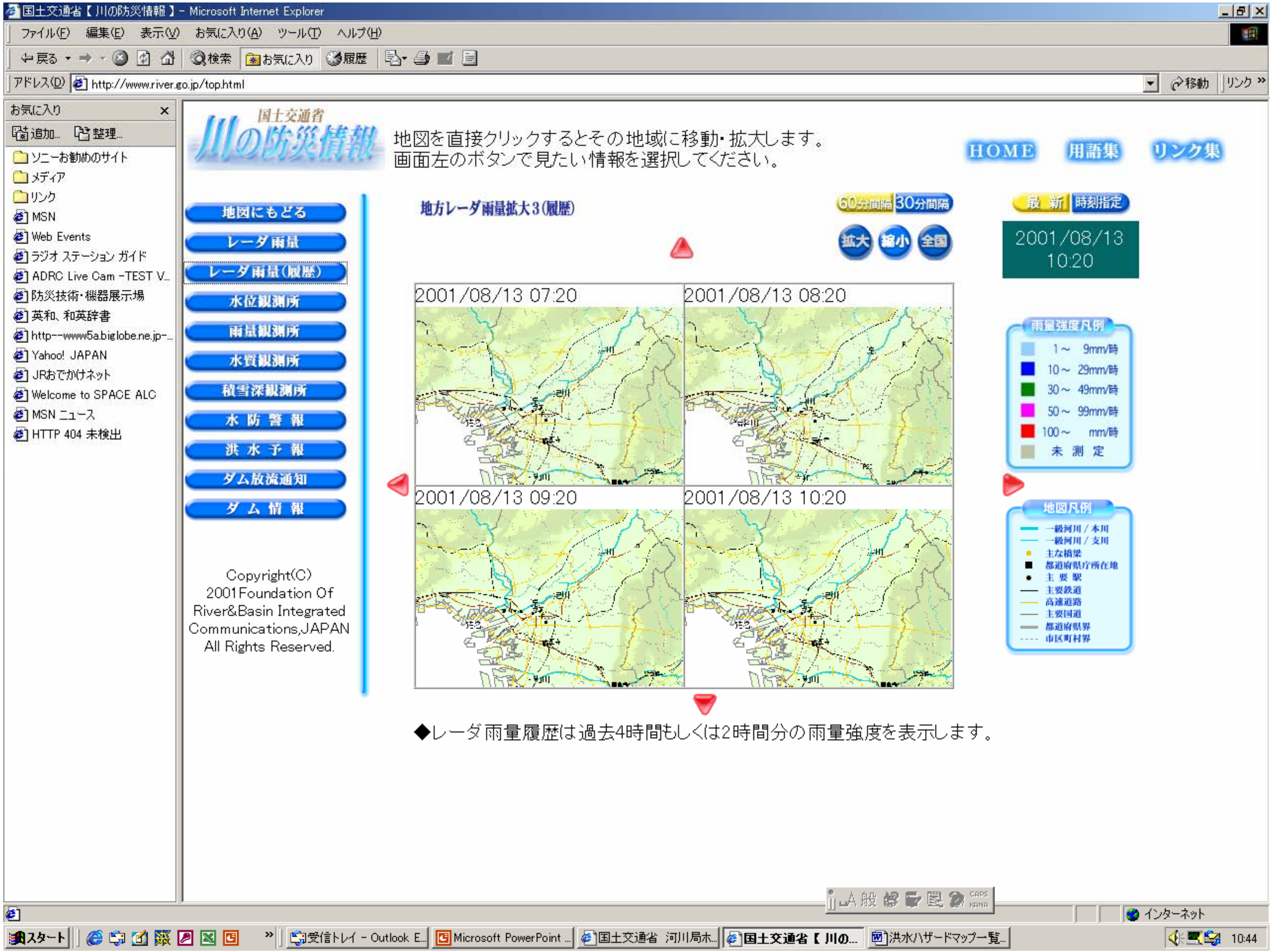
Real Time Water Level



計画高水位	7.42
危険水位	
警戒水位	5.50
指定水位	4.00
年月日時分	水位(m)
2001/08/13 10:00	3.16
09:00	3.17
08:00	3.17
07:00	3.17
06:00	3.17
05:00	3.17
04:00	3.16
03:00	3.16
02:00	3.16
01:00	3.15
2001/08/12 24:00	3.15
23:00	3.14
22:00	3.15
21:00	3.15
20:00	3.16
19:00	3.16
18:00	3.17
17:00	3.17
16:00	3.19
15:00	3.19
14:00	3.19
13:00	3.19
12:00	3.19
11:00	3.20

水 系 名	淀川
河 川 名	淀川
観測所名	本川毛馬(長柄)
所 在 地	大阪府大阪市都島区毛馬町

Real Time Data of Precipitation



Capacity building of Residents

- How to upgrade Citizen’s Awareness?
- Citizen’s Participation Program
  - Named “Disaster Mitigation Town Watching”
  - Developed in 1994

Town Watching Workshop at Qui Nhon in Vietnam at 2004.7


2004 7 1


BẢN ĐỒ QUY HOẠCH
TRUNG TÂM XÃ PHƯỚC HOÀ
2004 7 1


2004 7 1


2004 7 1


2004 7 1


2004 7 1


2004 7 1


2004 7 1


2004 7 1

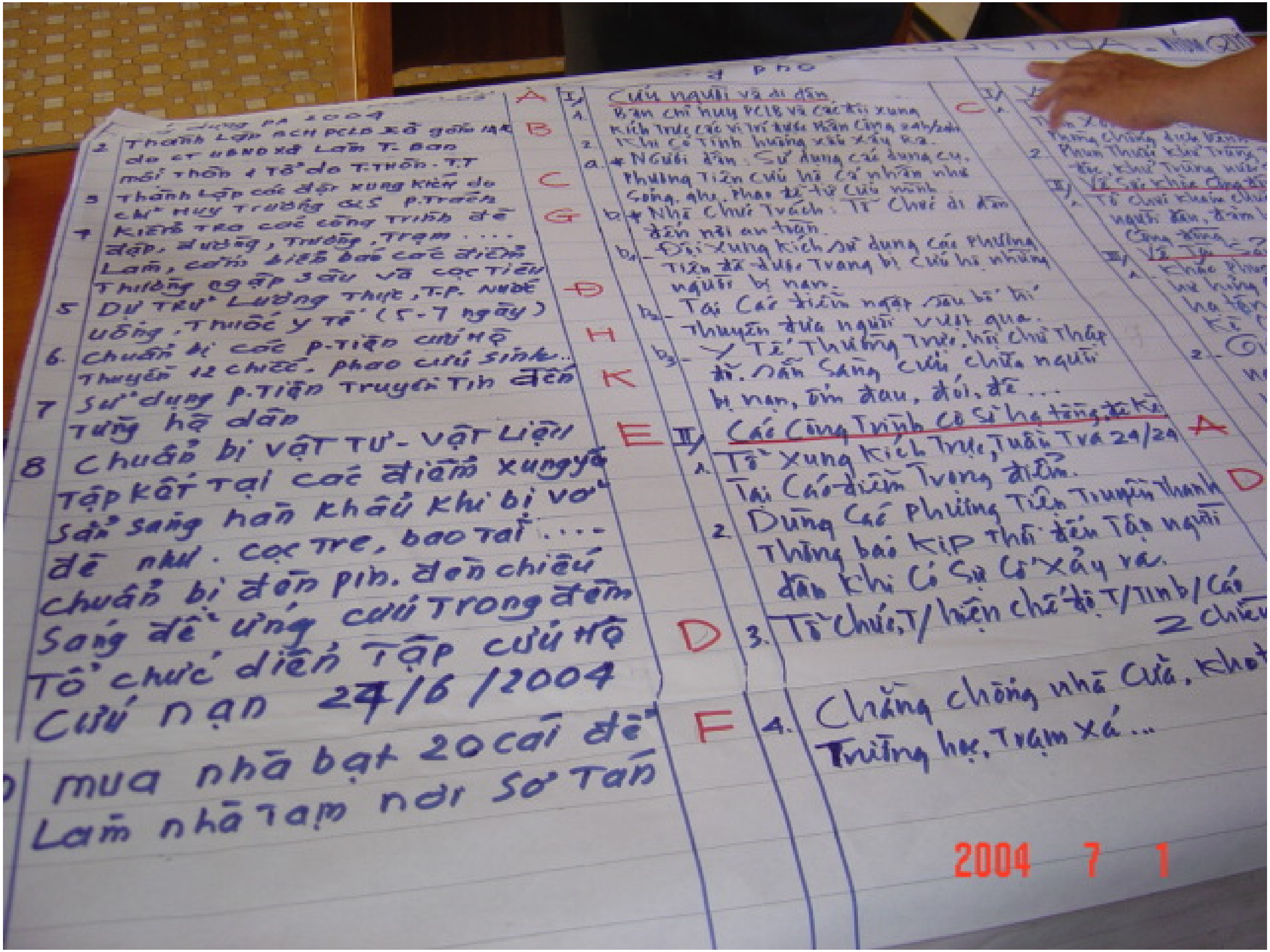

CỘNG SẢN VIỆT NAM QUANG VINH MUÔN NĂM
THỐNG NHẤT, PHÁT
2004 7 1


Sông Gò Bồi
Sơ họa thôn
Tân Giản
Phước Hòa
Nhóm
Q.trị
ghi chú
Xấu
Tốt
Tham khảo
Ngã ba Tốt
Trường Tốt
Cầu Tốt
Biển Gò Bồi Tốt
R.Lá
Rừng Lá
Tre Làng
2004 7 1


SƠ ĐỒ VÙNG NGẬP LỤT
2004 7 1

SƠ HỌA HIỆN TRẠNG THÔN TÙNG GIẢNG
XÃ PHƯỚC HÒA - HUYỆN TUY PHƯỚC
B
XÃ PHƯỚC THẮNG
SÔNG GÒ BỒI
○ : ĐIỂM TỐT
○ : ĐIỂM XẤU
GHI CHÚ
2004 7 1


2004 7 1



5 Dự trữ Lương thực, T.P. nước uống, Thuốc y tế (5-7 ngày)
6. Chuẩn bị các p.tiện cứu hộ Thuyền 12 chiếc. phao cứu sinh..
7 Sử dụng p.tiện Truyền Tin đến từng hộ dân
8 Chuẩn bị vật tư - vật liệu tập kết tại các điểm xung yếu sẵn sàng hàn khẩu khi bị vỡ đê như. cọc tre, bao tải ....
chuẩn bị đèn pin. đèn chiếu sáng để ứng cứu trong đêm
Tổ chức diễn tập cứu hộ cứu nạn 24/6/2004
mua nhà bạt 20 cái để làm nhà tạm nơi sơ tán
I/ Cứu người và di dân
b1- Đội xung kích sử dụng các phương tiện đã được trang bị cứu hộ những người bị nạn.
b2- Tại các điểm ngập sâu bố trí thuyền đưa người vượt qua.
b3- Y tế thường trực, hội chữ thập đỏ. sẵn sàng cứu chữa người bị nạn, ốm đau, đói, rét...
II/ Các công trình cơ sở hạ tầng
1. Tổ xung kích trực, tuần tra 24/24 tại các điểm trọng điểm.
2. Dùng các phương tiện truyền thanh thông báo kịp thời đến tận người dân khi có sự cố xảy ra.
3. Tổ chức T/hiện chế độ T/Tinb/cáo 2 chiều
4. Chằng chống nhà cửa, kho trường học, trạm xá...
2004 7 1


2004 7 2


2004 7 2


PHƯƠNG ÁN PCLB XÃ PHƯỚC HÒA
2004 7 2

Workshop in Yokohama targeting Earthquake Problems


カメヤ
中村町三丁目


駐輪禁止


MEASURE
BRIGADES
involvement)
POSTS
USE
LEGEND

AT LAST

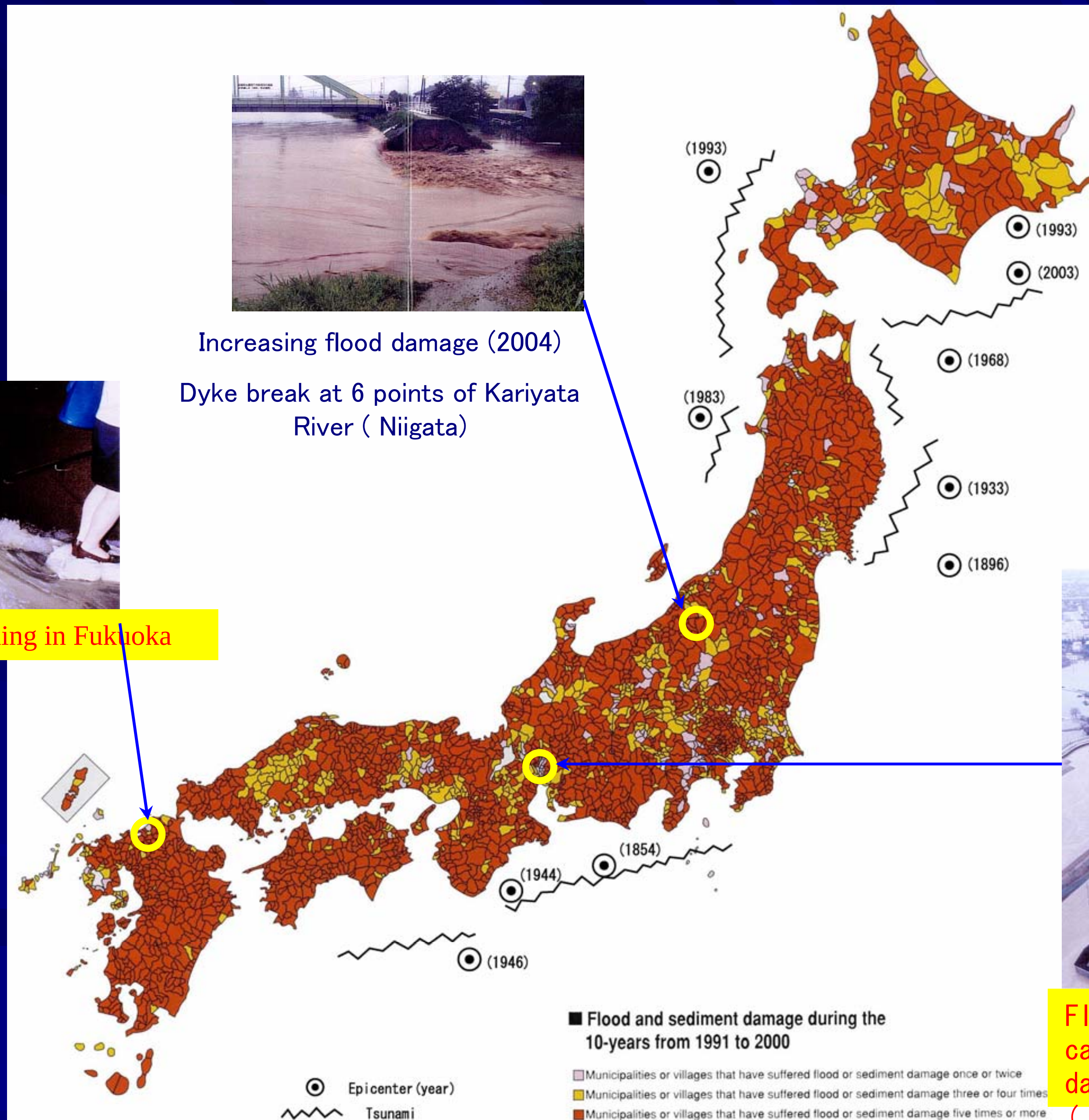
- Civil Engineering Approach have played great roll in Disaster Mitigation.
- Our build environment are and will be vulnerable for Natural Disaster.
- Citizen's Participation Approach will become much important.
- Citizen's Capacity Building Methodology such as "Town Watching" is just started.
- We need to expand Disaster Management by Holistic approach.

Present status of flood damage in Japan

Increasing flood damage (2004)

Dyke break at 6 points of Kariyata River (Niigata)

Underground space flooding in Fukuoka



Flood in Cities causes increased damage cost (Nagoya)

Flood damages and lessons taught from them

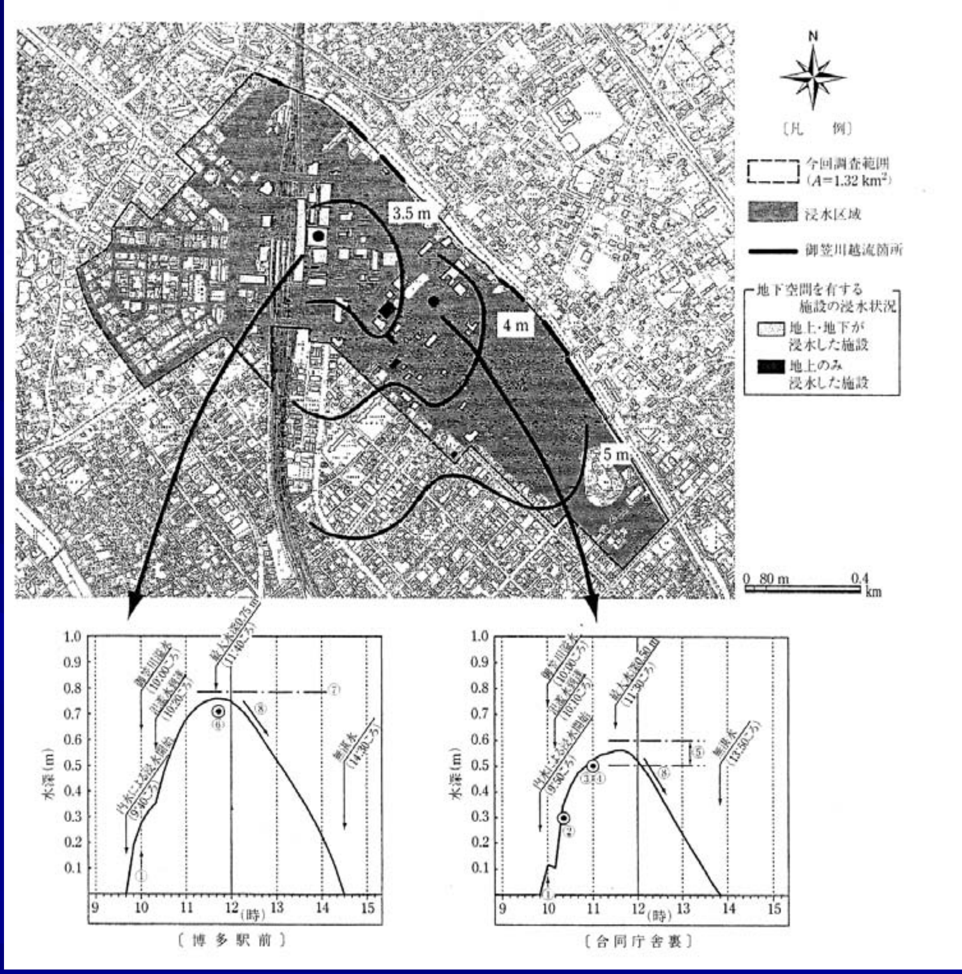
・Underground space flooding in Fukuoka（June,1999）

77mm/hr＞52mm/hr

Water from sewerage, Mikasa River and Sannoh diversion channel

→ Hakata St. (lower ground)

Inundation increase velocity: 10～20cm/10min.



・The extent of damage

Almost half of all the shops, except the underground shopping area, were inundated to more than 1m-deep.

Underground shopping area (Deitos) Water came in through 20 points and 10 of them were gateways.

・Measures

Drainage through 13 drain outlets into underground reservoir（13,000m3）

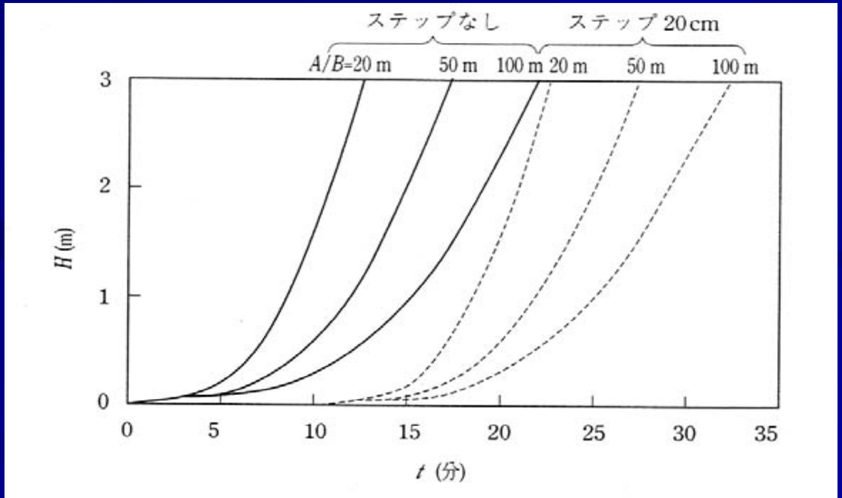
種類	年　月	被災箇所：被災概要	最大雨量
地下鉄	1973.8	名古屋市営 名城線：平安通駅でホーム上 40 cm 浸水	80 mm/h
	1981.7	都営三田線：内幸町駅が内水	—
	1985.7	都営浅草線：西馬込駅が内水	68 mm/h
	1986.8	仙台市営：開業前に浸水	—
	1987.7	京阪電鉄：鴨川支川の水が浸入	78 mm/h
		都営浅草線：五反田駅	70 mm/h
		営団丸の内線：赤坂見附駅	—
	1999.6	福岡市営：博多駅	77 mm/h
	1999.8	営団半蔵門線：渋谷駅が内水	—
		営団銀座線：溜池山王駅が内水	—
	2000.9	名古屋市営：名城線：平安通駅でホーム上 90 cm 浸水	93 mm/h
		名古屋市営：桜通線：野並駅が浸水	—
		名古屋市営：鶴舞線：塩釜口駅が浸水	—
	2001.8	名古屋市営：桜通線：名古屋駅が浸水	—
	2003.7	福岡市営：博多駅	太宰府 104 mm/h
地下街	1970.11	八重洲：河川の水圧で工事用防水壁が壊れ，水が浸入	—
	1971.7	名古屋駅前ユニモール	30 mm/h
	1981.7	*新宿歌舞伎町サブナードが内水（最高 30 cm）で浸水*	—
	1982.8	名古屋市セントラルパークが内水	33 mm/h
	1999.6	博多駅，天神で浸水	77 mm/h
	2000.9	名古屋駅前ユニモールが若干浸水	—
		名古屋市セントラルパークが若干浸水	—
	2003.7	博多駅地下街で浸水	太宰府 104 mm/h

Lessons from the underground space flooding in Fukuoka

- Limit of drainage capacity through sewer
- Inner water increases as quick as flooding water.
- Check boards and doors to the connecting passage to adjacent building
- Immediate evacuation is must if the water flows into narrow underground spaces.
- Underground reservoir of building is effective for drainage.

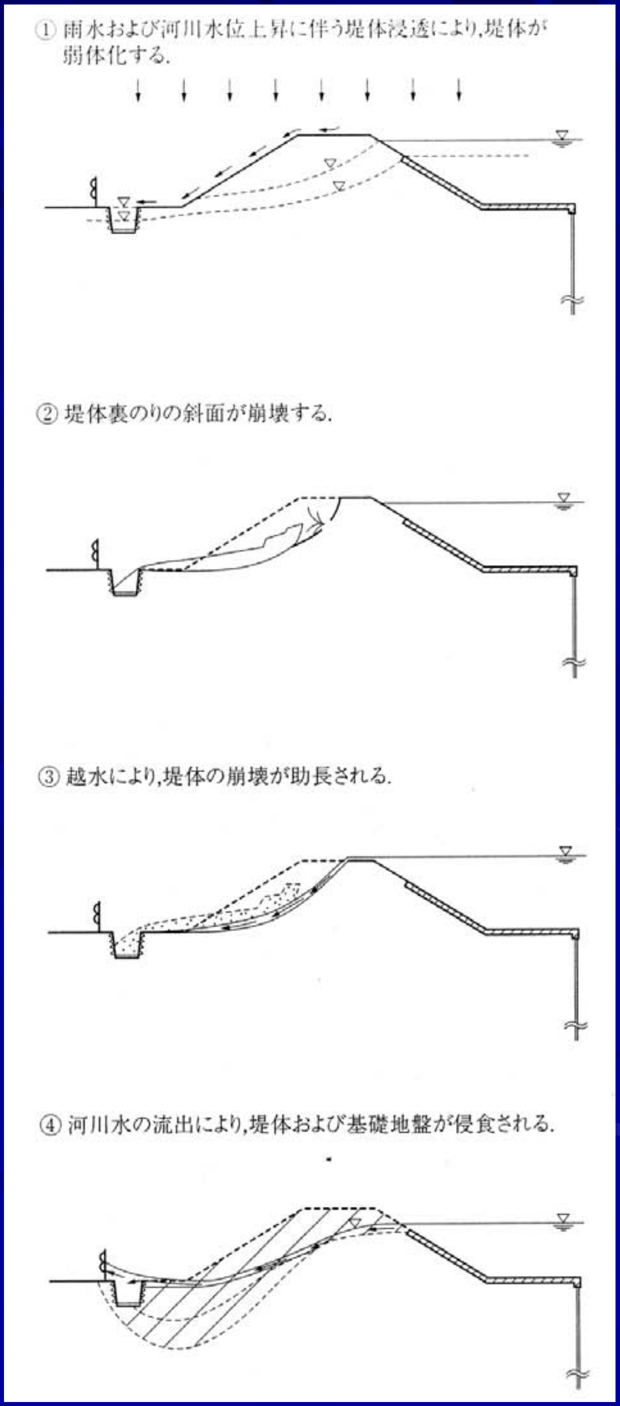
Underground space flooding

・Underground space flooding occurs when rainfall intensity exceeds 70mm/hr
・Just one water infall causes flooding←Caution needed for entrances and exits, connecting passages to the adjacent building
・Inundation hour : $T = 3(A/B \cdot H)^{0.35}$
A/B＝total floor area／total door width
The smaller is the value above, the faster is the inundation pace.
e.g.) 13min. at 20m (Fukuoka), 17min. at 50m (Tokyo)
・ Door becomes hard to be opened because of the water pressure regardless of whether it opens inward or outward
←set check boards and check doors at exits and entrances
・Set inundation check equipments to air vents of subway
Immediate evacuation is needed when the flooding water reaches basements and underground buildings



Rain Storm Disaster in Tokai

- Sep. 2000　Dyke break of diversion channel of Shonai River (Shin River)
- conceivable cause of the dyke break is over-topping or infiltration
  eyewitness, slope scouring, erosion depth
- Water level exceeded design water level for 11 hours.
  infiltration→slope scouring→overtopping →dyke break



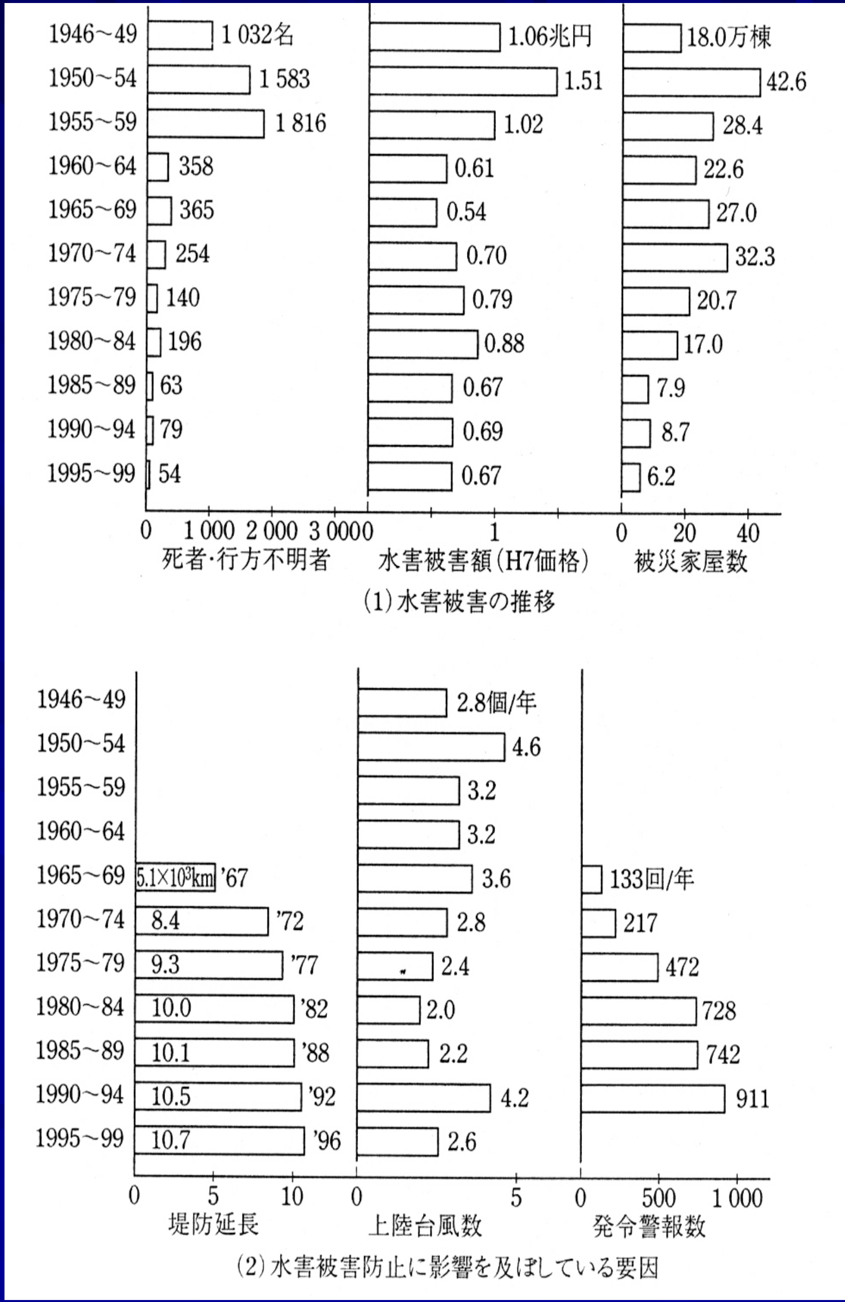
Flood Damage

・the number of dead and missing persons and the damaged houses are decreasing.

← River improvement
Weather information announcement

Installation rate of design height dyke
38%（1976）→ 56%（2002）
Development of AMEDAS（late 1960's）
6 times as many warnings as before

・Damage cost remains the same level.
←Inundated area is decreasing, but large and midsize cities are damaged.



Detailed contents of flood damage

- Death risk of dead and missing persons

  Man in his 40～50's died during his activity by the river side

  Less death risk of aged person ,

  compared with that of seismic and sand avalanches

  ←caution needed for activities during floods

- Damaged house

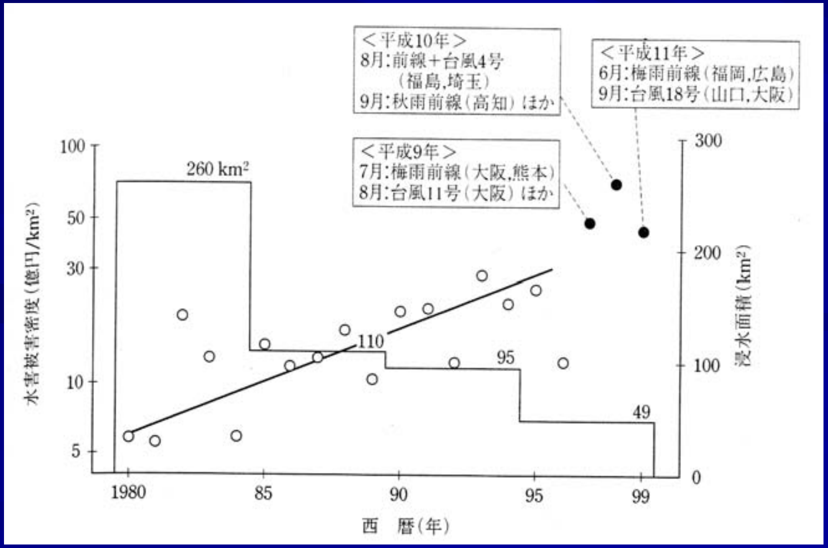
  Many houses used to be totally destroyed or washed away,

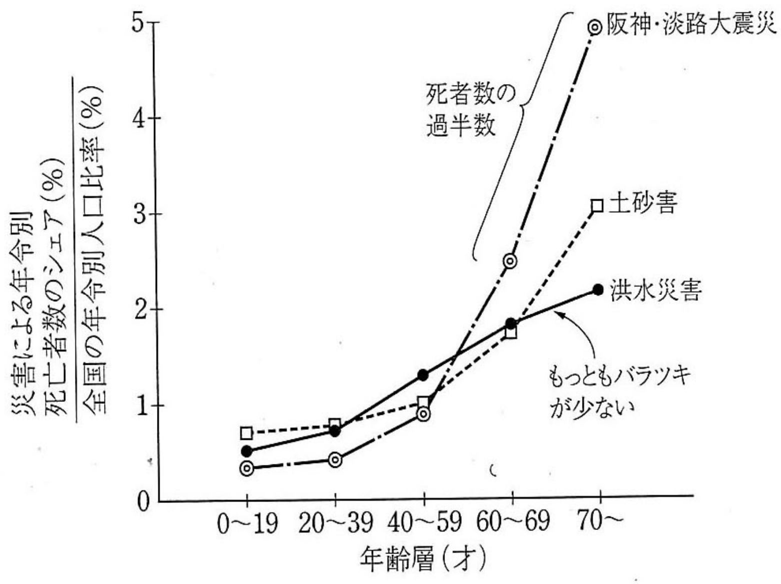
  now 80% of the damaged houses are under floor flooding

- Flood damage density tends to increase

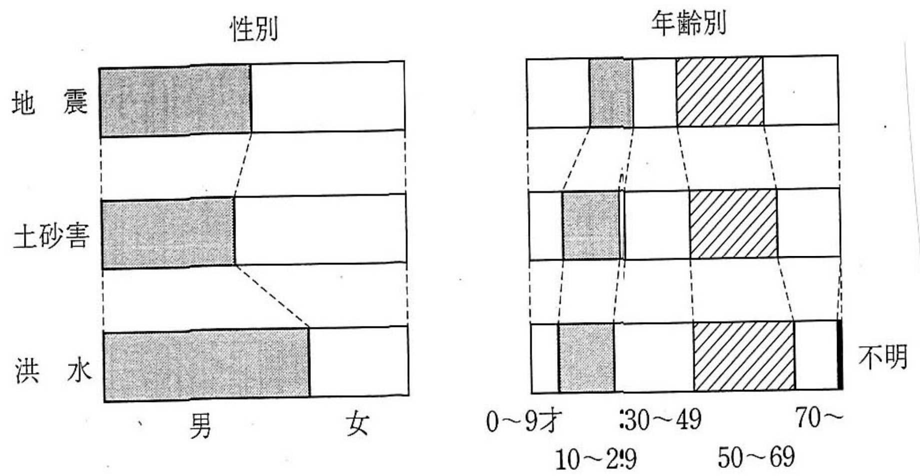
  Higher increasing rate especially since 1997,

  about \$60 million /km^2 was recorded in 1998





災害による年令別
死亡者数のシェア（%）
全国の年令別人口比率（%）
5
4
3
2
1
0
0～19
20～39
40～59
60～69
70～
年齢層（才）
阪神・淡路大震災
死者数の
過半数
土砂害
洪水災害
もっともバラツキ
が少ない



性別
年齢別
地　震
土砂害
洪　水
男
女
0～9才
10～29
30～49
50～69
70～
不明

Flood damage of the past 10 years

- 60 persons dead and missing
  40 victims by sand avalanches
- about 70,000 of damaged houses
  ¾ of them are under floor flooding.
- Total damage cost is about $6 billion
  70% flood damage cost by damages of public facilities
  60% of the total flood damage cost caused by inner-water and overtopping from no-levee section

Dyke break caused by Overtopping

- **state of overtopping**

  Undulations on crown of the levee causes non-overtopping and overtopping section.
  As overflow discharge increases, overtopping section becomes longer.

- **Process** overtopping → slope toe scouring → levee body collapse → dyke break

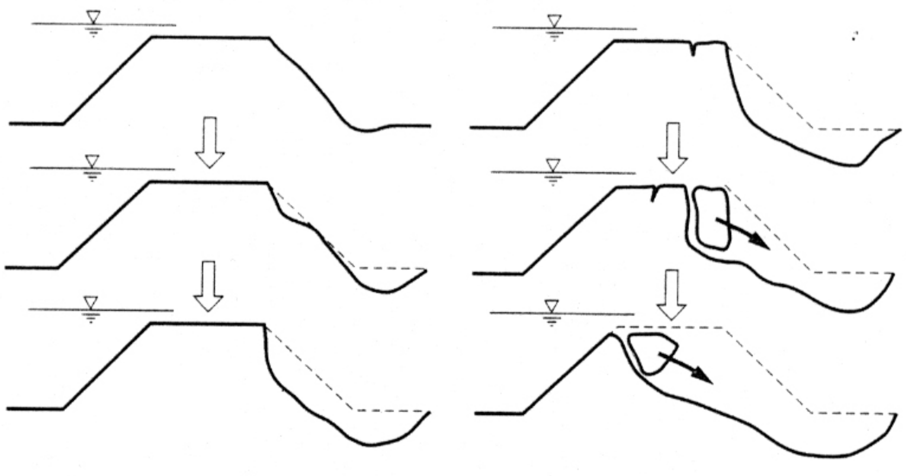
  overtopping → slope shoulder erosion → deep overtopping depth → levee body collapse

- **overtopping～ dyke break**

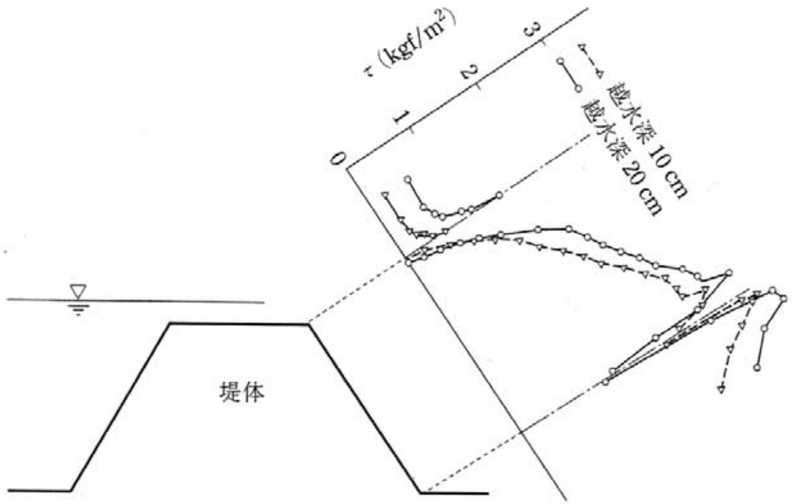
  within 40min(40%)、more than 2 hr. (20%)

- **Forms of dyke break**

  Dyke-break width is related to river width and it becomes wider at river confluence
  Elevation at dyke-break section is deeper or as deep as the ground level.



