

Worsening floods, subsidence and over extraction of groundwater in Metro Manila, Philippines

¹Fernando P. Siringan, ²Kelvin S. Rodolfo, ³Romeo Jacob, ³Enrique Macaspac, ¹Janneli Lea Soria, and ¹Peter B. Zamora

¹The Marine Science Institute, University of the Philippines, Diliman, Quezon City, 1101 Philippines

²Department of Earth and Environmental Sciences, University of Illinois at Chicago, Chicago, IL, USA

³Coast and Geodetic Survey Department, National Mapping and Resource Information Authority, Philippines

The Philippine Islands

In 2005

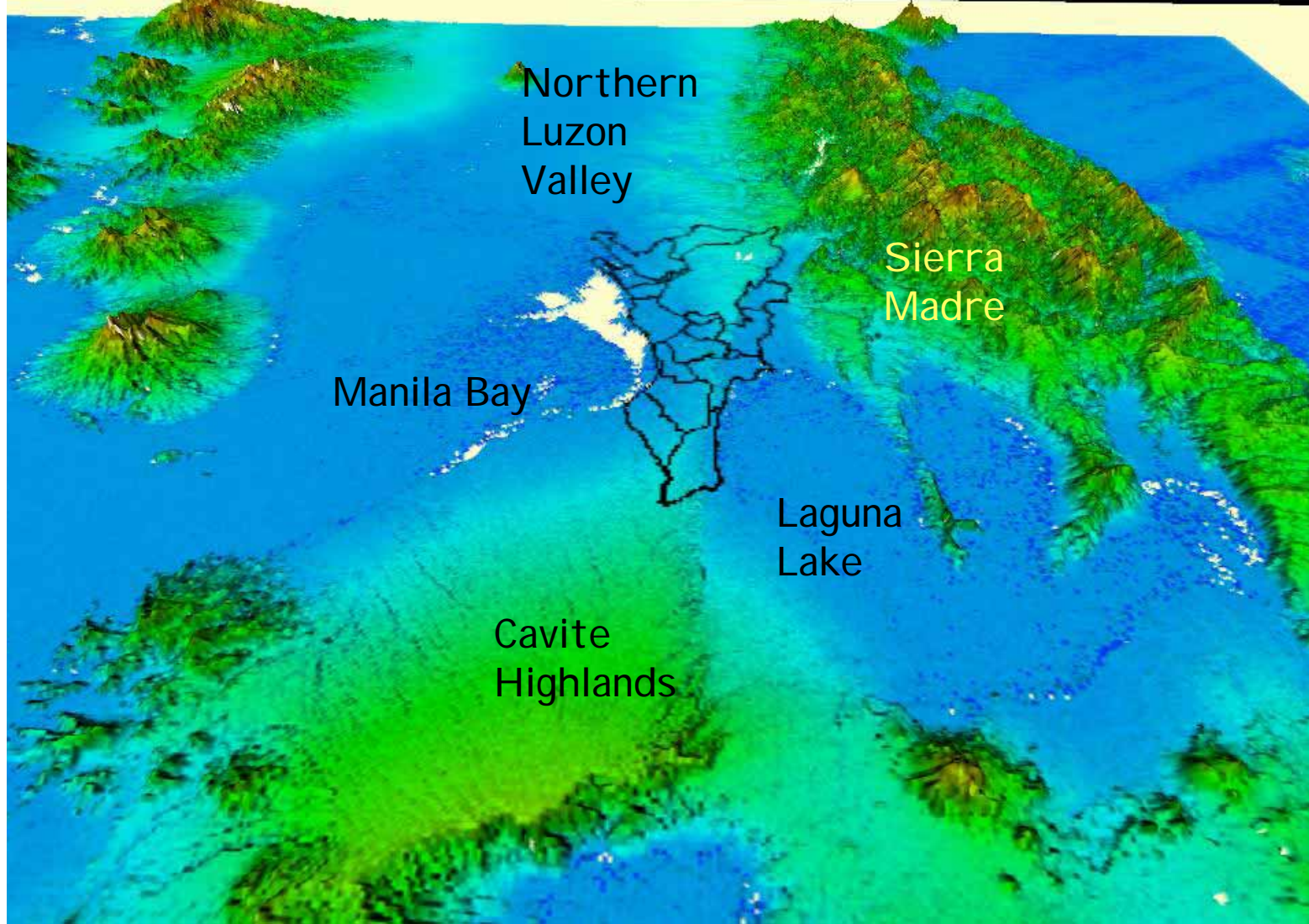
Population - 87.9 M

Metro Manila

In 2005

Population - 11.3 M





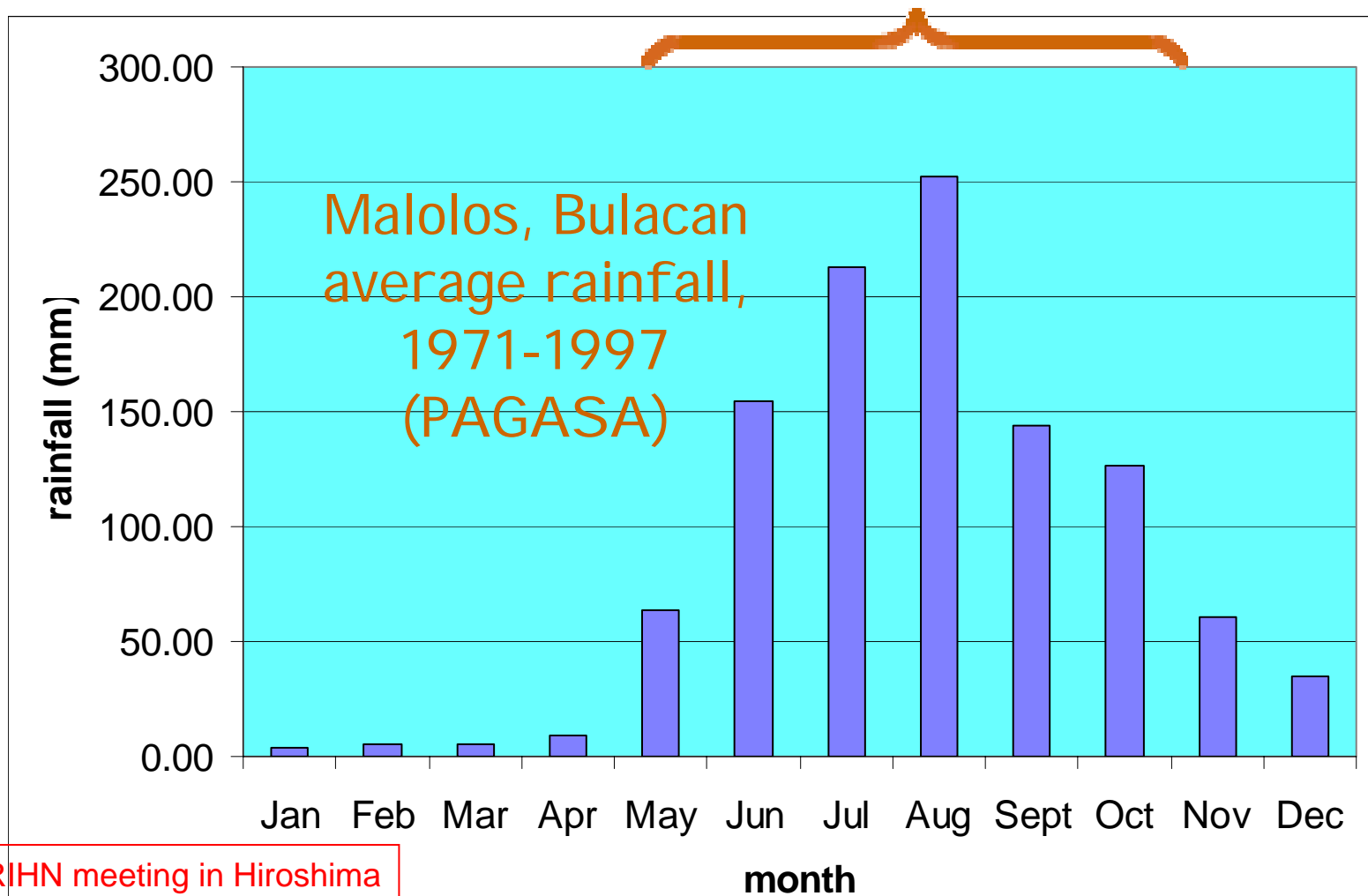
