Coastal flooding in Hong Kong

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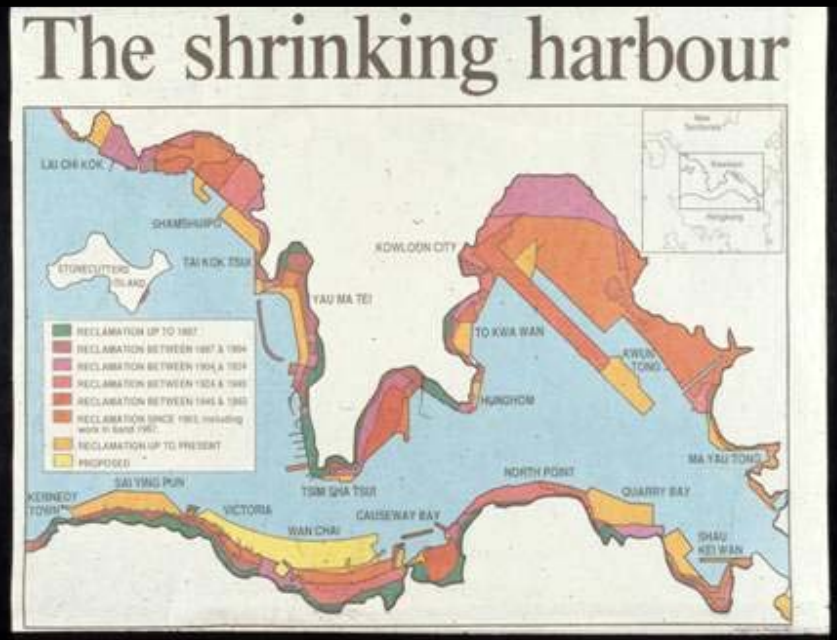
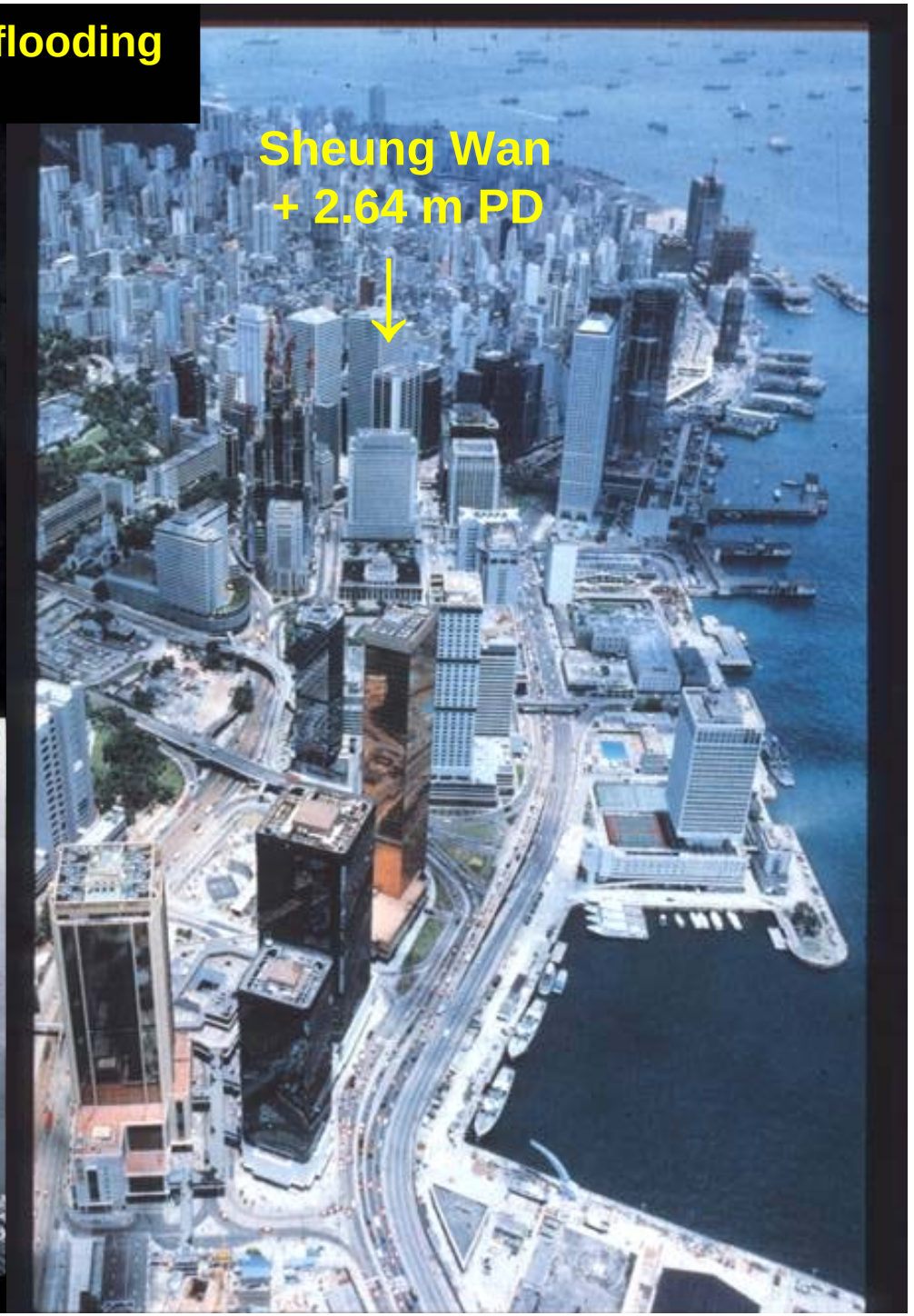
Why is this important?