(a) 裏のり・裏のり尻侵食過程　　(b) 天端崩壊過程



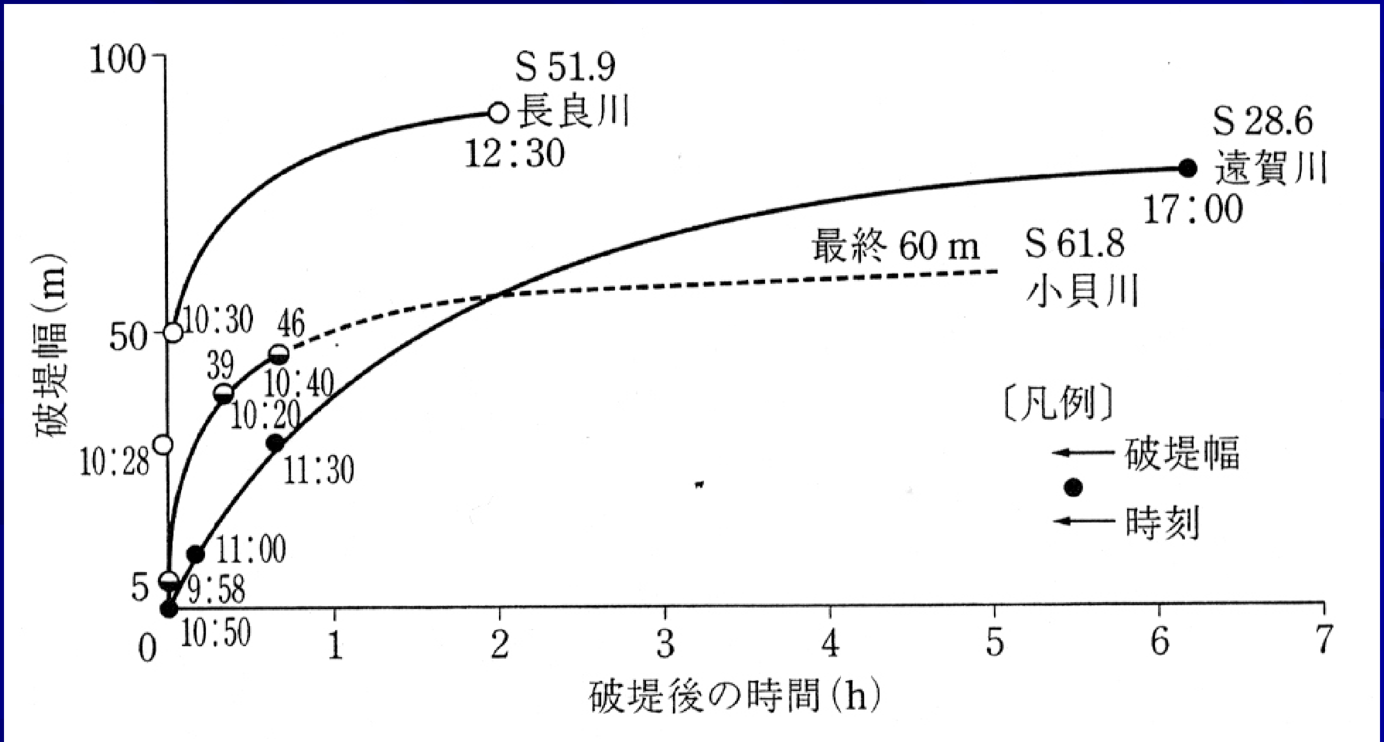
Forms of dyke break

- dyke-break width

  levee body becomes fairly wet→ Overall width (Bb) of the dyke is broken in a short time
- ground level at dyke break section

  same level as the inland of the dyke, or deeper than that
- Planner shape

  mostly trapezoid viewing from the river side



Flooding water propagation

- Embankment such as railroad or road has a great effect on flooding water propagation
- Flood water that flows into channels causes preceding floods
  e.g. Dyke break of Kokai River (1986)
- Propagation velocity is about 1 km/hr
  3～5 km/hr at steep slope floodplain

河川	破堤箇所	伝播速度	伝播地域（氾濫原勾配）
利根川	埼玉県東村(1947.9)	0.82 km/h 0.23 km/h	破堤箇所～埼玉県吉川町(1/6 800～1/3 700) 埼玉県三郷市～千葉県市川市
北上川	宮城県中田町(1947.9)	0.94 km/h	破堤箇所より 10 km 下流(1/4 000～1/3 000)
黒部川	富山県黒部市(1952.7) 富山県黒部市(1969.8)	2.7 km/h 4.5 km/h	破堤箇所～4 km 下流（1/120～1/90） 破堤箇所～1.5 km 下流（1/120）
長良川	岐阜県安八町(1976.9)	0.80 km/h	破堤箇所より 1.8 km 上流～旧森部輪中堤(1/4 000)
小貝川	茨城県石下町(1986.8)	0.60 km/h 0.90 km/h	破堤箇所～破堤箇所より 600 m 南地点 破堤箇所より 600 m 南地点～八間橋(1/2 000)
関　川	新潟県新井市(1995.7)	1.30 km/h	破堤箇所～島田橋（1/200）

出典）末次（2004）：氾濫被害軽減のための氾濫原管理，水利科学

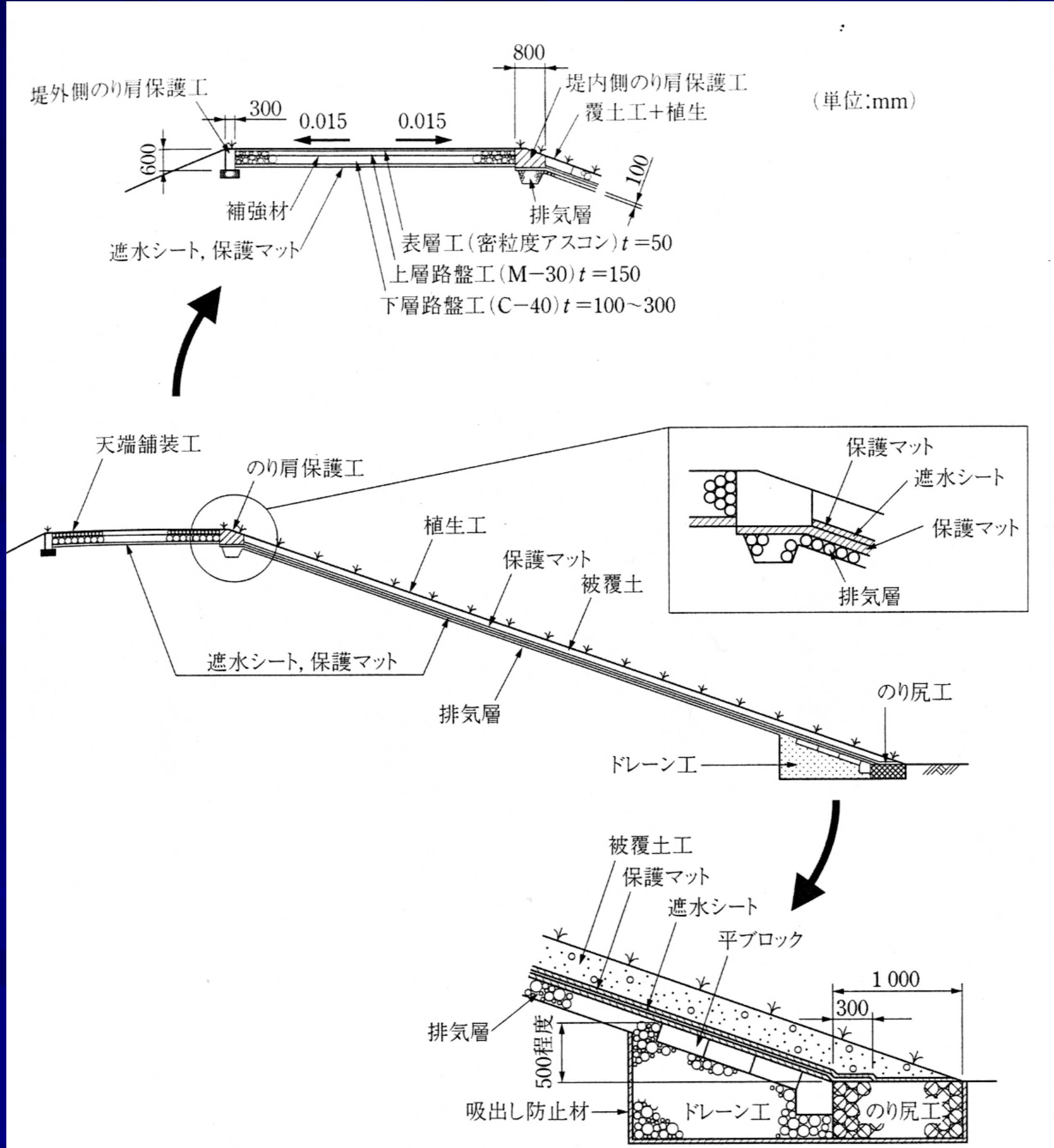
Countermeasures against dyke break caused by overtopping

・70-80% of dyke break is caused by overtopping (including medium or small rivers)

・Against overtopping, the significant protection methods are
1.levee-crown pavement / 2. back-slope coating/
3.slope-toe protection

・At high graded levee, 1. impermeable plastic sheet /
2. protection work for back slope
Naka River and Shin River

＊Levee-crown pavement can work effectively against overtopping in some cases.



800
堤外側のり肩保護工
300
0.015
0.015
堤内側のり肩保護工
（単位:mm）
覆土工＋植生
600
100
補強材
排気層
表層工（密粒度アスコン）t＝50
遮水シート，保護マット
上層路盤工（M−30）t＝150
下層路盤工（C−40）t＝100～300
天端舗装工
のり肩保護工
保護マット
遮水シート
保護マット
排気層
植生工
保護マット
被覆土
遮水シート，保護マット
排気層
のり尻工
ドレーン工
被覆土工
保護マット
遮水シート
平ブロック
1 000
300
排気層
500程度
吸出し防止材
ドレーン工
のり尻工

Measures for reducing flood

- Structural measures

  Overtopping→high graded levee、levee-crown pavement、smooth slope

  Infiltration→interception of rainwater from crown and slope, drain work

  Erosion→revetment, spur-dyke, vane work

- Non-structural measures

  secondary levee、flood control green zone、flood hazard map

  collecting and transmitting information, flood fighting activities, refuge action,flooding water control

Flooding water control

Induction of Measures	Diversion of flood water	Secondary levee	:Yoshida R. (Tributary of Naruse R.)
		Flood control green zone	:Ooi R., Kano R.
	flood water	Induced channel	:Kokai R. (Tributary of Tone R.) Agano R.
		Network of waterways	:Yanagawa City, Tributary of Nagara R.
		Pump or sluice gate	:Oohori R.(Tributary of Fuefuki R.)
	Local protection	Ring levee	:Nagara R. , OmonoR., Sakura R.
		Water-proofings	:Kanda R. basin, many other cases

Secondary Levee

・Aim：to decrease total damage cost even though it causes increase of damage locally

・Tone R. mid basin：Tsujoh secondary levee

（Flood control capacity is equivalent to Watarase retarding basin)

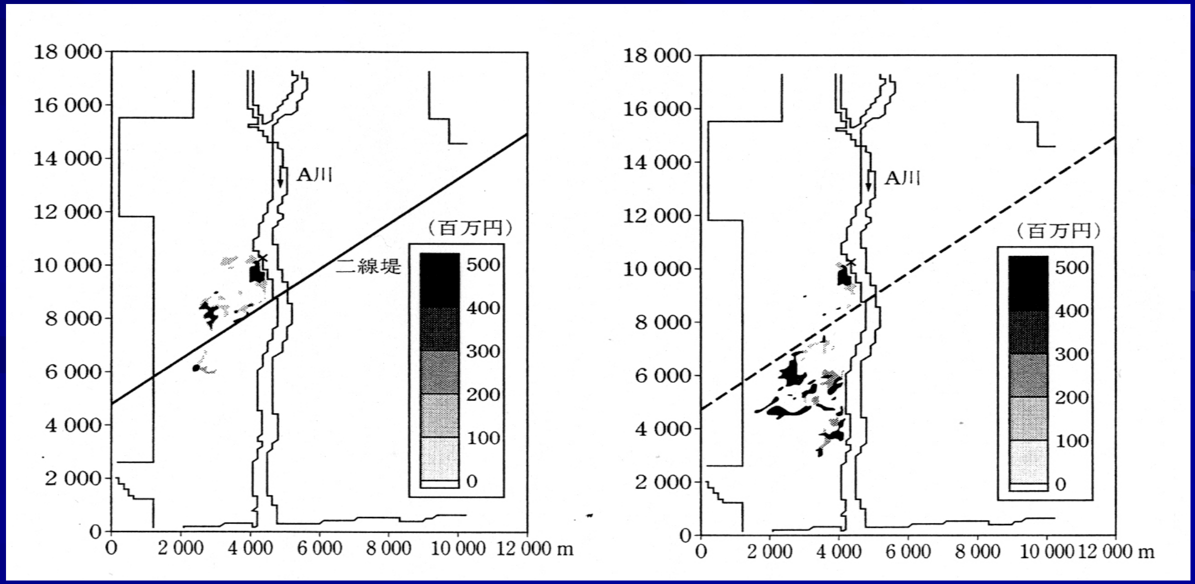
・Ara R. basin: Sumida levee, Nihon levee

From 1590'～ to 1912', 3 times of dyke break at Sumida levee and 0 at Nihon levee.

・Yoshida R. basin： Protect urban area around Kashimadai St. by making high leveled road and new bypass road as secondary levee.

Project for making City less vulnerable to floods

＊It is effective when floodplain slope is less than 1/1000, and the asset ratio of up and down stream of the secondary levee is more than triple.

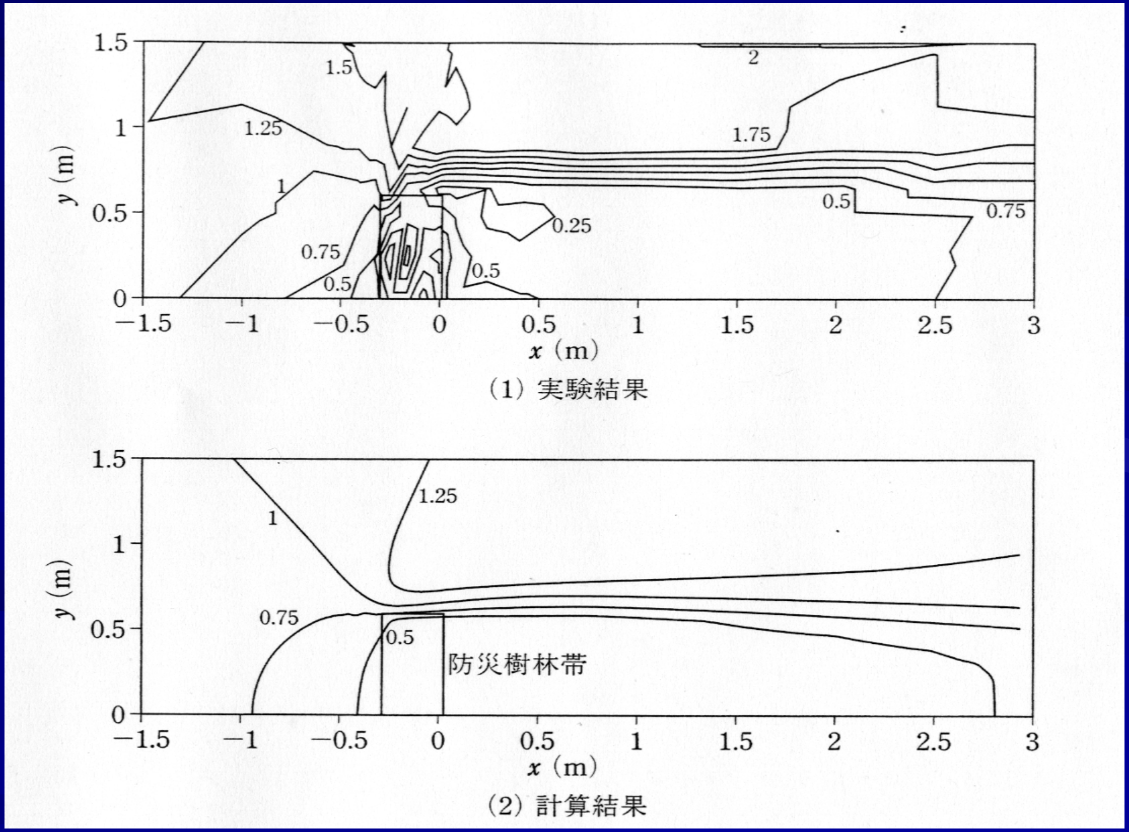


Flood control green zone

・Aim：To protect houses from flooding water

・Ooi R. basin（boat-shaped house）, Kano R. basin
green zone and embankment on the side of river

・Yosasa R. basin: The ratio of swept-away houses with green zone（shelter belt）is almost half of the houses with no green zone
←Green belt diverts the flooding flow and halve its flood force in the area that covers more than double width of green zone



Flood risk map

- Geomorphological map → Flood control geomorphological map, Land condition map
- Past inundated area map →Avoid map
  → Flood inundation frequency map
- Inundation predicted area map → Flood hazard map

・More than 1000 of flood risk map in total

・Not fully utilized

← Ingenuity is needed to avoid being dumped

by inserting beneficial information : community events, telephone number

Distribution right before the flood occurs：e.g.) Evacuation from Gokase R. in Nobeoka city

・ Publication of dynamic information

←Distribution map of propagation time: e.g.) Flood hazard map of Seki R. basin

はんらんした水はどのくらいの速さでやってくるの？

この図は、関川、保倉川、矢代川の堤防が洪水によって壊れた時に、はんらんした水がどのくらいの速さで広がっていくのかを表したものです。

河川沿いの地区では30分で、はんらんした水がかなりの範囲に広がることが分かります。堤防の近くや低い土地にお住まいの方は十分注意してください。

また、主要道路の50cm以上冠水する区間もあわせて示してあります。

洪水到達時間並びに主要道路冠水状況図

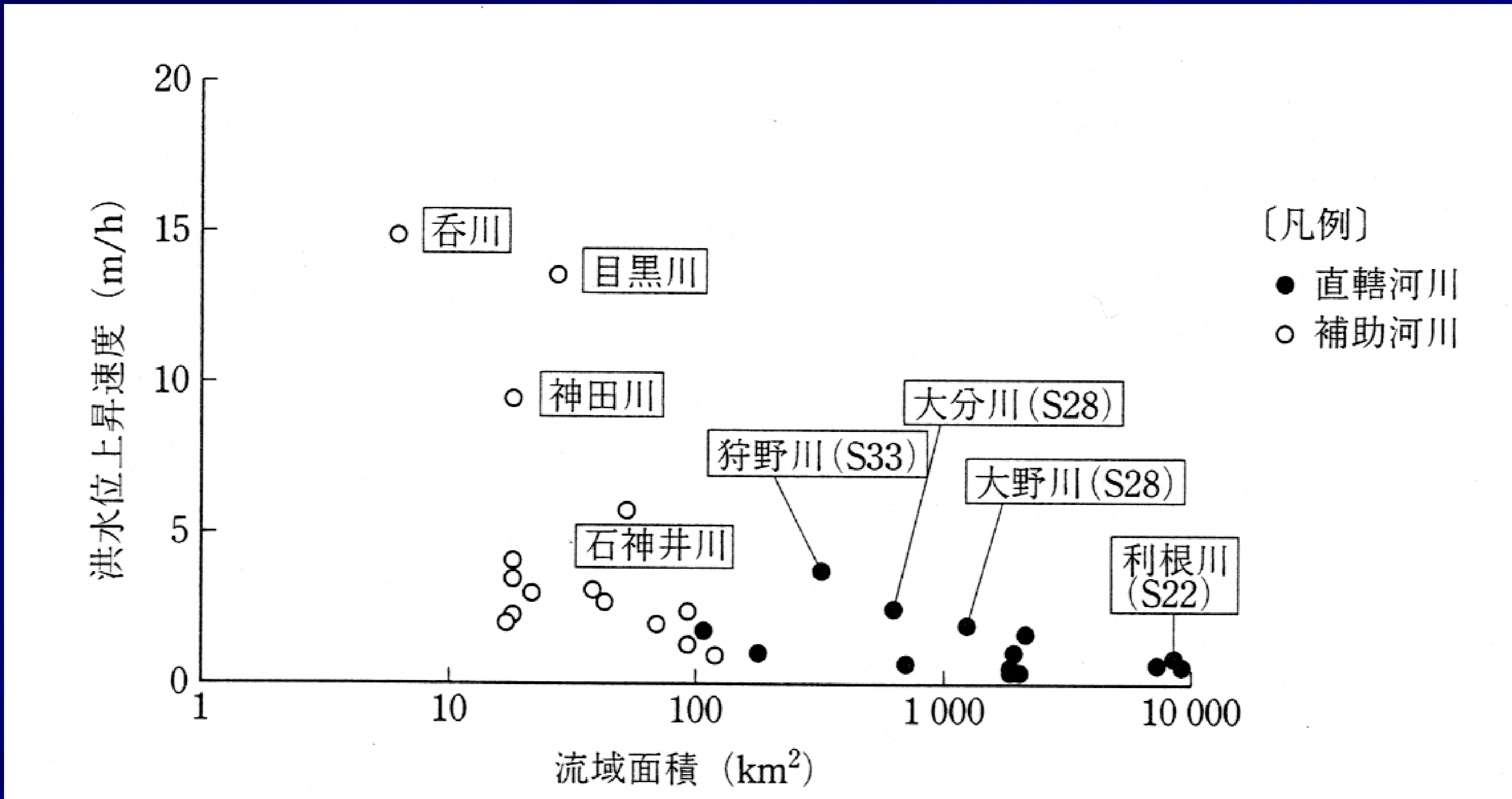
- はんらん水到達時間30分線
- はんらん水到達時間１時間線
- はんらん水到達時間２時間線
- 主 要 道 路
- 主要道路で50cm以上冠水する区間
- はんらん時にヘリコプターが離発着可能な広場

Evacuation system（Government side：normal times）

・ Designate different shelter for floods, and for earthquakes.
Conducting safety-level evaluation for inundation,
Distance from the river, Past inundation record
（shelter place, roads around the river）

・If it is difficult to designate public shelters,
Plains of valley bottom → private house for temporary shelter：Rumoi R.
Low-lying area → tall buildings for temporary shelter:Toyama city

・Water level criteria for alerting
Designate the critical water level from the time needed for evacuation and rising speed of flood water level,
If the water level criteria is too low, efforts are needed to set shorter time for evacuation.


洪水位上昇速度（m/h）
20
15
10
5
0
1
10
100
1 000
10 000
流域面積（km2）
呑川
目黒川
神田川
石神井川
狩野川(S33)
大分川(S28)
大野川(S28)
利根川
(S22)
〔凡例〕
● 直轄河川
○ 補助河川

Evacuation system（Government side：on floods）

- Collecting information
- Sure transmission of information

- Declaration of evacuation order through community wireless system for each house and speaker van, Voice cannot reach through community wireless-system when heavily raining

- Setting up shelters in early stage

- Map distribution to refugee's guide

＊Lending radio transmission to community leaders to collect and transmit information cooperation from taxi radio transmission, amateur radio transmission club

e.g.：Numazu city, Tsuruoka city, Kawasaki city

Evacuation activities

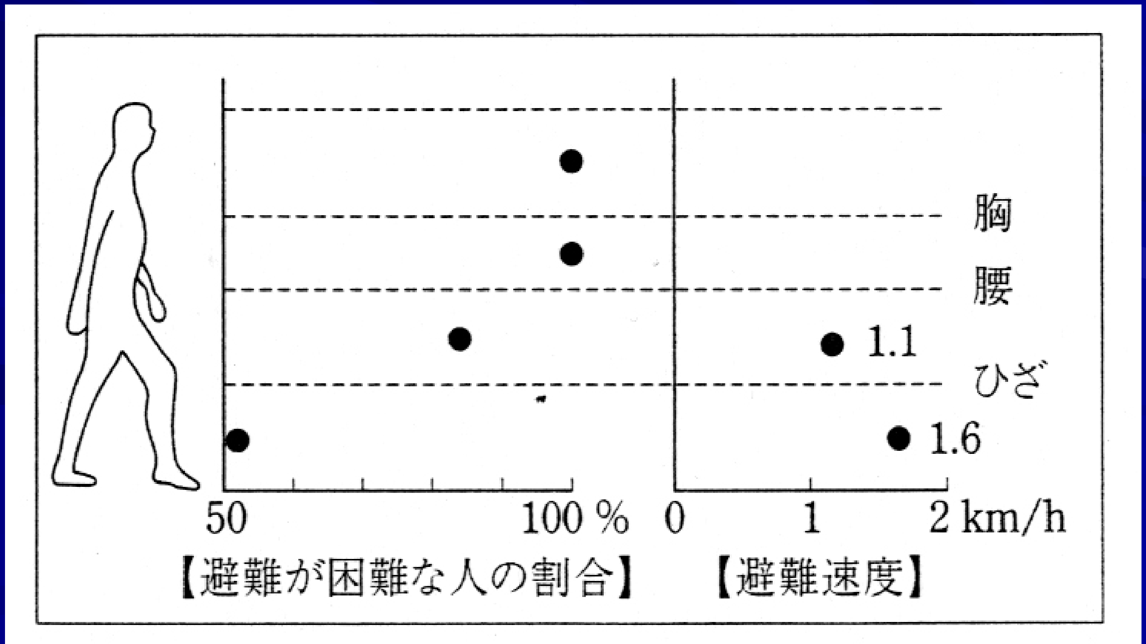
・Regardless of evacuation order,
only about 10 % of residents evacuate.
Slow in action
Evacuation order that stirs sense of urgency
of residents to evacuate in early stage
e.g.)Emergency declaration by the mayor
（Misumi town）

・How to evacuate？←Refugee’s guide, Shelter map

・Precautions about evacuation should be known
to everyone

- Points to keep in mind during evacuation activities

- If inundation depth becomes higher than 50cm, it causes difficulties in walking;
  Walking speed in inundated area:
  The speed is 1.6km/hr with water below the knee
  and 1.1km/hr for water between knee and waist,
- In inundated area, people should use lope and rod for search,
  Caution is needed since there are many cases that people fall into water channels or side ditch during the evacuation activity;
  In case of evacuation using roads of the base of a mountain,
  caution is needed for sand avalanches,
- Babies should be evacuated in a baby basket,
  and elderly persons by using ladder.

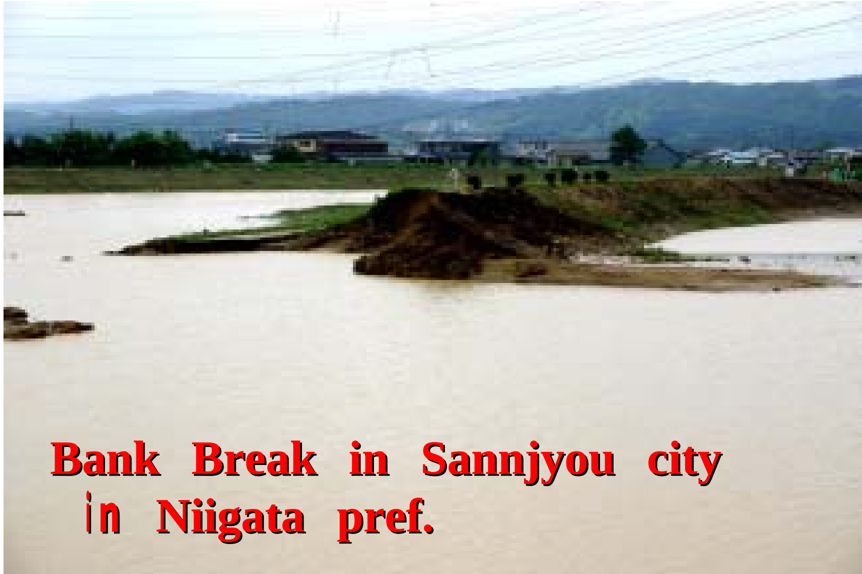


ASPECT OF RECENT
FLOODS IN JAPAN

HEAD,FLOOD DISASTER
PREVENTION DIVISION

TETSUYA NAKAMURA


NIIGATA
HUKUI
TOKYO
HYOGO
HIROSIMA
TAKAMATSU
MIYAZAKI
日本海
日本


Bank Break in Sannjyou city
in Niigata pref.


Bank Break in Nakanoshima
town in Niigata pref.


Flood in Sannjyou city





Flood damage in Sannjyou city


Bank break in central Hukui city

Flood in central Hukui city

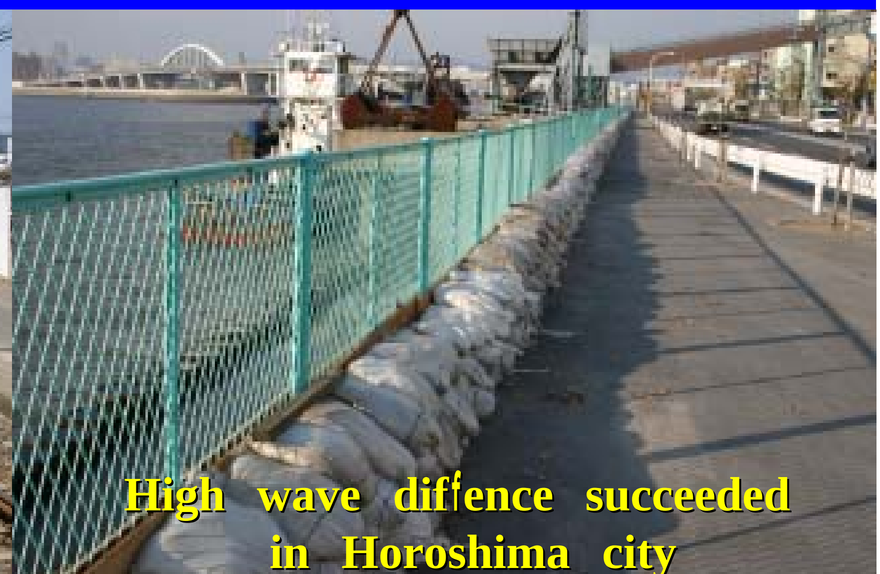
Pump Car for mud after flood

Separated Disposal after flood

Effect of high wave in Takamatyu city

High wave in central Takamatsu city

High wave overflow from river in Takamatsu city



High wave diffence succeeded in Horoshima city


Upstream flood damage


Broken piers of rail way


Drift woods after flood

Entrance of underground spill way in TOKYO

Damage in basefloor in TOKYO

Damage of facility for drinking water in MIYAZAKI city

Innundated hospital

Flood fighting in MIYAZAKI city

●Inundation Damage Control Law for Specific Urban Rivers (No.77/Law/2003)

This law aims to promote inundation damage prevention measures in urban river basins where significant inundation damage has occurred or likely to occur and the progress of urbanization makes it difficult to prevent inundation damage by improving river channels and the like, by designating specific urban rivers and specific urban river basins and establishing measures to prevent inundation damage such as formulation of **countermeasure plans against river basin flood** with the objective of comprehensively promoting measures against inundation damage and **development of rainwater storage and infiltration facilities**.

Frequent occurrence of inundation damage in urban river basins in recent years

- Inundation damage has been frequently occurring in urban areas including the Tokai Flood Disaster of 2000.
- The urban heat island effect has been causing frequent localized torrential downpours, resulting in increasing risk of inundation damage.
- Such issues as reclamation of once established regulating reservoirs by housing land development are occurring in part of urban areas.

↓

- Although significant inundation damage occurred or may occur, prevention of inundation damage by improvement of river channels or a flood control dam is difficult due to progress of urbanization.

↓

Countermeasures against inundation damage by establishment of a new scheme is required in urban river basins

- Countermeasures against inundation damage with river administrator, sewage system administrators and municipalities in one body are effective

Hard side measures | **Soft side measures**

Countermeasures against inundation by river water

River Law
(Prevention measures against flood and others)

- Flood control measures by improvement of river channels/dams
- **Development of rainwater storage and infiltration facilities in the basin (River administrators)**

Flood Fighting Law
(Measures taken in the event of flood and other disasters)

- Designation of estimated inundation areas
  (Targeting only inundation by river waters designated in terms of flood forecast)

New Law

- **Designation of specific urban rivers and specific urban river basins (The minister and prefectural governors)**
- **Formulation of "Countermeasure Plans against River Basin Floods" for comprehensive countermeasures against inundation damage (river administrator, sewage system administrator, prefectural governors and municipal chiefs)**
- **Designation of estimated urban flooded areas and estimated urban inundation area (targeting both river water and inland water)**
- **Designation of estimated urban flooded areas and estimated urban inundation area (targeting both river water and inland water)**
- **Obligation of notification of behaviors reclaiming existing regulating reservoirs and recommendation of required measures**
- **Conclusion of management agreement by municipalities**
- **Obligation of equipping drainage facilities with water storage and infiltration functions (by ordinance)**
- **Cost burdening by other municipalities**

Countermeasures against inundation by inland water

- Drainage and treatment of sewage

Sewage Water Law

- Development permission

City Planning Law

Outline of the Inundation Damage Control Law for Specific Urban Rivers
(No.77/Law/2003)

[Purpose of the Law]

This law aims to promote inundation damage prevention measures in urban river basins where significant inundation damage has occurred or likely to occur and the progress of urbanization makes it difficult to prevent inundation damage by improving river channels and the like, by designating such rivers as specific urban rivers and such areas as specific urban river basins respectively and establishing measures to prevent inundation damage such as formulation of countermeasure plans against river basin flood with the objective of comprehensively promoting measures against inundation damage and development of rainwater storage and infiltration facilities, for the purpose of protecting lives, bodies and properties of citizens; and thereby contribute to the securing of the public welfare.

1. Designation of specific urban rivers and specific urban river basin (Article 3)

[Requirements for designation of specific urban rivers]

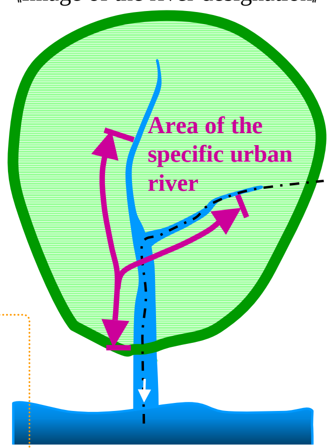
- Occurrence or possibility of occurrence of significant inundation damage.
- Difficulty of inundation damage control by improvement of river channels or flood control dam due to progress of urbanization.

[Designation of specific urban river basins]

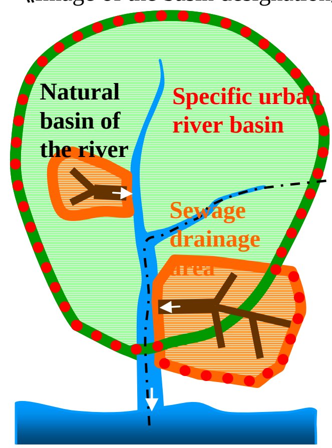
- Basins of specific urban rivers and the sewage drainage areas will be designated in combination.

*There are 30-40 rivers estimated to be designated as specific urban rivers Kanda River in all over Japan including the Kanda River (Tokyo), the Tsurumi River (Kanagawa/Tokyo), the Shin River (Aichi), the Neya River (Osaka).

《Image of the river designation》



《Image of the basin designation》



2. Formulation of countermeasure plans for river basin floods (Article 4)

- To be formulated jointly by the river administrator, the sewage system administrator, the prefectural governor, and municipal chiefs

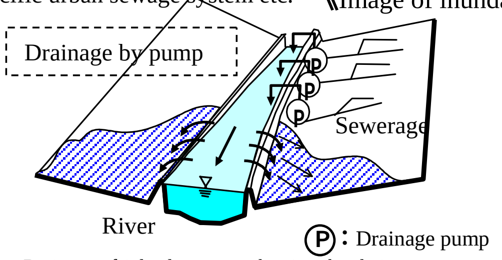
[Planned items]

- Basic policies for countermeasures against inundation damage
- The rainfall amount targeted for controlling urban floods or urban inundation.
- Matters concerning the improvement of the specific urban river
- **Matters concerning the development of rainwater storage and infiltration to be implemented by the river administrator**
- Matters concerning the improvement of sewage systems to drain the rainwater to rivers within the basin of the specific urban river in question
- Matters concerning the storage and infiltration of rainwater in the basin
- Matters concerning the operation control of the drainage pumps in the specific urban sewage system etc.

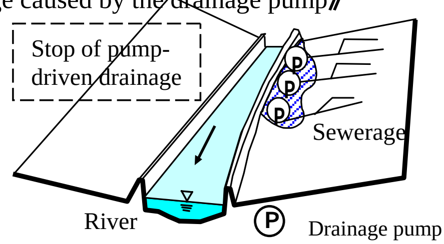
[Planning procedure]

- Hearing of opinions of citizens within the basin at a public hearing session and so on
- Hearing of opinions from men of learning and experience

《Image of inundation damage caused by the drainage pump》



Drainage of inland water to the river by drainage pumps will solve the inland water damage; however, it may cause inundation by the river water at the neck of the downstream river channel.



The drainage control may cause inland water damage in the periphery of the drainage pumps.

- Best effort duty of citizens and administrators within the specific urban river basin to store and infiltrate rainwater

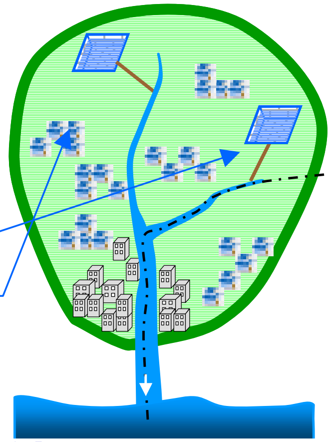
3.Measures Based on Countermeasure Plans against River Basin Floods

(1) Development of rainwater storage and infiltration facilities by river administrator (Article 6)

・Development of rainwater storage and infiltration facilities in the specific urban river basin based on the countermeasure plans against river basin floods

・Such **facilities will be regarded as river management facilities in the River Law** and the like.

Development of rainwater storage and infiltration facilities in the basin

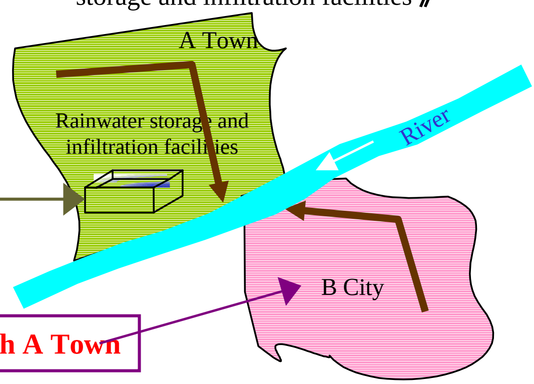


(2)Burden charge shared by other municipalities (Article 7)

•Municipalities that implement the projects including the sewage system specified in the countermeasure plans against river basin floods may burden the charge on other municipalities benefiting from the project implementation.

《Image of a broad-based case of rainwater storage and infiltration facilities》

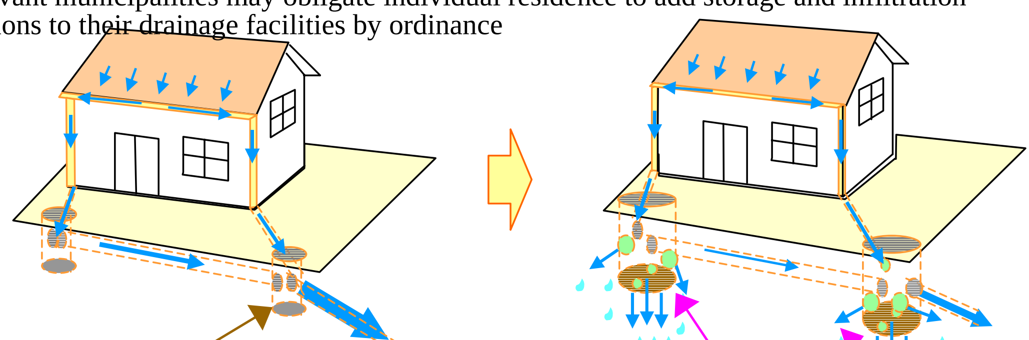
The rainwater storage and infiltration facilities are not installed by A Town and B City respectively; instead, **the storage required of B City is covered by the facilities of A** Town to secure the outflow discharge of both municipalities.



B City will share the cost burden with A Town

(3) Special exception concerning the technical requirements of the drainage facilities (Article 8)

•Relevant municipalities may obligate individual residence to add storage and infiltration functions to their drainage facilities by ordinance



Ordinary gully

Rainwater outflow will be reduced with the storage and infiltration functions added to the gully within a residence

4. Regulation for control of rainwater outflow in specific urban river basins

(1) Permission of behaviors hindering infiltration of rainwater (Articles 9-22)

○ Behaviors hindering infiltration exceeding a certain amount (estimated at 1,000m2) of rainwater (behaviors bringing about significant overflow increase) performed in lands other than housing land will require permission of the prefectural governor.

《Rainwater infiltration hindering behaviors falling under this category》

•Land transformation performed for housing land development

Example) Transformation of farmland to a parking area

•Land pavement

Example) Transformation of farmland to a parking lot

•Construction of a golf course and so on

○ In obtaining a permission, installation of rainwater storage and infiltration functions compliant with the technical requirements will be required

○ Behaviors that are likely to hinder the functions of rainwater storage and infiltration facilities installed associated with the permission will require the permission of the prefectural governor

Rainwater hindered from infiltrating into the underground by housing land development and the like will flow out into the river and so on at once and bring about inundation damage

(2)Notification of behaviors associated with the conservation and regulating reservoir (Articles 23-26)

•The prefectural governor will designate a flood control reservoir exceeding a certain capacity (estimated at 100m3) as a conservation and regulating reservoir

•Behaviors likely to hinder the functions of the conservation and regulating reservoir (such as reclamation) will be obliged to be notified to the prefectural governor.

•The prefectural governor will advise/ recommend required measures

Former flood control reservoir (of a capacity level of approximately 500m3)

Status after reclamation

(3)Management agreement associated with the conservation and regulating reservoir (Articles 27-31)

•Municipalities may manage conservation and regulating reservoirs with an agreement concluded with owners of the conservation and regulating reservoirs.

•The management agreement will be also effective on the of the conservation and regulating reservoir (effect on transferee).