Topographically, Metro Manila is composed of coastal lowlands along its western side, a central plateau, and alluvial lowlands on its eastern side.

1942 - high water levels inundated the city for several days

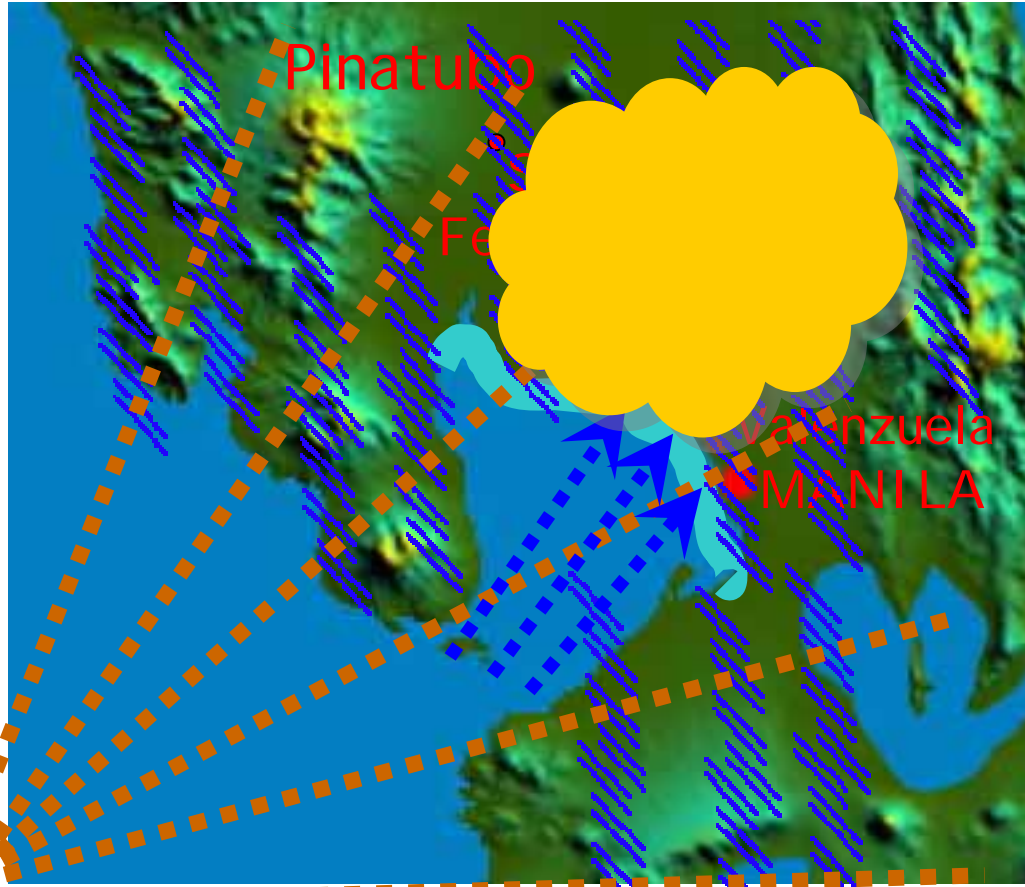
first widely recorded instance of serious flooding - (Fano, 2000 in Bankoff, 2003)

but in the past 40 years - flood frequency, depth, duration and coverage are increasing

Every year, 80% of the rains
come during the 6 rainy season months
(season of SW winds and typhoons)



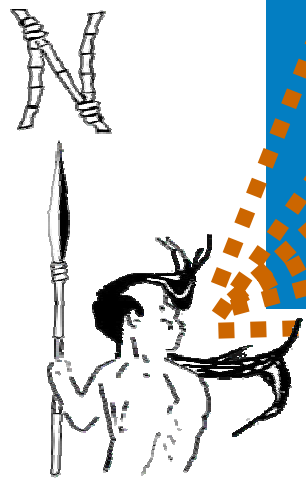
The SW winds that bring in much rain ...



also piles up seawater along the northeast coast of the bay

This increases the high tide level.

...which dams the outgoing flood waters.



SW winds

But it has always been this way , so why the worsening floods?