- **About 15% of Hong Kong's total land area of 1,100 km^2 is below 5 m above Principal Datum (~1.23 m below mean sea level)**
- **At least part of this land is densely populated with concrete pavements and unprotected**
- **'Trough effect' created by land reclamations**
- **Coastal flooding during rainstorms, storm surges and abnormal tidal conditions**
- **Crustal subsidence/ground settlement**
- **Relative future sea-level rise**
- **Coastal flood prevention design is usually based on a 100-year instrumental record which is increasingly becoming inadequate due to the short record**

Human impact in exacerbating coastal flooding

‘Trough effect’ created by land reclamation





Causes of coastal flooding

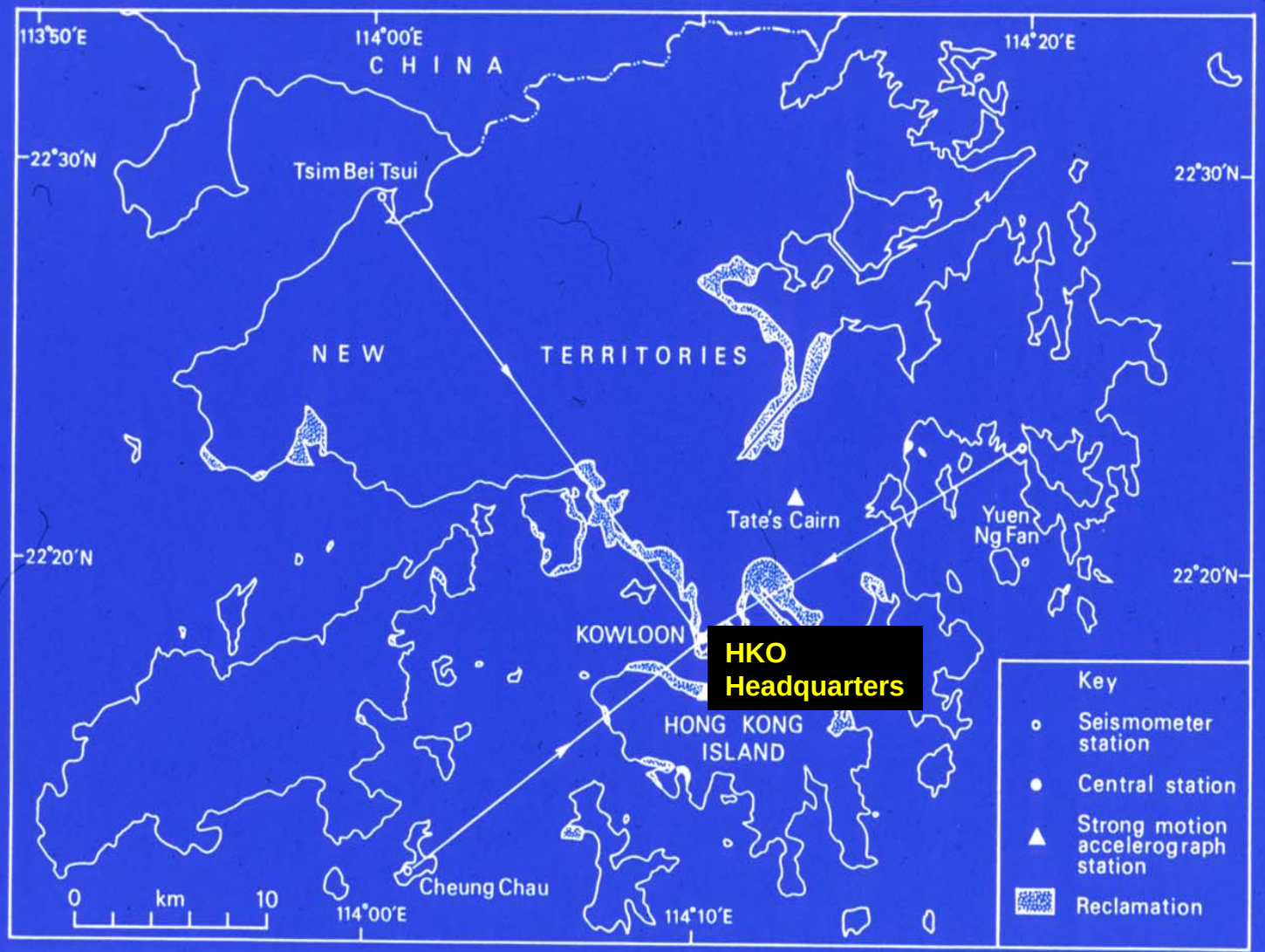
(1) ‘Long’ term

- **Crustal subsidence**
- **Ground settlement**
- **Relative sea-level rise**

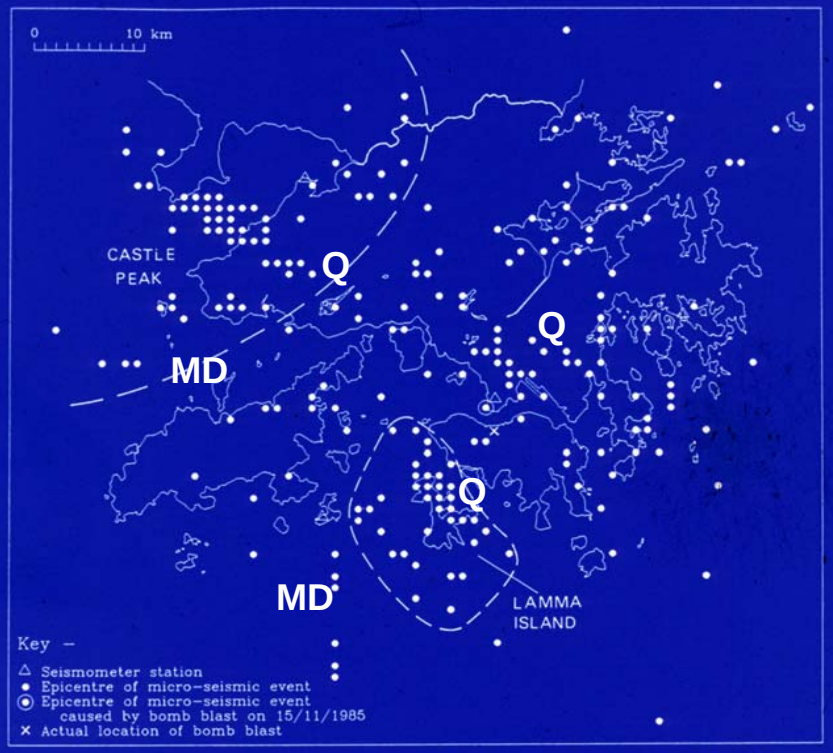
(2) ‘Short’ term

- **Rainstorm**
- **Storm surge (maximum ~6 m above P.D.)**
- **High tide (maximum range 2.7 m)**
- **Tsunami**

Evidence for crustal instability

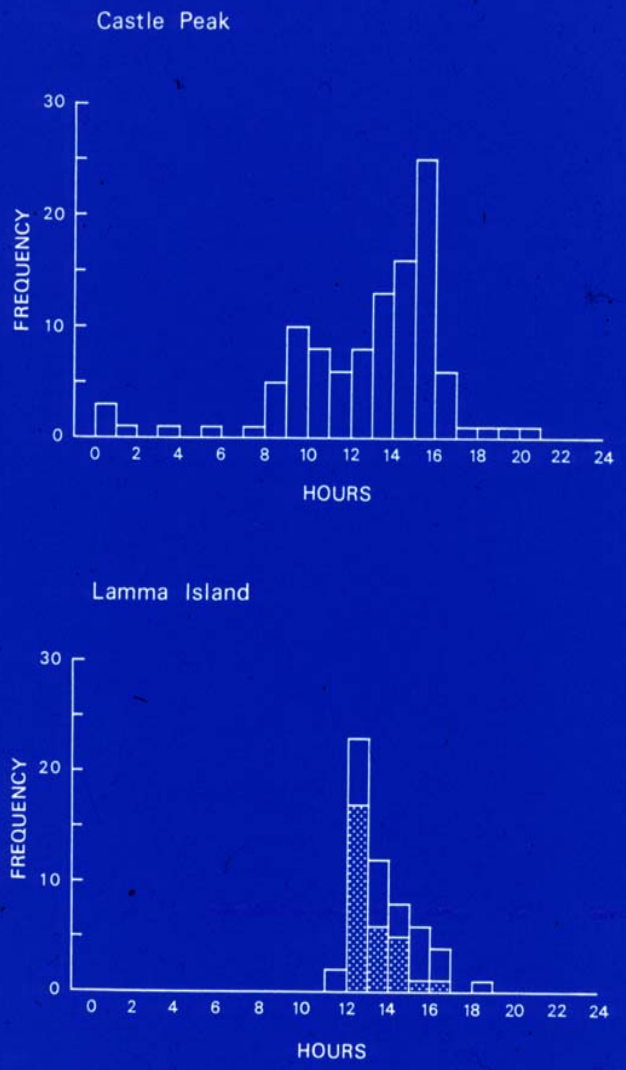


LOCATION MAP OF THE SEIMOGRAPH AND STRONG MOTION ACCELEROGRAPH NETWORK OF THE HONG KONG ROYAL OBSERVATORY.