5. Designation of estimated urban flooded areas and estimated urban inundation area (Articles 32 and 33)

・" Estimated Urban Flooded Areas" = Areas where inundation caused by urban flood (River flooding) is estimated

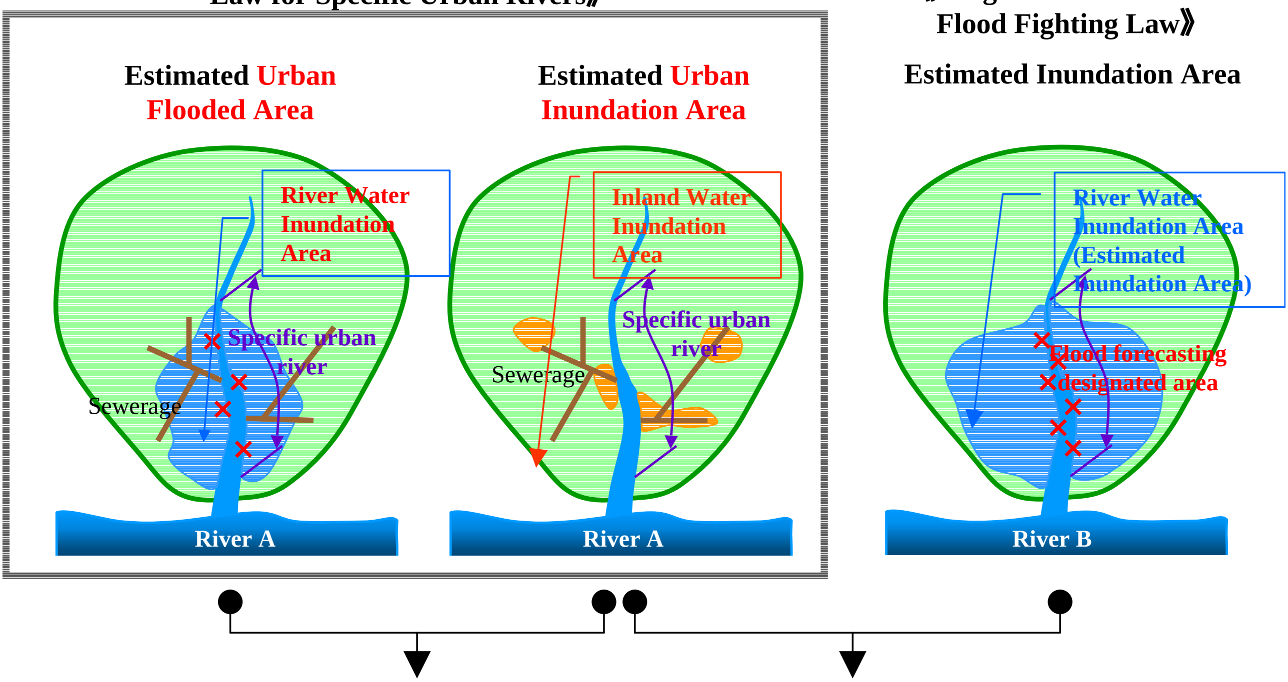
・" Estimated Urban Inundation Area" = Areas where urban inundation (inundation caused by inland water such as overflow stream or pooling) is estimated will be designated and announced

・The **municipal conference will establish information transfer methods about inundation and evacuation areas and information transfer methods to underground shopping areas and announce them to citizens**

・Best effort duties of underground shopping area administrators to prepare and announce plans on evacuation in the event of inundation etc.

《Designation Based on the Inundation Damage Control Law for Specific Urban Rivers》

《Disignation Based on the Flood Fighting Law》



A case where the specific urban river is not a flood forecasting designated river (such as the Kanda River and Neya River)

A case where the specific urban river is a flood forecasting designated river (such as the Tsurumi River and Shin River)

Date of enforcement

•A day designated by a government ordinance within one year after the promulgation date (May 15, 2004)

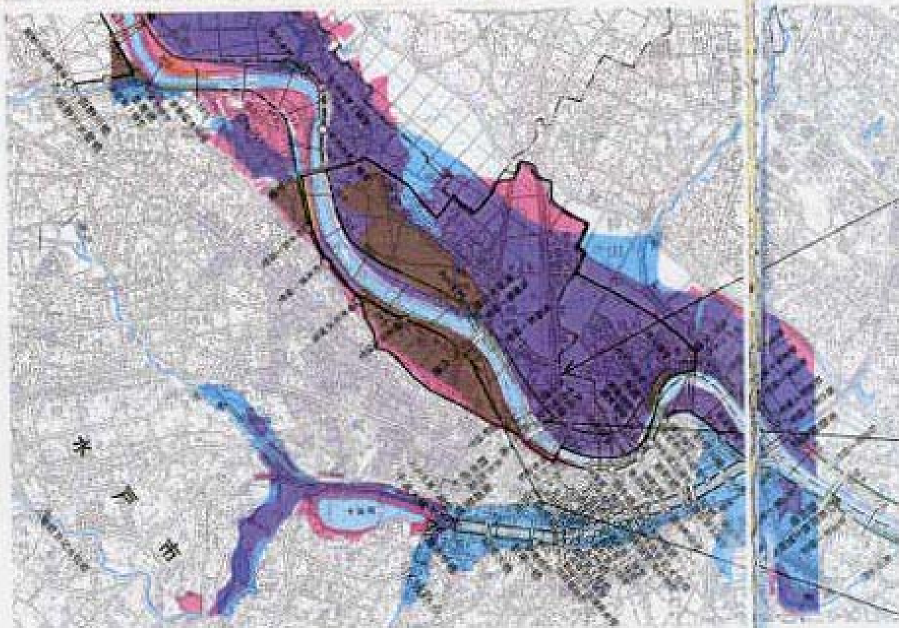
Countermeasures against urban flood

HEAD,FLOOD DISASTER PREVENTION DIVISION

TETSUYA NAKAMURA

Past Inundated Area Map

Past Inundated Area Map (Mito City)



Data on past inundation

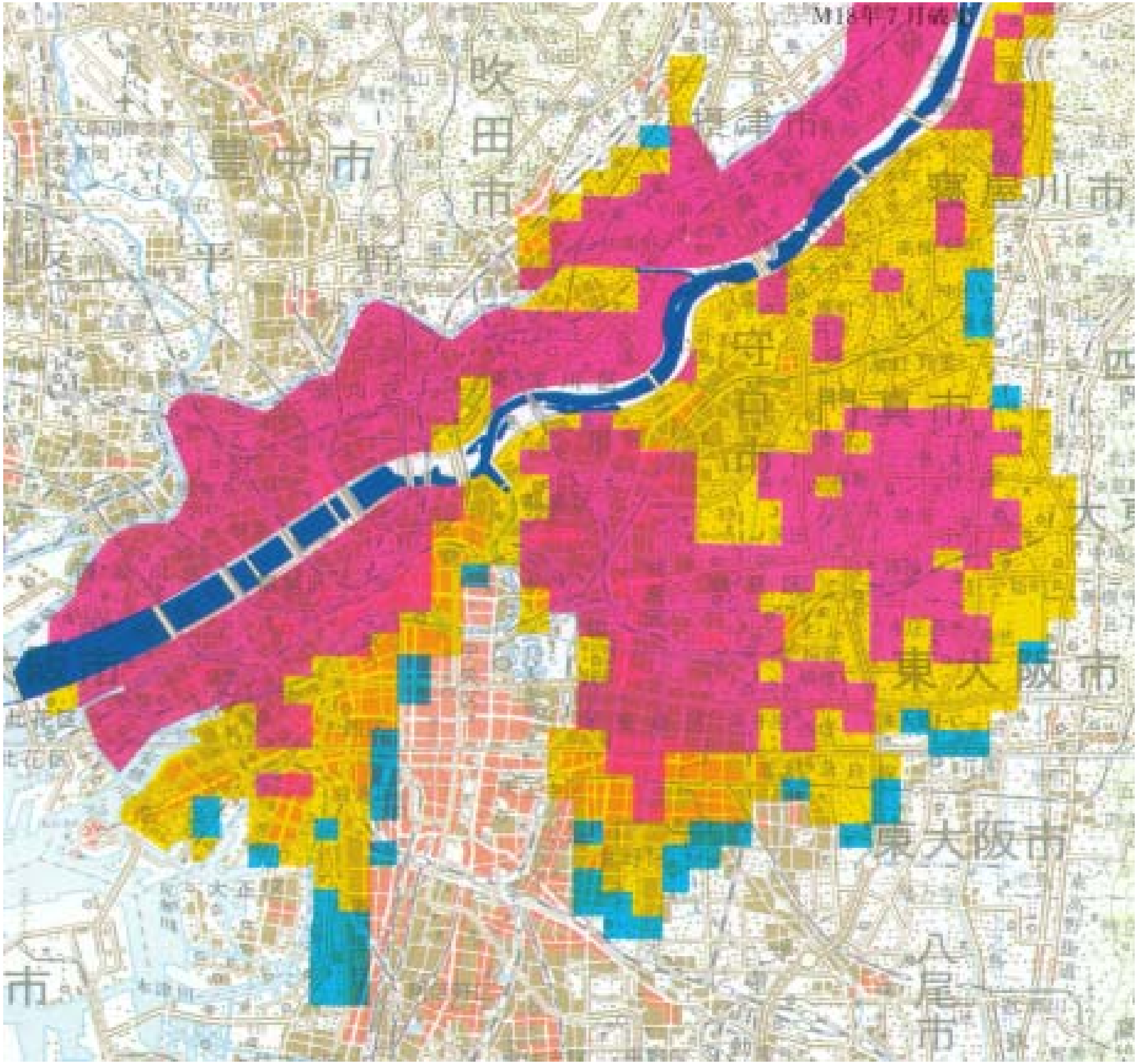
年月日	気象要因	流域最大雨量			浸水被害				浸水深 (m)	主要施設の浸水状況
		時間最大(mm)	総雨量(mm)	観測所名	面積(ha)	床上	床下	計		
S36-6-28	梅雨前線	48	362	水戸	56,555	1,789	6,456	8,245		
S57-9-10-14	台風18号	35	232	[illegible]	1,147	65	152	217		
S61-8-4-5	台風10号	49	313	大田原	3,618	2,775	624	3,399		

Predicted Inundation Area Map

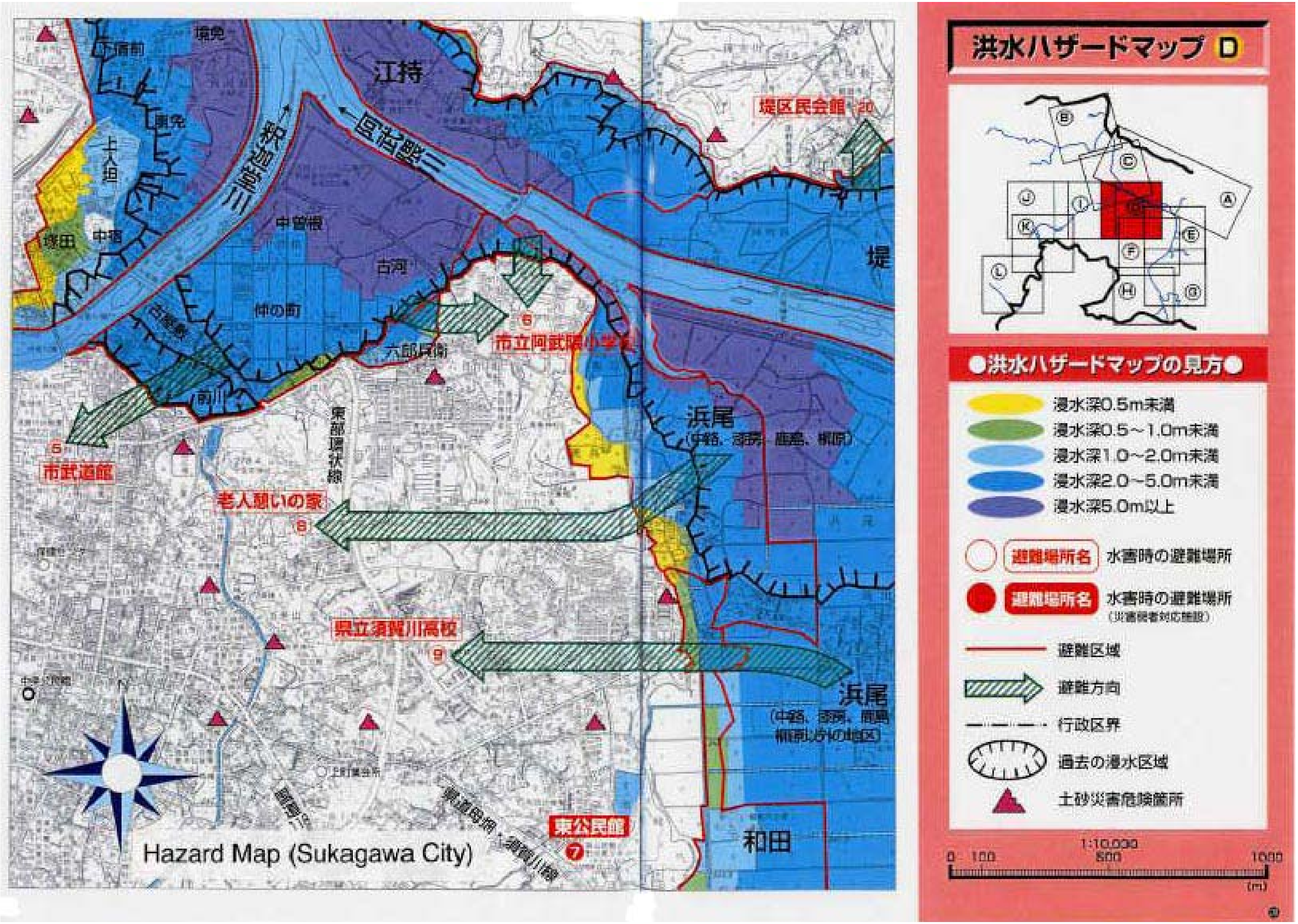
凡　例

- 浸水深が0.5m以下の区域
- 浸水深が0.5m~2.0m未満の区域
- 浸水深が2.0m以上の区域
- 過去の破堤箇所
- 対象としている河川区間

洪水氾濫危険区域内面積		29,000 ha
洪水氾濫危険区域内戸数	0.5m以下	68,000 戸
	0.5m~2.0m未満	354,000 戸
	2.0m以上	467,000 戸
	合　計	889,000 戸
洪水氾濫危険区域内人口		2,680,000 人

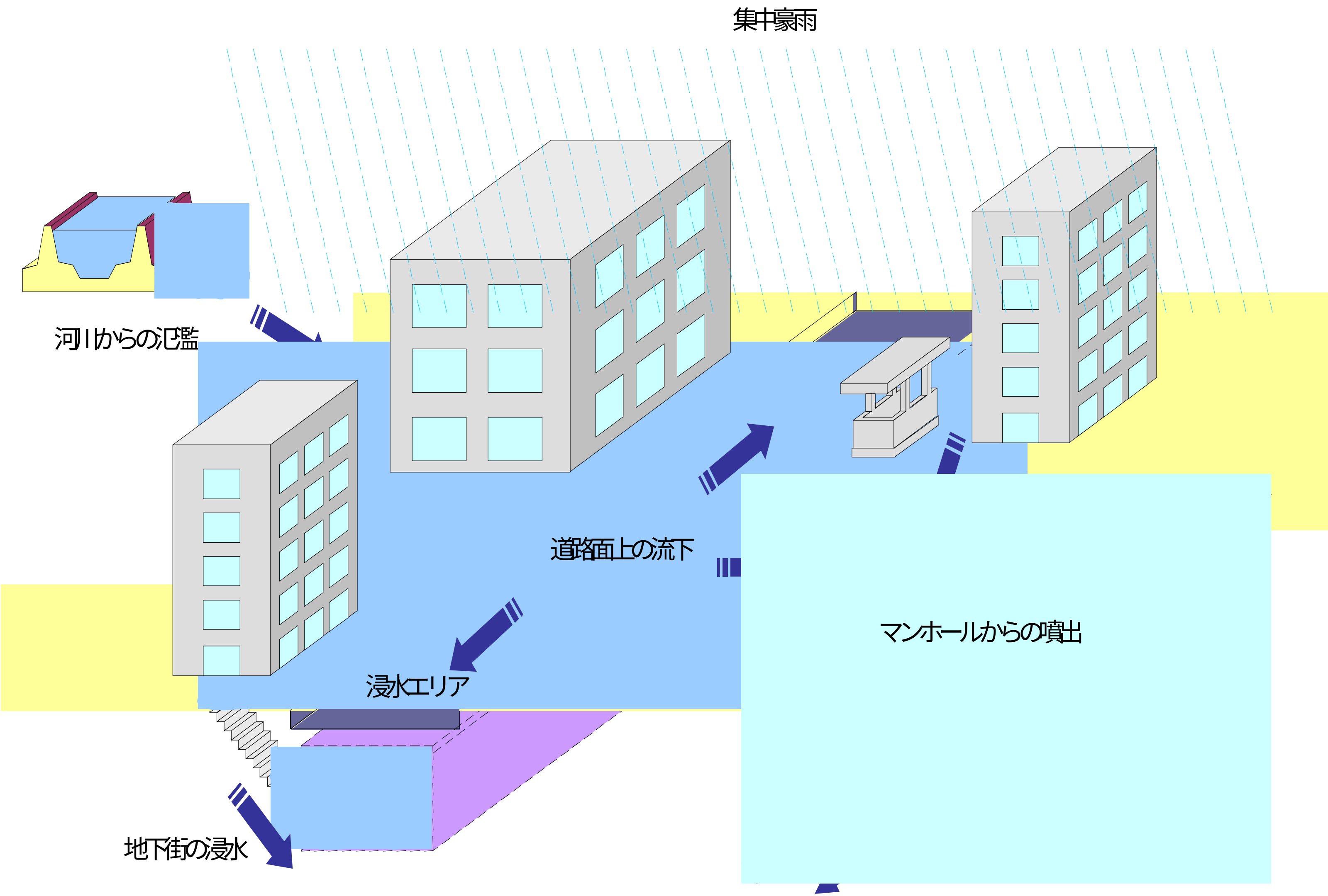


Hazard Map

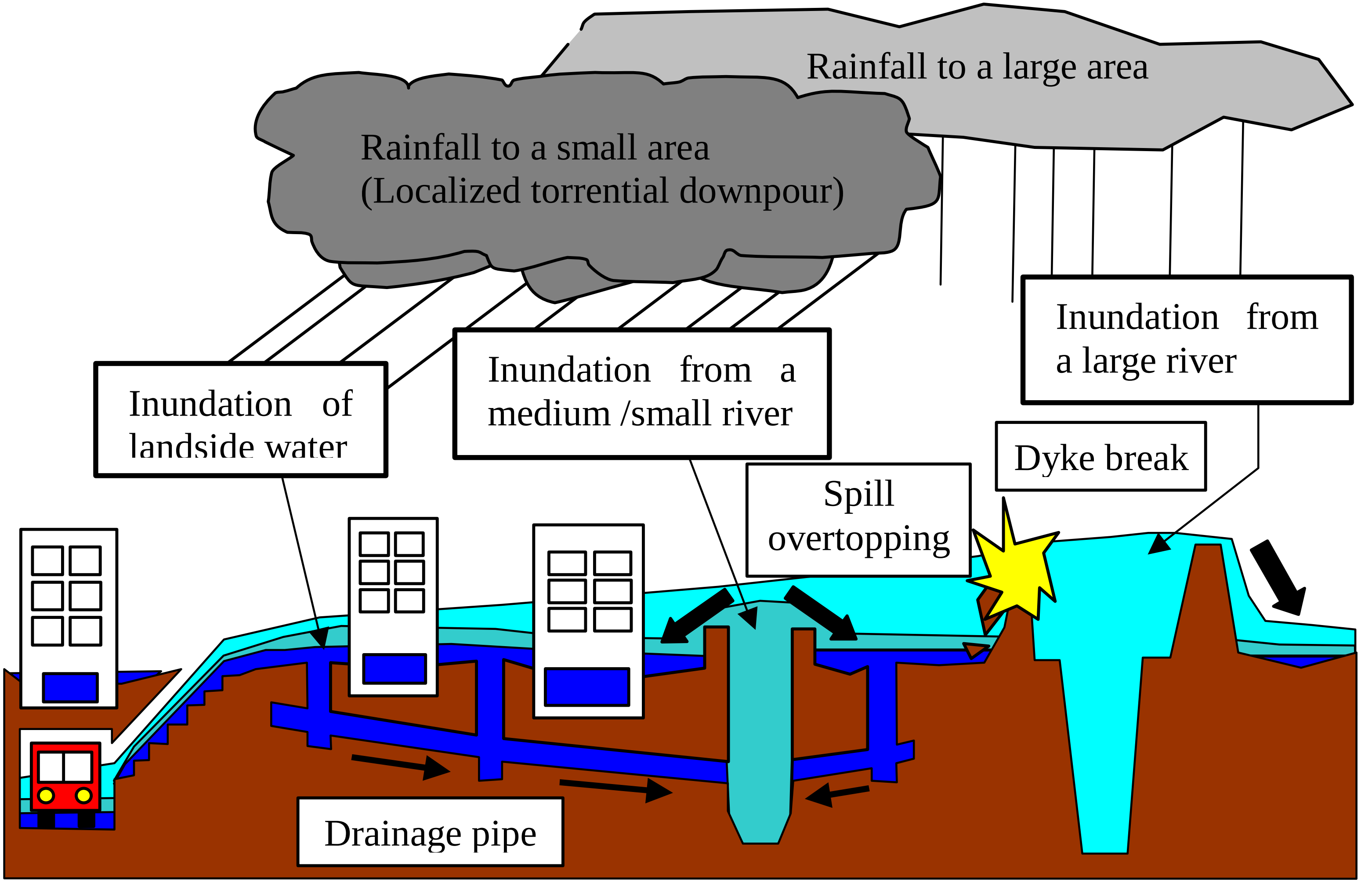


洪水ハザードマップ D
●洪水ハザードマップの見方●
浸水深0.5m未満
浸水深0.5～1.0m未満
浸水深1.0～2.0m未満
浸水深2.0～5.0m未満
浸水深5.0m以上
避難場所名 水害時の避難場所
避難場所名 水害時の避難場所
避難区域
避難方向
行政区界
過去の浸水区域
土砂災害危険箇所
1:10,000
0 100 500 1000
(m)
江持
堤区民会館 20
堤
中曽根
古河
仲の町
市立阿武隈小学校
6
浜尾
(中路、須房、鹿島、桐原)
東部環状線
市武道館
5
老人憩いの家
8
県立須賀川高校
9
浜尾
(中路、須房、鹿島、桐原以外の地区)
東公民館
7
和田
Hazard Map (Sukagawa City)

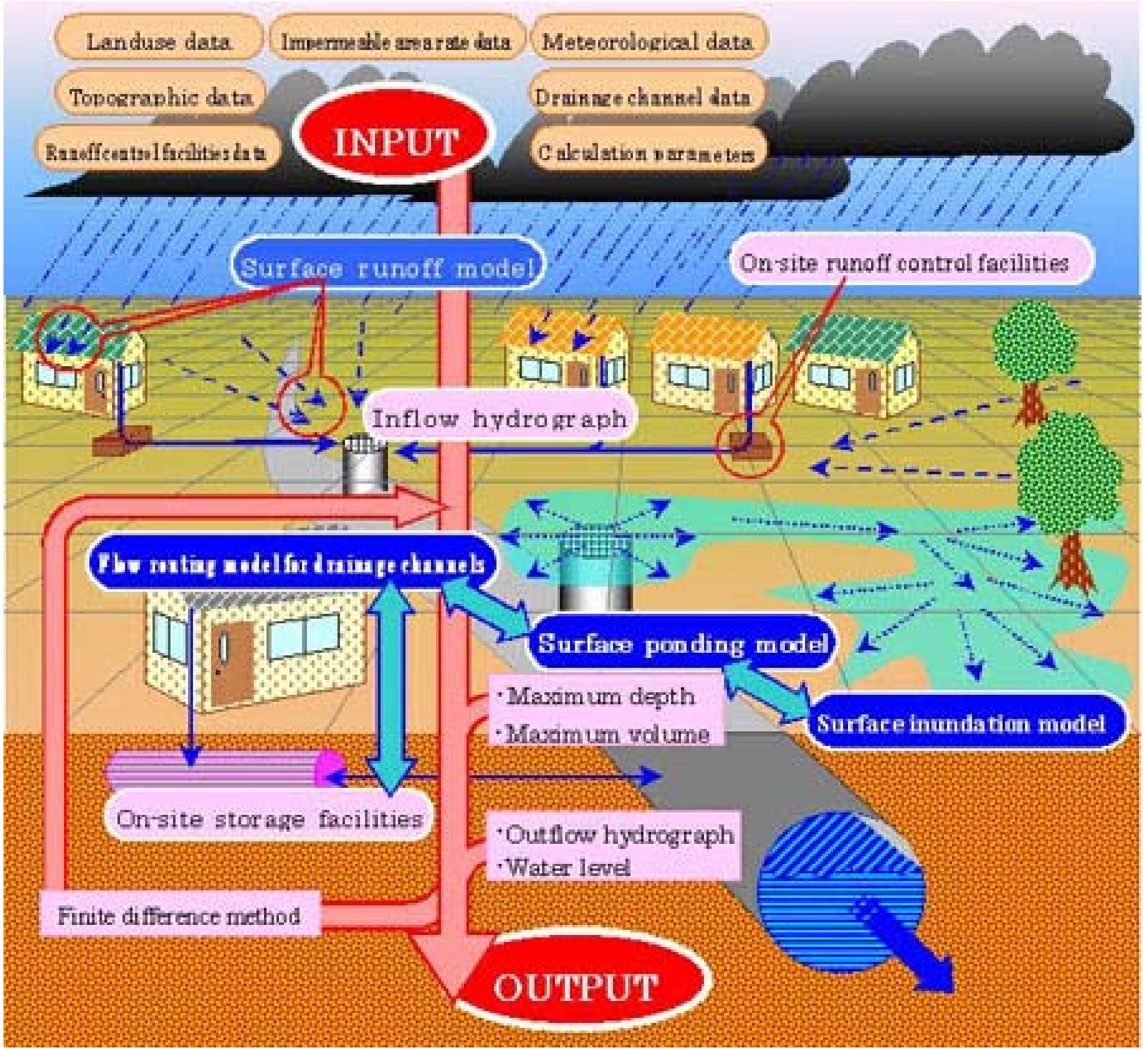
How urban inundation occurs?



Development of flood hazard simulation method considering both riverine flood and landside water inundation CONSISTENTLY.



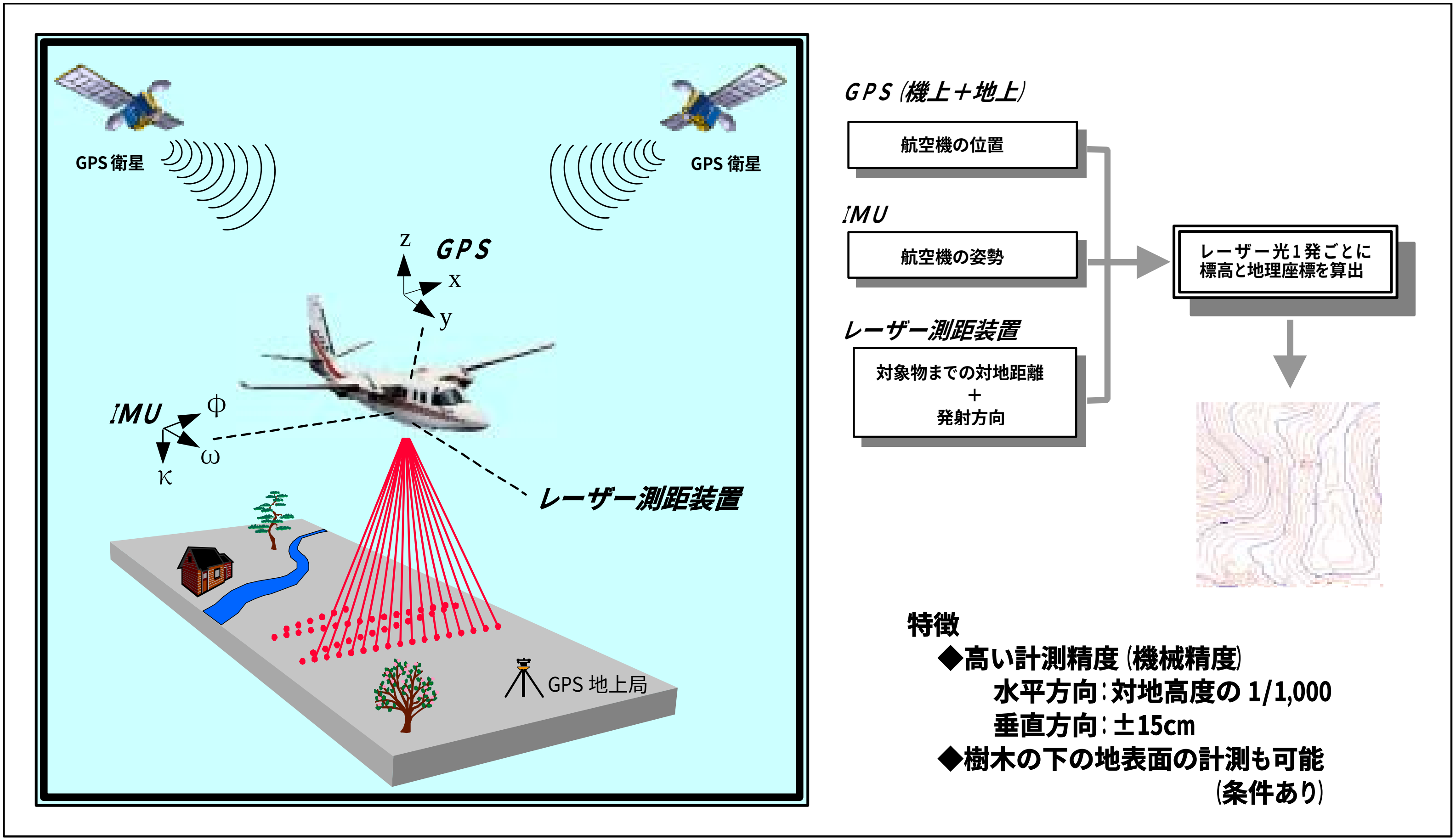
NILIM
(New Integrated Lowland Inundation Model)

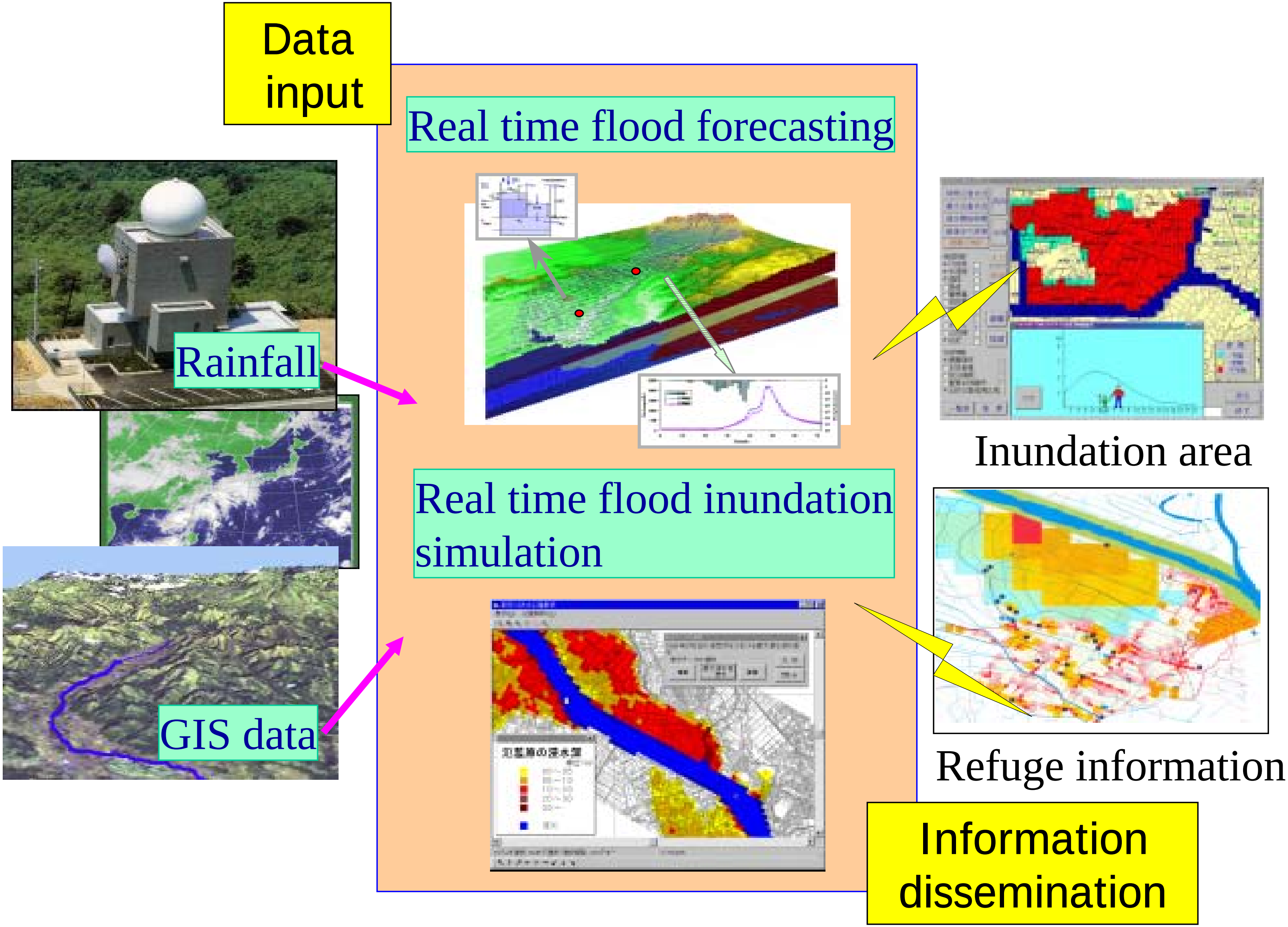


New challenges on flood simulation

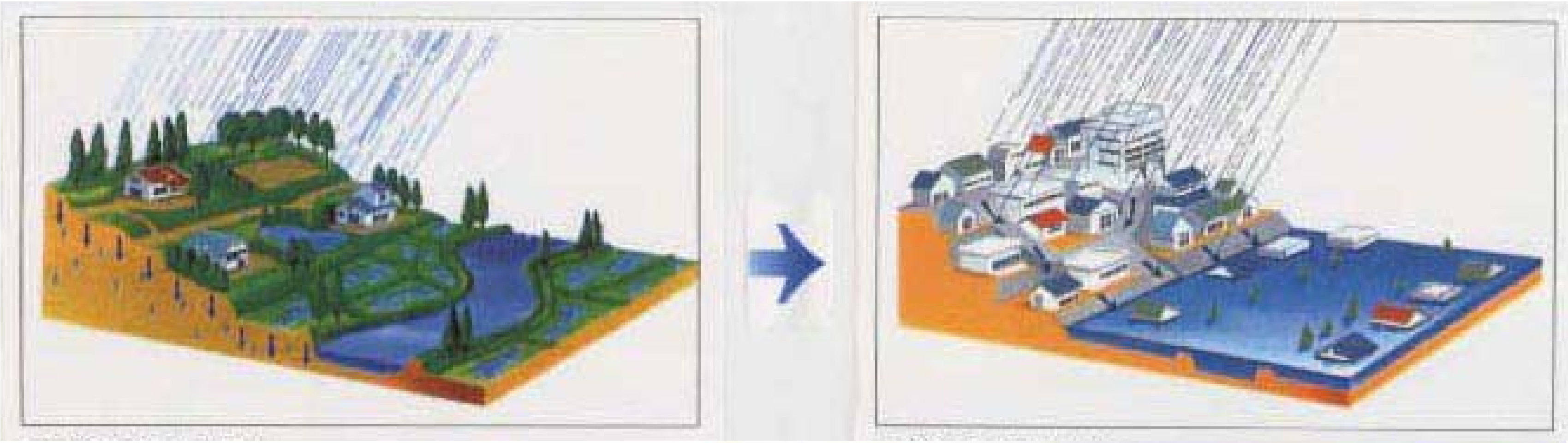
Data Collection Using New Technology

Use of Laser Scanner for Ground Level Measurement

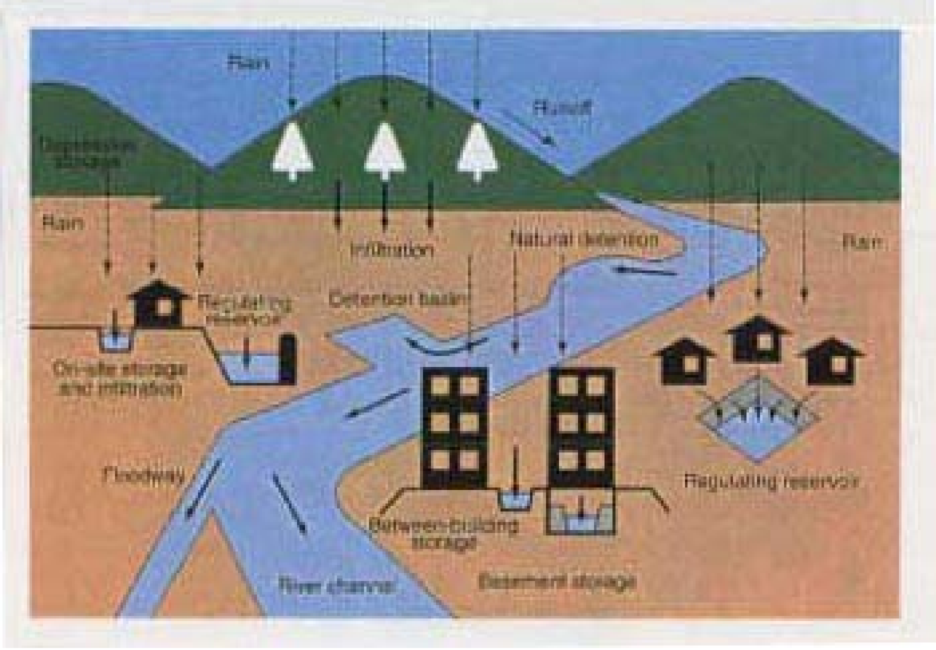



Data input
Real time flood forecasting
Rainfall
Inundation area
Real time flood inundation simulation
GIS data
Refuge information
Information dissemination

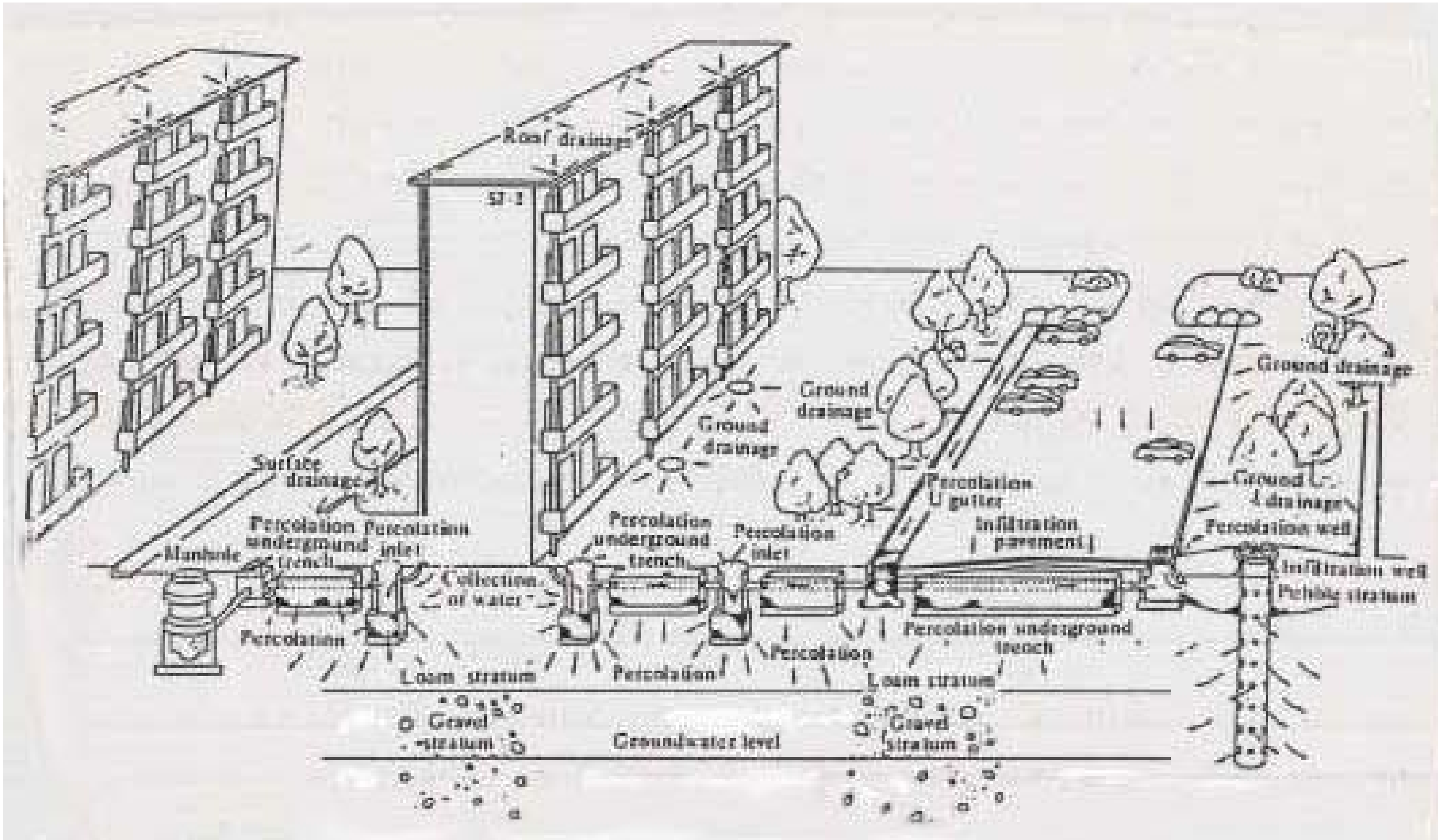
Conservation & Restoration of Natural Function of the Catchment



Measures with Facilities in the Basin



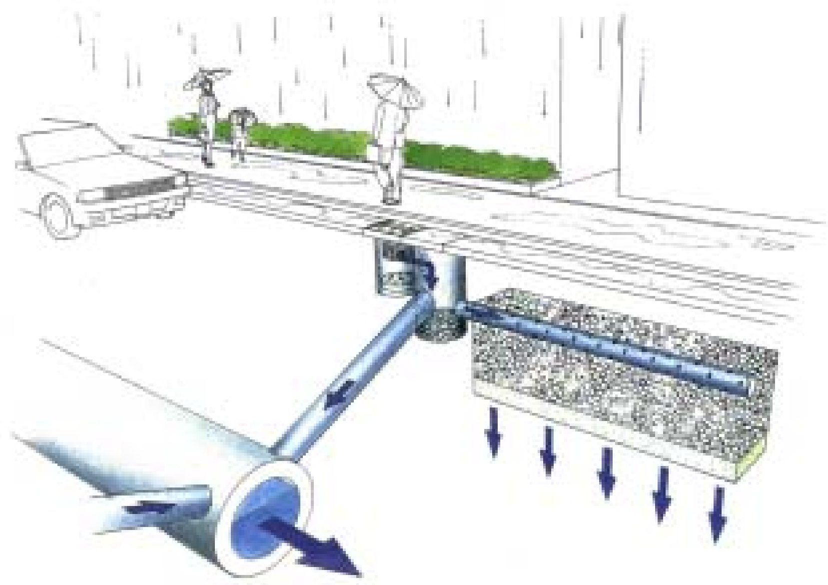
Combination of Rainwater Infiltration Facilities



Infiltration facilities

In urban areas, typically roads and sidewalks are paved with artificial materials such as asphalt and concrete. In this situation, infiltration facilities are effective structures that facilitate rainwater to infiltrate into the ground to reduce storm water runoff.