Worsening floods in Metro Manila is typically attributed to insufficient drainage ...

drainage structures are outdated relative to degree of urbanization ... some are century old

channel capacities decreased by...

encroachment of structures ...

river bed aggradation ... from sediments and garbage

small rivers, estimated at 21 km, have disappeared (Zoleta-Nantes, 2000) – converted for housing or other uses

At present, flooding affects all areas of Metro Manila, but some areas are more vulnerable than others due to their location and height relative to sea level.

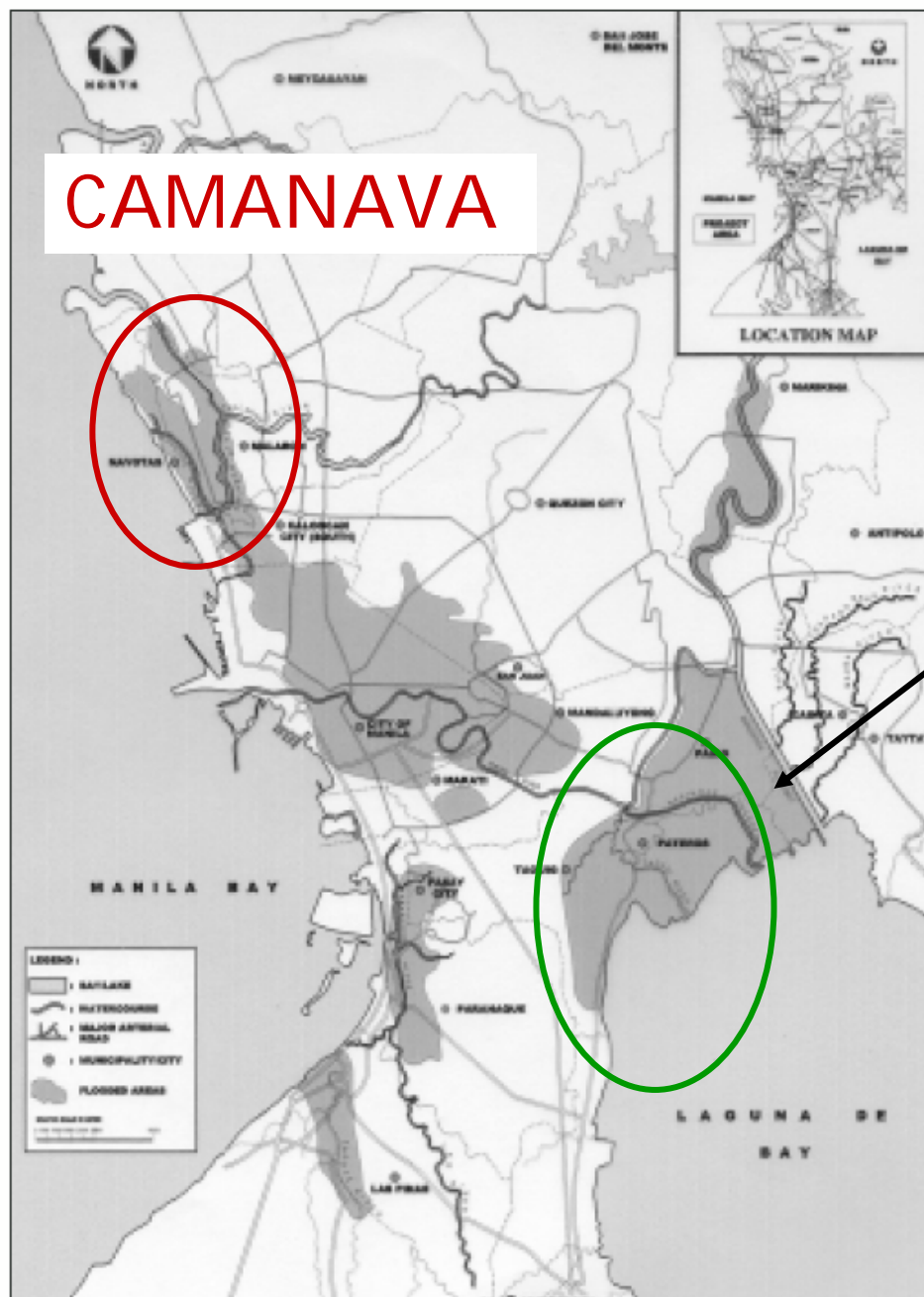
About 20% of Metro Manila is designated as flood prone of which 59% suffer frequent and longlasting inundation (MMDA in Bankoff, 2003).

CAMANAVA

Floods that now last for months occur in...

and the Pateros-Taguig-Muntinlupa areas where floods are due to elevated lake levels during the rainy season