DISTRIBUTION OF MICROSEISMIC EVENTS IN HONG KONG DURING 1/11/1979 TO 31/7/1985. BASED ON INFORMATION SUPPLIED BY THE HONG KONG ROYAL OBSERVATORY.

MD Marine dumpsite
Q Quarry



FREQUENCY OF MICROSEISMIC EVENTS TO THE NEAREST HOUR IN THE CASTLE PEAK AND LAMMA ISLAND AREAS. THE PROPORTION OF EVENTS CONFIRMED BY THE PRESENT STUDY IN THE LAMMA ISLAND AREA ARE INDICATED BY THE STIPPLED PORTION OF THE BAR.

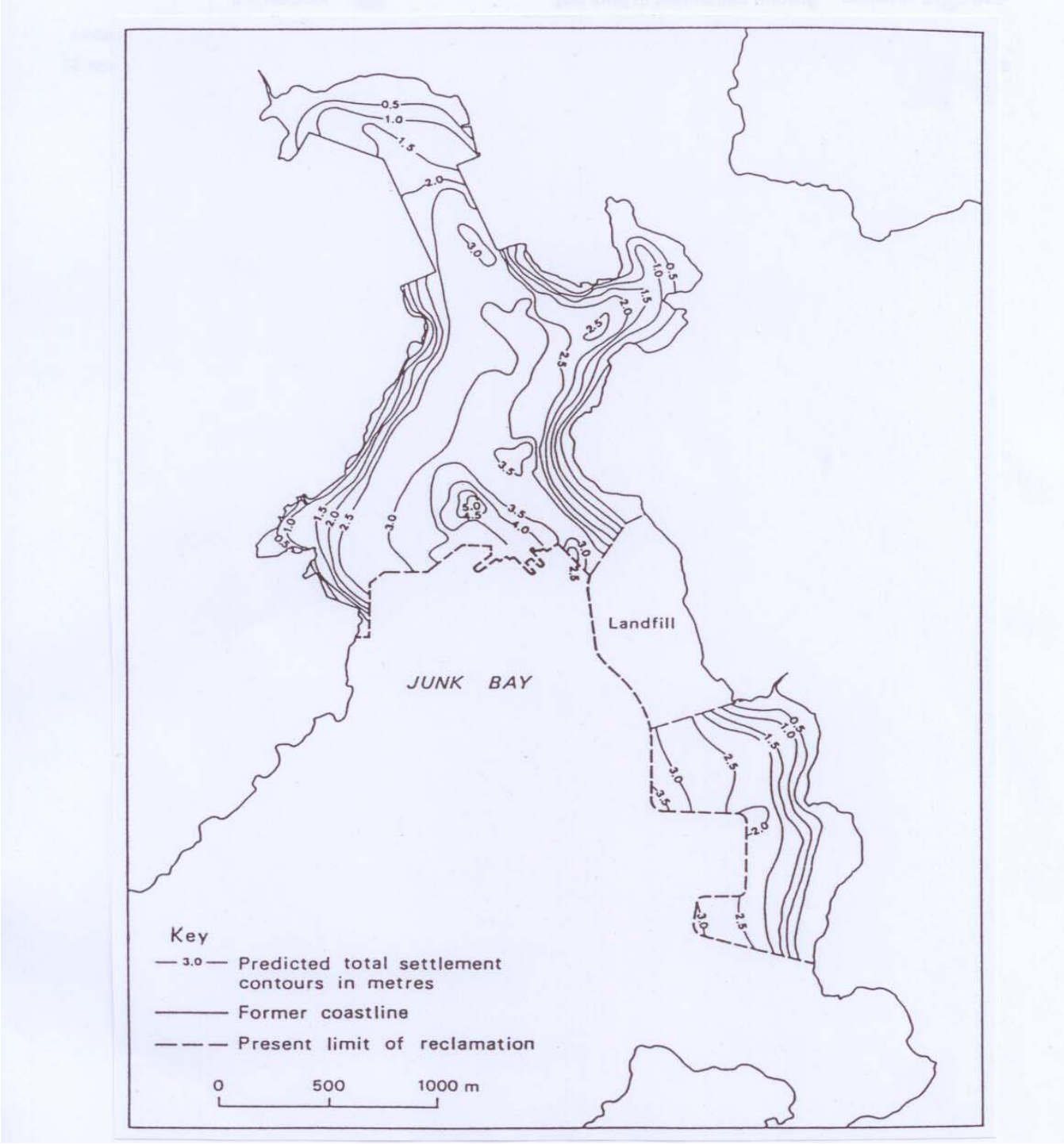
Locally felt earth tremors since 1979 within 50 km from the Hong Kong Observatory Headquarters