Infiltration inlet installed in front of a house



Infiltration inlet installed under roads

At ordinary times

In the event of a heavy rain, rainwater is detained to control flow into rivers.

Municipal Kumagaya Nishi Elementary School (Kumagaya City, Saitama Prefecture: Oshi River)

Tsurumi River Multipurpose Retarding Basin (Yokohama City, Kanagawa Prefecture)

Piloti Type

The underground structure of the building and the parking lot absorb water and let it drain gradually so that flooding and water invasion can be avoided.

Storage Plus Filtration

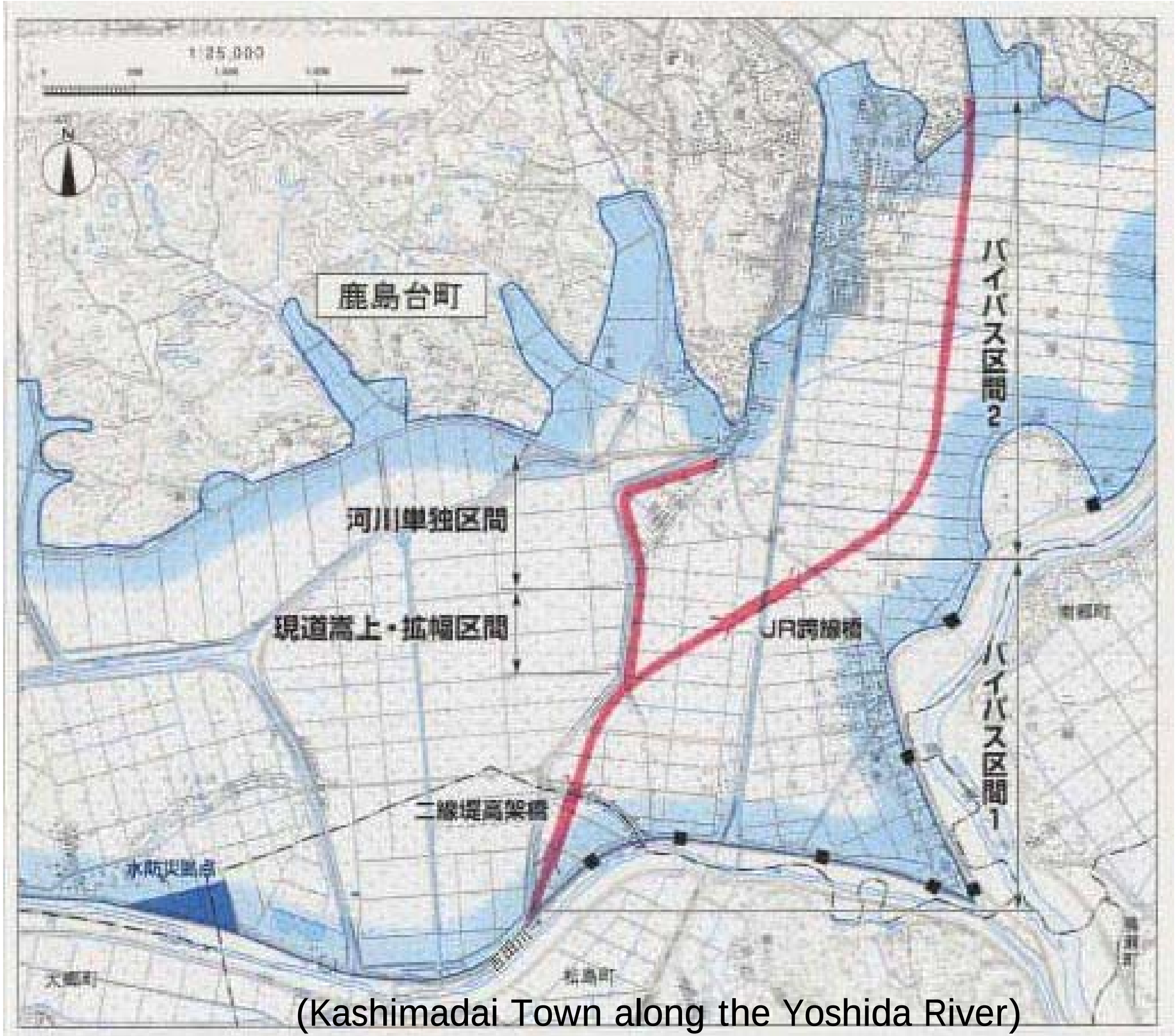
The storage function of the adjusting pond and the filtering of the well serve to both control outflow and process the drained water.

Figure 4.8 flood-Pumping Engines

Flood-control vehicles, such as drainage pump vehicles, satellite communication vehicles, and commander vehicles, are to be deployed at the flood-control stations and other flood-control centers.

Drainage pump vehicle deployed in Sukagawa City

Secondary Levee to Restrict Inundated Area

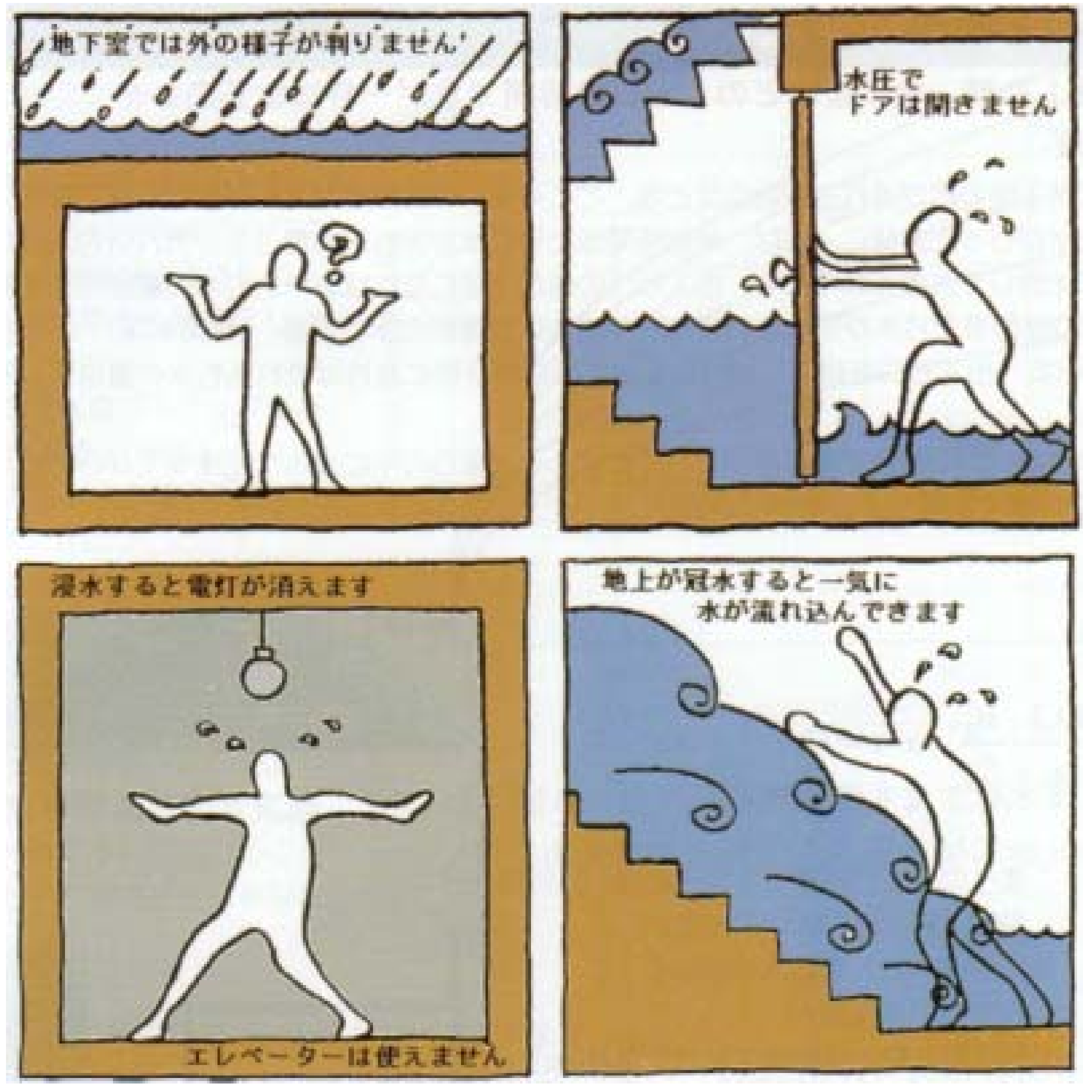


(Kashimadai Town along the Yoshida River)

Flood in Fukuoka City June 1999

Inundation of Underground Spaces

Brochure to notify the danger of staying in basements during flood



Coastal Disaster and Its Countermeasures




Coast Division

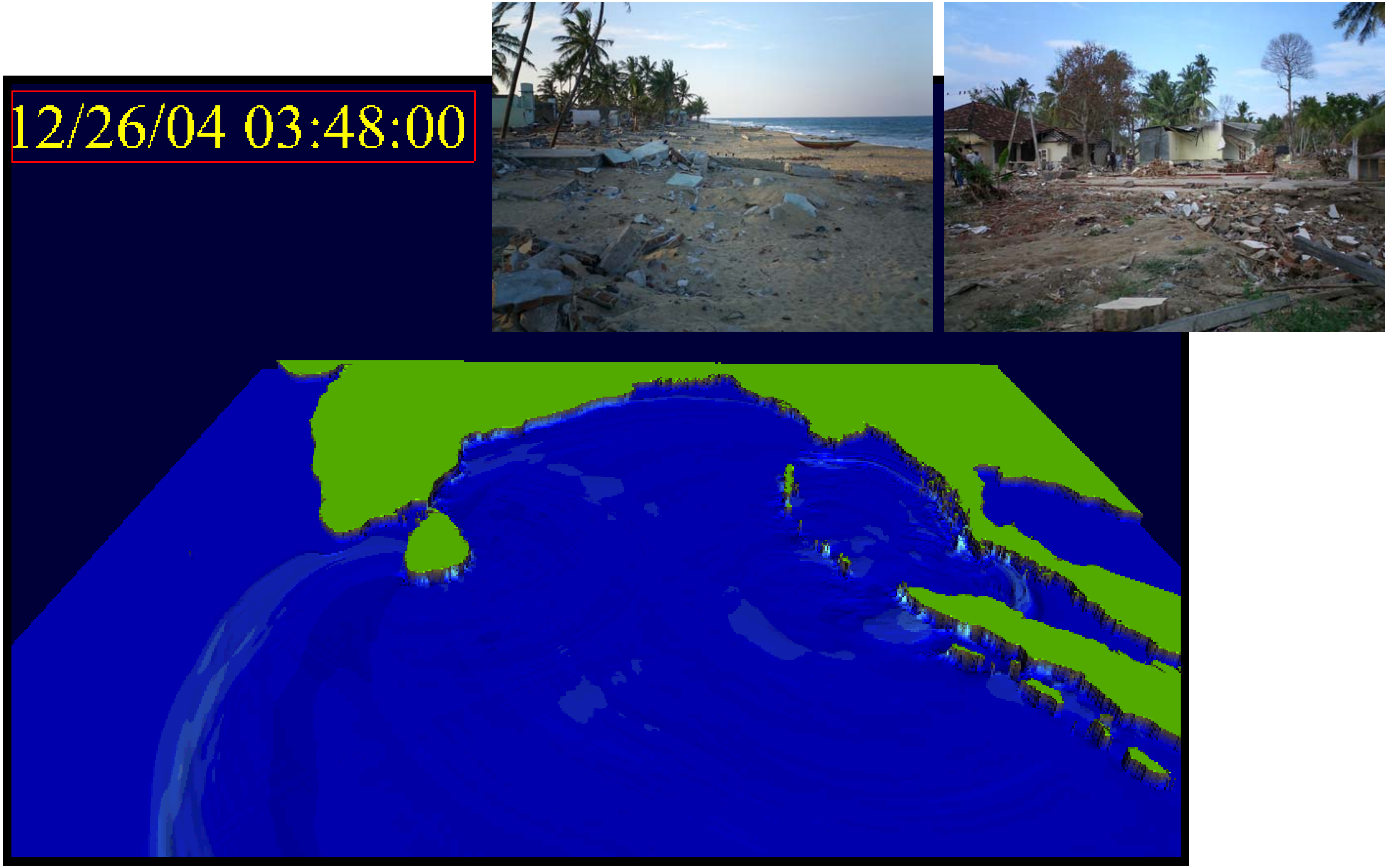
National Institute for Land and Infrastructure Management, Japan

Agenda

1. Recent Coastal Disasters
   tsunamis, storm surges, coastal erosion

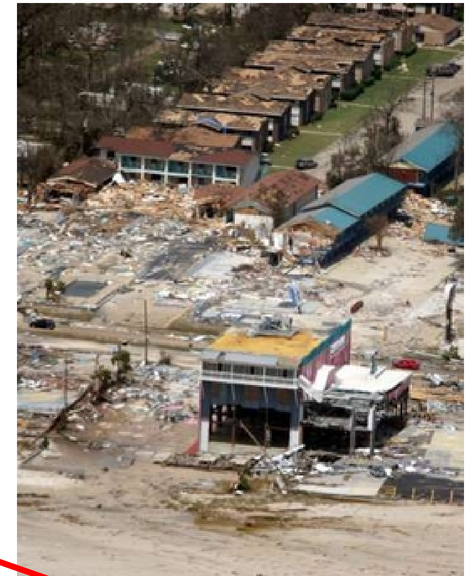
2. Measures against Coastal Disasters
   basic policy against tsunamis
   shore protection facilities
   storm surge warning system
   comprehensive sediment management

Indian Ocean Tsunami in 2004

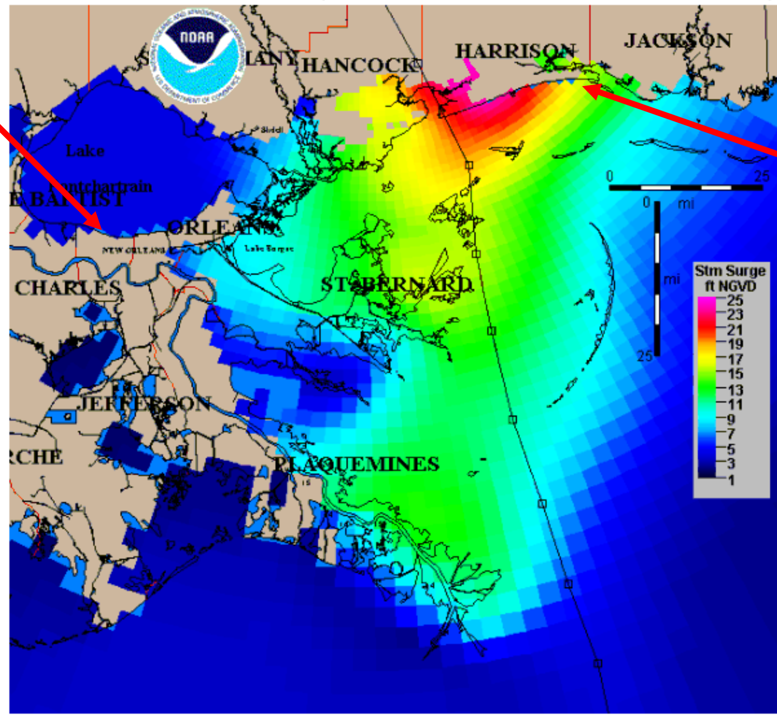


Hurricane Katrina in 2005

(Wilson Shaffer, National Weather Service/NOAA)



New Orleans



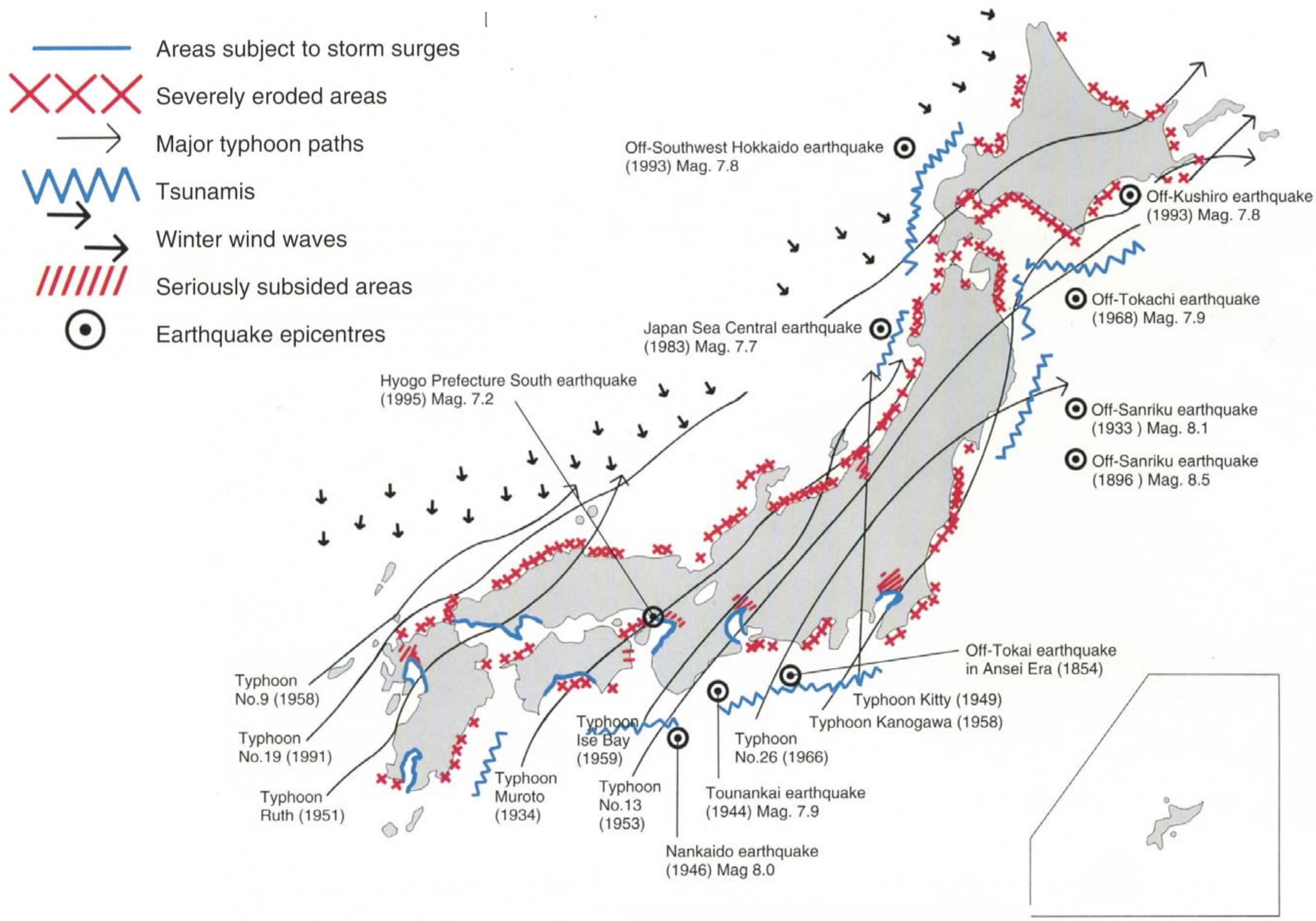
Camille's Envelope of High Water From SLOSH Model

Biloxi

Storm surge of up to 7.5m high

(photo: Reuter)

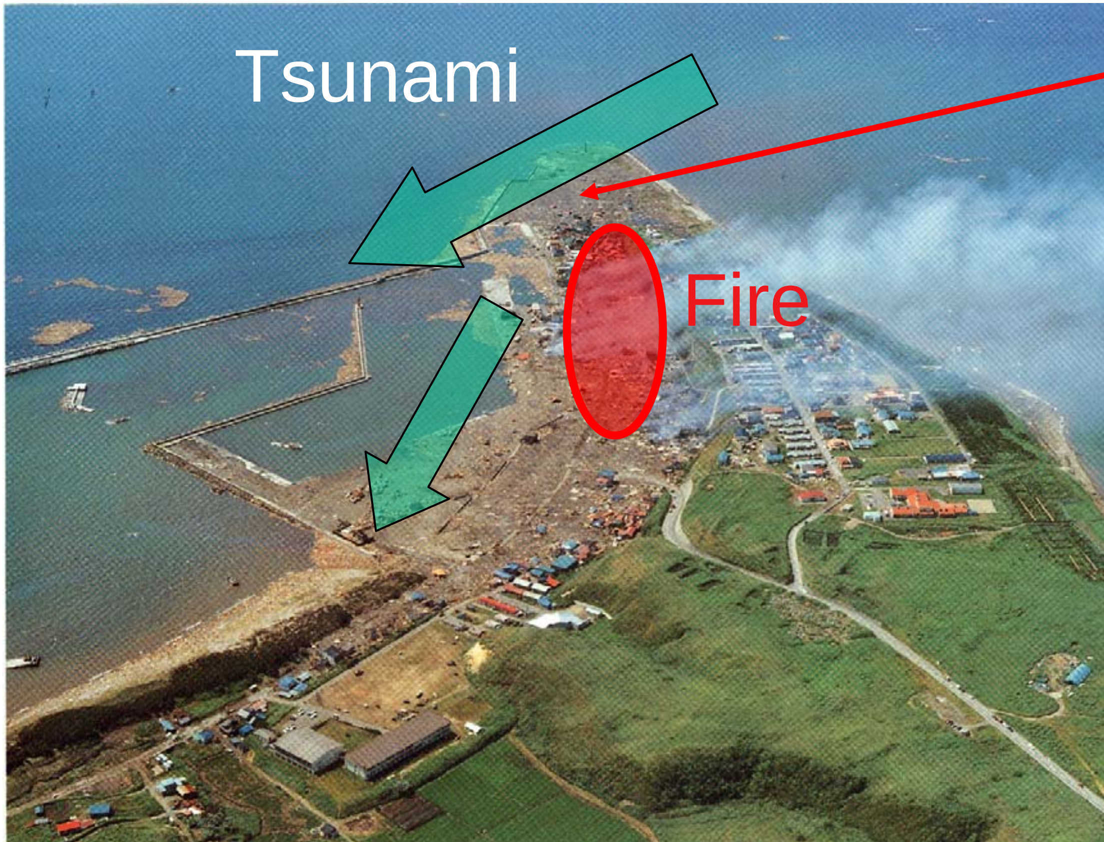
Coastal Disasters in Japan



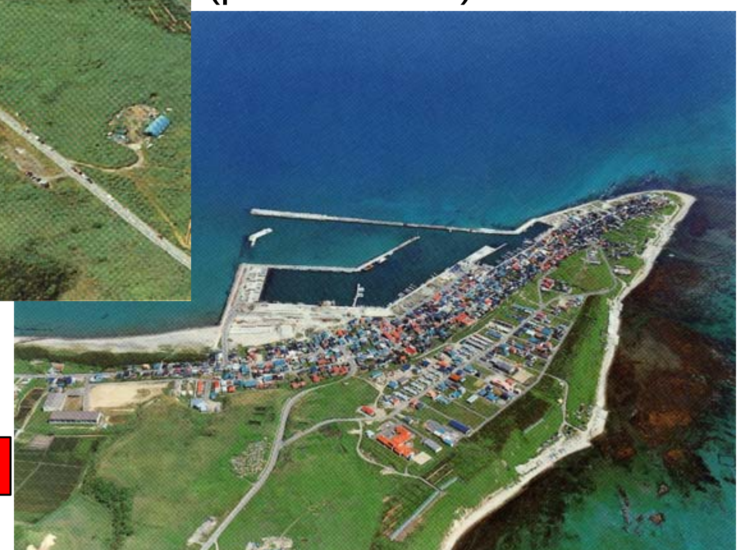
Tsunami Disasters in Japan

Date	Major damaged area	Damage				Earthquake	Remarks
		Dead	Injured	Missing	Houses		
15 June 1896	Sanriku	21,759	4,403		14,087	Meiji-Sanriku	
3 Mar. 1933	Sanriku	1,522	1,092	1,542	9,869	Showa-Sanriku	
7 Dec. 1944	Mie, Wakayama	189	129	449	10,626	Tonankai	
21 Dec. 1946	Wakayama, Mie, Tokushima, Kochi	1,330	3,942	113	68,006	Nankai	including earthquake damage
23 May 1960	Sanriku	119	872	20	22,693	Chilean	
16 May 1968	Aomori	52	329		19,695	Off-Tokachi	including earthquake damage
26 May 1983	Akita, Aomori	104	163		6,359	Japan Sea Central	including earthquake damage
12 July 1993	Hokkaido	202	305	29	3,443	Off-Southwest Hokkaido	including earthquake damage

Tsunami hit Okushiri Island (1993)



(photo: JSCE)



about 200 residents died

Earthquake

Storm Surge Disasters in Japan

Date	Major damaged area	Human casualties			Damage to houses		
		Dead	Injured	Missing	Completely destroyed	Partially destroyed	Washed away
1 Oct. 1917	Tokyo Bay	1,127	2,022	197	34,459	21,274	2,442
13 Sep. 1927	Ariake Sea	373	181	66	1,420		791
21 Sep. 1934	Osaka Bay	2,702	14,994	334	38,771	49,275	4,277
27 Aug. 1942	Suo Sea	891	1,438	267	33,283	66,486	2,605
17 Sep. 1945	Southern Kyushu	2,076	2,329	1,046	58,432	55,006	2,546
3 Sep. 1950	Osaka Bay	393	26,062	141	17,062	101,792	2,069
14 Oct. 1951	Southern Kyushu	572	2,644	371	21,527	47,948	1,178
25 Sep. 1953	Ise Bay	393	2,559	85	5,985	17,467	2,615
7 Sep. 1959	Ise Bay	4,697	38,921	401	38,921	113,052	4,703
16 Sep. 1961	Osaka Bay	185	3,897	15	13,292	40,954	536
21 Aug. 1970	Tosa Bay	12	352	1	811	3,628	40
30 Aug. 1985	Ariake Sea	3	16	0	0	589	0
24 Sep. 1999	Yatsushiro Sea	12	10	0	52	99	0

Storm Surge Flood in 2004

Takamatsu City

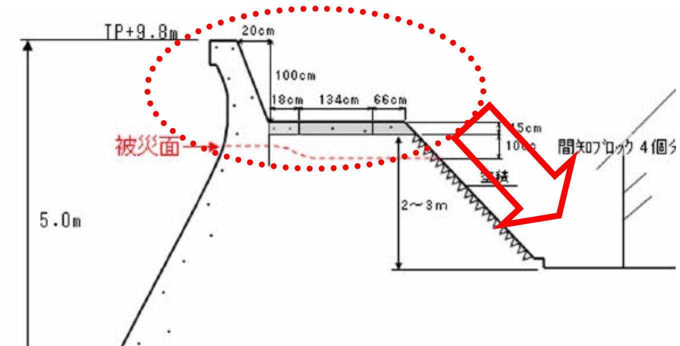
(facing the Seto Inland Sea)

3 people died, 15561 houses flooded

(photo: Shikoku Regional Development Bureau)

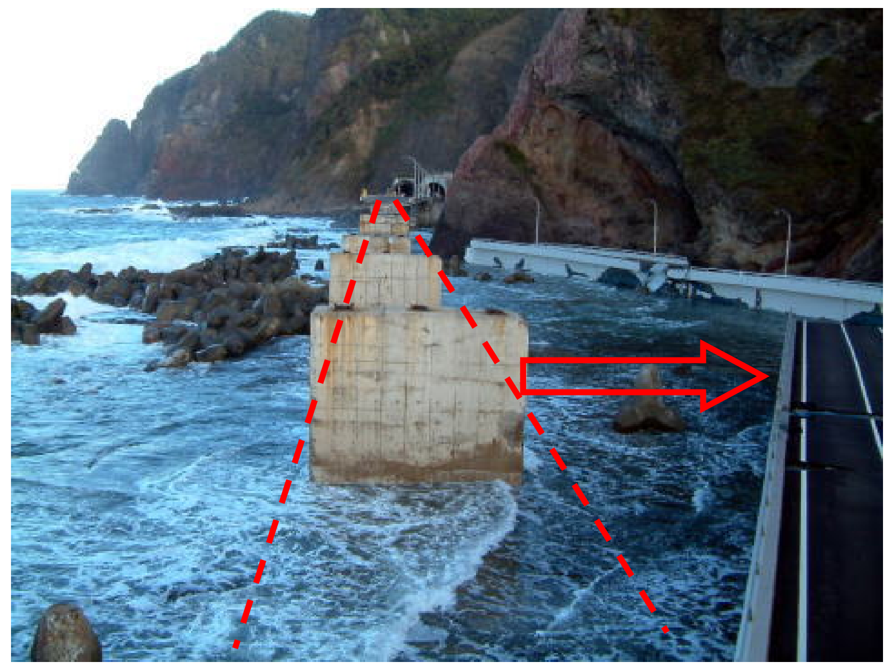
Recent Disasters caused by High Waves (2004)

Dike Failure



$H_{1/3}$: 13.55m

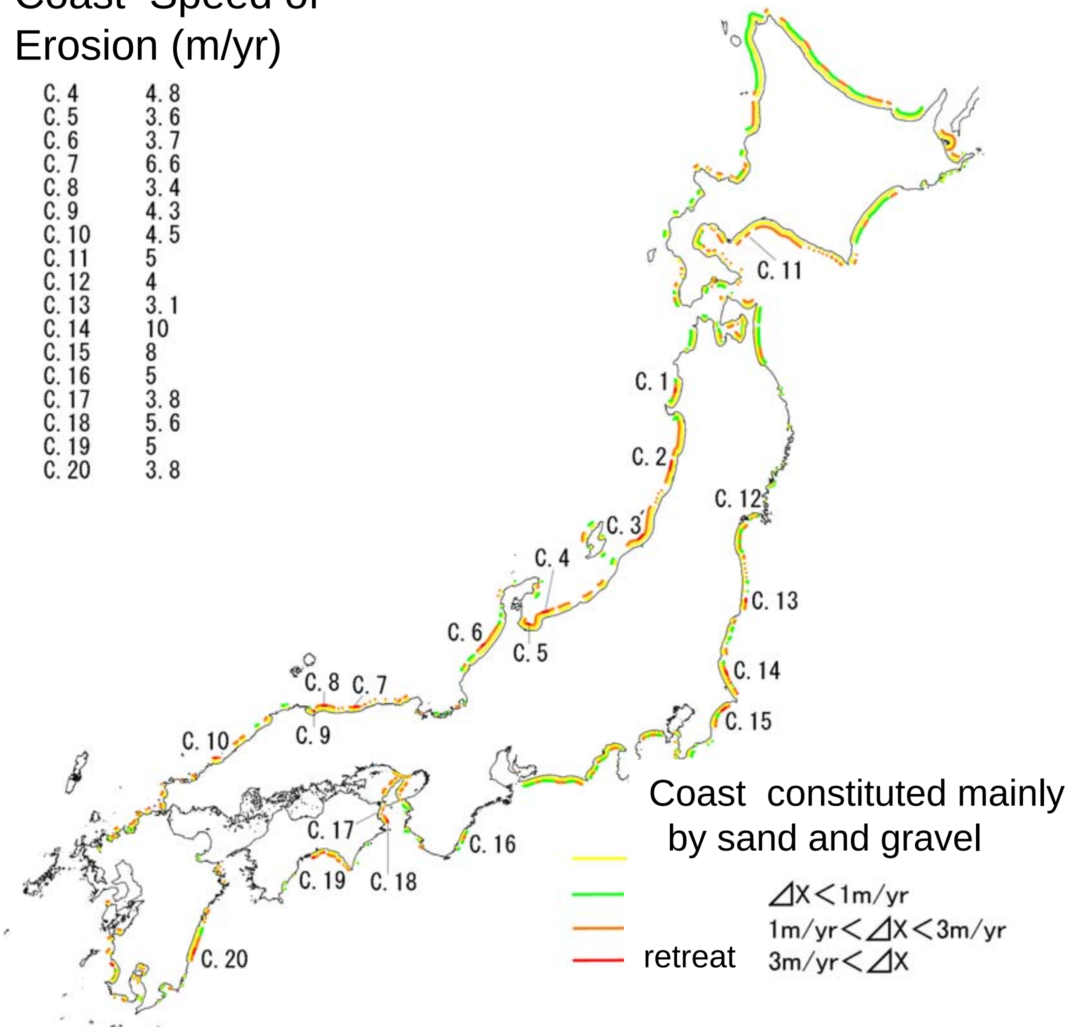
Fall of Bridge Girder



Coastal Erosion in Japan

Coast Speed of Erosion (m/yr)

C. 4	4. 8
C. 5	3. 6
C. 6	3. 7
C. 7	6. 6
C. 8	3. 4
C. 9	4. 3
C. 10	4. 5
C. 11	5
C. 12	4
C. 13	3. 1
C. 14	10
C. 15	8
C. 16	5
C. 17	3. 8
C. 18	5. 6
C. 19	5
C. 20	3. 8



Erosion Area: 1.6km^2/year

Main causes:

- Steep coast
- Shortage of sediment supply from rivers and coastal cliffs
- Interruption of sediment transport by coastal facilities

Recommendation of The Tsunami Protection Committee

(March, 2005)

Basic Policy:

To strategically and strongly implement an integrated combination of structural and nonstructural measures as comprehensive disaster mitigation measures

Specific Urgent Goals and Damage Mitigation Measures

Medium to Long Term Goals and Tsunami Protection Measures

Specific Urgent Goals and Damage Mitigation Measures

(1)Warning and Information Provision

warnings, communication, observation

(2)Preventive Measures

evacuation, shore protection, tsunami-resistant communities

(3)Post-tsunami Measures

damage information, transportation network, restration

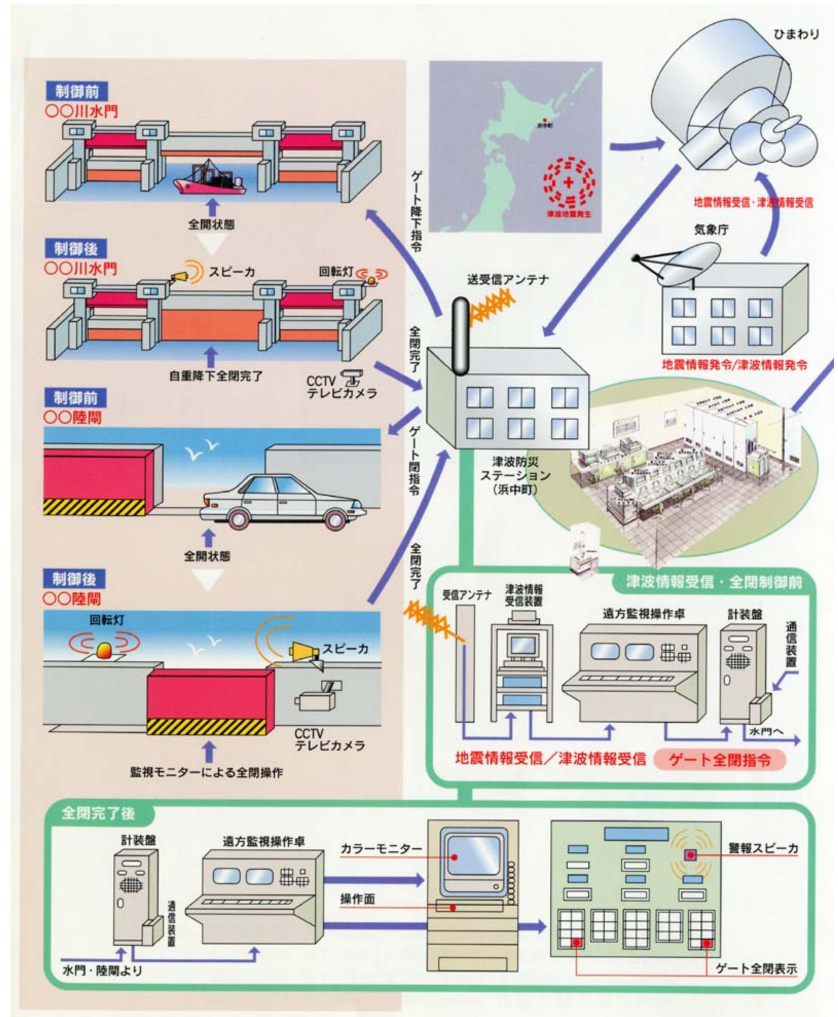
(4)Accumulation and Dissemination of Technology and Knowledge for Tsunami Disaster Prevention

research for administration

Facilities against Tsunami

Seawall

Tsunami Breakwater



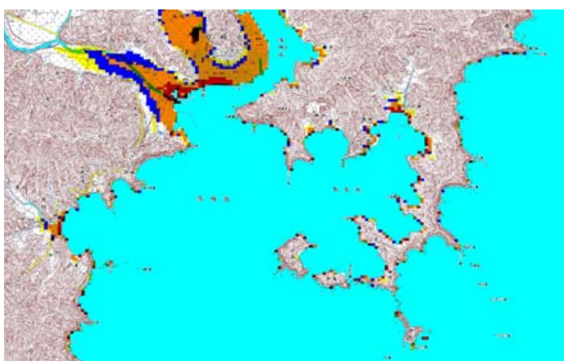
Tsunami Disaster Prevention Station

(Remote Gate Control)

Tsunami Information for Evacuation

Tsunami Warning (Japan Meteorological Agency)

Type of forecast	Message	Contents
Tsunami attention	Tsunami attention	Some minor tsunami may be anticipated. Height of tsunami is up to several tens centimeters.
Tsunami Warning	Tsunami anticipated	Tsunami is anticipated. Height of the tsunami is up to 2 meters in the maximum.
	Major tsunami anticipated	Major tsunami is anticipated. Height of the tsunami is more than 3 meters in the maximum. Greatest caution is required for tsunami.