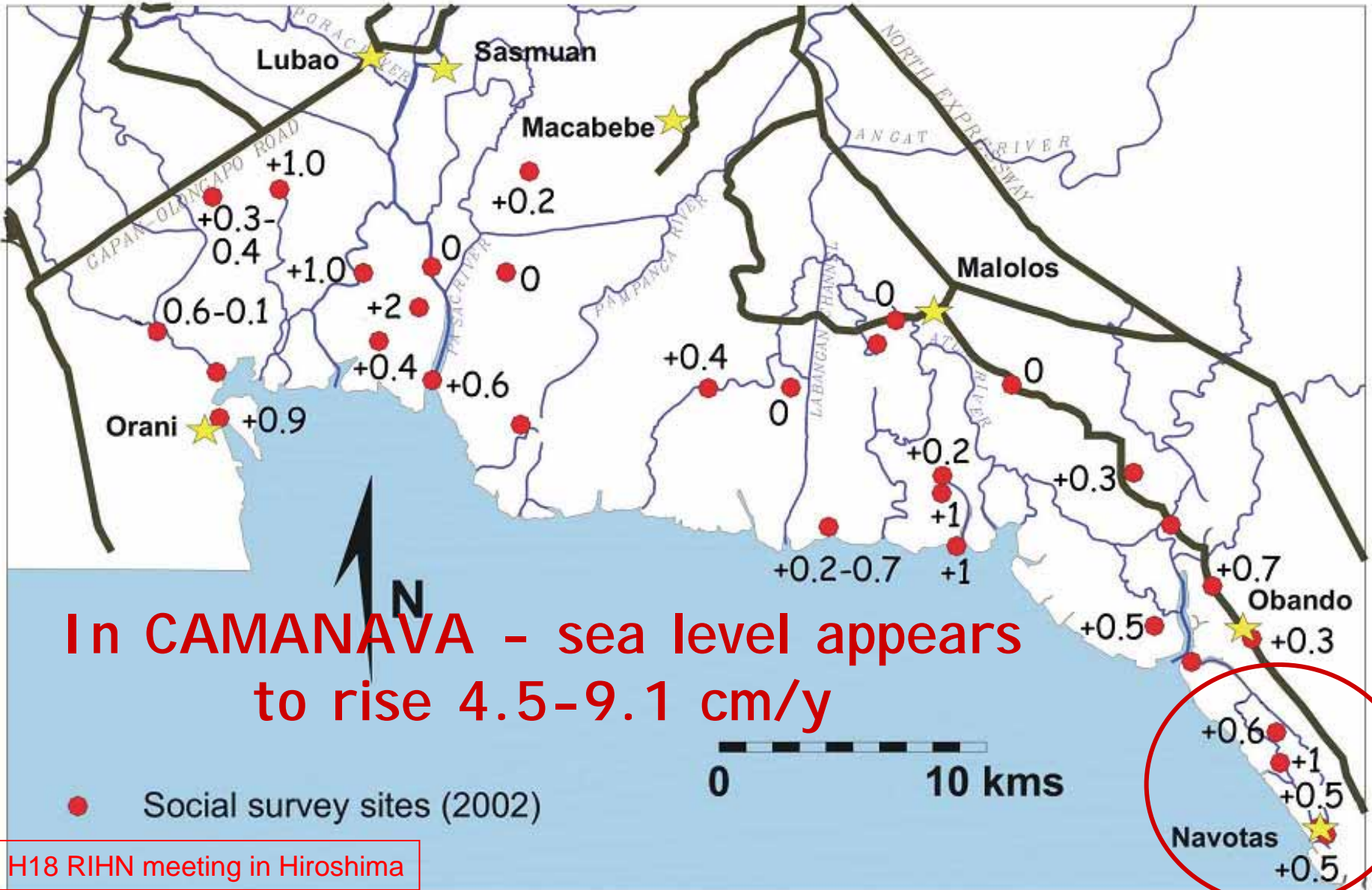
But in CAMANAVA, floods can be caused by high tide alone... but this was not so in the past



Metro Manila Development Authority

Flood prone areas in Metro Manila.

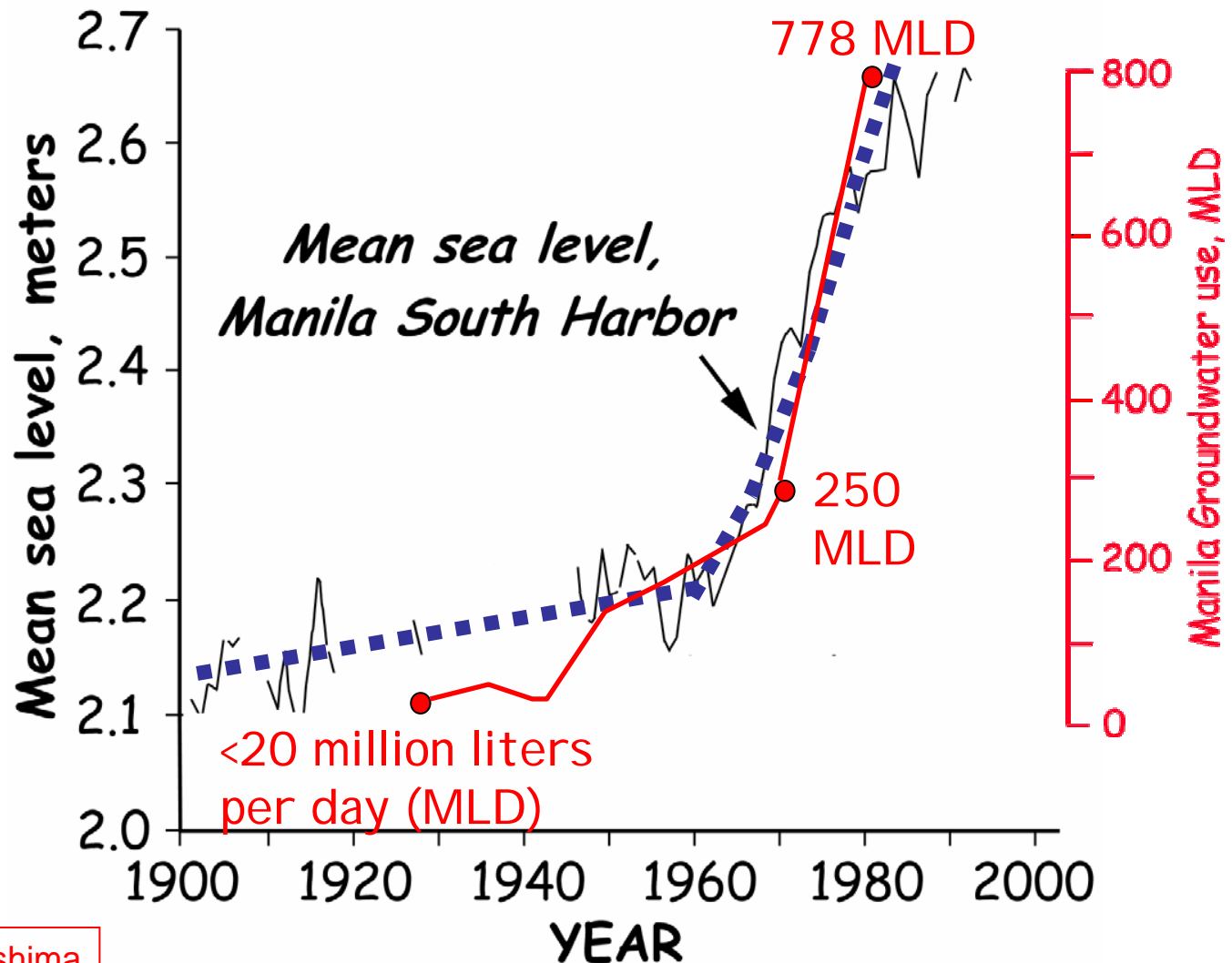
Increase in highest tide, 1991-2002 (meters)