Date	Origin time	Epicentre location	Epicentre	Magnitude	Distance	No. of reports
30/8/1982	04:23	East Lantau Island	22.3ºN 114.0ºE	1.5	18 km	12
7/10/1982	22:13	East Lantau Island	22.3ºN 114.0ºE	1.5	18 km	12
6/12/1983	22:26	Mai Po	22.5ºN 114.0ºE	2.8	28 km	12
11/5/1995	09:59	East Lantau Island	22.3ºN 114.1ºE	3.1	12 km	47
29/5/1995	09:47	East Lantau Island	22.3ºN 114.0ºE	2.4	18 km	2
29/5/1995	15:05	East Lantau Island	22.3ºN 114.0ºE	2.2	18 km	3
30/9/1999	13:24	Dapeng Peninsula	22.5ºN 114.5ºE	3.8	40 km	47
14/9/2006	19:53	Dangan Island	22.0ºN 114.3ºE	3.5	36 km	200+
19/11/2010	14:42	Deep Bay	22.5ºN 113.9ºE	2.8	30 km	200+

Underestimation of ground settlement

Predicted total ground settlement in Junk Bay New Town

(Source: Maunsell Consultants Asia)



Rates of relative sea-level change in Hong Kong and the South China Sea based on different studies

Source	Area studied	Years examined	Data analysed	Rate of change
Wong et al. (2003)	Hong Kong	1954-1987	Tide gauge data	Fall of 2 mm/yr
Wong et al. (2003)	Hong Kong	1987-1999	Tide gauge data	Rise of 22.1 mm/yr
Wong et al. (2003)	Hong Kong	1999-2003	Tide gauge data	Fall of 21 mm/yr
HKO (2010)	Hong Kong	1954-2009	Tide gauge data	Rise of 0.56 mm/yr+
Cheng and Qi (2007)	South China Sea	1993-2000	Merged altimetry	Rise of 11.3 mm/yr
Cheng and Qi (2007)	South China Sea	2001-2005	Merged altimetry	Fall of 11.8 mm/yr

+ The rate of change found is similar to Ding et al. (2002) who studied the period 1954-1999.

Storm surge flooding

(1) Parameters of storm

- central pressure
- distance of closest approach
- translational speed
- path
- size

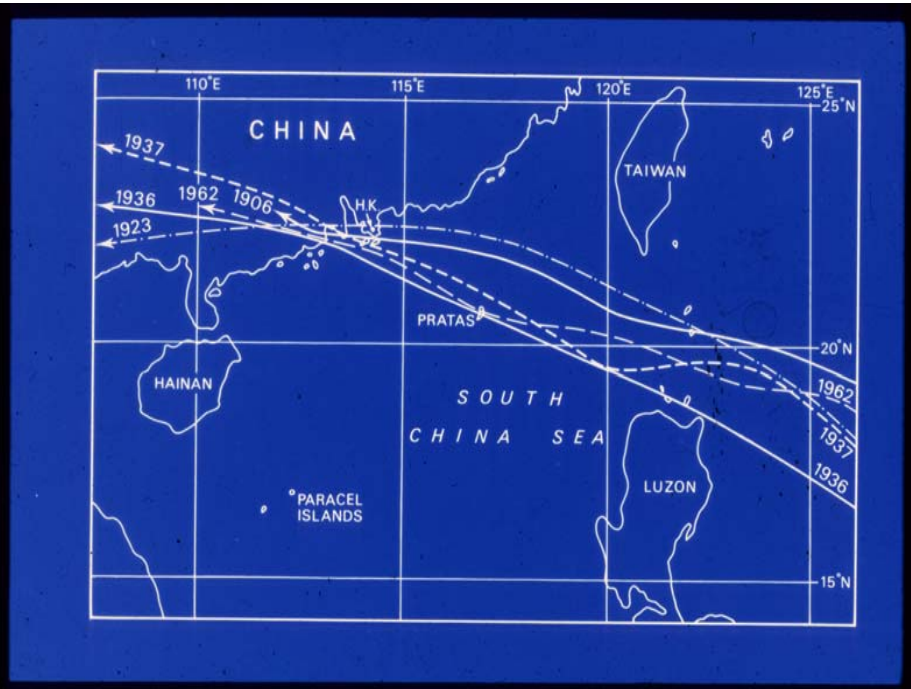
(2) Coastal parameters

- sea-floor topography
- coastline configuration

(3) Local factors

- river discharges
- seiching
- rainfall runoff
- tidal effects
- wind effects

FACTORS AFFECTING STORM SURGE LEVELS



Typhoon Wanda September 1962 - Happy Valley (left) Tai Po (right)

Typhoon Brenda May 1989 - Tin Shui Wai

Death toll, casualties and damage of the top 10 typhoons in Hong Kong since 1906. Source: Hong Kong Observatory.