Hazard map

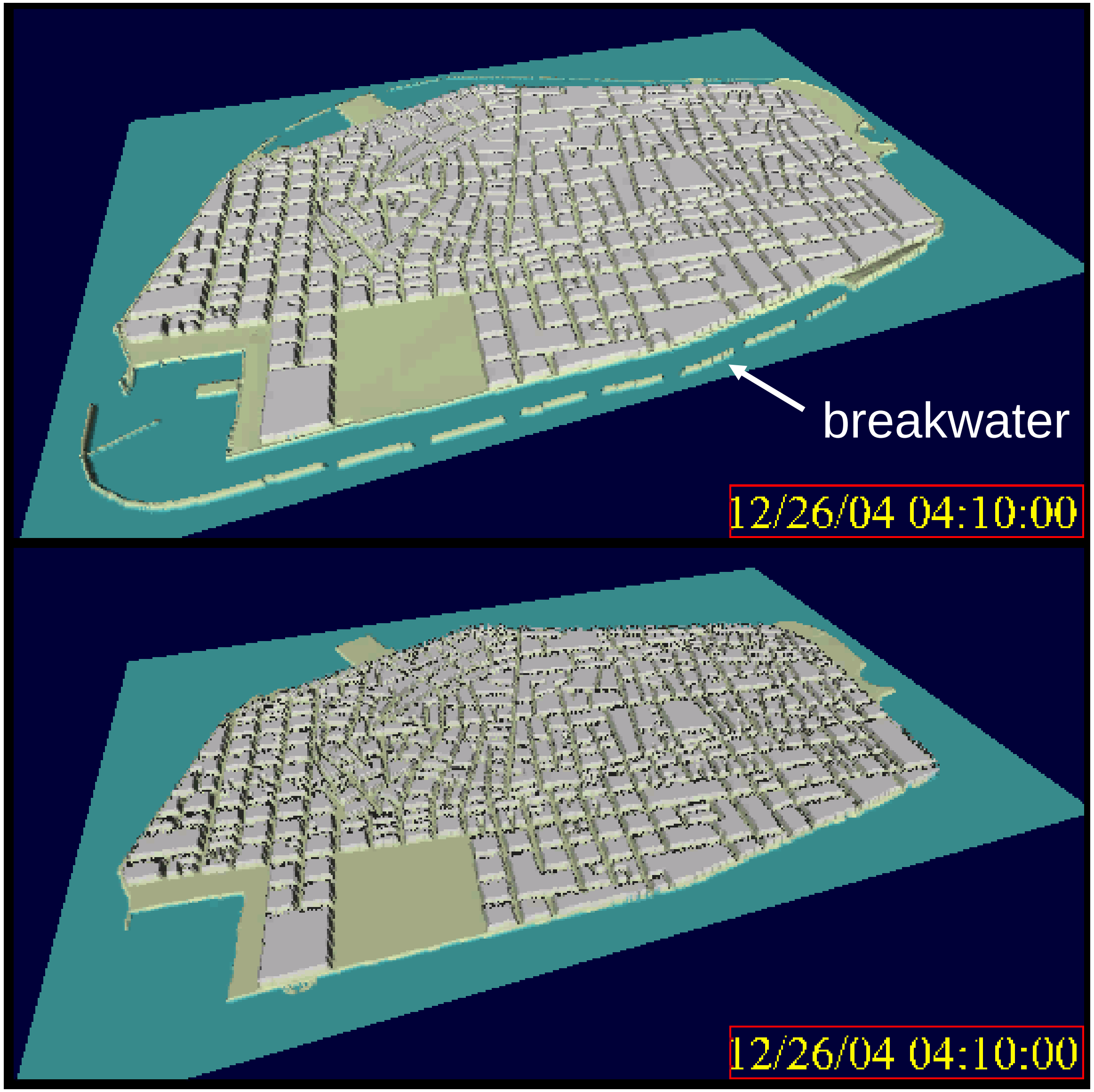
Tsunami Shelter

Effect of Shore Protection Facilities

<u>Male (Maldives)</u>

with parapet and breakwaters

without parapet and breakwaters



Measures against Storm Surge

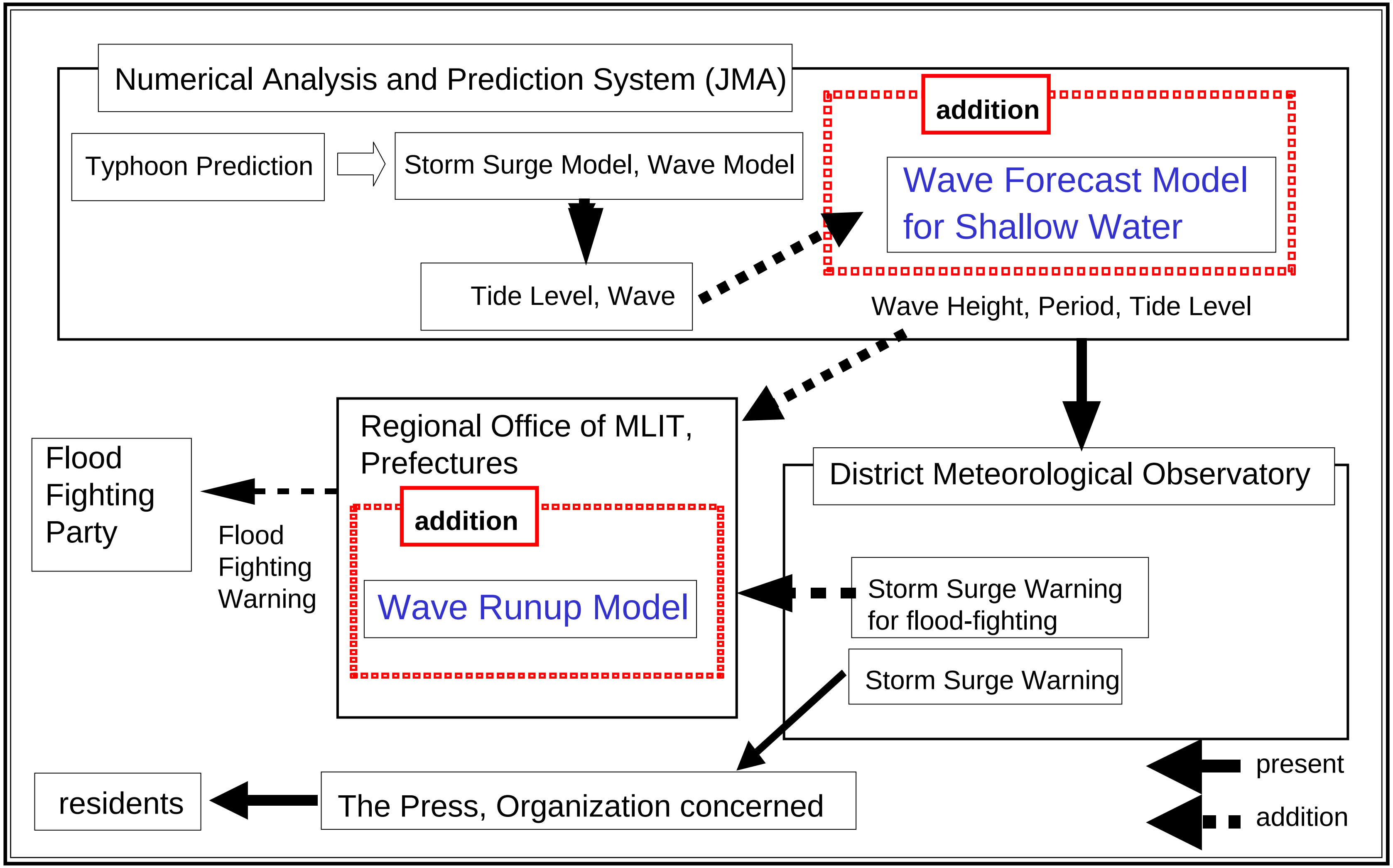
‘Hard’ Measures

‘Soft’ Measures

Coastal Dike

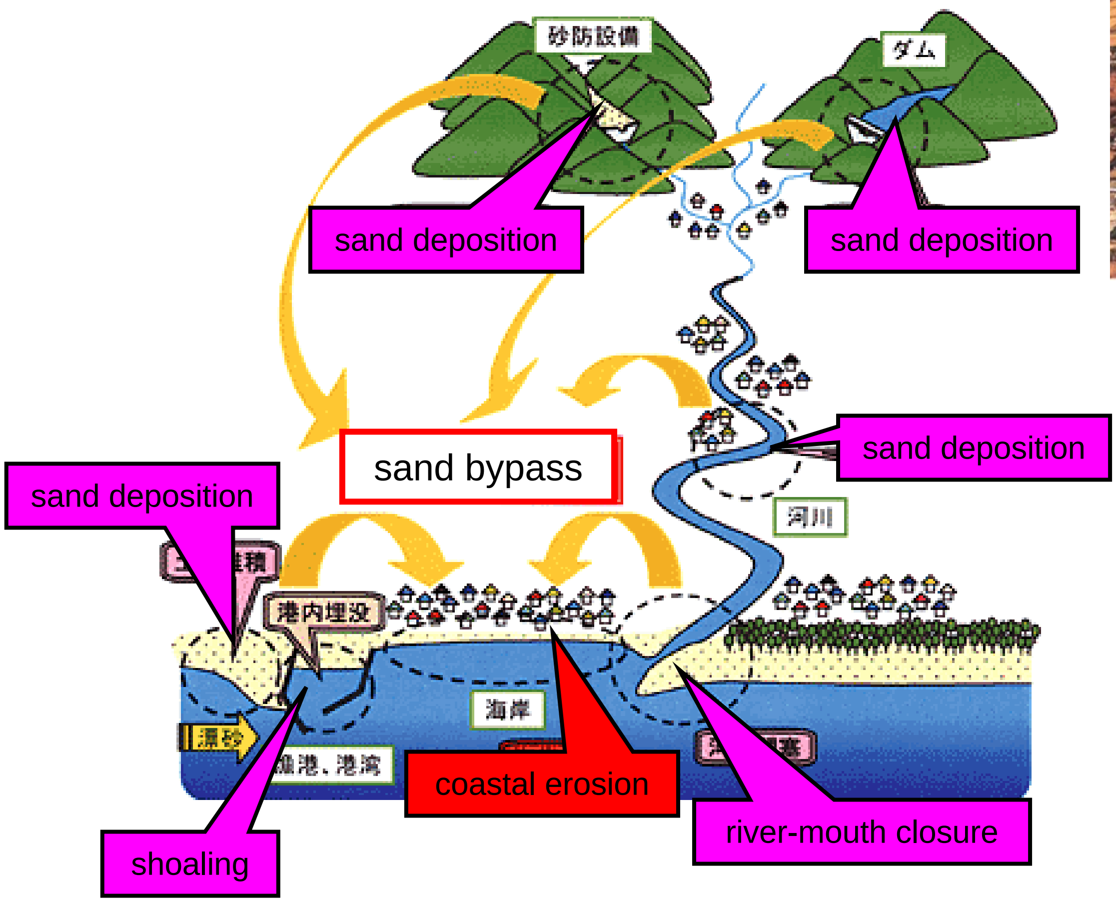
Hazard Map

Improvement of Storm Surge Warning System



Measures against Beach Erosion

Comprehensive Sediment Management



Coastal Facilities

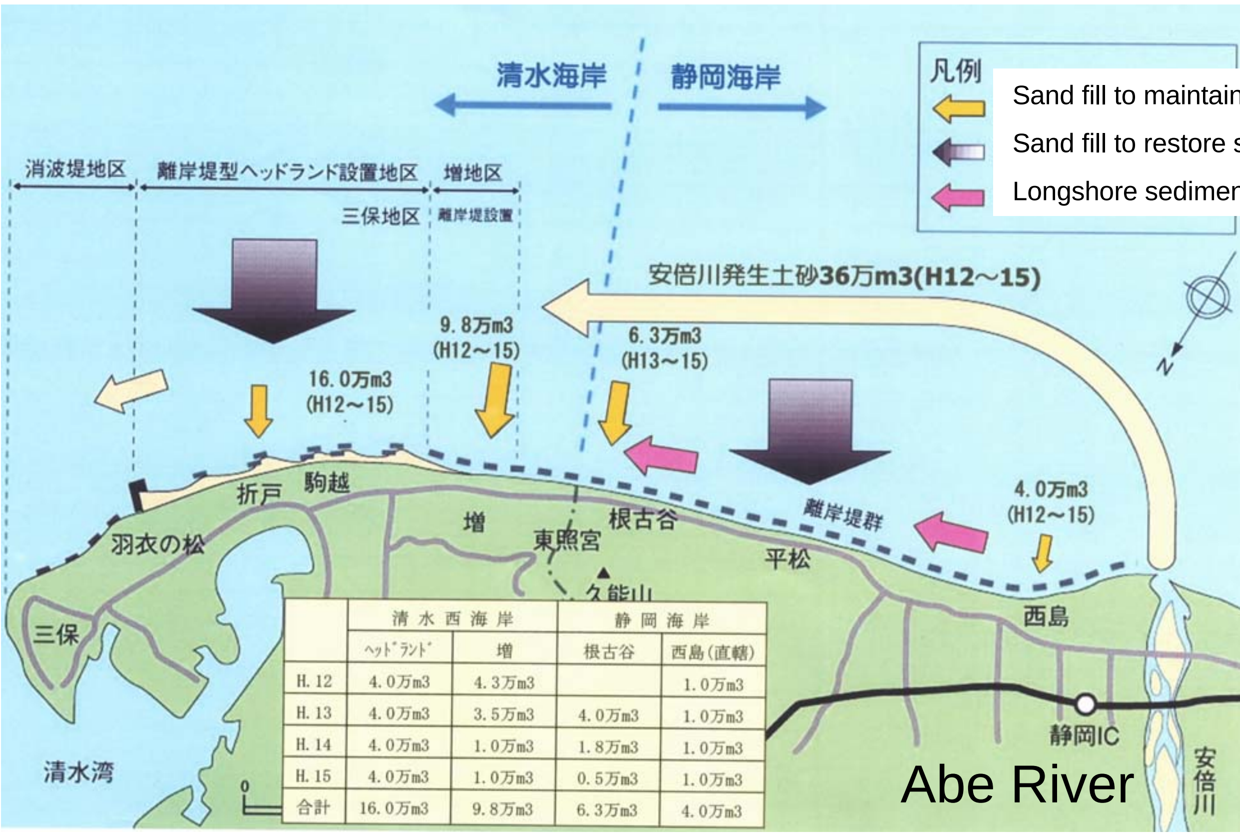
artificial headland

detached breakwaters

An Example of Comprehensive Sediment Management

1) To control floods of the Abe River, approximately 450,000 m^3/year of sediment on the river bed is to be dredged from 2000 to 2003.

2) The dredged sediment will be used for constructing high-water channels and as fill materials for Shizuoka-Shimizu Coast.



	清水西海岸		静岡海岸	
	ヘッドランド	増	根古谷	西島(直轄)
H.12	4.0万m3	4.3万m3		1.0万m3
H.13	4.0万m3	3.5万m3	4.0万m3	1.0万m3
H.14	4.0万m3	1.0万m3	1.8万m3	1.0万m3
H.15	4.0万m3	1.0万m3	0.5万m3	1.0万m3
合計	16.0万m3	9.8万m3	6.3万m3	4.0万m3

RECOMMENDATIONS OF THE TSUNAMI PROTECTION COMMITTEE

MARCH, 2005

TSUNAMI PROTECTION COMMITTEE

CONTENTS

INTRODUCTION

Japan has undergone many great tsunami disasters, and the scars left by tsunamis can be found everywhere in the land and culture of the country like fingerprints and genes. The measures that Japan has been taking to mitigate tsunami-induced damage are recognized as being advanced in the international community.

There were many people, however, who were not fully aware of the horror of tsunami because a great tsunami is a once-in-several generations occurrence.

Vivid photographs and video footages of the recent Indian Ocean tsunami have taught us how dreadful and disastrous a tsunami could be. A number of important pieces of knowledge have been gained and some important lessons have also been learned.

In view of lessons learned from the tsunami disaster, therefore, we have re-examined a wide range of tsunami disaster mitigation measures that Japan has been taking.

In order to ensure safety from tsunami, it is necessary to take comprehensive measures over a large area, knowing how disastrous a tsunami can be and identifying vulnerable places and safety measures that can be taken. It is also important to regard tsunami protection efforts as a continuous process beginning with prevention efforts and ending with restoration and rehabilitation and use a strategic combination of structural measures and nonstructural measures.

The basic policy for the coming years, therefore, is to try to implement an effective combination of structural measures and nonstructural measures before and after tsunami, instead of relying solely on structural measures to prevent disasters, in order to minimize tsunami-induced damage.

In accordance with this policy, "minimizing human suffering" has been set as an urgent goal and "minimizing damage and human suffering" as a medium to long range goal, and targets and concrete measures to achieve them are described in this report.

The central government should be responsible for taking tsunami protection measures, but damage and suffering cannot be minimized by the administrative authorities alone. Awareness and actions of the public and people in all circles and at all levels are essential. It is our sincere hope that the recommendations described in this report will help to start various forms of cooperative efforts of the public and private sectors.

1. TSUNAMI PROTECTION MEASURES IN JAPAN: CURRENT STATE AND PROBLEMS

Sitting practically on top of four tectonic plates, Japan is prone to large-scale ocean-trench earthquakes. In fact, Japan has suffered major tsunami damage roughly once every 10 years.

Furthermore, only about 10 percent of the land of Japan can be used as residential land, and population and industry are inevitably concentrated in alluvial plains and coastal areas. Even in those dangerous areas, intensive and efficient use is made of available space including underground space and highly urbanized cities have been constructed.

The imminence of ocean-trench earthquakes such as the Tokai, Tonankai and Nankai earthquakes* has been pointed out for some time, and the occurrence of nearshore tsunamis caused by those earthquakes has been predicted. There is also concern about a major tsunami caused by a Cascadia earthquake†† expected in the North Pacific Coast or a Chilean earthquake. A nearshore tsunami reaches a shore soon after an earthquake occurs and inflicts secondary damage on earthquake-damaged areas.

Under these circumstances, the current state and problems of pre- and post-tsunami safety measures are as follows.

(1) Current state and problems of warning and information provision

(a) Today, it is possible to issue a tsunami warning within three to five minutes after the occurrence of an earthquake. In the event of some earthquakes such as the Tokai, Tonankai and Nankai earthquakes, however, the first wave is likely to arrive within several minutes after the occurrence of the earthquake.

(b) Tsunami height is highly dependent on such factors as coastal and submarine topography. The percentage of people who can evacuate in the event of a tsunami is low, and effort to provide information to help the public to understand the true nature of tsunami is insufficient.

(c) Facilities for communicating information to visitors such as tourists are inadequate.

(d) Existing systems for providing tsunami information to moving vehicles and running trains, watercraft, etc., in a timely manner are inadequate.

(e) Tide and wave height observation is not timely enough, and offshore observation is inadequate. Reference levels used by different organizations for tide observation are not consistent, and there is no established system for providing easy-to-understand information to local public bodies, local residents, etc.

(f) There is no established standard for conveying information for people who need help in a time of disaster.

---

1) * It has been pointed out that besides the Tokai, Tonankai and Nankai earthquakes, ocean-trench earthquakes along the Nippon Trench and the Chishima Trench are also likely to occur.

2) † A Cascadia earthquake is a magnitude 8–9 earthquake that has occurred in the region along the Northwest Pacific Coast mainly along the Canada–US boarder at recurrence intervals of 300–350 years. The last Cascadia earthquake occurred in 1700. It has been said for some time that another Cascadia earthquake is imminent.

(2) Current state and problems of preventive measures

(a) Inspection and performance evaluation of facilities that have a tsunami protection function are inadequate. The target levels of the tsunami protection function are inadequate.

(b) The seismic performance and gap-closing performance of 59 percent and 55 percent, respectively, of the seawalls in important coastal zones ‡ have not been checked.

(c) Even in important coastal zones, somewhere between 10 and 20 percent of all municipalities have published their tsunami hazard maps.

(d) There should be more shelters and evacuation routes designed taking topography and evacuation time into consideration.

(e) In areas where it is difficult to provide sufficient shelters because of relatively flat topography, adequate consideration has not been given to the designation of buildings that are to be used as tsunami shelters and requirements for such shelter buildings.

(f) Roads, railways and airports located near coastlines have not been inspected adequately with respect to safety against the expected tsunami height.

(g) There are many facilities for storing hazardous and noxious substances (HNS) such as LNG located in coastal areas. Many of these facilities are not protected from tsunami.

(h) Marine vessels sunk, stranded, broken or swept away and cargoes or other objects washed away could impair port and harbor functions, cause water pollution, and aggravate damage in the hinterland areas.

(3) Current state and problems of post-tsunami measures

(a) It has been pointed out that the systems for collecting tsunami damage information from municipalities to prefectural governments and the Ministry of Land, Infrastructure and Transport are not functioning well.

(b) There is no system for timely collection of such information as whether or not port and harbor facilities are usable.

(c) Damage to emergency transportation roads or important ports and harbors could impair the function of regional transportation networks.

(d) Helicopters and other means of transportation for collecting information and performing rescue and relief operations and disaster prevention bases necessary for relief and emergency restoration operations are inadequate.

(e) The ability to pick up many people drifting in the sea is limited.

(f) Disposal of large volumes of debris containing saltwater in tsunami-affected areas is a problem that needs to be addressed.

(g) Since there are as yet no plans for creating highly disaster-resistant communities, appropriate and timely rehabilitation is difficult to achieve.

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3) ‡ Important coastal zones are coastal areas that are likely to be affected by the Tokai, Tonankai and Nankai earthquakes and ocean-trench earthquakes occurring along the Nippon Trench or the Chishima Trench (as of August, 2004, a total of 402 municipalities are located in important coastal zones).

(4) Current state and problems of accumulation and dissemination of tsunami protection technology and knowledge

(a) Even in important coastal zones, about 20 percent of the municipalities do not conduct tsunami response drills.

(b) There is no institutional system under which the causes of major disasters are determined promptly and the findings are reflected in government actions.

(c) Neither administrators, researchers nor citizens can easily obtain information regarding tsunami disaster prevention.

2. BASIC POLICY FOR TSUNAMI PROTECTION MEASURES IN THE COMING YEARS

Tsunami protection measures in the past relied mainly on structural measures such as seawalls designed to guard against a tsunami of an expected magnitude, and there was even no policy for dealing with a tsunami of a greater magnitude.

In view of the current state and problems, the basic proposition in the coming years is to enhance the level of safety as soon as possible despite the limitations in the amount of investment and the response time requirements and strategically promote activities for minimizing damage even in the event of a beyond-design-basis tsunami.

The magnitude of damage is determined by the level of tsunami risk reduction achieved by means of structural measures such as seawalls and the level of effectiveness of nonstructural functions such as the safety level of the social organization of the local community and the inherent fire resistance and disaster tolerance of land use patterns.

In order to minimize damage in an area, therefore, it is necessary to take appropriate and reliable structural measures so that the risk level can be lowered and to take nonstructural measures so that the safety level, disaster resistance and disaster tolerance of the area can be enhanced.

In short, it is necessary to strategically and strongly implement an integrated combination of structural and nonstructural measures as comprehensive disaster mitigation measures.

Since, however, those measures are interrelated, their implementation requires close coordination among the people concerned in view of the realities in the area. At the same time, effort should be made to implement conventional, more or less standardized structural measures in a manner suitable for the area.

On the basis of this concept, comprehensive measures ranging from pre-tsunami to post-tsunami measures that can be taken against tsunami through the allocation of the roles of "self-help," "mutual assistance" and "public assistance" and through cooperation must be taken.

Public awareness of the importance of tsunami preparedness is apt to fade because tsunami is characterized by long recurrence intervals. "Self-help," "mutual assistance" and "public assistance" are based on public awareness. Continued effort must be made, therefore, in the areas of safety education, public relations and tsunami response drills.

3. SPECIFIC URGENT GOALS AND DAMAGE MITIGATION MEASURES

The first step in damage mitigation is to take urgently needed measures to "minimize human suffering."

To this end, educational effort should be made make the residents of coastal areas and tourists and other visitors in coastal areas aware that it is their duty in the spirit of "self-help" and "mutual assistance" to escape to higher areas in the event of an earthquake.

As a provider of assistance to the "self-help" and "mutual assistance" efforts, the government should implement comprehensive measures to disseminate basic knowledge about tsunami, provide tsunami information in an appropriate manner and in a timely manner, and improve the evacuation environment for rescue and relief operations by making evacuation routes and shelters available and providing tsunami protection facilities for tsunami risk reduction.

In so doing, it is necessary to keep in mind that the level of understanding on the part of the public at the receiving end of information and the level of functionality of facilities with a tsunami protection function are deciding factors.

Therefore, with the aim of "minimizing human suffering" due to tsumanis induced by ocean-trench earthquakes whose probability of occurrence is thought to be high such as the Tokai, Tonankai and Nankai earthquakes, specific urgent measures that should be taken within five years from now have been identified.

(1) Warning and information provision

1) Better tsunami warnings

- To improve the earthquake observation network using nowcasting seismographs and achieve faster tsunami forecasting by use of the emergency earthquake information technology
- To construct a system for directly conveying tsunami forecasts and other information to municipal governments
- To disseminate knowledge about tsunami height, methods for expressing the destructive power of tsunami, etc.

2) Conveying and providing tsunami information in an appropriate manner

- To provide easy-to-understand tsunami information such as inundation depth, tsunami arrival time, flow velocity and destructive power in the form of tsunami-prone area maps
- To construct a system for providing information on areas that are likely to be flooded immediately in the event of tsunami for a model area
- To provide information to visitors such as tourists, road users and moving trains, ships, etc. through a variety of means of communication such as telecommunications devices such as cellular phones and other communications facilities
- To establish a method for conveying tsunami-related information to facilities used by people in need of assistance in the event of a disaster
- To exchange opinions with the media on a regular basis about what disaster information should be like and deliberate on methods for conveying information, the content of the information to be provided, etc.

3) Better tsunami observation

- To collect more real-time tsunami observation data obtained at a greater number of locations including offshore locations and to share with the organizations concerned and publish the data thus collected

(2) Preventive measures

1) Improvement of evacuation measures

- To prepare and publish tsunami-prone area maps so that all municipalities in the important coastal zones can compile their tsunami hazard maps
- To ensure the availability of shelters and evacuation routes that are friendly to people in need of assistance in the event of a disaster and assist in eliminating difficult-to-evacuate areas in important coastal zones
- To compile information on buildings to be evacuated in the event of a tsunami, such as requirements and improvement methods, and promote the dissemination of such information
- To disseminate tsunami risk information on a continual basis by use of standardized graphic symbols
- To strengthen evacuation measures so as to facilitate the evacuation of coast and port users
- To create an environment in which moving vehicles, running trains, and ships and boats can evacuate easily

2) Provision of facilities with tsunami protection function

- To substantially complete the compiling and publicizing of coastal conservation area registers, the inspection and performance evaluation such as earthquake resistance studies of facilities with a tsunami protection function, and a review of the master plans for coastal conservation for important coastal zones
- To substantially complete the automation, remote control implementation or other upgrading of water gates in key regional function concentration districts§ and promote the seismic retrofit and raising of levees in important coastal zones; and establish an improvement method suitable for each area
- To promote the raising of breakwaters at ports and harbors along important coastal zones

3) Promotion of tsunami protection measures for facilities located in coastal areas

- The managers of the facilities located near coasts will inspect their facilities with respect to safety against the expected tsunami height and take protection measures in cooperation with one another.
- The administrative authorities (e.g., port managers, regional development bureaus, maritime safety departments, district transport bureaus) and private sector stakeholders will draw up comprehensive tsunami protection plans and implement protection measures.
- To establish an organizational system for control to be activated in the case where a tanker or coastal facility storing a large volume of a hazardous and obnoxious substance (HNS) such as crude oil or LNG has been damaged by a tsunami; and implement

4) § Areas behind which there are facilities that are to perform crisis management functions such as relief and restoration (e.g., municipal government offices, police stations, fire stations, hospitals)

measures to prevent cargoes and small marine vessels from being swept away and protect other marine vessels
- To provide guidance to passenger ship operators so as to ensure safety of passenger ships in the event of a tsunami

4) Damage reduction through better land uses and better ways of living
- To recommend that developers incorporate damage mitigation measures into their integrated development plans for coastal areas in order to create communities that are highly resistant to tsunamis.
- To promote the application of the philosophy of damage mitigation to the siting, project methods and usage of public facilities
- To conduct studies on the requirements for disaster-resistant communities in order to reflect the findings in community planning and regional planning

(3) Post-tsunami measures

1) Collecting regional damage information
- To build an investigation system that can respond quickly in the event of a disaster
- To strengthen the system for exchanging damage information between the central and local governments
- To enhance information gathering ability by making more effective use of helicopters, etc.
- To construct an information collection system using artificial satellites
- To assist in establishing organizational systems for cooperation in collecting information in affected areas

2) Ensuring the availability of regional transportation networks in a time of disaster
- To promote the seismic retrofit of road bridges and the construction of high-standard arterial expressway and other road networks in order to secure the availability of emergency transportation roads that play an important role in relief activities and the transportation of relief goods
- To restore damaged roads quickly by, for example, removing obstacles from damaged roads and carrying out emergency rehabilitation
- To construct a system for managing information on the usability of port facilities in an integrated manner and providing such information to users
- To promote the construction of earthquake resistant seawalls at ports in important coastal zones; and to improve detection systems using the laser-based depth measurement technology and other related technologies and establish systems for urgent removal of obstacles on sea routes that can be activated in conjunction with the detection systems

3) Promoting measures related to isolated areas
- To upgrade the functions of facilities that can be used as disaster prevention bases, such as tsunami/storm surge disaster prevention stations, river disaster prevention stations, Michi-no-Eki stations, coastal disaster prevention bases, located in the areas in important coastal zones where such functional upgrading is necessary, and promote the construction of such facilities; and to collect information that can be used to assist in disaster prevention efforts, and share such information among the organizations concerned
- To establish systems for wide-area joint operations involving the administrative authorities concerned

- To select emergency heliports and share the information on such heliports
- To build a system for cooperating with NGOs
- To enhance the rescue and relief capability of helipcopters

4) Strengthening restoration and rehabilitation measures

- To promote the research and development of equipment for disaster response operations such as debris removal and strengthen the institutional framework for providing assistance
- To improve rehabilitation assistance measures for disaster-resistant areas
- To strengthen the ability to pick up and transport people rescued from the sea

(4) Accumulation and dissemination of technology and knowledge for tsunami disaster prevention

1) Accumulating technology and knowledge for tsunami disaster prevention

- To promote disaster prevention education at schools, provide assistance for the education of community leaders in the area of disaster prevention and conduct comprehensive tsunami response drills every year in order to maintain and enhance public awareness of the importance of disaster prevention efforts
- To prepare pictorial illustrations showing expected tsunami behavior on the land or in the sea at ports in important coastal zones
- To construct a three-dimensional database integrating the information on terrestrial and submarine topography
- To compile high-accuracy terrain data for important coastal zones
- To establish a system for sharing information related to tsunami disaster prevention

2) Tsunami disaster prevention research and use of research findings for administration

- To conduct research on tsunami disasters drawing on expert knowledge and build a system for reflecting research findings in administration on a continual basis
- To promote research on the following:

  mechanism of tsunami generation; tsunami behavior on the land and in the sea and the spread of damage; building behavior in response to tsunami and control methods; strength performance of structures against tsunami; rehabilitation policies and methods of rehabilitation planning and implementation; study on the content of information and appropriate communication methods, etc.

4. MEDIUM TO LONG RANGE GOALS AND TSUNAMI PROTECTION MEASURES

The goal of tsunami protection measures is to minimize tsunami-induced damage including property damage.

Humankind is destined to inherit tsunami risk from generation to generation. The best way to mitigate tsunami damage, therefore, is to incorporate damage mitigation measures into land uses and the way of living in each of future generations so that the philosophy of damage mitigation is reflected in daily life.

In this country, which is not blessed with geographic conditions from the viewpoint of tsunami disaster prevention, it is necessary to make consistent efforts to raise the level of protection in areas where key community functions or key economic and social functions are concentrated. At the same time, it is necessary to implement various measures making effective use of every community planning and building construction opportunity in order to prevent destructive damage even in the event of a beyond-design-basis tsunami.

Furthermore, it is also important to reduce the use of high-tsunami-risk areas as living zones and steer land use so that living zones occur more in low-tsunami-risk areas than in high-risk areas.

Japan has entered an era of population decline, and it is predicted that the population of Japan will begin to gradually decrease in about 20 to 30 years and the demographic composition will change considerably. During the same period, sea level is expected to rise because of global warming. In order to cope with these unprecedented changes in changes in demography and natural conditions, it is necessary to accumulate and utilize scientific and technological knowledge and take appropriate measures.

In any case, a new policy is essential, and various institutional systems need to be constructed with the understanding of the public.

In accordance with these requirements and taking into consideration the expected changes in demography and natural conditions, medium to long range measures that should be taken over a period of about 20 years have been identified with the aim of "minimizing tsunami-induced damage and suffering including property damage."

(1) Medium to long range tsunami protection measures including emergency measures

1) Warning and information provision

- To develop methods for estimating the magnitude of tsunami-induced earthquakes to enhance the accuracy of tsunami forecasting
- To perform recomputation of tsunami simulation reflecting the effects of topography and land use changes
- To establish a system for providing information on areas that are likely to be flooded immediately in the event of a tsunami and enhance the accuracy of prediction

2) Preventive measures

- To construct shelters and evacuation routes to help to eliminate difficult-to-evacuate areas
- To perform the seismic retrofit of coastal conservation facilities, construct seawalls and breakwaters, and perform the automation and remote control implementation of water gates at openings, on an as-needed basis, mainly in important coastal zones
- The managers of the facilities located near coasts will take necessary measures.
- To promote the formulation of land use plans (municipal plans) that give consideration to disaster prevention

3) Post-tsunami measures

- To construct systems for urgent removal of obstacles such as sunken ships in port areas throughout the country
- To construct facilities that can be used as disaster prevention bases in the areas where such facilities are necessary
- To establish the technology and support systems for equipment for disaster response operations such as debris removal

4) Accumulation and dissemination of technology and knowledge for tsunami disaster prevention

- To establish functional maintenance methods and design technology for various facilities subjected to beyond-design-level external forces
- To promote widespread use of the knowledge gained and the research results obtained in administrative authorities and society

(2) Measures that take demographics into consideration

- To improve assistance to the growing number of people in need of assistance in the event of a disaster
- To upgrade the measures designed to steer land use so that living zones occur in low-tsunami-risk areas than in high-risk areas

(3) Measures against sea level rise due to global warming

- To decide on conservation measures to be taken as part of the tsunami protection measures against sea level rise
- To decide on measures to be taken in order to create a country and economic and social systems that are highly resistant to increases in external force caused by natural disasters

CONCLUSION

The recommendations described in this document are the first of their kind to deal specifically with tsunami protection measures. It is significant that the Tsunami Protection Committee deliberated on the varied themes falling into the categories normally covered by the National Land Development Council, the Infrastructure Development Council and the Council for Transport Policy, addressed short- and long-range policies under a clearly defined strategy, and has come up with a wide-ranging set of concrete measures to be taken.

In order to implement the recommendations, it is necessary to draw up action plans, carry them out, verify their effectiveness and, if necessary, modify them. It is also important to reflect the knowledge gained by analyzing the recent Indian Ocean tsunami in the administrative measures to be taken in the coming years. The challenge of developing new types of measures that need to be debated on a nationwide scale should also be taken up.

Tsunami protection measures that require follow-up as part of earthquake disaster prevention measures, should be implemented by more than one ministry or agency and require further deliberation should be implemented jointly by the ministries and agencies involved with the help of expert knowledge.

Whether or not these recommendations will have historical value is solely dependent on the efforts of not only the government but also the public and the various circles at various levels. Needless to say, the Ministry of Land, Infrastructure and Transport (MLIT) should promptly set out to implement the recommended measures that fall into the categories for which the ministry is directly responsible. In addition, MLIT should also present the other measures to the local public bodies concerned. Furthermore, MLIT should ask the local public bodies to report on the measures they have implemented or the measures they intend to implement, and should collect the reports and present the results to the public.

Members of the Tsunami Protection Committee

Tsunami
Fumihiko Imamura, Professor, Graduate School of Engineering, Tohoku University

Local government
Mitsuhisa Ito, Mayor, Owase City, Mie Prefecture

Disaster Prevention
Yoshiaki Kawata (Chairman), Professor, Disaster Prevention Research Institute, Kyoto University

Transportation
Katsuhiko Kuroda, Professor of Engineering, Kobe University (Chairman, Port Transportation Subcommittee)

Law
Tsuyoshi Nishitani, Professor, Law School, Kokugakuin University (Chairman, River Subcommittee, Infrastructure Development Council)

Housing
Tsuneo Okada, Professor Emeritus, The University of Tokyo; President, Japan Building Disaster Prevention Association (Chairman, Building Subcommittee, Infrastructure Development Council)

Local government
Kazuo Ozawa, Mayor, Kamaishi City, Iwate Prefecture

Coasts
Shinji Sato, Professor, Graduate School of Engineering

Maritime safety
Masaru Takahashi, Professor, Maritime Safety Technology, Japan Coast Guard Academy

Information
Atsushi Tanaka, Professor, Faculty of Sociology, Toyo University

Meteorology
Koji Yamamoto, Chairman, HALEX Corporation (former Director-General of the Japan Meteorological Agency)

Media
Noboru Yamazaki, Commentator, Japan Broadcasting Corporation (NHK)

(Arranged alphabetically)

APPLICATION TO PAST DISASTERS OF A METHOD OF SETTING THE RANGE OF DEBRIS FLOW DAMAGE TO HOUSES

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Today's topic

- Background
- Objectives
- Method
- Results of application
- Conclusion

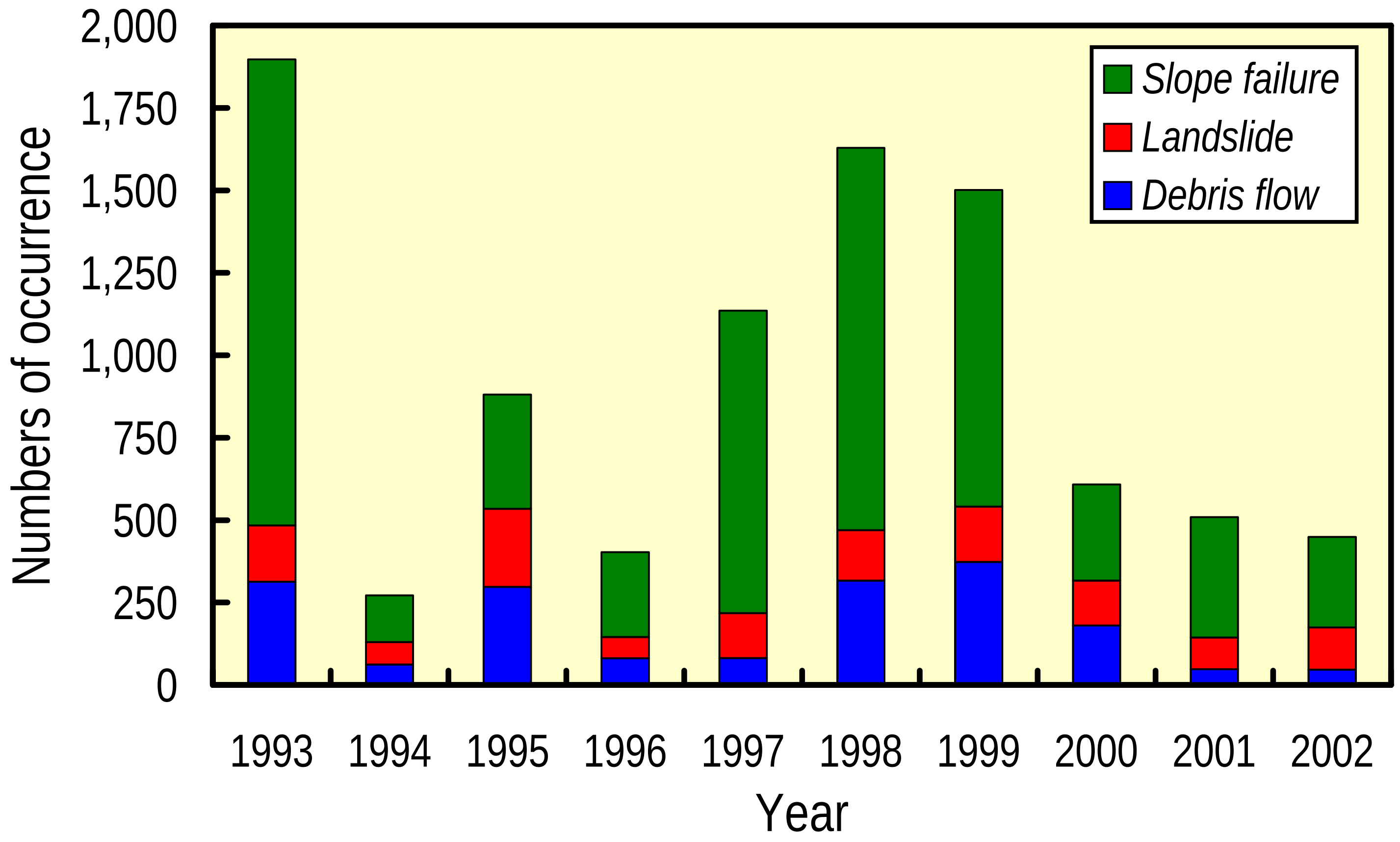
Sediment-related disasters

Debris flow

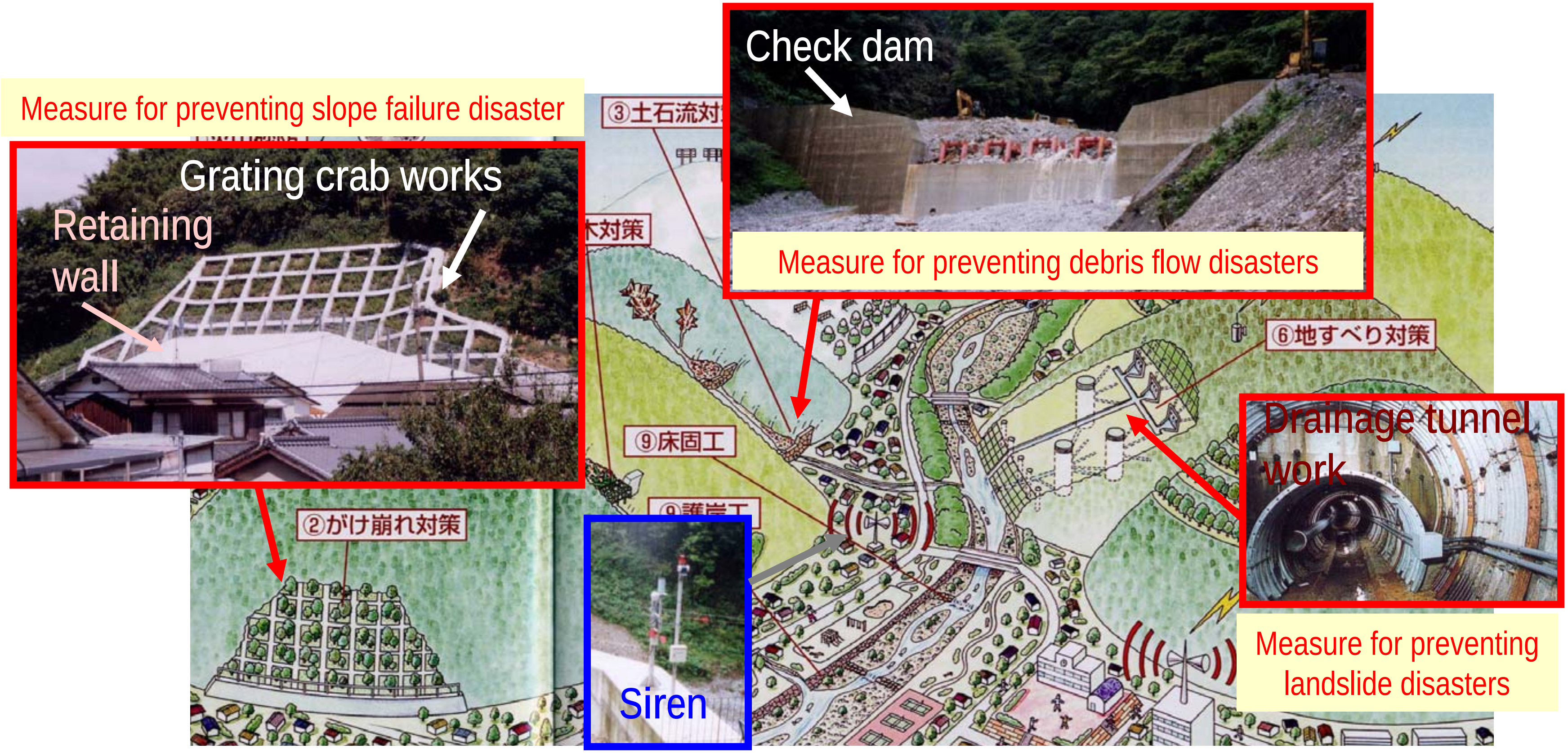
Slope failure

Landslide

Recent occurrence of sediment-related disasters



Physical and Non-physical measure



Measures with constructs are called “physical measure”.