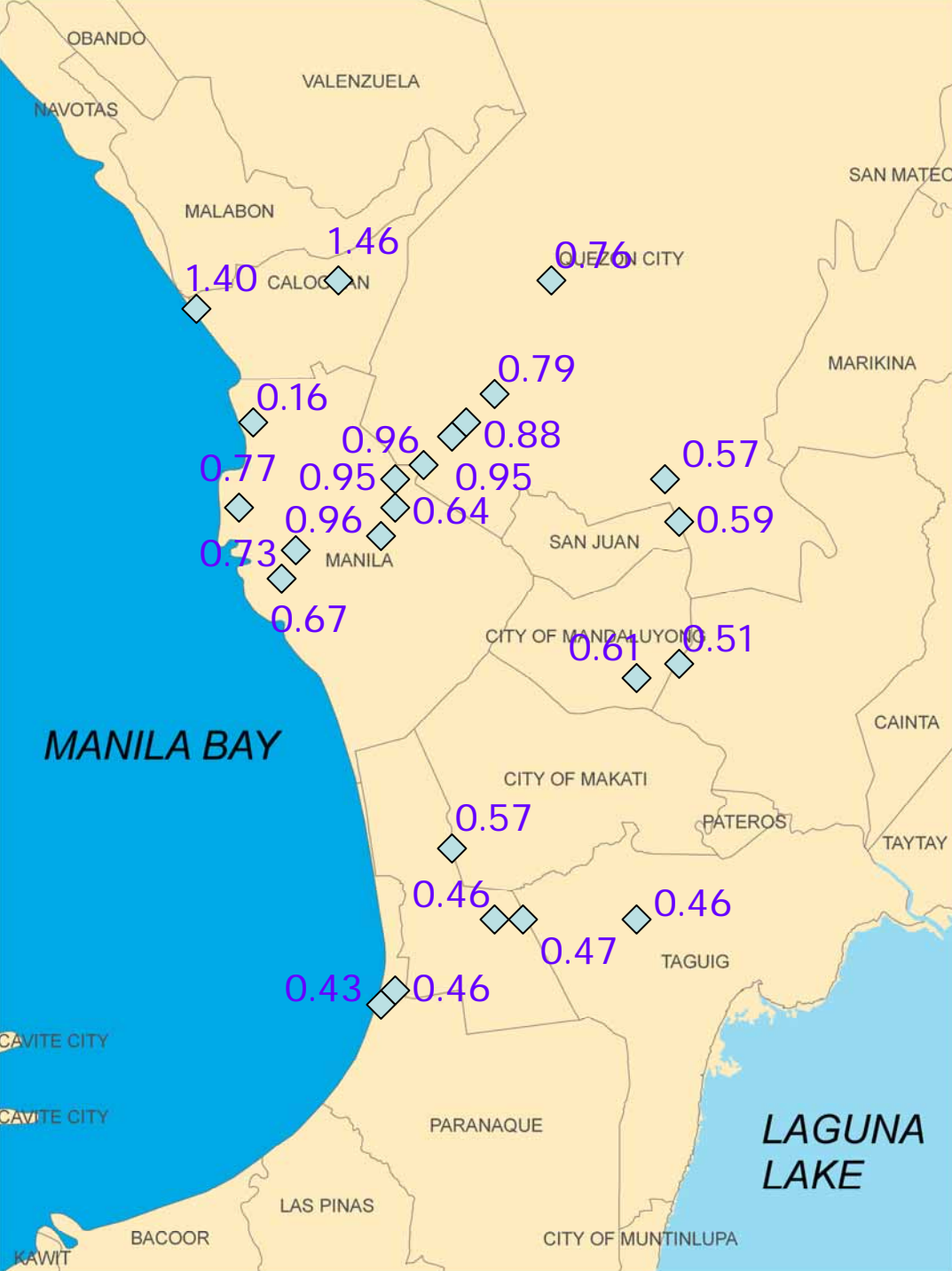


At Manila's South Harbor mean sea level rose at about 2 millimeters per year from 1902 to the early 1960's. . . . then started rising ten times as fast. **WHY?**

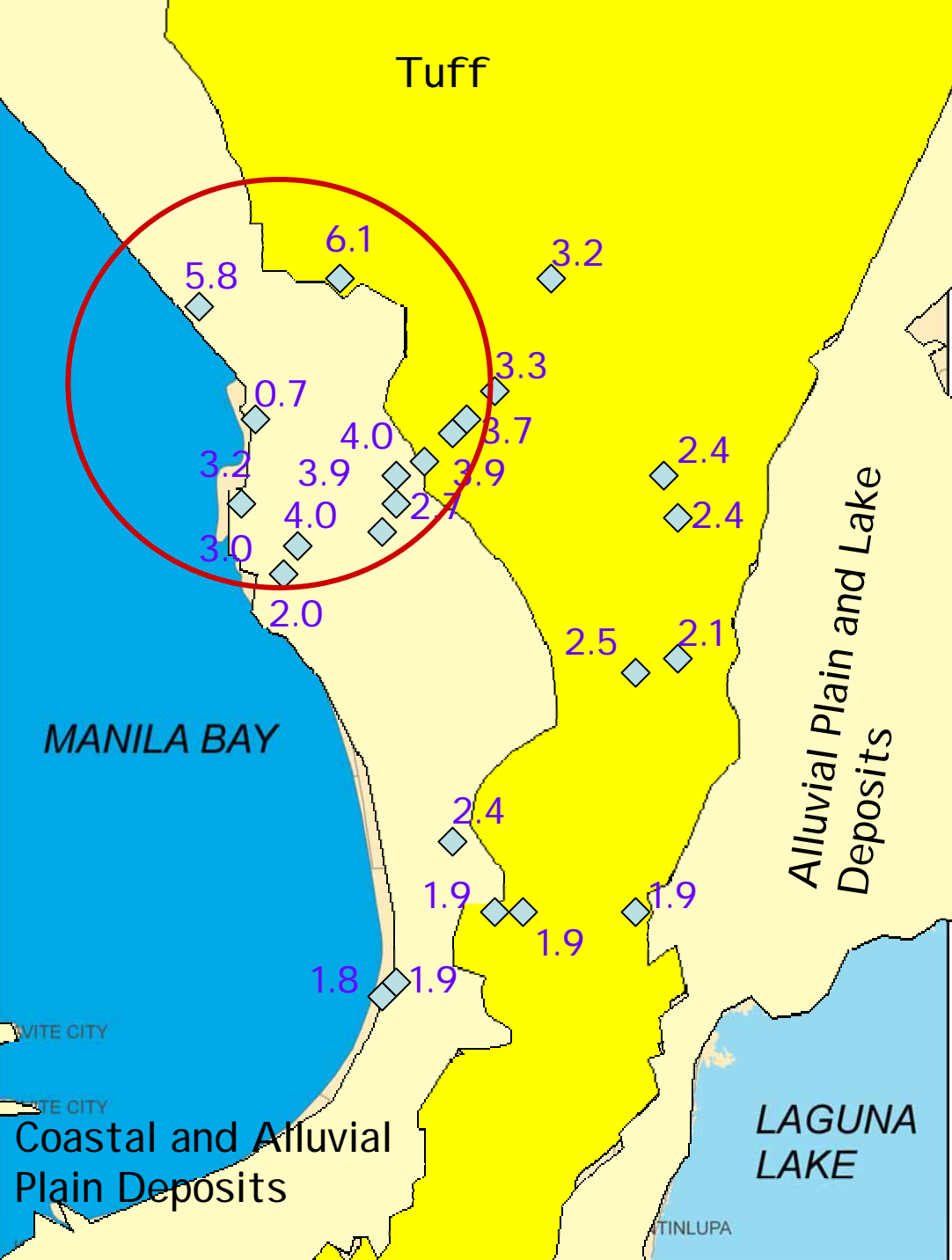
Groundwater withdrawal!