Typhoon	Year	Death toll	No. injured/missing	Oceangoing vessels in trouble	Crafts sunk/damaged
Unnamed	1906	> 10,000 (3%)	Unavailable	Unavailable	Unavailable
Unnamed	1937	> 11,000 (1%)	Unavailable	28	1,855
Mary	1960	45	138	6	814
Wanda	1962	130	Unavailable	36	2,053
Ruby	1964	38	306	20	314
Dot	1964	26	95	2	90
Rose	1971	110	291	34	> 303
Hope	1979	12	260	29	374
Ellen	1983	10	345	44	360

Rainstorm flooding

Kwai Chung Road flood in August 1982

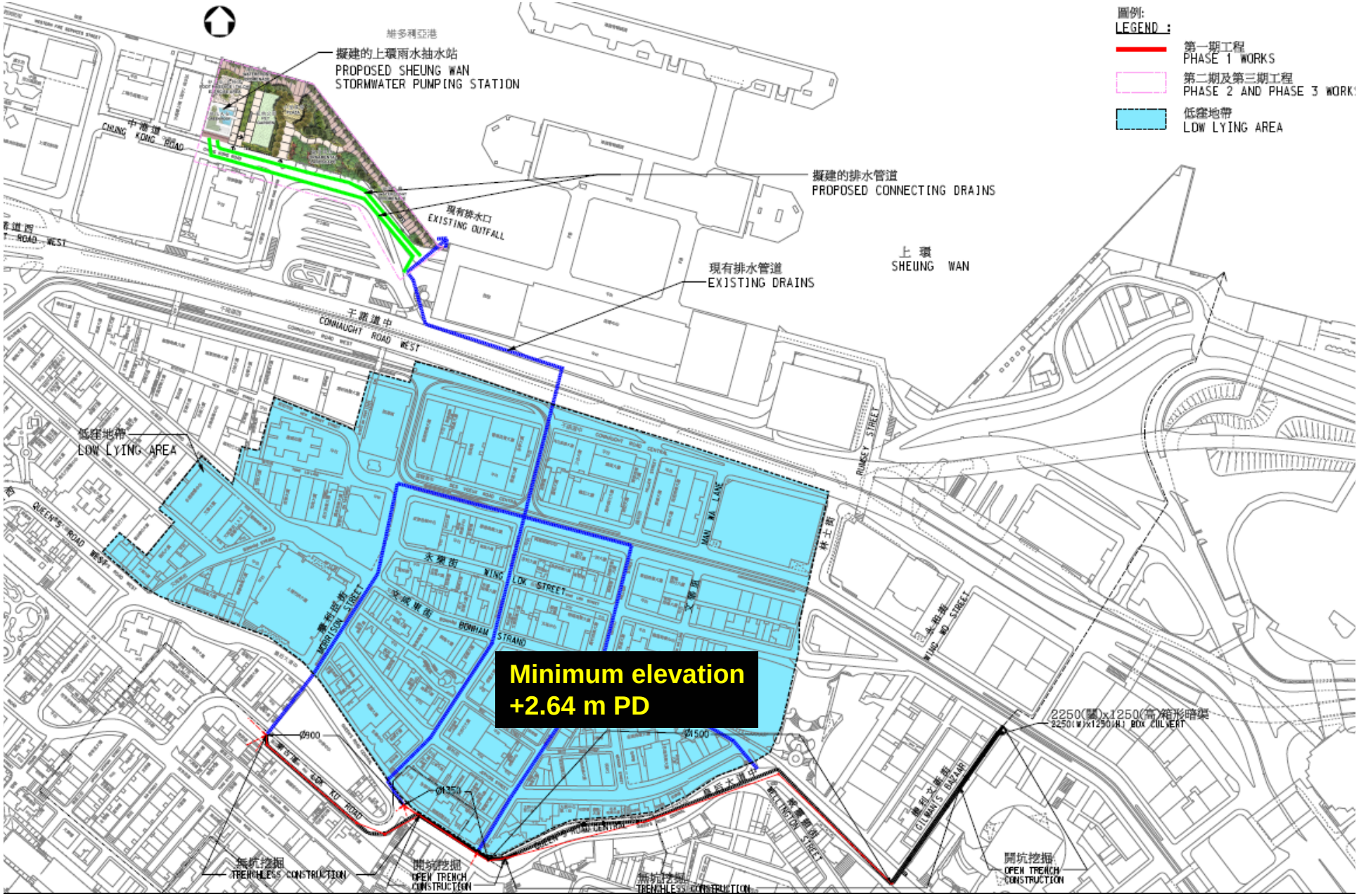
A rainstorm exacerbated by the spread of the volcanic cloud from the eruption of the El Chichón volcano in Mexico on April 4, 1982