Measures without constructs are called “non-physical measures”.

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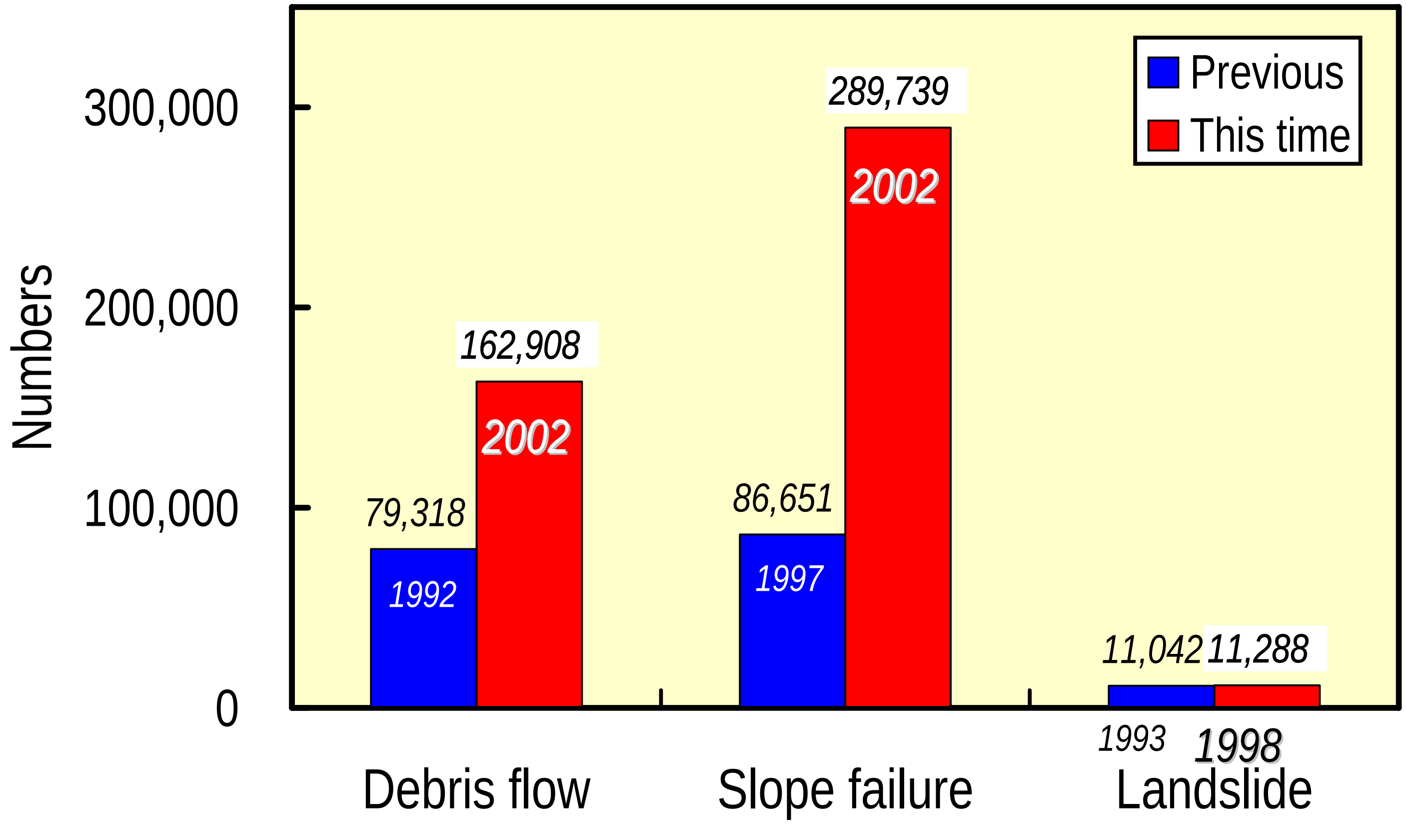
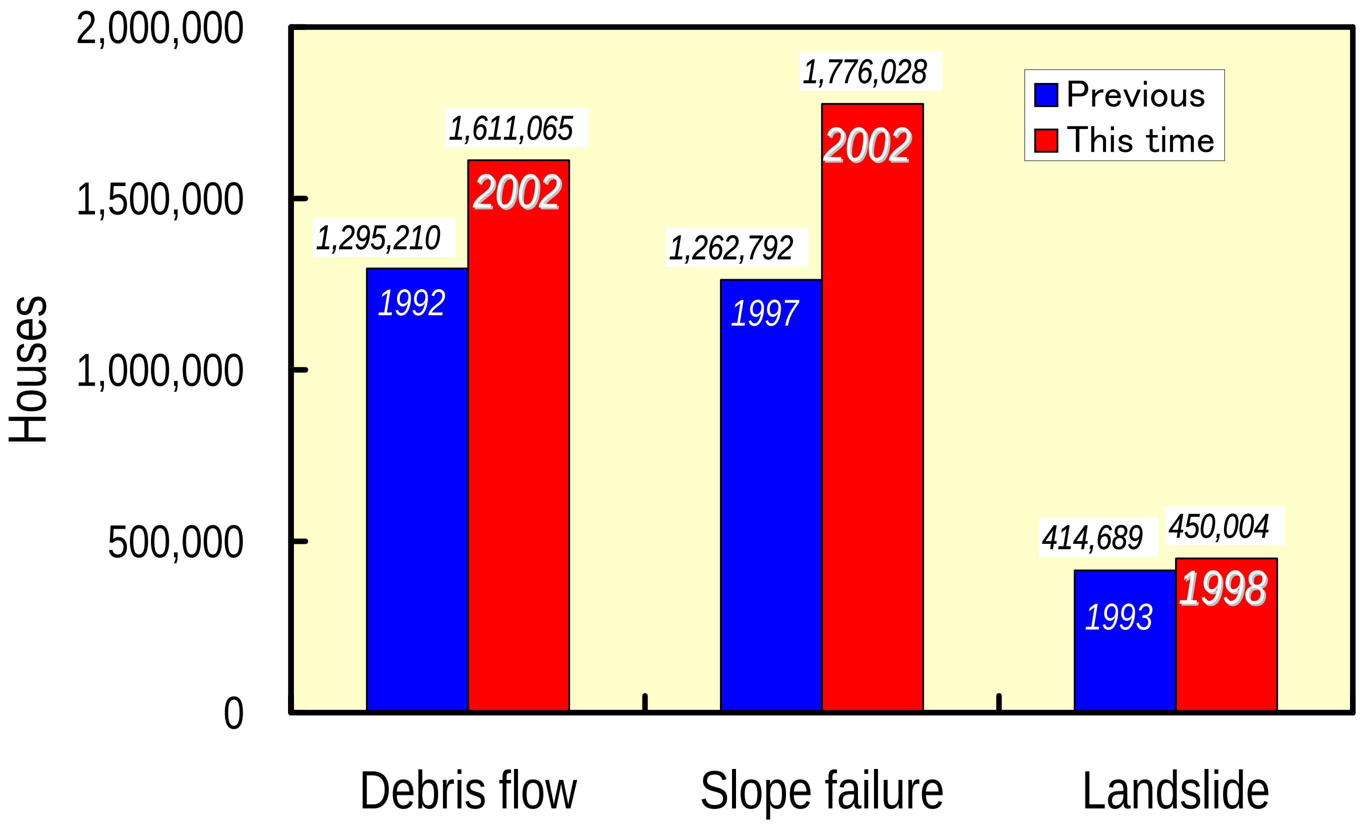
Number of hazardous area

- Numbers of hazardous area are increasing.



Number of houses in hazardous area

- Numbers of houses in the hazardous area are also increasing.



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Establishment a new law

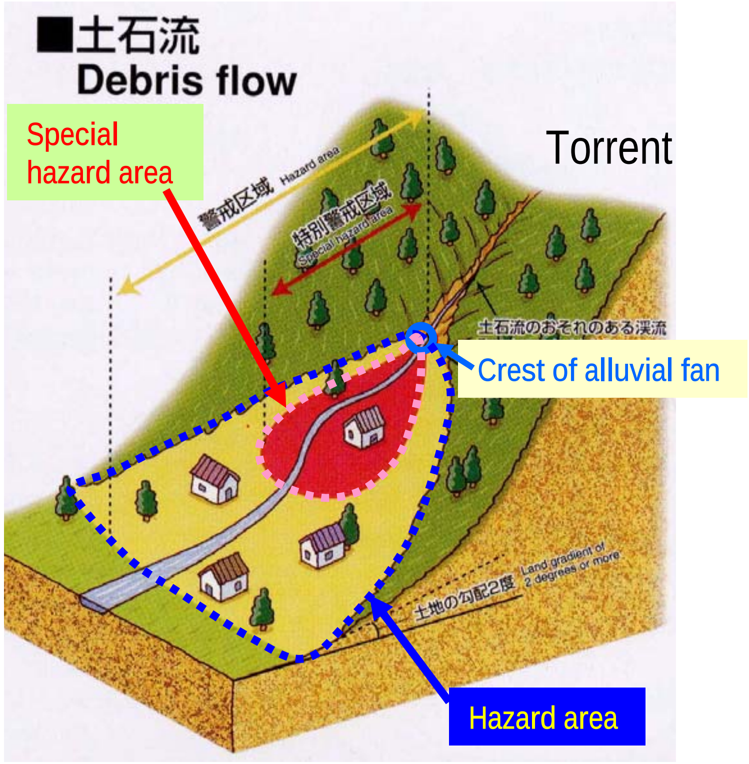
- The number of hazardous area is increasing.
- A lot of time and money will be needed to make the hazardous area safety with physical measures.

To inform the risk of the hazardous area
To install warning and evacuation systems
To restrict new land developments for housing in the hazardous area
To promote relocations of houses existing in the hazardous area

- The "Sediment-related Disaster Prevention Law" was established in 2001.

Hazardous areas in the new law

This study focuses on the sediment-related disasters due to debris flow.



Hazard zone…

Area vulnerable to sediment disasters

Land gradient of two degrees or more.

Special hazard zone…

Among hazard areas, special hazard areas are designated where is a fear of damages to buildings and serious human injuries.

Special hazard area

- Special hazard area is the range of the land where the hydrodynamic force of a debris flow exceeds the strength of its buildings

Debris flow

Photo Damaged house in Kamaishi 2002

Method for setting a special hazard area

(1) Field survey

↓

(2) Set a reference point

↓

(3) Estimate sediment volume deposited on a torrent

↓

(4) Estimate the flow route

↓

(5) Set calculation points on the flow route

↓

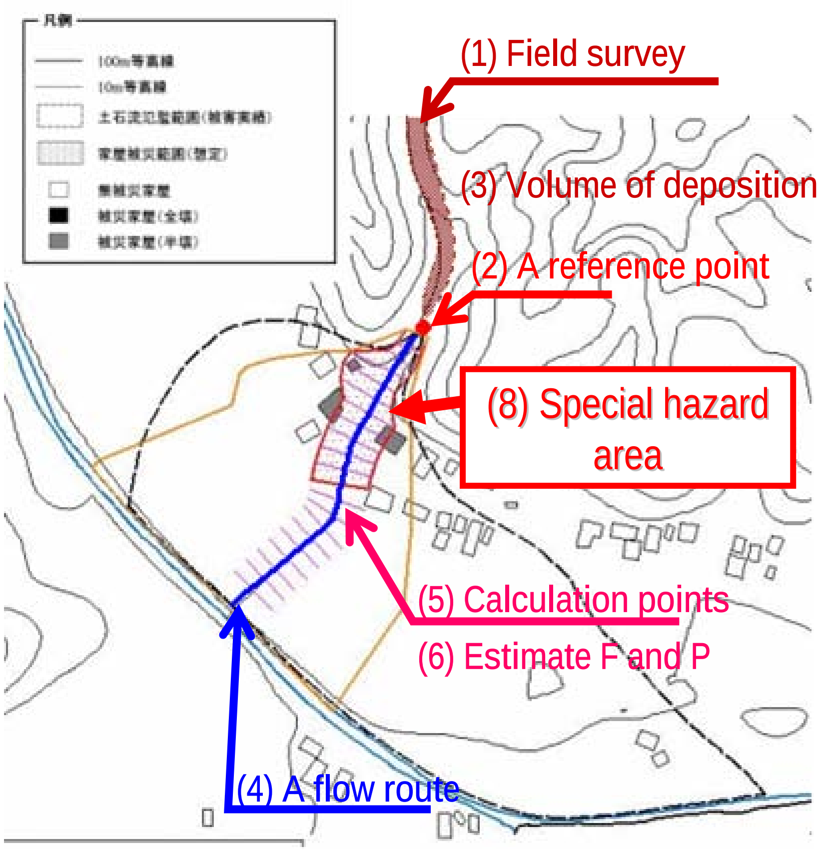
(6) Estimate the hydrodynamic force and the strength of the buildings at the calculation points

↓

(7) Compare the hydrodynamic force (Fd) and the strength of the buildings (P)

↓

(8) Draw the range where Fd>P



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Estimation of the hydrodynamic force and the strength of houses

- Hydrodynamic force

$$F_d = \rho_d U^2$$

U :flow speed of the debris flow (m/s)

- Strength of houses

$$P = \frac{35.3}{h(5.6 - h)}$$

h :flow depth of the debris flow (m)

In order to estimate the hydrodynamic force and the strength of house, we have to estimate the velocity (***U***) and depth (***h***) of debris flow. However a method for estimation is not defined…

Objects of this study

- To develop a simplified method for estimating velocity and depth
- To apply the method to the past disasters and verify the accuracy

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National Institute for Land and Infrastructure Management

Method for estimating velocity and depth of debris flow

- Combining five equations

Continuity equation

$$Q_{SP} = BUh$$

Momentum equation

$$U = \frac{1}{n} \cdot h^{2/3} \cdot (\sin\theta)^{1/2}$$

Empirical formula for discharge

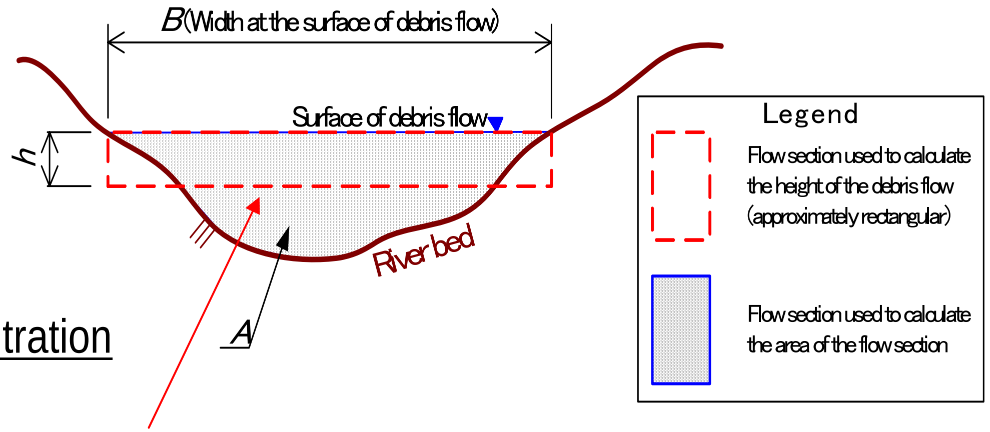
$$Q_{SP} = \frac{0.01VC_*}{C_d}$$

$$V = \frac{C_* - C_{d0}}{C_* - C_d} \cdot \frac{C_d}{C_{d0}} \cdot V_0$$

Formula for sediment volumetric concentration

$$C_d = \frac{\rho \tan\theta}{(\sigma - \rho)(\tan\phi - \tan\theta)}$$

U :flow speed of the debris flow (m/s)
n :roughness coefficient
H :flow depth of the debris flow (m)
θ : gradient of slope of the torrent bed (degrees)
Q_{sp} :peak flow volume of the debris flow (m^3/s)
B :flow width of the debris flow (m)
C_*: sediment concentration of deposition on the torrent bed



The shape of the flow section resembles a rectangle such as the one enclosed by the dotted lines.

Estimation of the flow width

- If B is calculated by the above method, there are presumed to be cases where, on an alluvial fan, the value of B is identical to the full width of the alluvial fan or cases where it cannot be set.
- So B is set as the upper limit value (B_{MAX}).

$$B_{\max} = 4\sqrt{Q_{SP}}$$

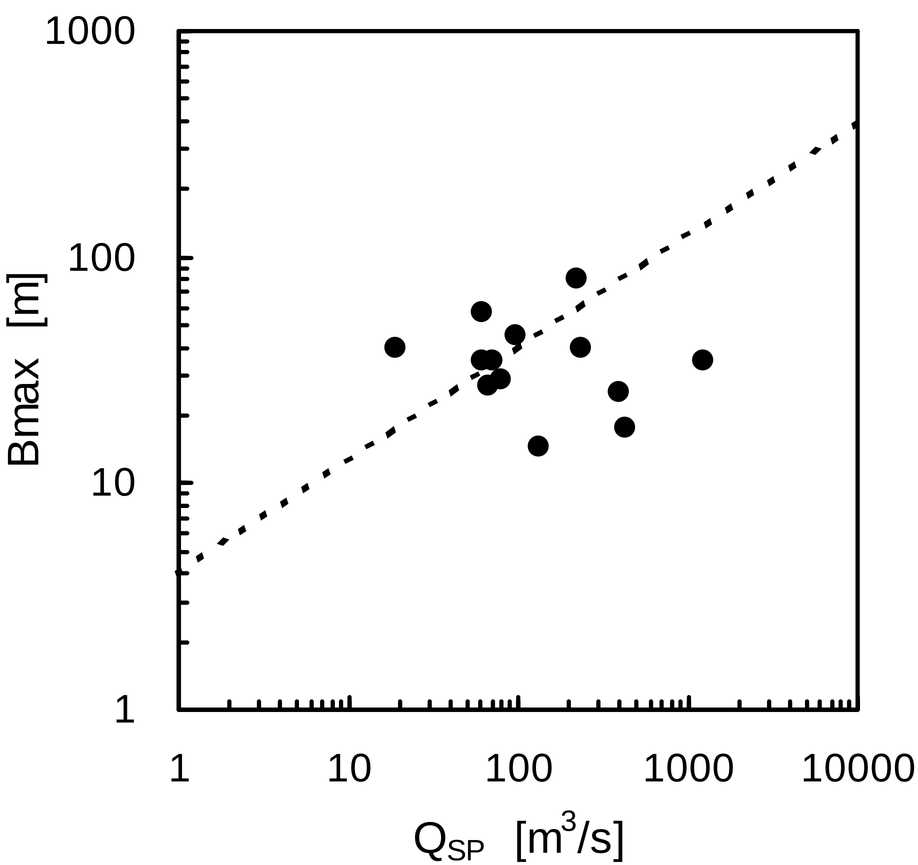
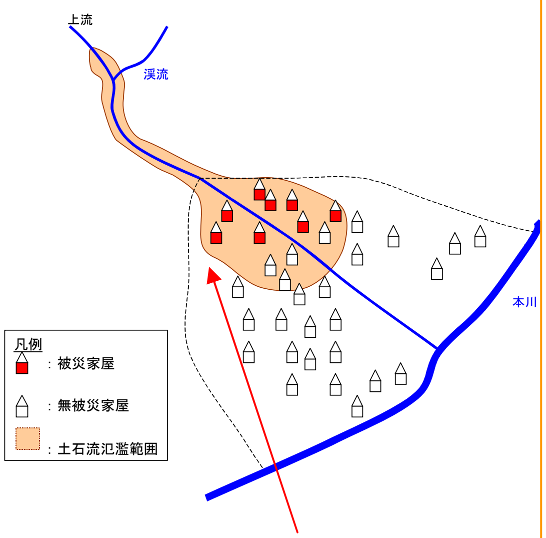
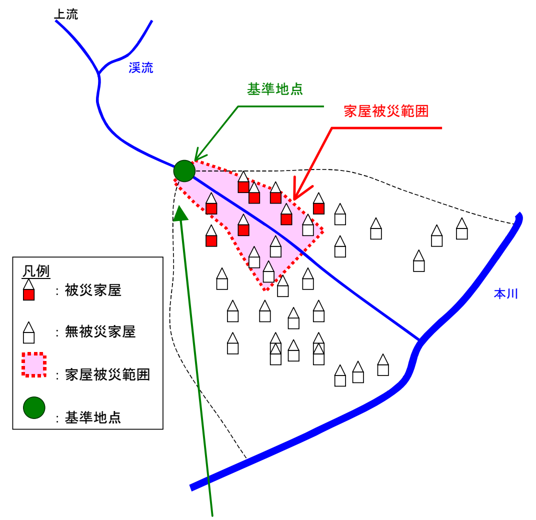


Fig. Relationship between peak discharge and maximum flow width

Application to past debris flow disasters

- Two new indices are designated for use in evaluating the results of the application - the "damaged house inclusion percentage" and the "undamaged house percentage."



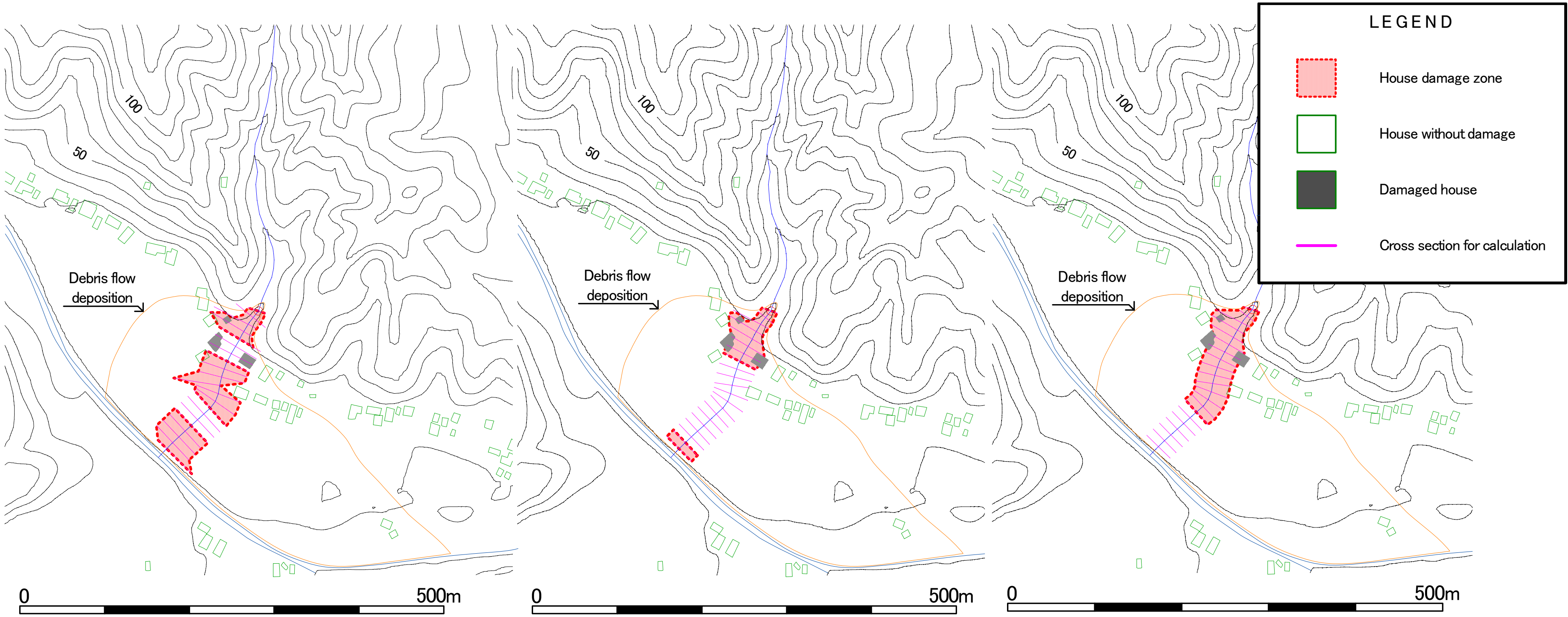


	Debris flow spreading area	Range of debris flow damage to house
Damaged house	8	6
Undamaged house	4	4

Damaged house inclusion percentage
=6/8
=0.75

Undamaged house percentage
=4/(6+4)
=0.40

Examples of the applications



(a) 10m (b) 100m (c) 200m

The damaged house inclusion percentage was 33% (10 m case) and 100% (100m case and 200 m case). Because there were two undamaged houses (10m case) and one undamaged house (100m case and 200m case), the undamaged house percentage was 66.7% (10 m case) and 25% (100m case and 200m case)

Results of the application

		Horizontal distance used to calculate gradient of the land (m)								
		10m			100m			200m		
		①／②	Breakdown		③／④	Breakdown		⑤／⑥	Breakdown	
			Pertinent number ①	All ②		Pertinent number ③	All ④		Pertinent number ⑤	All ⑥
Damaged House Inclusion Percentage	Total completely or partly destroyed	0.567	17	30	0.667	20	30	0.700	21	30
	Completely destroyed	0.400	4	10	0.500	5	10	0.600	6	10
	Partly destroyed	0.650	13	20	0.750	15	20	0.750	15	20
Undamaged house percentage		0.874	118	135	0.780	71	91	0.796	82	103

Table. Damaged House Inclusion Percentage and Undamaged House Percentage

Conclusion

- Maximum value of debris flow width is estimated by $B_{\max} = 4\sqrt{Q_{SP}}$.
- About **70%** of the damaged houses in the past debris flow disasters were included in the range of debris flow damaged to houses set by the method.
- Because the undamaged house percentage is high, ranging from 70% to 80%, a method of studying a way of **lowering the undamaged home percentage** should be studied.

Development of Warning and Evacuation System against Sediment-related Disasters

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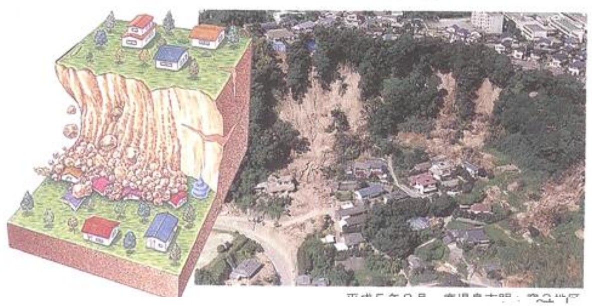
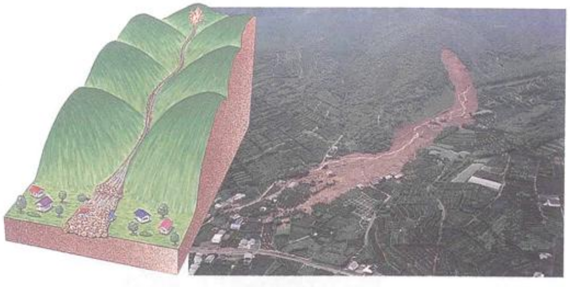
Types of sediment-related disasters

Slope failure



A phenomenon where soil is weakened by the rain, earthquakes, etc. causing a slope to crumble suddenly

Debris flow

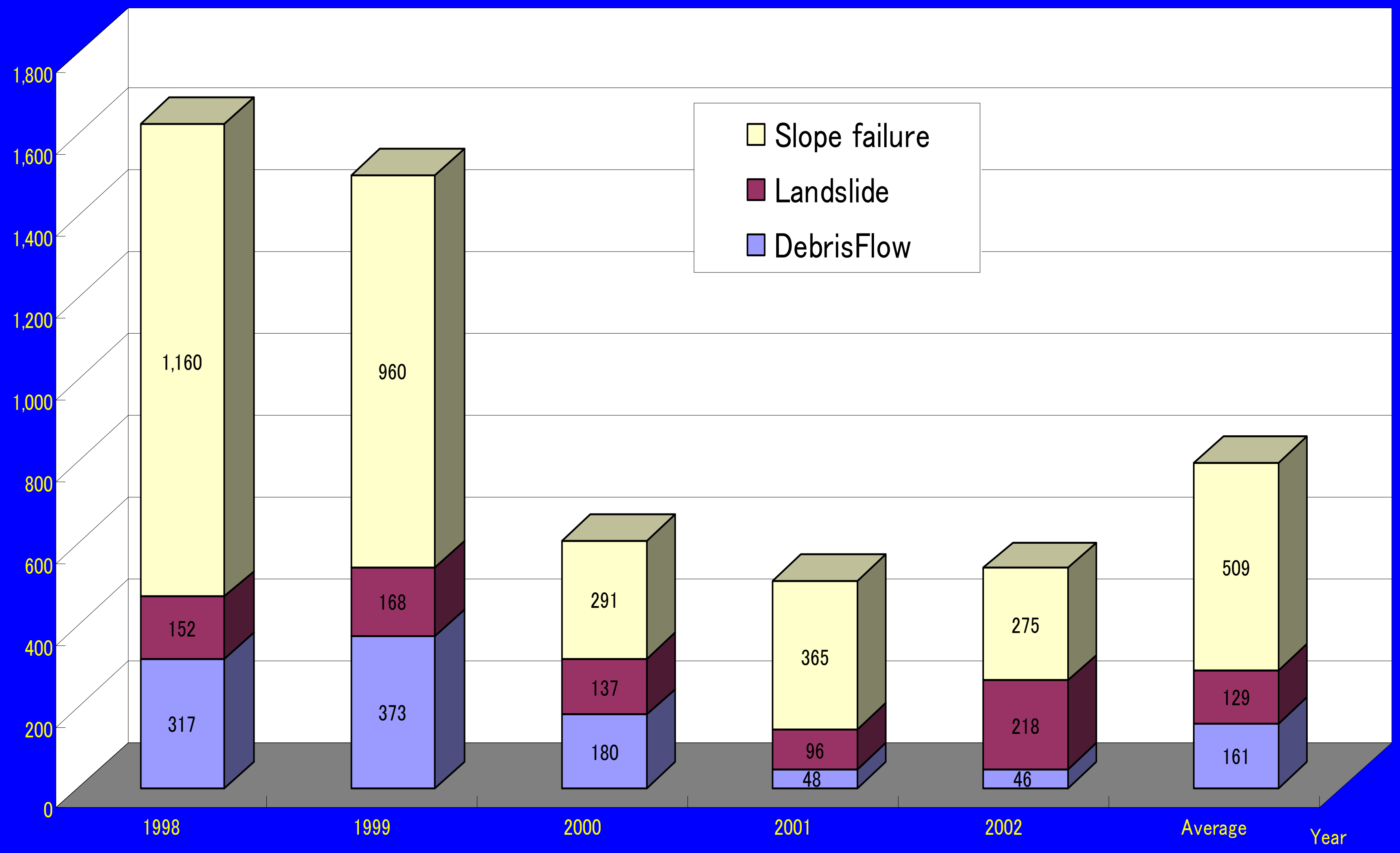


A phenomenon where long or localized torrential rainfall causes mountainside soil, sand, and gravel (debris) from hillsides or stream beds to fall into lower reaches, where they are suddenly washed away downstream at speeds from 20 to 40 km/h

Landslide

A phenomenon where dirt clods on a slope are slowly moved downward by groundwater, etc., along a landslide surface at speeds from 0.01 to 10 mm/day.

Sediment-related disasters which occurred these 5 years



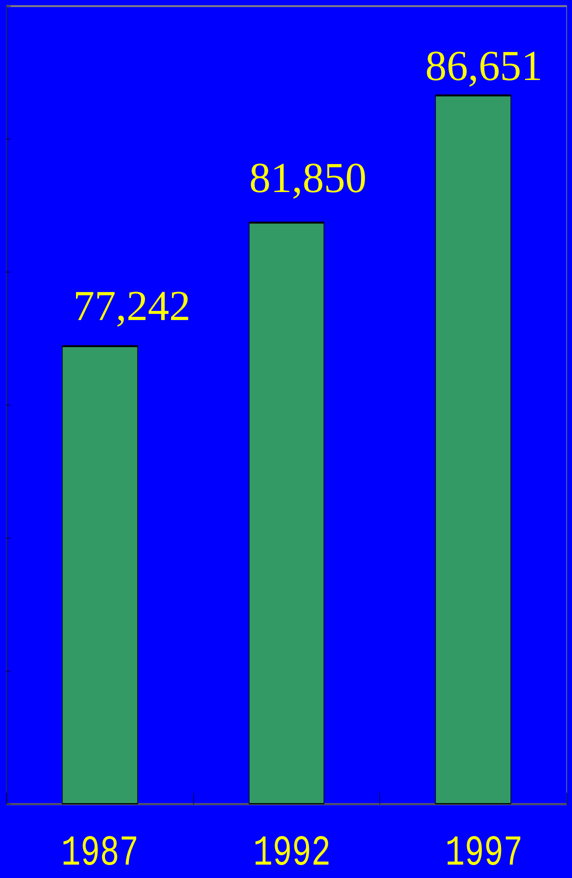
○Sediment-related disasters costing invaluable lives are commonplace in many countries in the world.

○The sediment-related disaster hazard area is numerous in number and extends over a vast area.

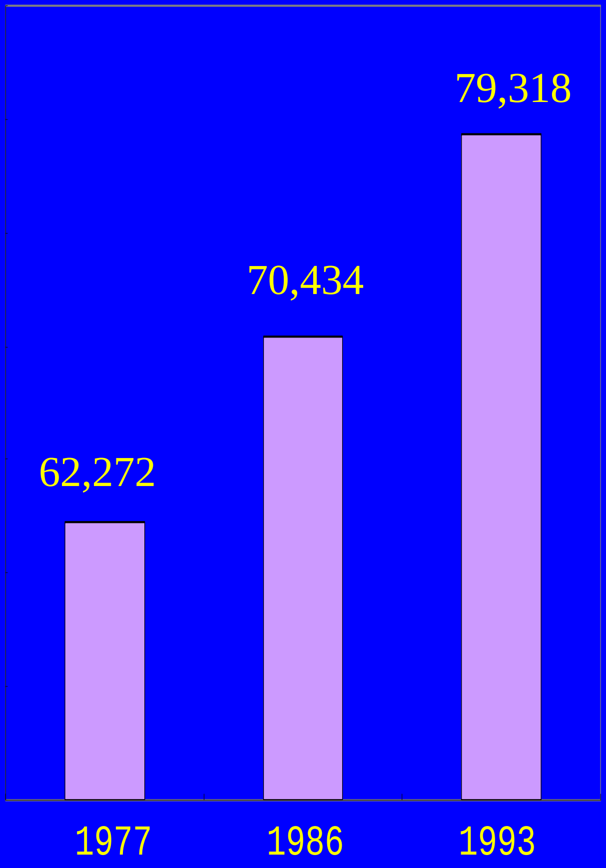
○An enormous amount of time and cost are required to make all the hazard areas safe with the installation of disaster prevention works.

Increases in the number of dangerous spots for sediment-related disasters

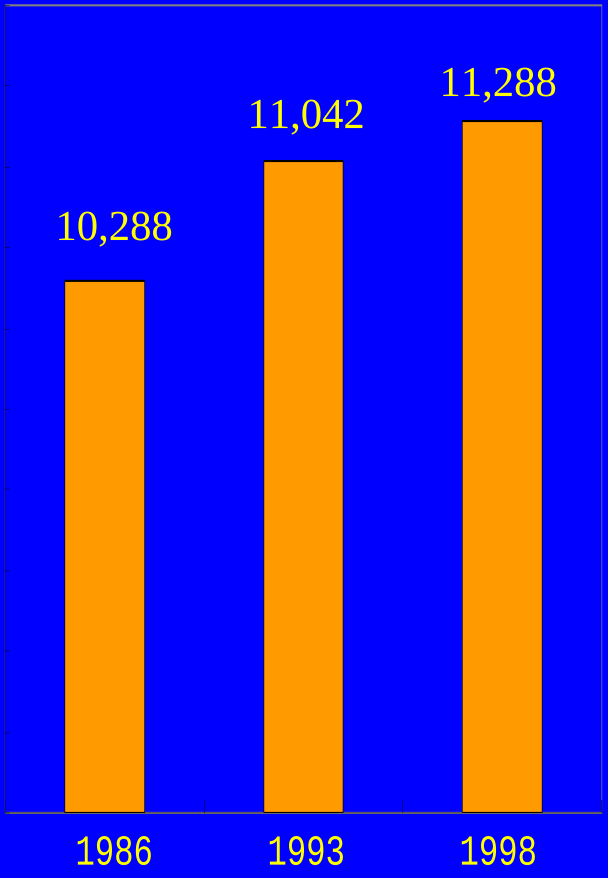
The number of dangerous slopes of slope failure



The number of streams or rivers that posed the danger of mud and debris flows

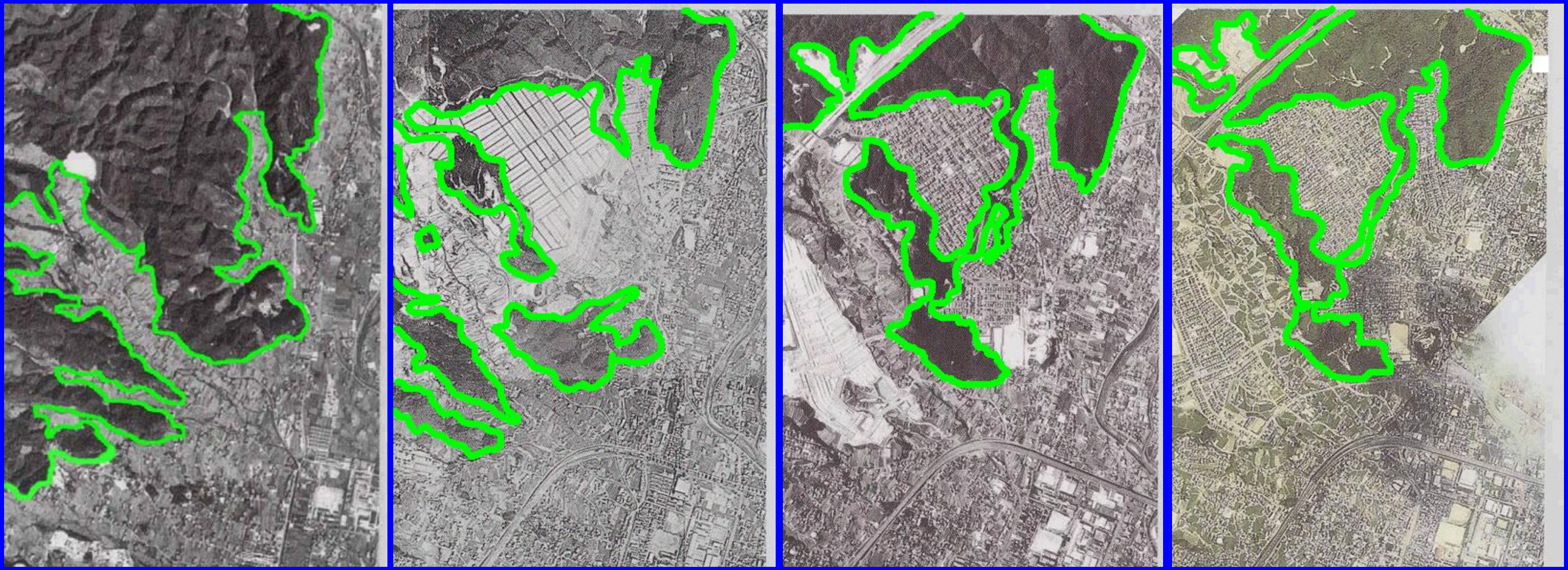


The number of potential landslide sites



What caused the increase of sites?

- The Ministry of Construction thought that one of the main reasons was the development of residential areas on hillsides as well as on foothills.



1966 1974 1986 1999 (Presented by MLIT)

Example of Hiroshima City: disaster-prone sites increased from 4 to 24 between 1966 and 1999.

What should be done to mitigate the damages?

- The Japanese government was prompted to establish a new act for designating hazard areas in order to:
  - Restrict new development for housing and other purposes,
  - Promote relocation of existing houses, and
  - Develop an early warning system.