However, JICA (1992) asserted that subsidence due to groundwater withdrawal is not likely as the aquifer system is comprised predominantly by volcanic tuff.

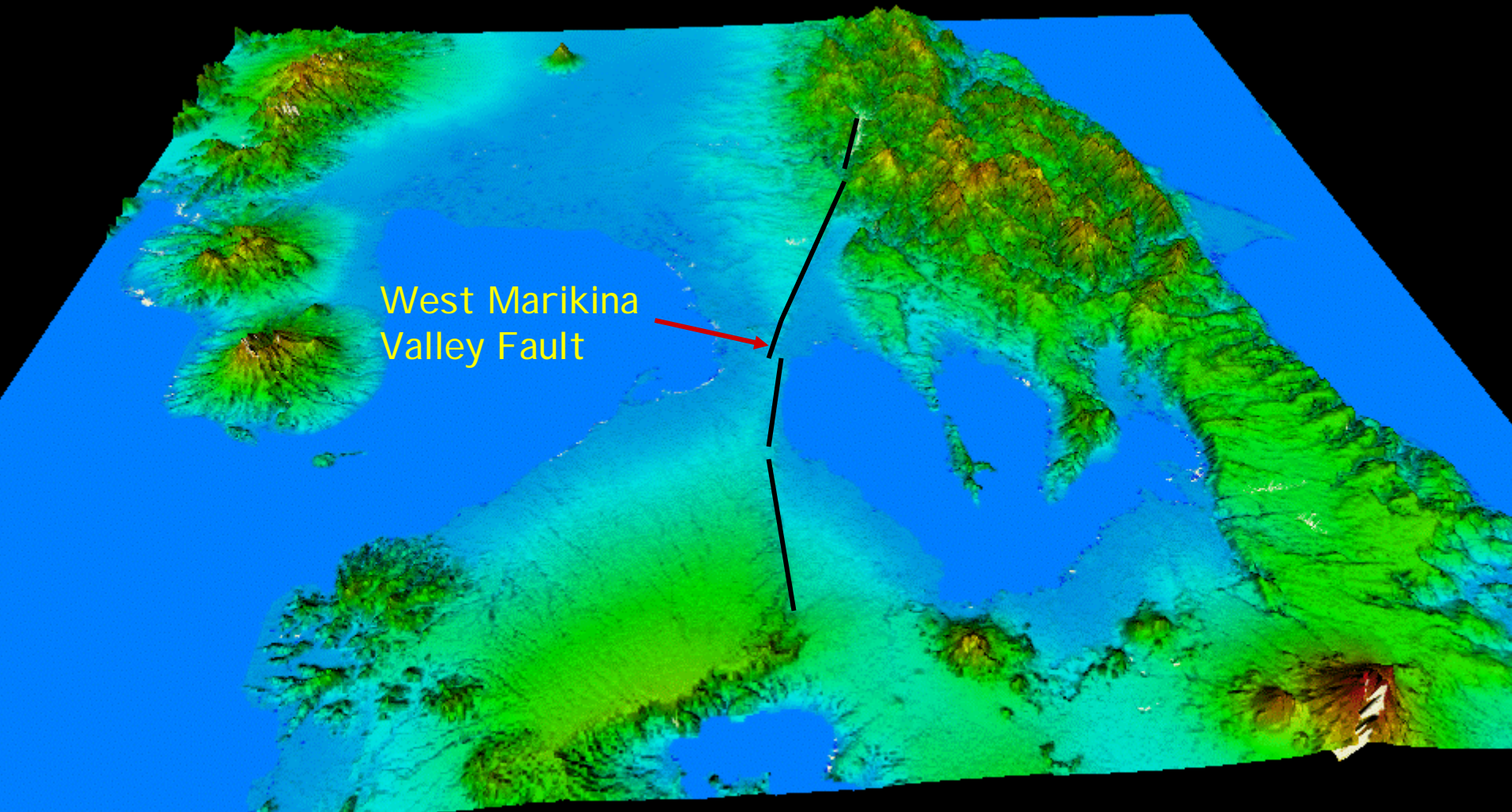




Magnitude of subsidence (in meters) from 1978 to 2000 from re-leveling data (Jacob 2004)