June 7, 2008 rainstorm flooding in Sheung Wan

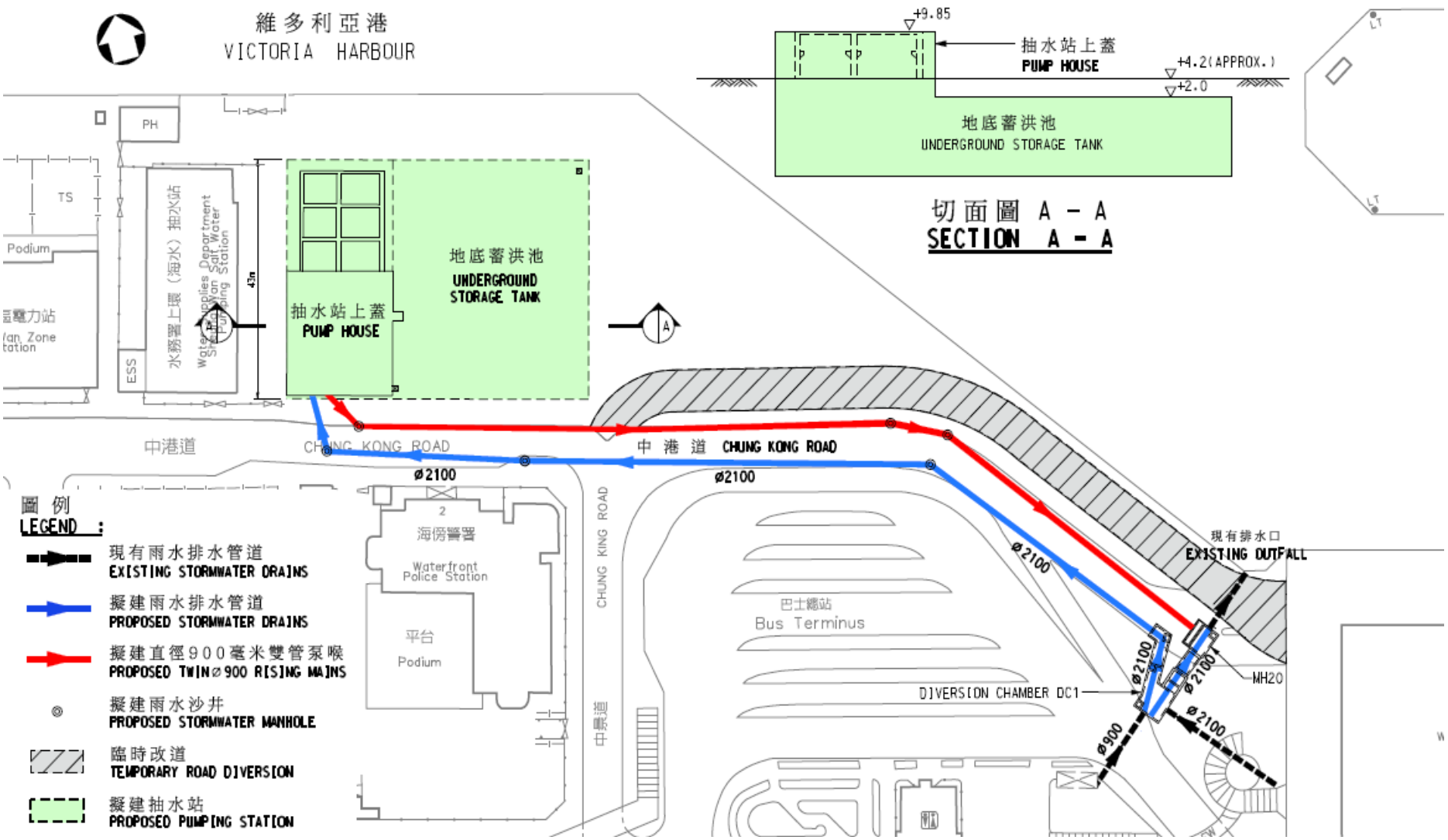
A 1-in-1100 year event ? exacerbated by the volcanic cloud from the May 2, 2008 eruption of the Chaitén volcano in Chile

Flood record at Sheung Wan 2001-2008
Source: Drainage Services Department

Date	Rainfall (daily total)	Highest tide level	Maximum flood depth
6/7/2001	142 mm	+3.25 mPD (typhoon Uter)	600 mm
24/6/2005	233 mm	+2.45 mPD	600 mm
16/7/2006	196 mm	+1.50 mPD	700 mm
19/4/2008	237 mm	+1.85 mPD	500 mm
7/6/2008	302 mm	+2.50 mPD	1,500 mm