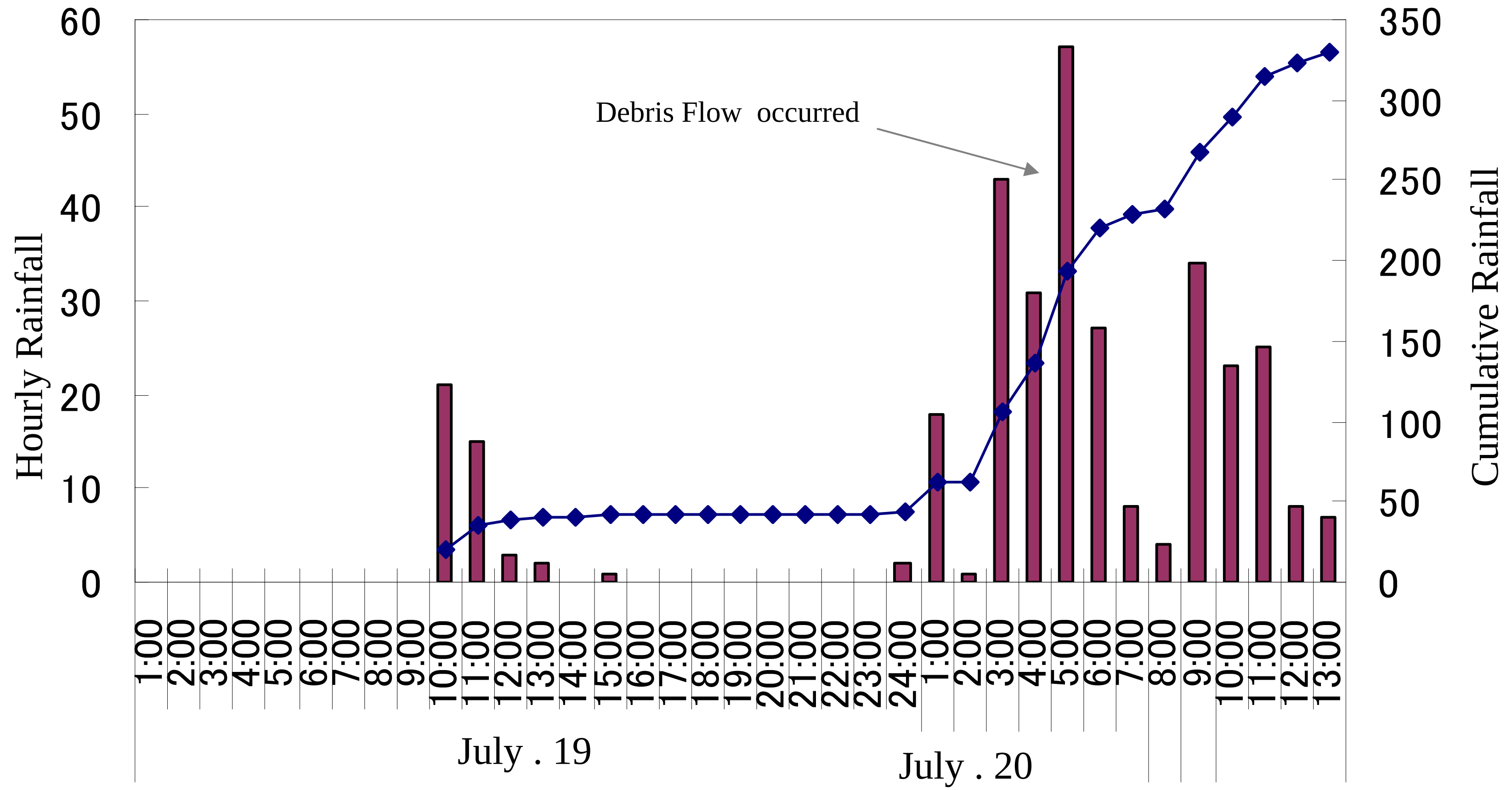
○When promoting sediment-related disaster prevention measures, versatile non-structural measures should be taken in addition to structural measures.

○Non-structural measures include the designation of a sediment-related disaster hazard area and the development of a warning and evacuation system.

Debris Flow Disaster in Kumamoto

Date of occurrence	Number of dead (persons)	Damaged houses (partially destroyed)
July. 2003	15	14 (1)

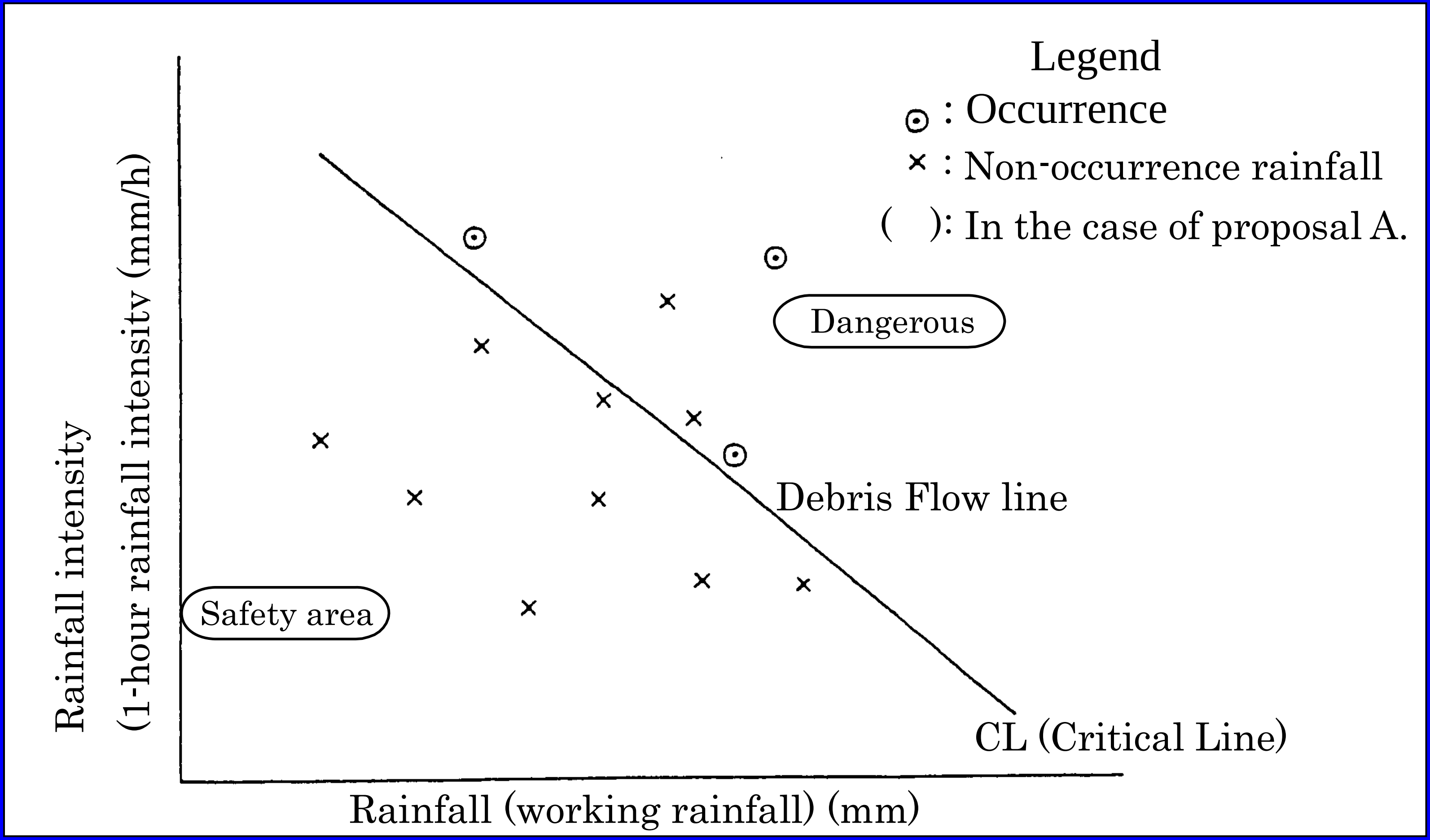
Cumulative Rainfall and Hourly Rainfall



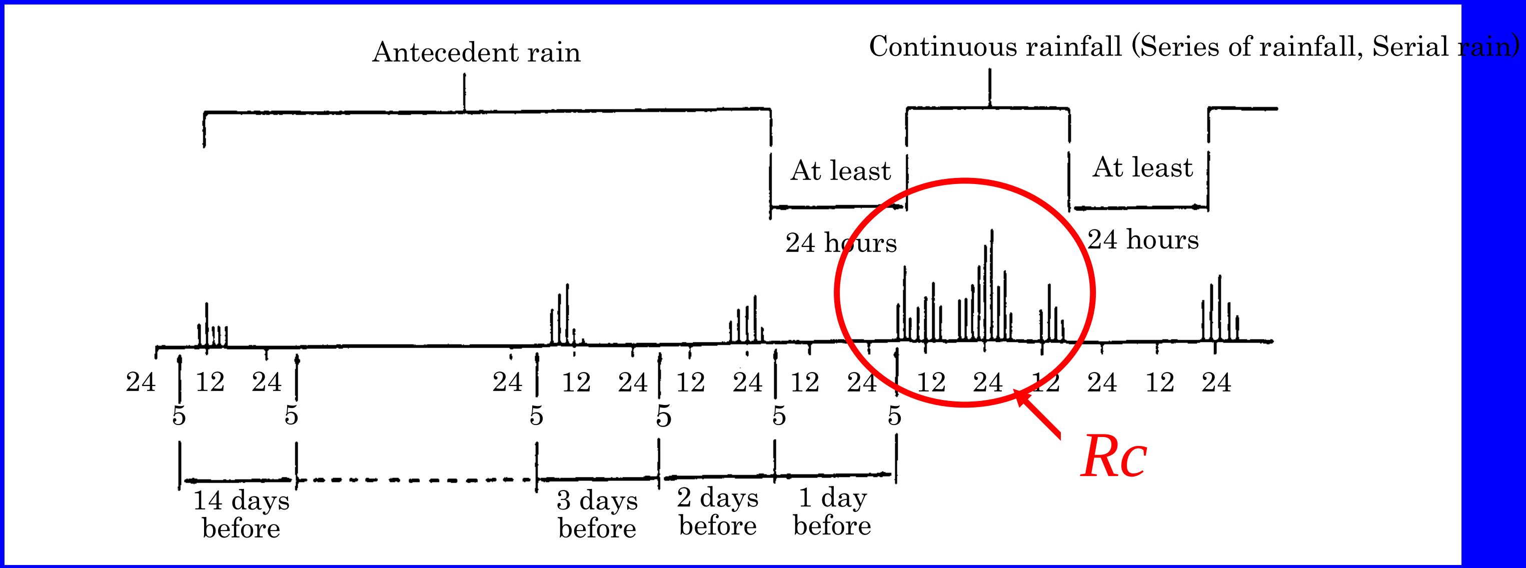
Target Phenomena

• Debris flow	➢ Mostly predictable
• Volcanic mudflow	➢ Mostly predictable
• Landslide	➢ Difficult to predict
• Slope failure	➢ Depending on a method and a disaster pattern

Concept of Critical Line



Calculation of Working Rainfall



$$R_{WA} = \sum_{t=1}^{14} \alpha_t \, R_{dt}$$

R_{WA}: Antecedent working rainfall

$$\alpha_t = 0.5^{t/T}$$

T: Half-life period (Days)

Definition of Working rainfall

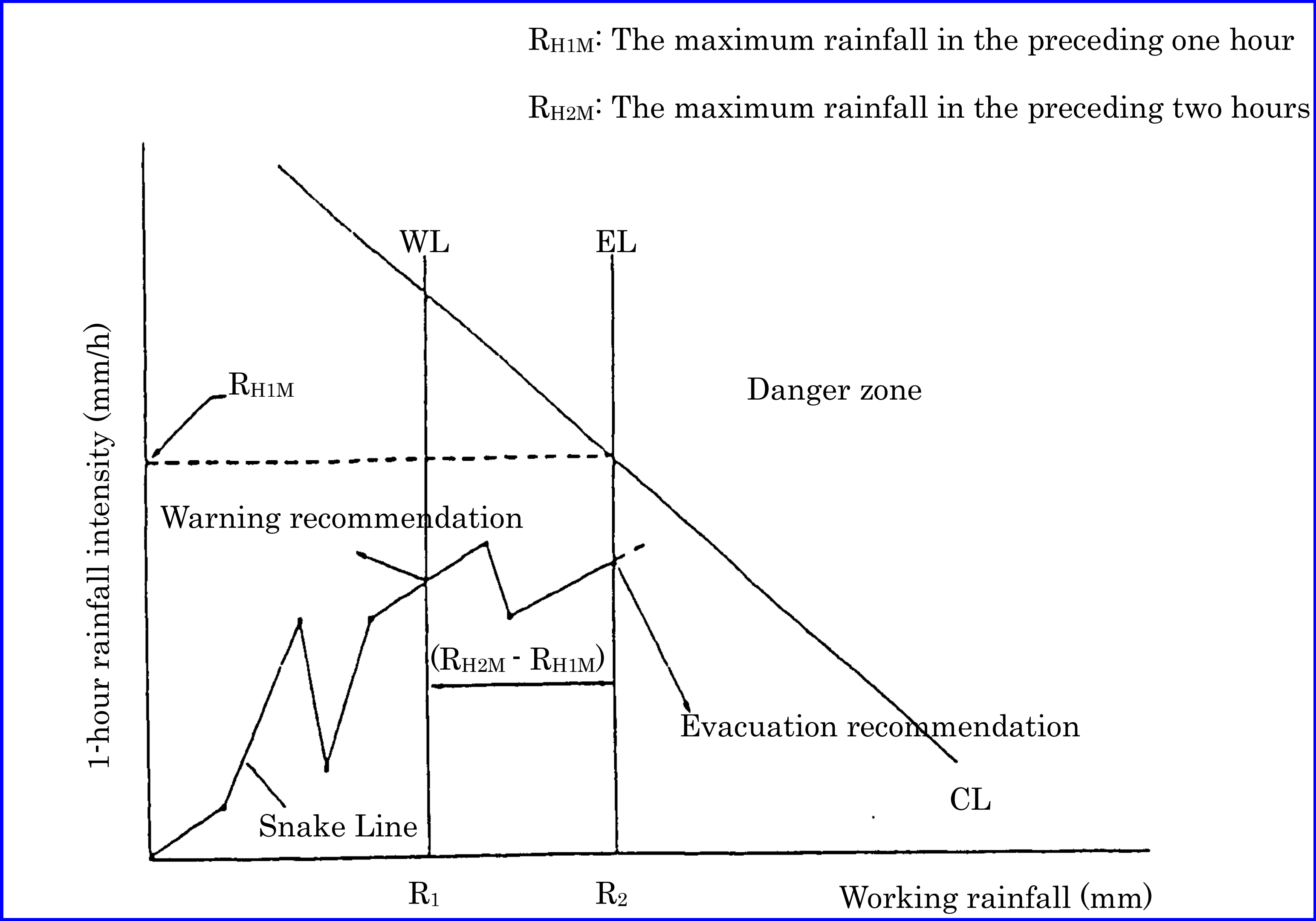
- R_W : *working rainfall*
- R_{WA} : *Antecedent working rainfall*
- R_C : *continuous rainfall*
- $R_W = R_{WA} + R_C$

(Example) Antecedent working rainfall (In case of T=1 day)

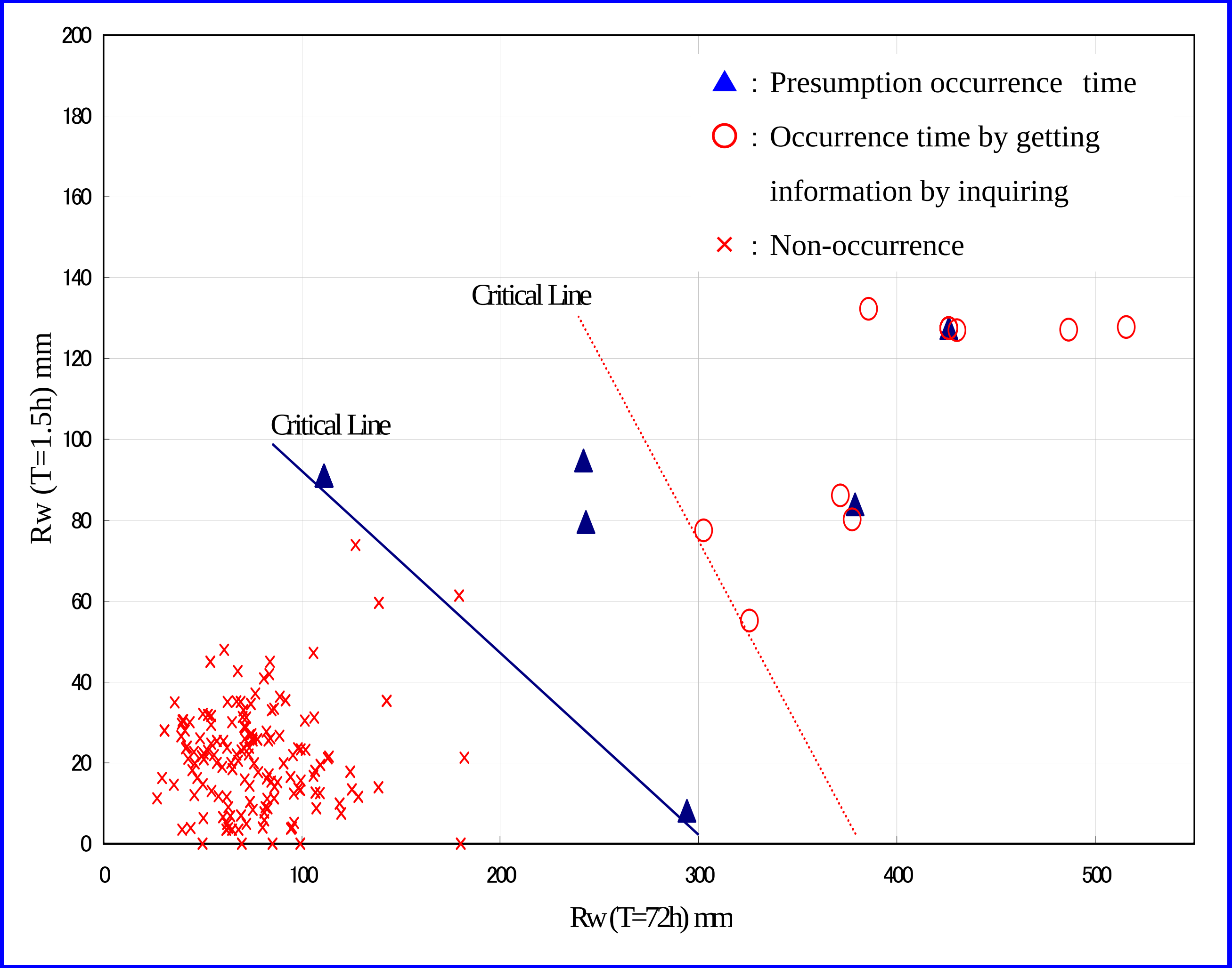
•$R_{WA} = Rd_1 \times 0.5 + Rd_2 \times (0.5)^2 \ldots + Rd_{14} \times (0.5)^{14}$

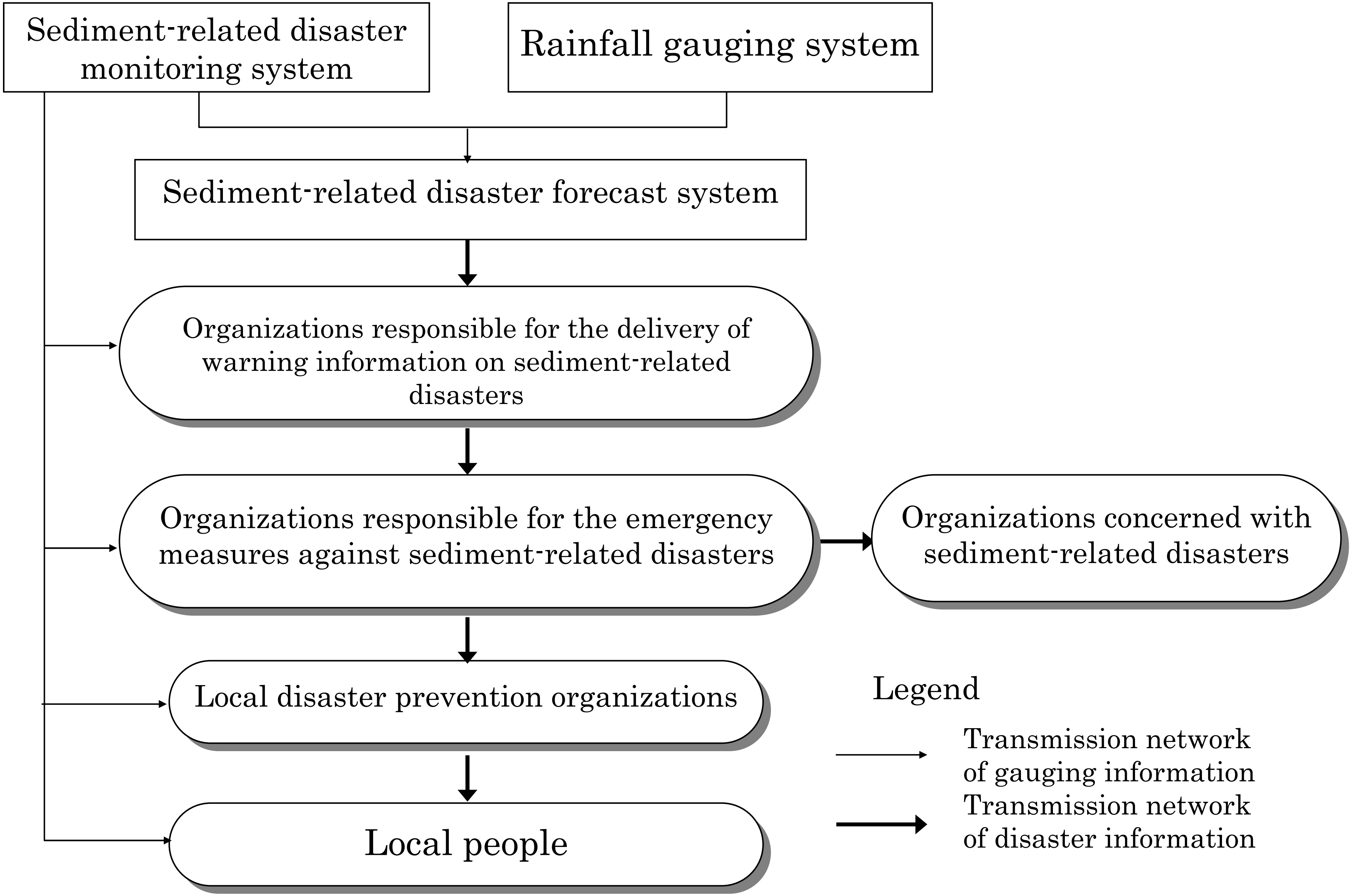
•*Rdt: daily rainfall t days before*

Warning, Evacuation and Snake Line



Example of changing the occurrence time





The structure of the sediment-related disaster warning system

Debris Flow Detection Sensors

Jun'ichi Kurihara
Volcano and Debris Flow Team
Erosion and Sediment Control Research Group
Public Works Research Institute

1. Significance of Debris Flow Detection Sensors

In Japan, sediment related disasters occur frequently, claiming many human lives. To protect people's lives from sediment disasters, it is important that in addition to constructing sabo works such as sabo dams and channel works, we establish warning and evacuation systems.

One technical challenge is to use sensors to reliably detect a debris flow.

This means using sensors to detect a debris flow that has occurred as a standard for evacuating residents.

The following are cases where debris flow detection sensors are needed.

(1) Cases of emergency installation in order to prevent secondary disasters during, for example, work to rescue missing people following a disaster.

(2) Cases of emergency installation where there is danger of a debris flow caused by the formation of a natural dam or by rainfall after a volcanic eruption.

(3) Cases where safety of the sites of sabo works is guaranteed.

(4) Cases where it is used as a trigger to start the evacuation of residents to escape a debris flow.

In Japan, worsening finances have sharply reduced sabo works project budgets, making it difficult to perform works to ensure safety. The future will bring a growing need to use detection sensors etc. to establish reliable warning and evacuation systems.

2. Sensors: Outline and Problems

(1) Contact type sensors

A type of sensor that is activated by direct contact of a debris flow with the sensor.

Wire sensor, Touch sensor

(2) Non-contact sensors

A type of sensor that is activated without direct contact with a debris flow.

Vibration sensor, Optical sensor, Ultrasonic wave sensor, Sensing movement on a screen

a) Wire sensor

A wire that has been laterally stretched at a height between 0.6m and 1m, it detects a debris flow when it is cut.

Wire sensors are inexpensive and the type most widely used in Japan.

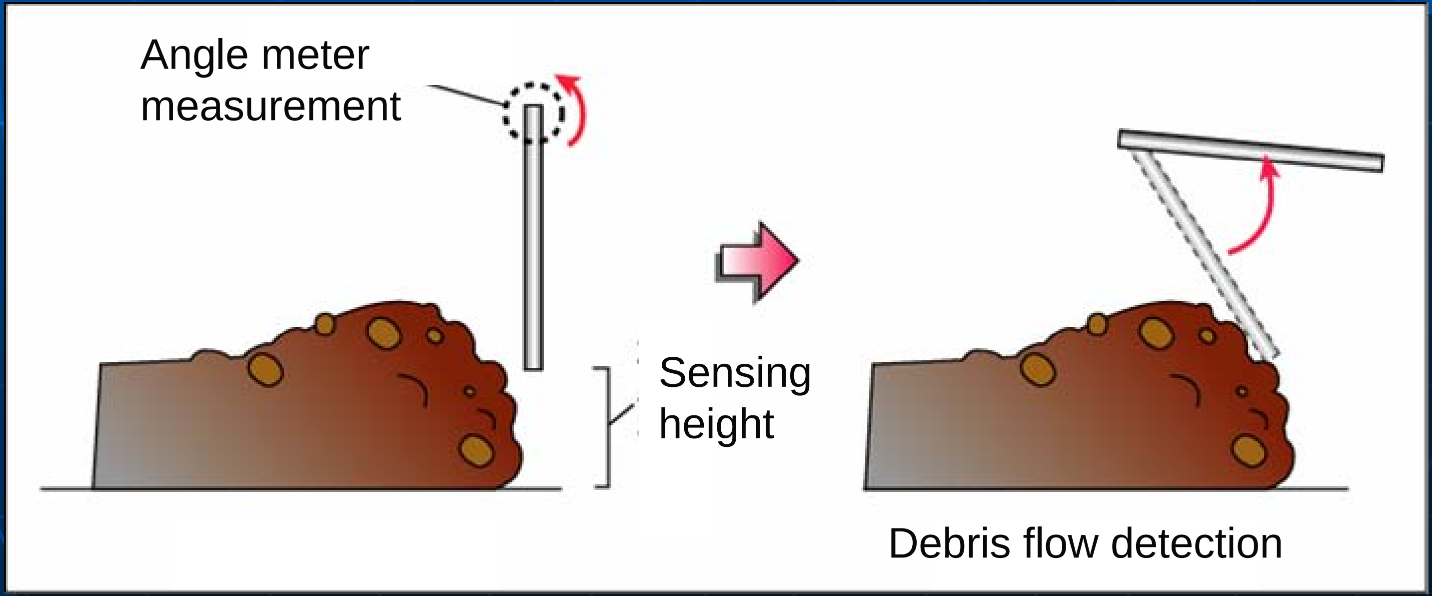
But once a wire has been cut, it cannot detect subsequent debris flows. Personnel must, therefore, return to the site to replace the wire. Wires may also be cut by animals, snow, wind, or falling rocks, causing incorrect operation.

Wire Sensor

Sensor Being Installed

b) Touch sensor (Swinging rod-type surface detecting sensor)

A rod-shaped pendulum sensor is suspended above a torrent so that it when it is pushed upwards by the front of a debris flow and reaches a specified inclination, the system indicates that a debris flow has occurred.



Touch sensor
(Swinging rod-type surface detecting sensor)

c) Optical sensor

An optical sensor transmits an infrared beam laterally across a river course to detect a debris flow when it breaks the beam. This type is not widely used in Japan.

It may operate incorrectly because of intensive rain, mist, or falling ash, etc.

d) Ultrasonic wave sensor

This type measures the flow depth by transmitting ultrasonic waves vertically. It also measures flow velocity by transmitting the waves diagonally. The precision of its data falls if the shape of the surface of the debris flow fluctuates remarkably because it contains large rocks.

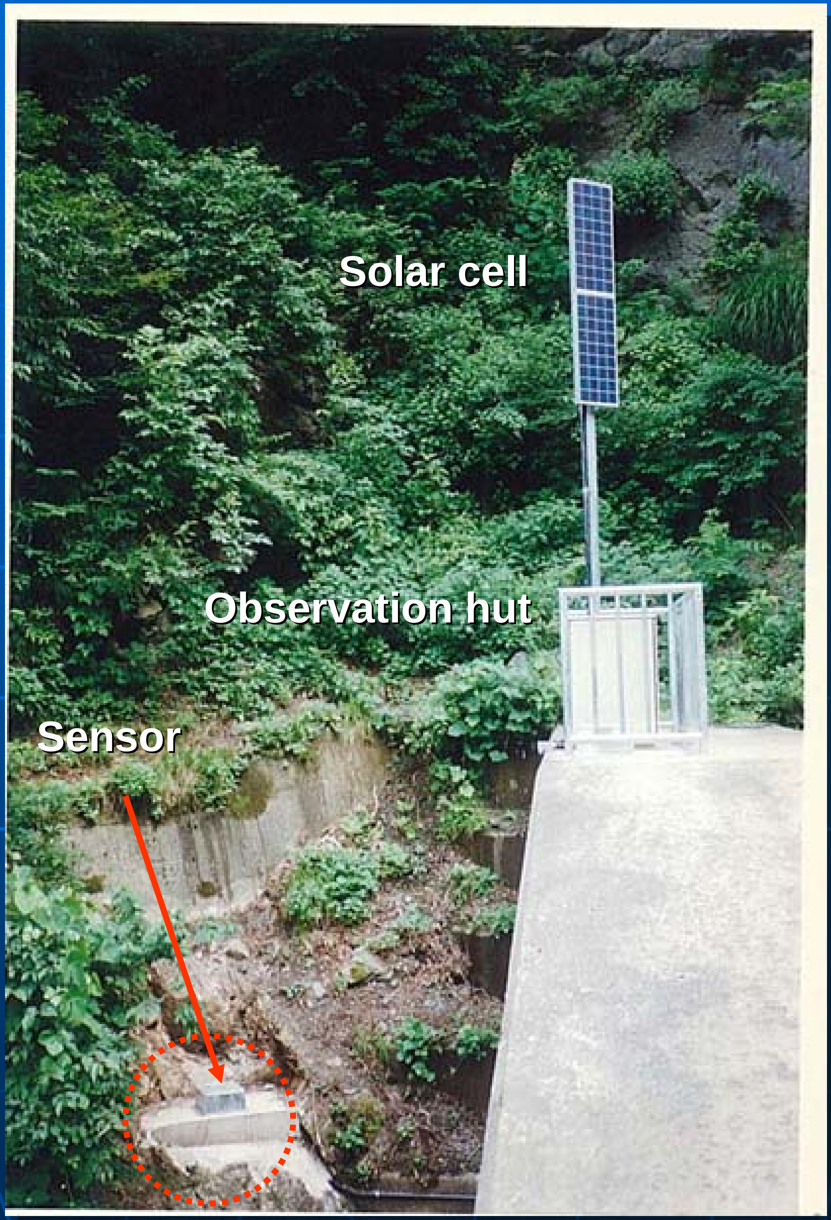
Ultrasonic wave water gauge

e) Vibration sensor

This is a sensor embedded in the ground where it senses the ground vibration caused by the flow of a debris flow. It can detect a series of debris flow and requires little maintenance.

But no objective method of setting the threshold of detection has been established.

Embedded Sensor
(Acceleration Gauge)



Vibration Sensor System

f) Sensing movement on a screen

Video images obtained by CCTV are processed by a computer to detect a debris flow from movement on the screen. In Japan, it is at the trial stage and has not been introduced as a practical system. Because the images can be monitored automatically, it is expected to come into wide use.

Analysis screen

Debris flow occurrence sensor

* Red ellipse shows the sensed debris flow

3. Vibration sensor trigger level setting method

In order for a vibration sensor to accurately sense debris flows, the trigger level of the vibration sensor must be accurately set. If the trigger level is low, it detects small debris flows or noise so its false-alarm rate is high. If the trigger level is set too high, it may fail to detect debris flows.

The Public Works Research Institute (PWRI) has prepared an objective trigger level setting method that will now be introduced.

(1) Debris flow vibration – discharge relational equation

The PWRI decided to estimate the ground vibration intensity that is the sensor standard value based on the discharge of the debris flow.

Based on the results of debris flow observations in Japan, it has been reported that the discharge and vibration of debris flows is represented by the following equation (Suwa et al., 1999).

$$P = CQ^{2/3} \quad \cdots ①$$

Where: P: intensity of vibration caused by a debris flow

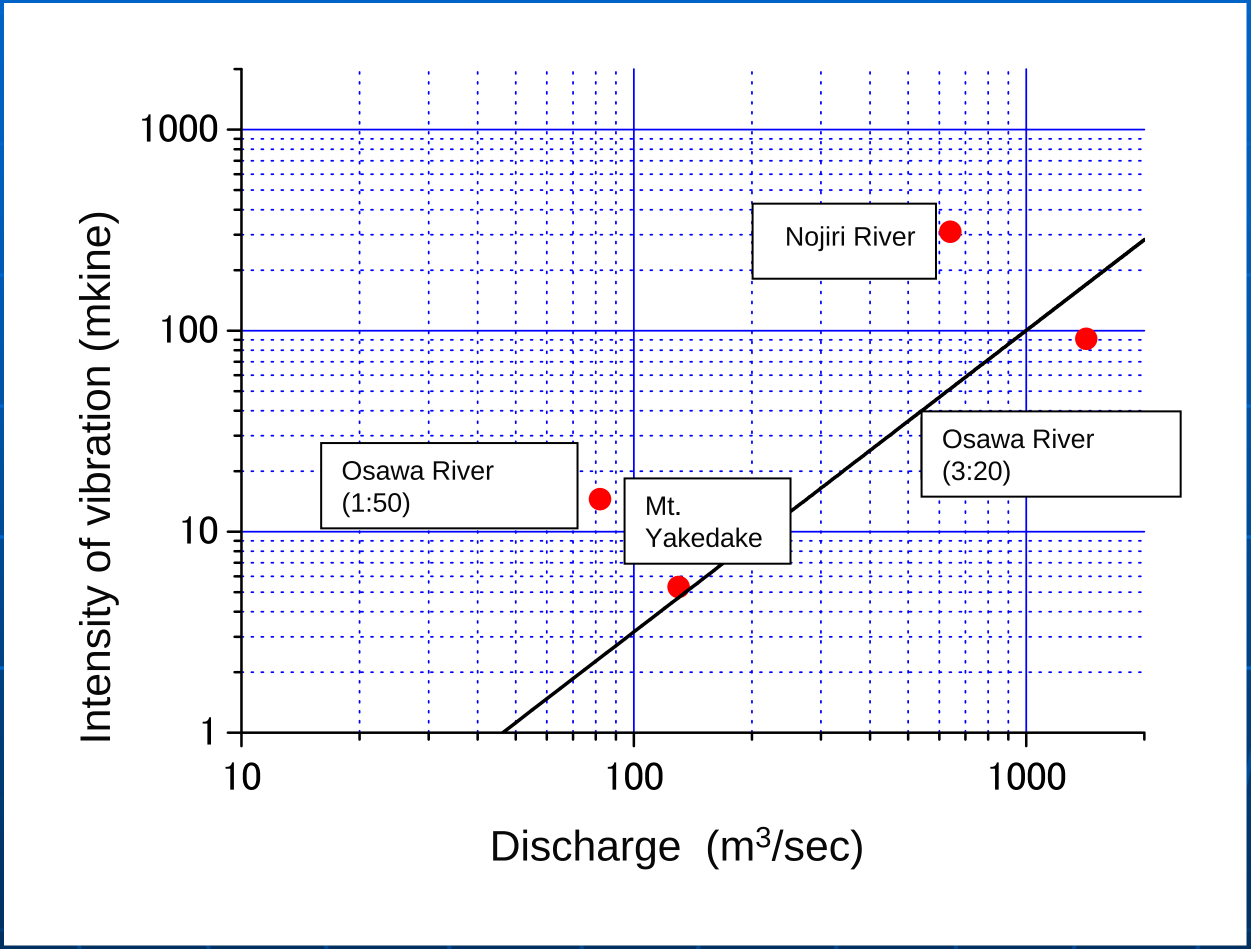
Q: discharge of the debris flow

C: coefficient

The following equation representing the relationship between Q and P is obtained based on the observed data.

$$P = 0.003Q^{2/3} \quad \cdots ②$$

But because there are only 4 cases of observed data, more data must be accumulated in the future.



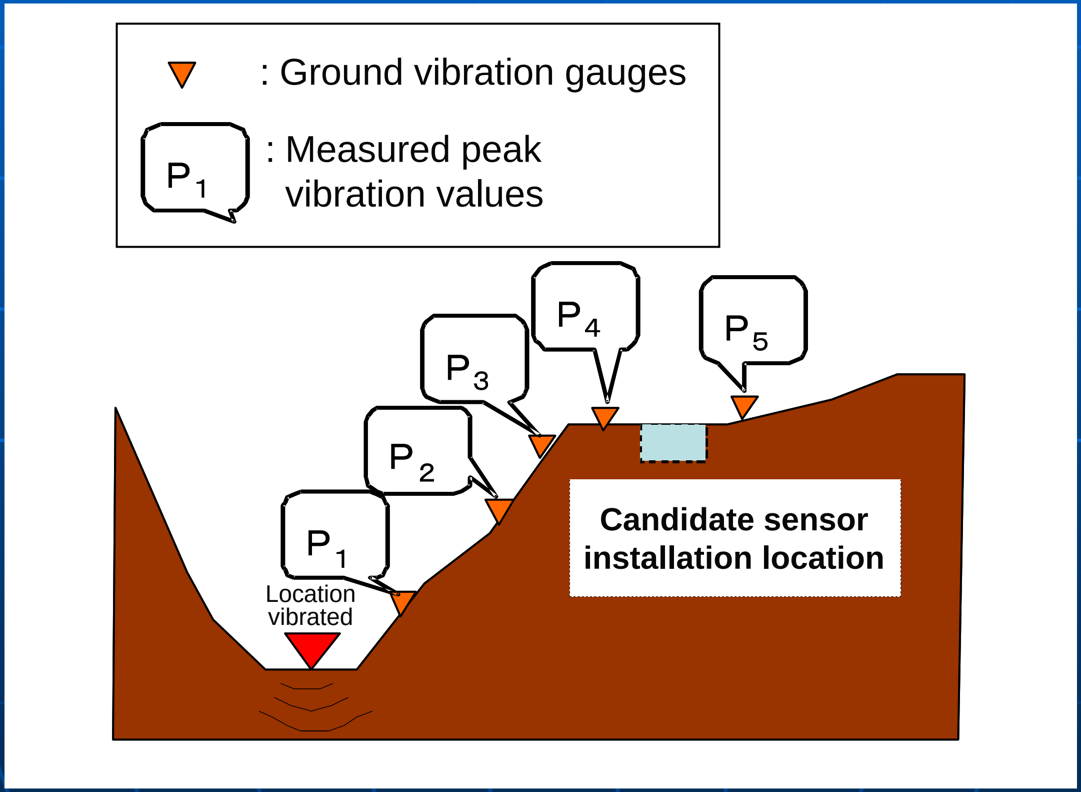
Relationship between the discharge and ground vibration intensity of a debris flow estimated based on past observations (value at a standard distance (25m))

Above, the standard distance was assumed to be 25m for the calculation, but because the actual distance between a sensor and the center of flow varies from place to place, a general equation that finds P for an optional distance was obtained. So the equation is obtained by a vibration damping equation for a semi-infinite homogenous plastic body that is in general use.

$$P = P' \cdot \left(\frac{d'}{d} \right)^{-n} \cdot e^{-\alpha (d - d')} \quad \cdots ③$$

P : vibration intensity at the standard distance of 25m
P' : vibration intensity at distance d'
d' : standard distance (25m)
d : distance from the source of the vibration
α : coefficient
n : 0.75 (constant)

α is a coefficient that is assumed to vary according to the ground. α is obtained by striking the ground surface at the site with a wooden mallet to vibrate the ground and performing a back calculation of data observed at varying distances (P1 – P5) from the center of the flow.



Layout of measurement instruments used to obtain α

(2) Future subjects facing vibration sensors

[1] Observations will be done to accumulate data. Because the reliability of the precision is not fully satisfactory, they will be applied in combination with other types of sensors for the time being.

[2] A large capacity memory device is necessary. It is also necessary to guarantee electric power.

[3] Motor vehicles passing near sensors may cause incorrect sensor operation. There was a case where a sensor recorded 3gal as heavy equipment passed 30m from it has been reported.

[4] It is now determined if vibration is caused by the peak discharge of the debris flow. But errors will be further reduced in the future if not only the peak discharge, but the vibration wave shape etc. is also sensed to make such a determination.