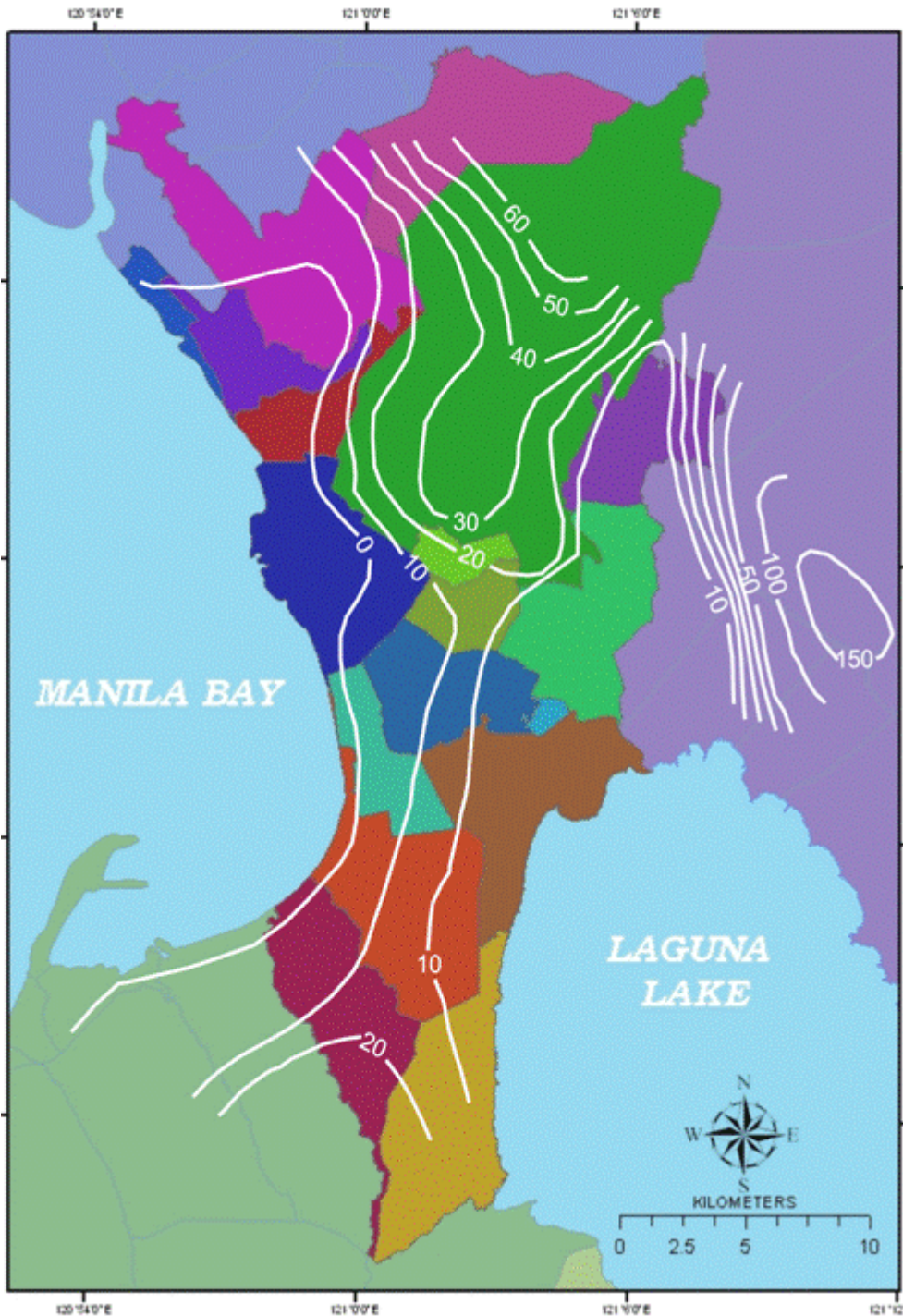


Average rate of subsidence (in cm) from 1978 to 2000 from re-leveling data (Jacob 2004)



West Marikina
Valley Fault

Ground deformation due to differential compaction resulting in formation of fissures and sag ponds following the shears of the West Marikina Valley Fault



Piezometric Level 1951 (NHRC, 1991)

Metro Manila Water Demand

(JICA, 1992 and CEST, 2004)

- 1,278 M³m in 1990 (7.9 million people)
 - 361 M³m from groundwater
- 328 M³m abstracted by private wells

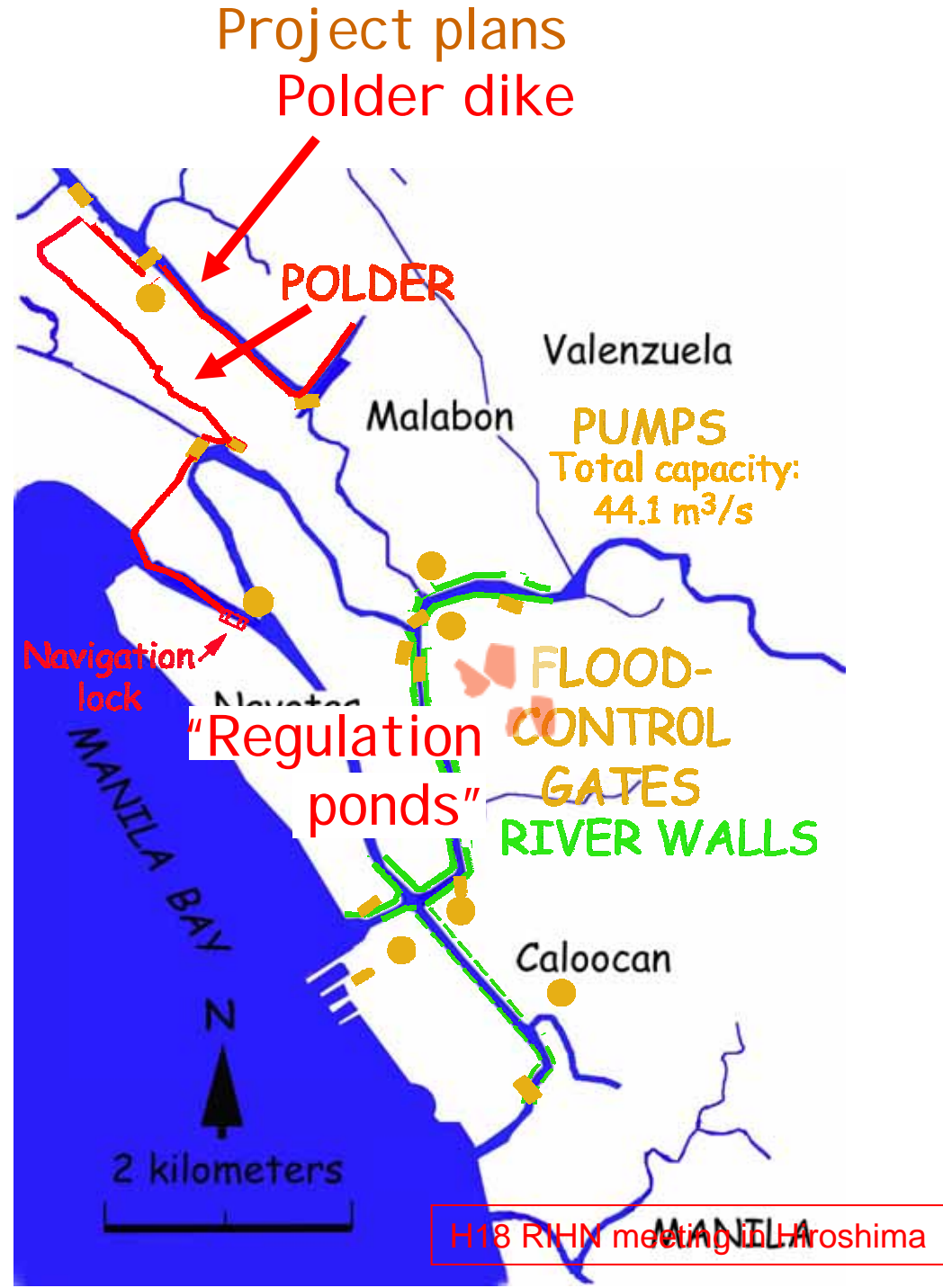
- 2,140 M³m in 2004 (10.2 million people)
 - 680 M³m from groundwater
- 647 M³m abstracted by private wells