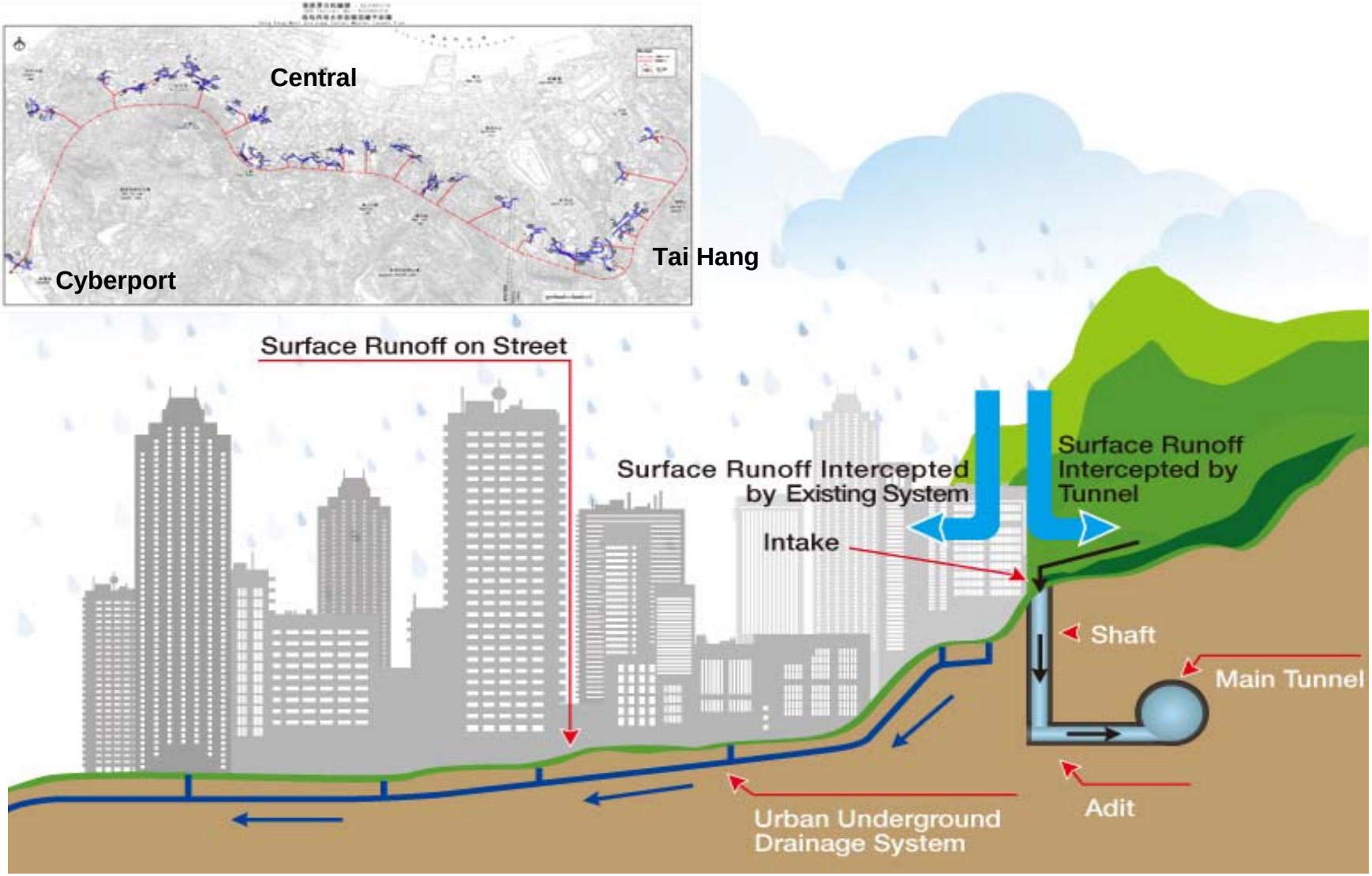


Engineering solution – construction of a flood pumping station



Underground storage tank for reducing short-term flood risk

Hong Kong Western Drainage Tunnel from Tai Hang to Cyberport



Conclusions

- **Need to better understand what cause extreme rainstorms in the region including far-field ‘major’ volcanic eruptions**
- **Need to better understand the crustal stability of the region including possible human induced-impacts (land relamations, excavations, landfills, marine dredging and dumping)**
- **Need to continuous monitor relative sea-level change using state-of-the-art methods particularly on land reclamations with a history of subsidence**
- **Need to better protect coastal areas with a history of flooding**

Note - There is also need to consider the saturated greenhouse gas theory of Ferenc Miskolczi in coastal flooding.