Development of the landslide displacement detection sensor using optical fiber

Extensometer using optical fiber

Landslide Research Team

Erosion and Sediment Control Research Group

Public Works Research Institute

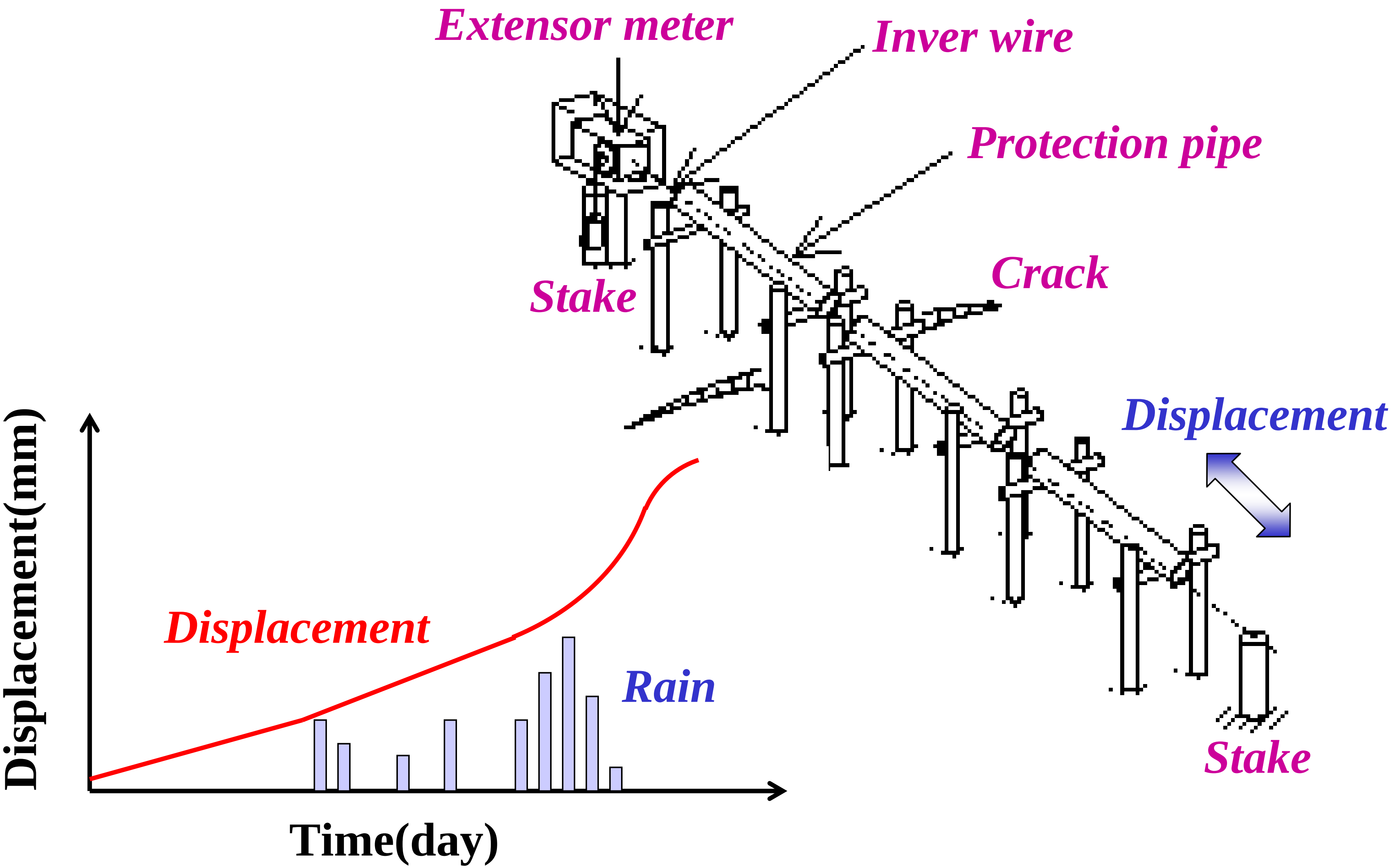
Monitoring of land slide

Aerial photograph of landslide

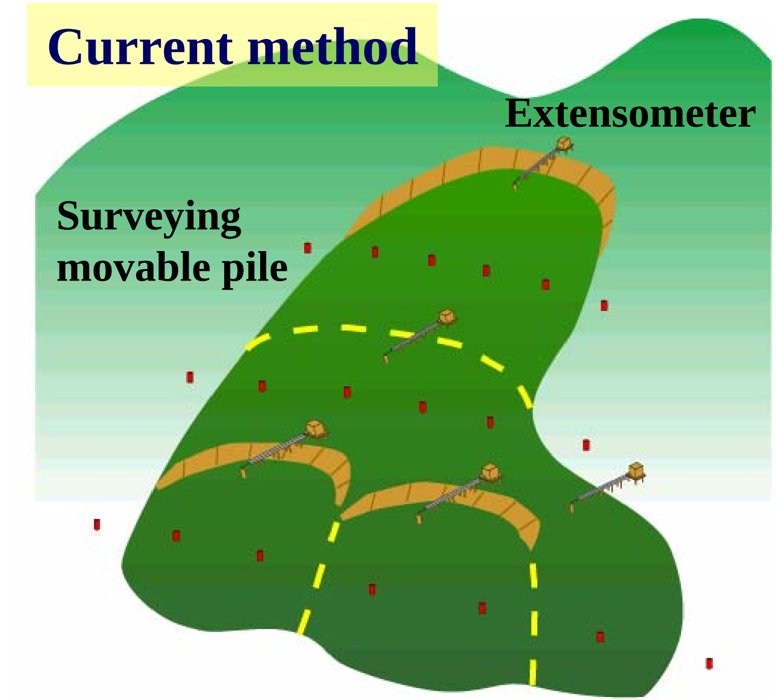
Photo showing how extensometer is installed

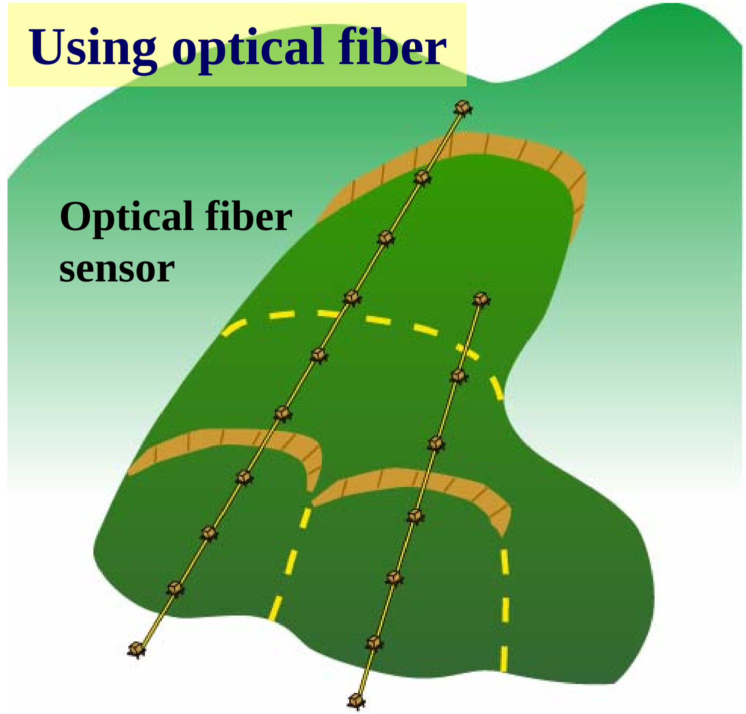
Crack

Conventional extensometer



Merit of monitoring by optical fiber sensor





Problem of current method

- Need many measurement equipments
- Take many time, cost, and effort
- Breakdown by thunderbolt

Merit of optical fiber

- Measure cover a wide area
- Measure at the end of fiber
- No breakdown by thunderbolt

⇒ reduce a time, cost, effort

Optical fiber sensing

Characteristic of optical fiber

The characteristics of light that passes through optical fiber are altered by temperature and distortion.

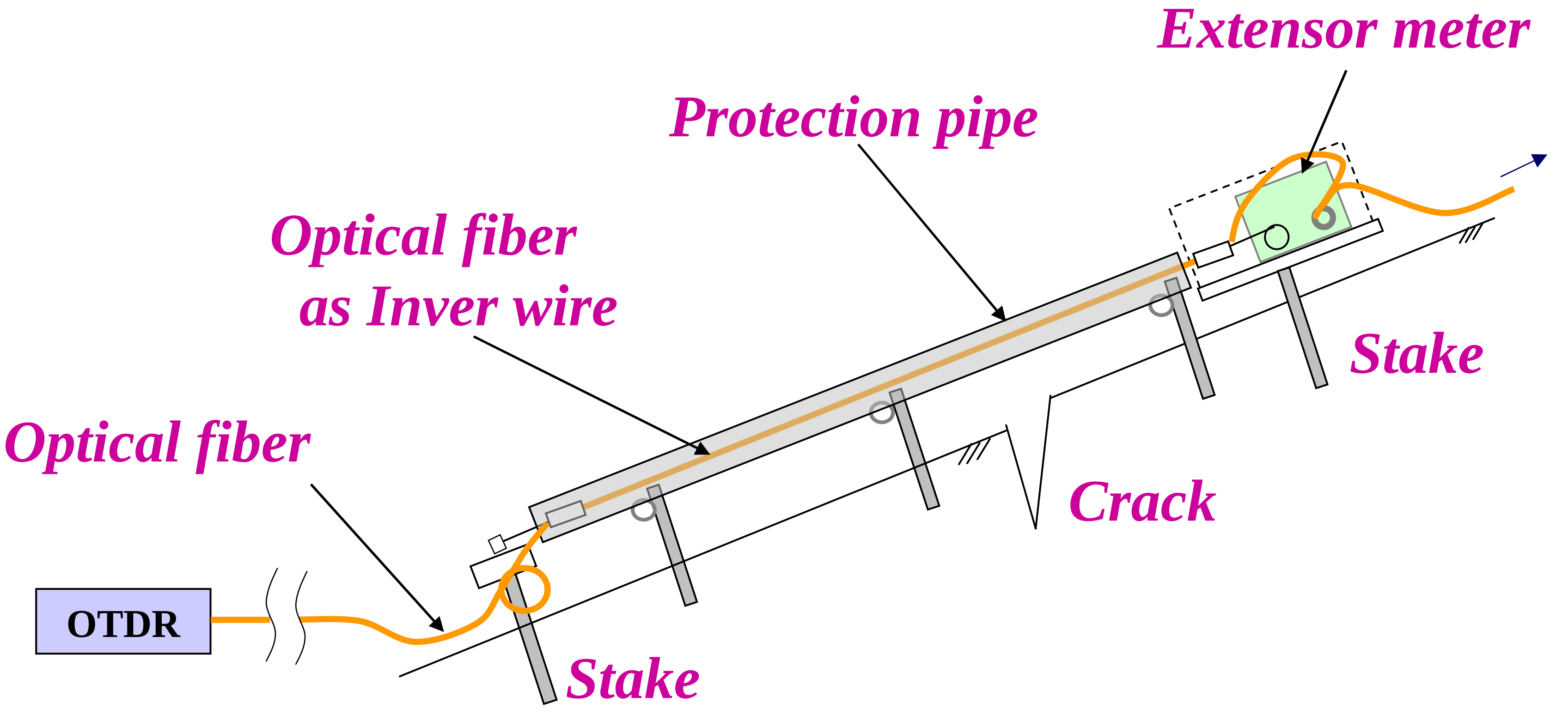
↓

Optical fiber can be used not only for communication but also as a sensor.

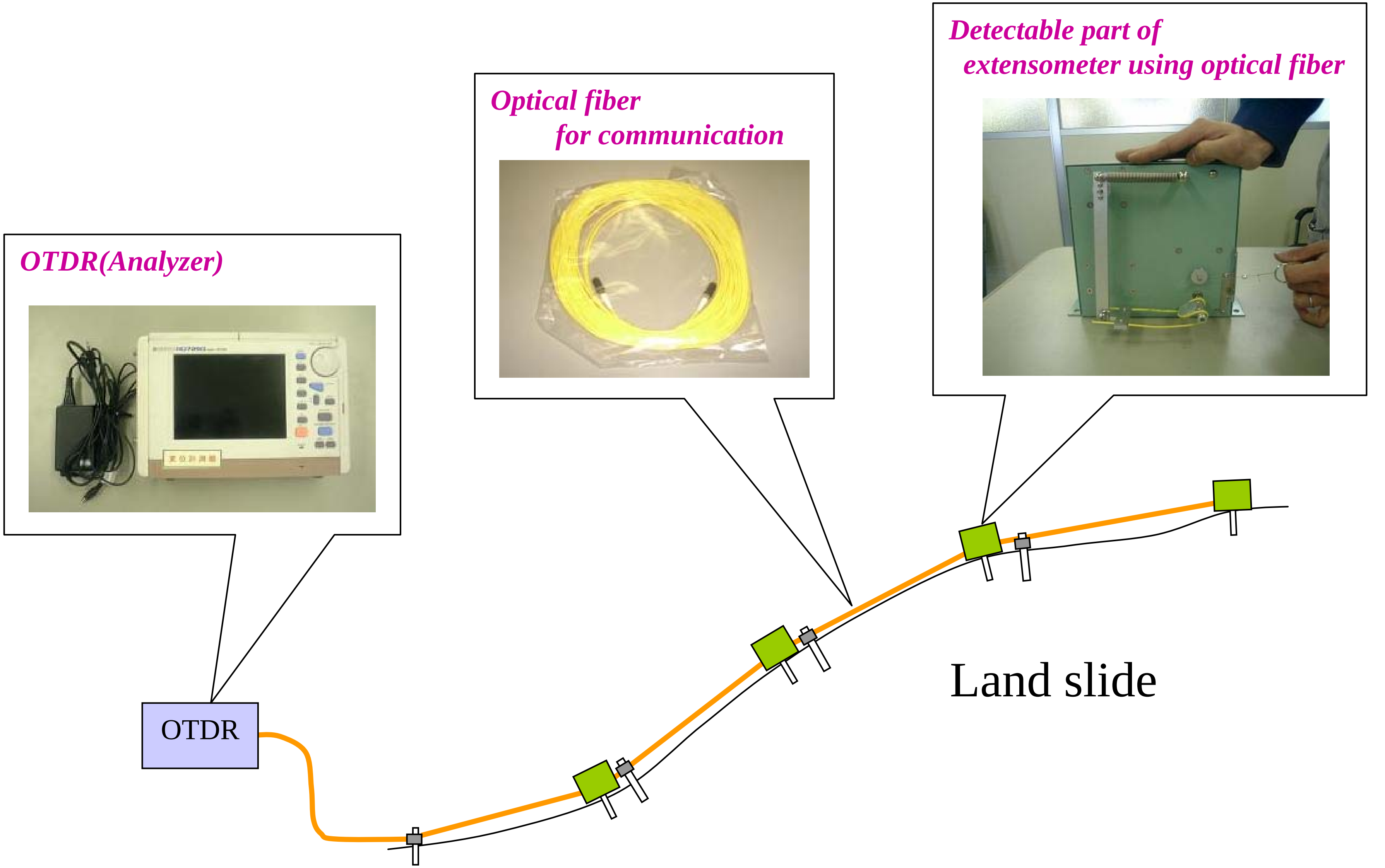
For example:

- ***Measurement of distortion (FBG)***
- ***Measurement of distortion distribution (BOTDR)***
- ***Measurement of displacement (SOFO, MDM)***
- ***Measurement of vibration (OFRI)***
- ***Measurement of temperature (Raman scattering)...***

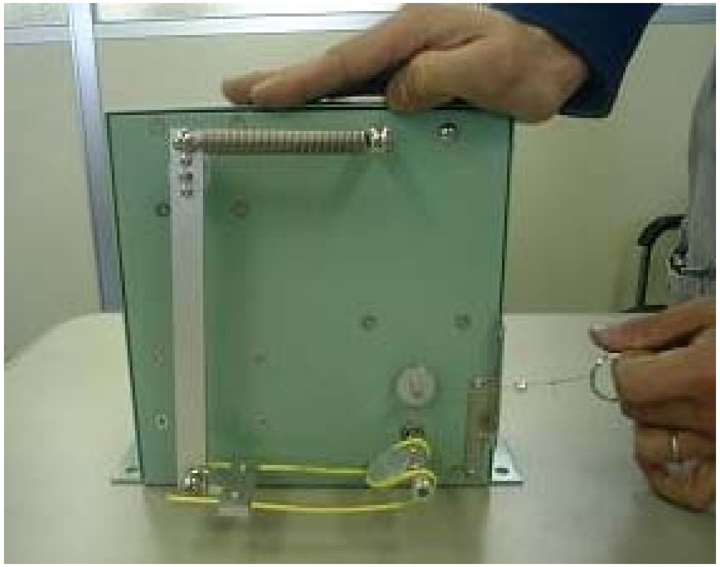
Extensometer using optical fiber

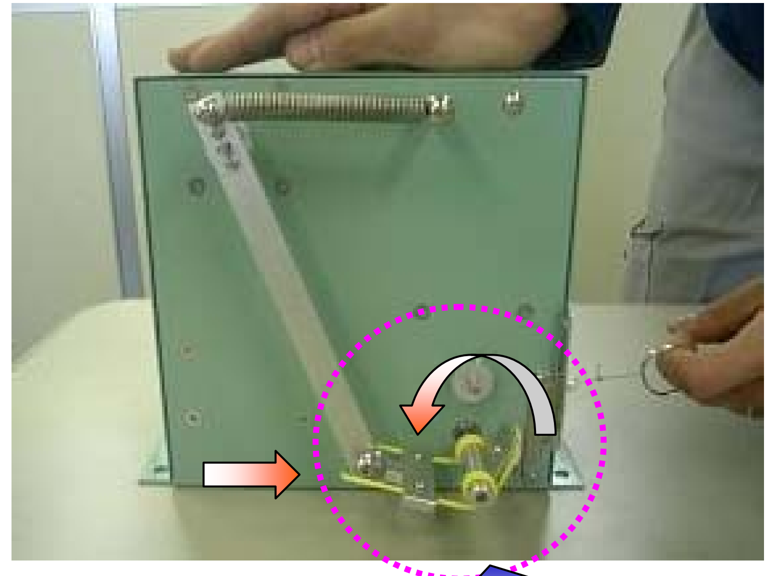


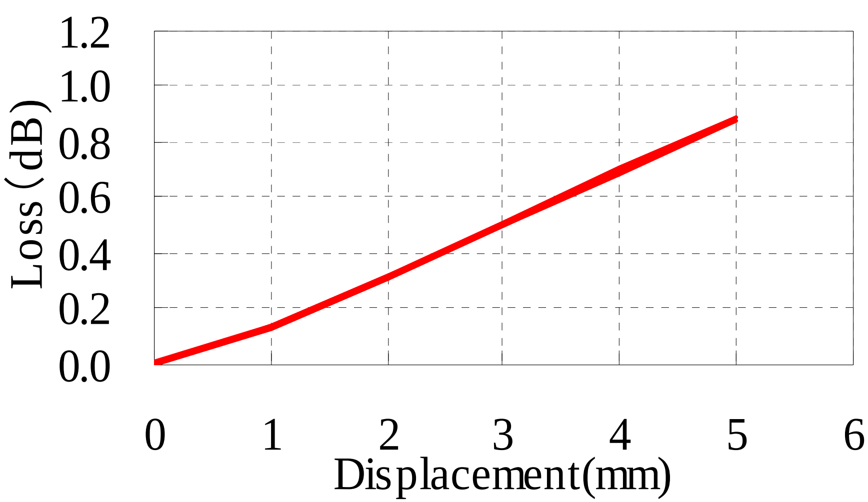
Extensometer using optical fiber

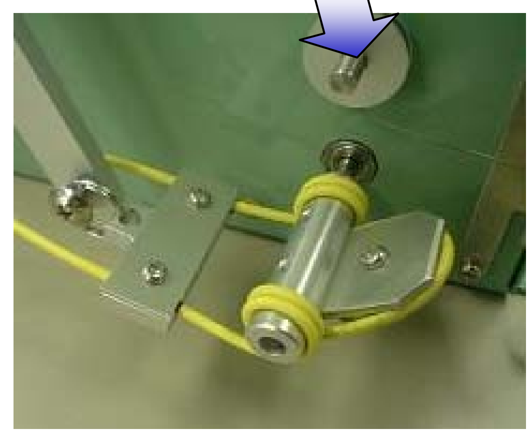


Extensometer using optical fiber

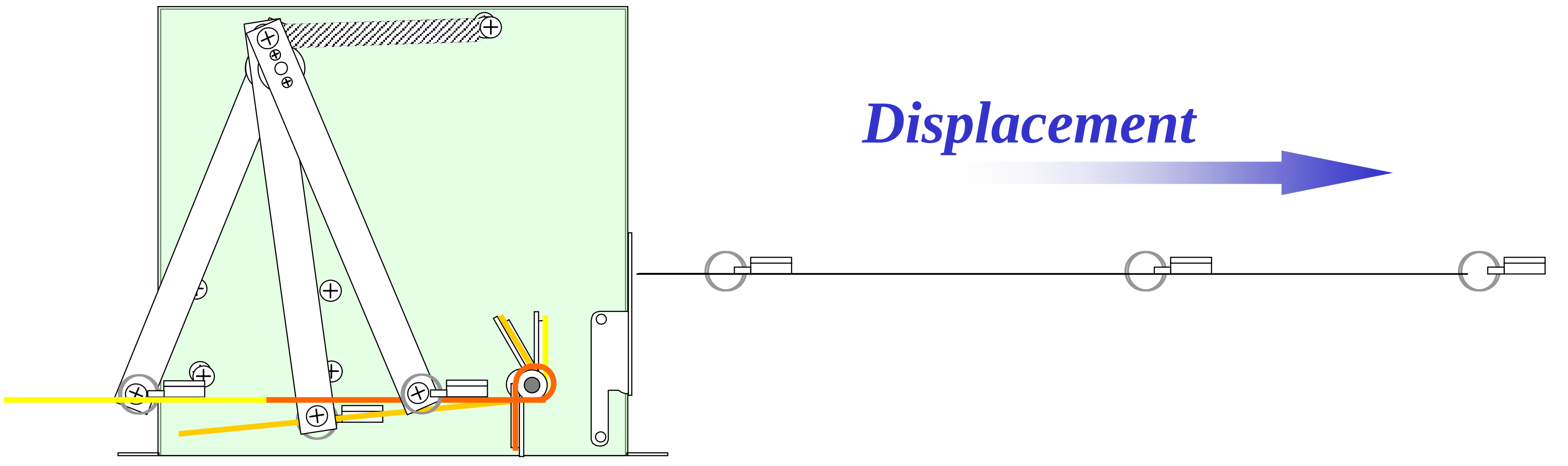


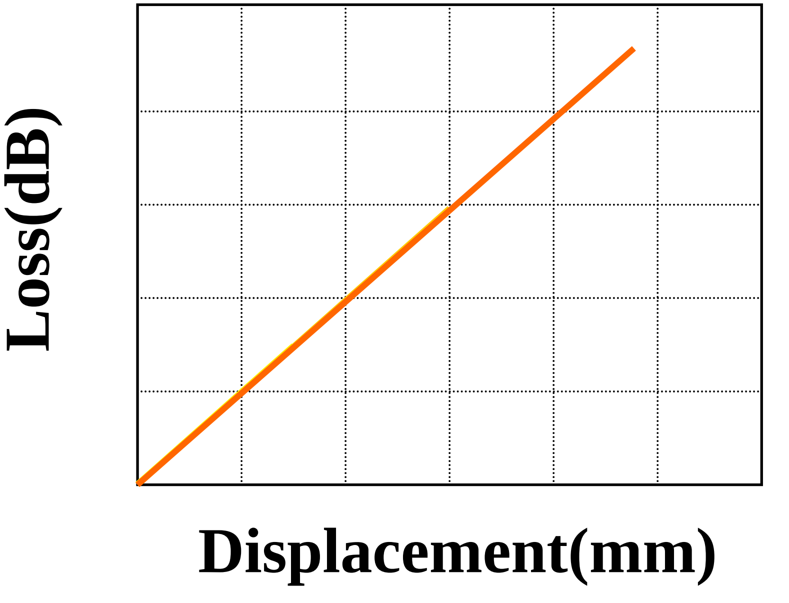






Extensometer using optical fiber

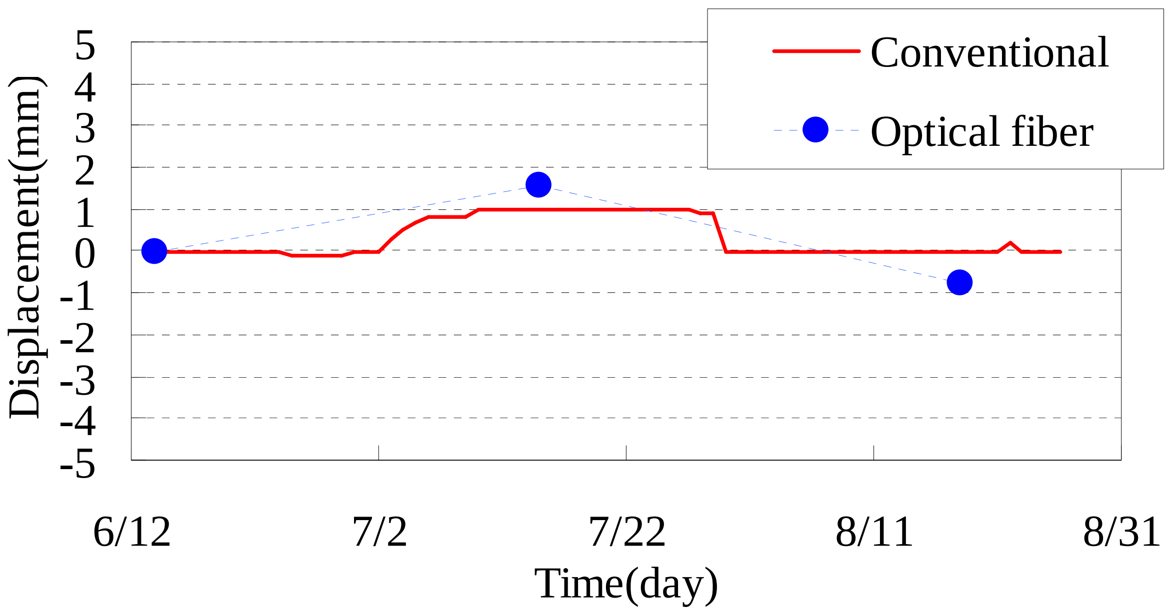




Extensometer using optical fiber

Measurement in the field based on joint installation with conventional extensometers

The behavior shown is roughly the same for both.



The 14th Conference on Public Works Research and Development in Asia

Special Session on Flood Forecasting and Warning

by

Secretariat for Preparatory Activities of UNESCO-PWRI Centre
Public Works Research Institute

October 21 (Fri.) 2005

Summary

The Special Session on Flood Forecasting and Warning (hereafter PWRI session) was held on 21 October 2005, at the opportunity of the 14th Conference on Public Works Research and Development in Asia. The conference was organized by the National Institute for Land and Infrastructure Institute (NLIM), Ministry of Land, Infrastructure and Transport (MLIT), supported by the Japan International Cooperation Agency (JICA) during the period from 17 to 28 October 2005 in Tsukuba and Sendai, Japan. The session was participated by representatives of seven countries, namely, Cambodia, India, Lao PDR, Philippines, Thailand, Vietnam and Japan.

The objective of the Special Session by the PWRI was to introduce the current flood forecasting and warning systems in each country and discuss their efficiency and deficiency to reduce death tolls during actual sever floods. The outcomes of the discussion are prospected to serve as complementary base to derive practical and serviceable action plan for advancing scientific research and technical approaches to enhance flood warning and forecasting systems with the ultimate goal to reduce death tolls. To this aim the presentations and discussion was directed to focus on the following three goals: (1) to deeply understand the real causes of death in actual flood disaster events; (2) to identify critical weakness in the whole cyclic system of “Risk Reduction” - “Damage Reduction” - “Emergency Management” - “Rehabilitation and Restoration” that are supported by role-sharing work by individual, community, and government; and (3) to analyze the significance and limitation of flood forecasting and warning systems for saving loss of lives.

The opening address was presented by Mr. Yoshitani (PWRI) to introduce the current issues in flood forecasting and warning in Japan and in developing countries. He emphasized that the future directions in flood disaster mitigation should seek for the best combination of structural and non-structural alternatives that are defined under an appropriate role and responsibilities sharing and involvement of all related people in the decision process. Mr. Suwa (PWRI) summarized the country reports solely prepared by each participant to serve the objective of the Special Session. He emphasized the need to clarify the problems that our society is facing during disasters. The Niigata flood disaster experience in Japan in 2004 raised important considerations and concerns to accurately evaluate the real causes of death and general public responses for each flood disaster.

Mr. Janak Jerambehai Siyani from India introduced the particular conditions of the flood of 26 July 2005, acknowledged the worst ever recorded flood event in the history of the Numbai City. The major issue during the flood was the incapability of the existing forecasting system to predict the highly localized phenomena. Despite the issuing of flood warning, the death toll was unprecedented high and reached 736 in Mumbai City and more than 1000 death in Maharashtra State. During the flood about 150,000 people were stranded in their offices and schools and many people died drown inside their cars. The coincidence of high tide and heavy rain worsened the situation. The state government had released Rs.5 billion for emergency relief.

Dr. Bunna Yit from Cambodia introduced the existing efforts of the government represented by the Ministry of Public Works and Transport (MPWT) with the National Committee for Disaster Management in putting concrete actions to improve the efficiency of current flood mitigation issues despite the limited number of measuring stations. Promoted actions are to (1) collect disaster information along the affected or damaged road and hydro-structure, (2) inspect and survey critical section and ready to warn the road users and people when the flood water reaches the freeboard design level. Many sections of road in the flood basin are considering as evacuate place for the animals and people from the villages nearby. MPWT shall and is ready to warn the transporters of possibility to disrupt traffic or minimize the loading traffic by heavy trucks for high risk and high safety. Boats are also valuable mean for rescue activities during flood.

Mr. Keophilavanh Aphaylath from Lao PDR introduced the existing flood forecasting system in Lao PDR, which is coordinated with the Mekong River Commission (MRC). The real-time information (water level and rainfall data) includes data from five key hydrological and meteorological stations in Thailand, and five key hydrological and meteorological stations in Lao PDR to transmit flood information by radio or facsimile to the MRC Secretariat daily at 17 00 hours or, during peak periods twice daily, at 11 00 and 17 00 hours. Normally, the forecast is issued five days in advance. The death toll in Lao PDR is very small or none existing but economic damage to agriculture in particular is still very high.

Ms. Rebecca Trazo Garsuta from the Philippines emphasize that the Disaster mitigation program in The Philippines include both proactive and reactive responses are adopted. As proactive measures, communities undertake exercise and evacuation drills along many awareness campaign and volunteer team actions. As damage mitigation measures, the local communities issue guidelines on safety measures such as suspension of school classes) as well as local ordinances to use calamity fund. Much legislation for water disaster mitigation are continuously formulated by the Government.

Mr. Akkapong Boonmash from Thailand introduced the current flood conditions in the country and the concurrent impacts afflicting the country on a yearly basis. Flooding in

Thailand occur in average 10 times/year. The inundated land is about 32% of the total. Every year more than 100 people die due to flood and more 16 thousand people are affected. The average damage is as high as 4,094 million Baht. Disaster preparedness in Thailand is conducted as part of the country's civil defence management, which is comprised of three levels: National Level (the Department of Disaster Prevention and Mitigation (DPM) is the principal government agency responsible for formulating policy on disaster management and prevention), Provincial Level (the Provincial Governor is designated as Director of Provincial Civil Defence) and Local Level (the Mayor is concurrently the Municipal Civil Defence)

Mr. Nguyen Xuan Hien from Vietnam emphasized that flood forecasting in the Mekong delta is not an easy task. Thailand has tried to carry out the long-term flood forecasting (month, season), medium-term flood forecasting (10-15 days) and short-term flood forecasting (3 to 7 days). The results show that short-term flood forecasting is enough accuracy and the others are only for reference. In Vietnam we found that most of the death people were children. As a response the government establishes the child care houses during the flood season. The statistical data clearly shows that the current efforts have resulted in net decrease in the number of death. For instance the 2000 floods killed 448 people, in 2001 floods 412 people, in 2002 floods 170 people, in 2003 floods 85 people and in 2004 floods 42 people.

The second period of the half day workshop was free-flowing discussion to evaluate the practical significance and limitation of flood forecast and warning systems for saving loss of life as a part of a holistic flood management framework highlighting the importance to implement systematic analysis of the cause of death and the added value of sharing roles, lessons and experiences. The outcome of the discussion that was simultaneously recoded and presented at the closing of the session by Dr. Tarek Merabtene was circulated among all participants for review and final feedback. The findings and outcomes of the special session are reported at the end of this summary.

General Outcomes and Recommendations from the Session

Outcomes and Reflections from the Session

The Special Session was a unique opportunity to discuss the actual state (i.e., effectiveness and limitations) of flood forecasting and warning systems in our region. The knowledge shared clearly shows that there is a need to undertake intensive research and capacity building programmes to achieve our ultimate goal behind flood forecasting and warning systems, that is to reduce the loss of life.

The global trend of the number of flood disasters has been continuously increasing. The international figure shows that floods kill about 5000 people in average (See Figure 1) and affect more than hundreds million people every year (see Figure 2). In order to derive concrete conclusions from this global disastrous picture and advance our policies in flood mitigation it is important to segregate the real causes of death during any flood events.

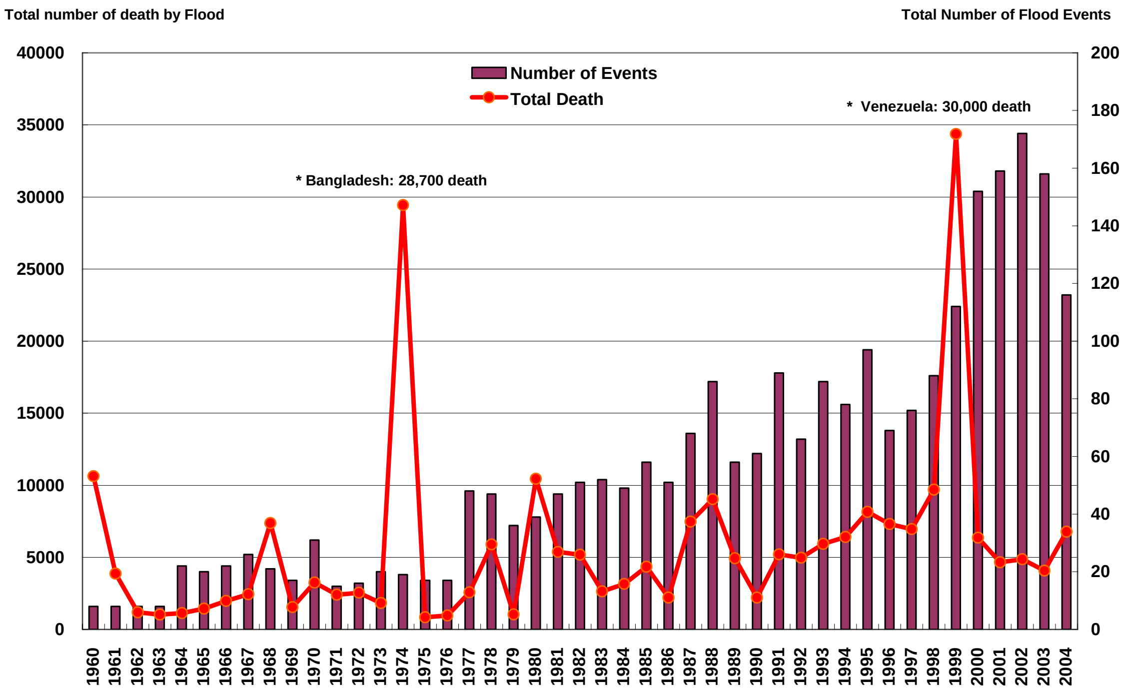


Figure 1. Trend of killed people by flood worldwide. Source CRED/EMDAT database.

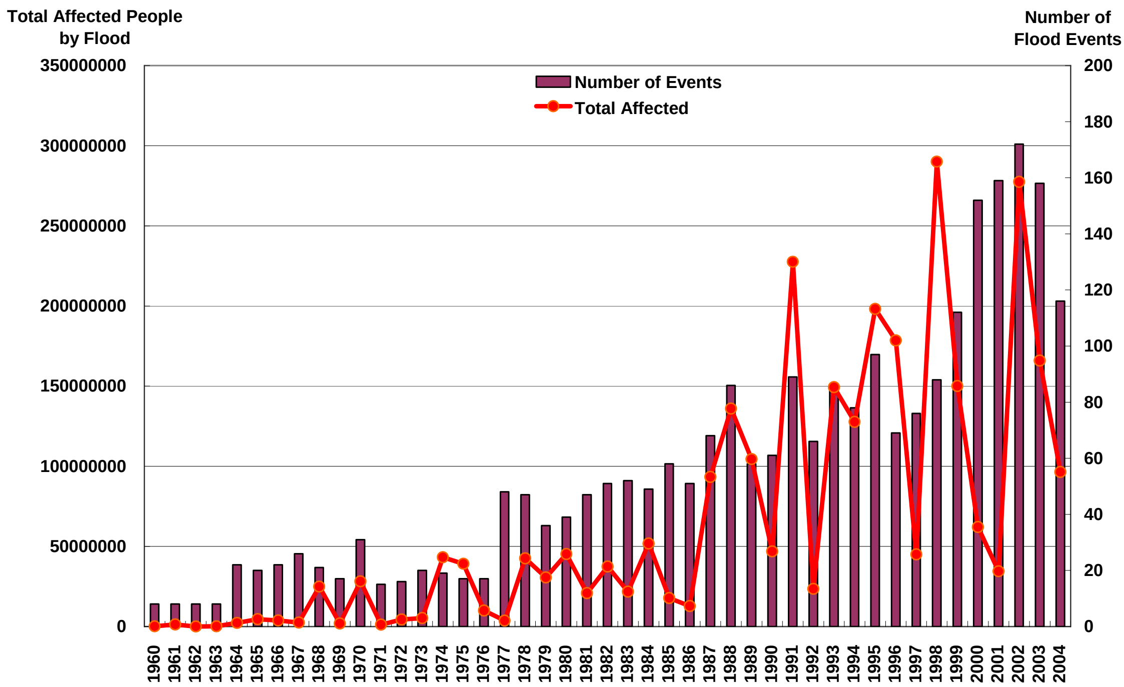


Figure 2. Trend of affected people by flood worldwide. Source CRED/EMDAT database.

The outcomes of the discussion outlined the following items:

- While governments have the responsibility to develop flood forecasting and warning systems, it is the responsibility of the community and citizens to initiate and take proactive measures to safe their lives. For instance, refusal of early evacuation by citizens has proved to increase difficulties to mobilize enough facilities such helicopters and boats for rescue operation.
- The issue of why people do not respond to warning is still questionable. In many areas poverty and lack of safety are some prevailing reasons. Nevertheless, in many cases the real reasons are still needed to be identified. In this regard undertaking case basis analysis is an important mean to improve the utilization of the existing warning systems.
- In Japan recent problems such as death of old people had put forward the issue of evacuation system and evacuation order and directive for elderly people.
- Disaster from small scale rivers, where no flood forecasting and warning system exist, should be carefully considered. The recent floods in many countries including Japan are increasingly suffering flood hazards from small rivers.
- During flood event, car's traffic control is an important issue to be retaken under discussion.
- Sharing good practices and examples for safe evacuation: Good practices such as the case of the flood fighting in Kochi Prefecture, Japan, must be promoted and analyzed to draw lessons for the future. In this case "community flood fighting", "smooth communication between citizens" and "mutual support between individual" have highly demarcated the event.

- Another outstanding practice is the initiative of the government of Vietnam to create “child care centers” during the flood season in aim to reduce the loss of life among children.
- Evacuation systems are proven to be as important as warning system. In many cases, precious human lives have not been saved because of the lack of proper evacuation systems hampered by the poor social and security conditions as well as the lack of warning systems.
- For instance, the flood water level in the Mekong Delta rises very slowly and thus it questionable to be considered as the direct cause of death. Further investigation based on actual flood hazard situation is required to understand the real impediment to ensure smooth and safe evacuation.
- Analysis of the real causes of death for every flood disaster is recognized to be a very important issue to accurately assess the reliability and effectiveness of FFWS.
- The mechanism of the flow of information concerning flood warning is proven to be different among countries. Efficient of each mechanism if well documented is foreseen to improve our global view for implementation of flood warnings.
- In major rural area the main limitation for effective warning is the lack of the perception of information. For instance, farmers have a very poor or even absent knowledge to understand forecasting and warning information.
- There is an emerging need to establish accurate database for global analysis of flood disasters in order to draw robust indicators to assess the effectiveness of adopted counter measures.
- Rescue of animals during flood hazard is also a major concern in many rural and agriculture areas. For instance, many people are using their private boat, mostly made of timber, as mean to rescue their property. There are witnessed cases of people drawn because they also tend to rescue their valuable animal resources. Other cause of death is sudden biting by wild animals such as by snake, absence of high spot, submergence of occupied vehicles, etc.
- Strengthening of the international collaboration for technical support, data and information exchange, sharing knowledge base and experiences on flood forecasting and warning is very important and indispensable more then ever before..
- The FFWS are limited in many of our countries due to limited rain gauges.
- The efficiency of measurement stations was brought forward by the case of Mumbai flood where two meteorological stations recorded different precipitation.
- Practical case study, such as in the case of the localized rain in Mumbai, has proven that even with higher resolution system it would be difficult to make accurate flood forecast. Therefore, forecasting of flash floods due to localized rain is another important issue to research.
- The preparation of manuals and warning information in local languages, such as practiced in The Philippines, is a leading initiative for efficient risk communication to local residents.
- People in remote area are not connected to media, therefore indigenous approaches and communication means are also valuable information that we need to survey and document properly.