Annual recharge, given the land use and climatological conditions in 1990, is estimated to be at 206 MCM

CAMANAVA Flood Control Project

Project design
assumes that
subsidence -

- is in the order of
a few millimeters
per year
- that the rate is
relatively uniform
across
- will be even more
minimal in the
coming years



Project design says top of new dike is 2.60 m above MLLW so old wall which was supposed to be at 2.25 m above MLLW

But highest tide of 1.52 above MLLW in 10 August 2006 overtopped the top of the river old wall

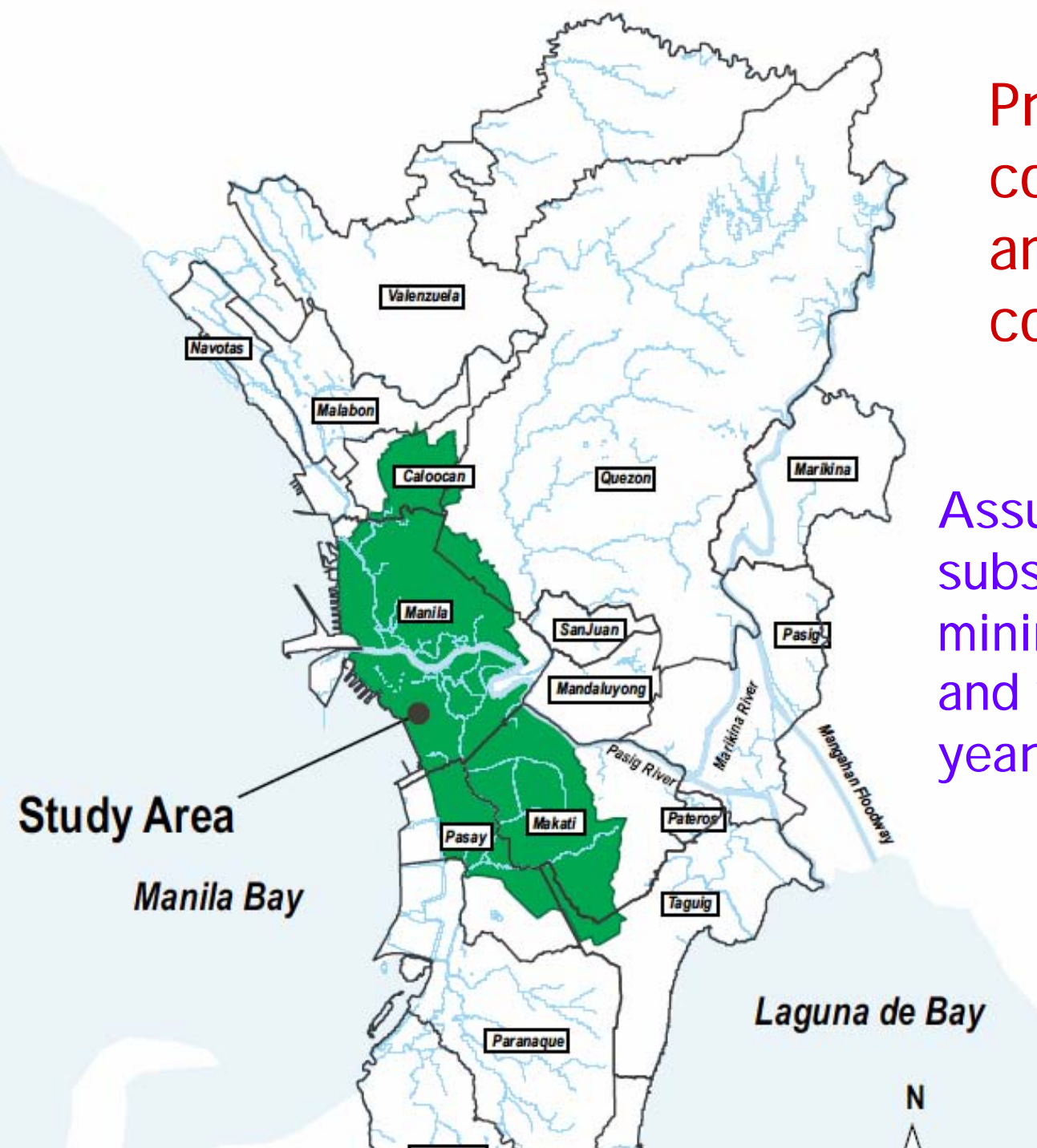
Site of 10 August 2006 tide monitoring

River wall with newly raised top 35 cm from top of old wall

Segment of River in CAMANAVA about 850 meters from the coast

Proposed area of coverage of another flood control project

Assumes that subsidence has been minimal in recent years and will be in coming years



Subsidence due to over extraction of groundwater appears to be a major contributor to the worsening floods in Metro Manila.

But this relationship is still poorly understood.

There is an urgent need to understand it better so development of Metro Manila can be better planned and implemented.

We would like to employ SAR interferometry combined with GPS and Total Station re-leveling of selected benchmarks in Metro Manila.