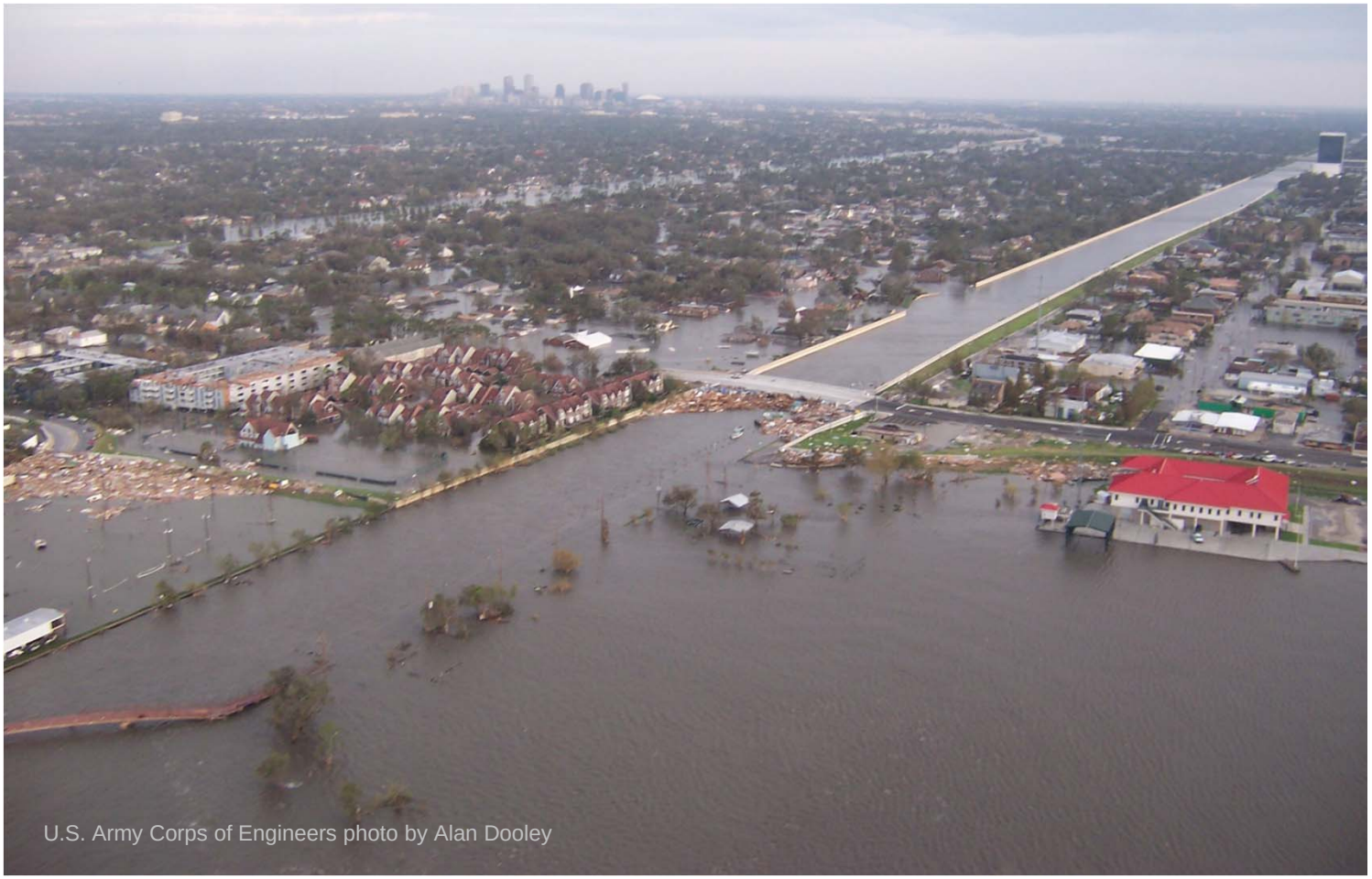
Role of Geologists in Flood Control



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Role of Geologists in Flood Control

- **Provide the Long Term Perspective**
- **Provide a Perspective on Expected Variability**
- **Provide Link Between Science & Engineering**

Provide the Long Term Perspective

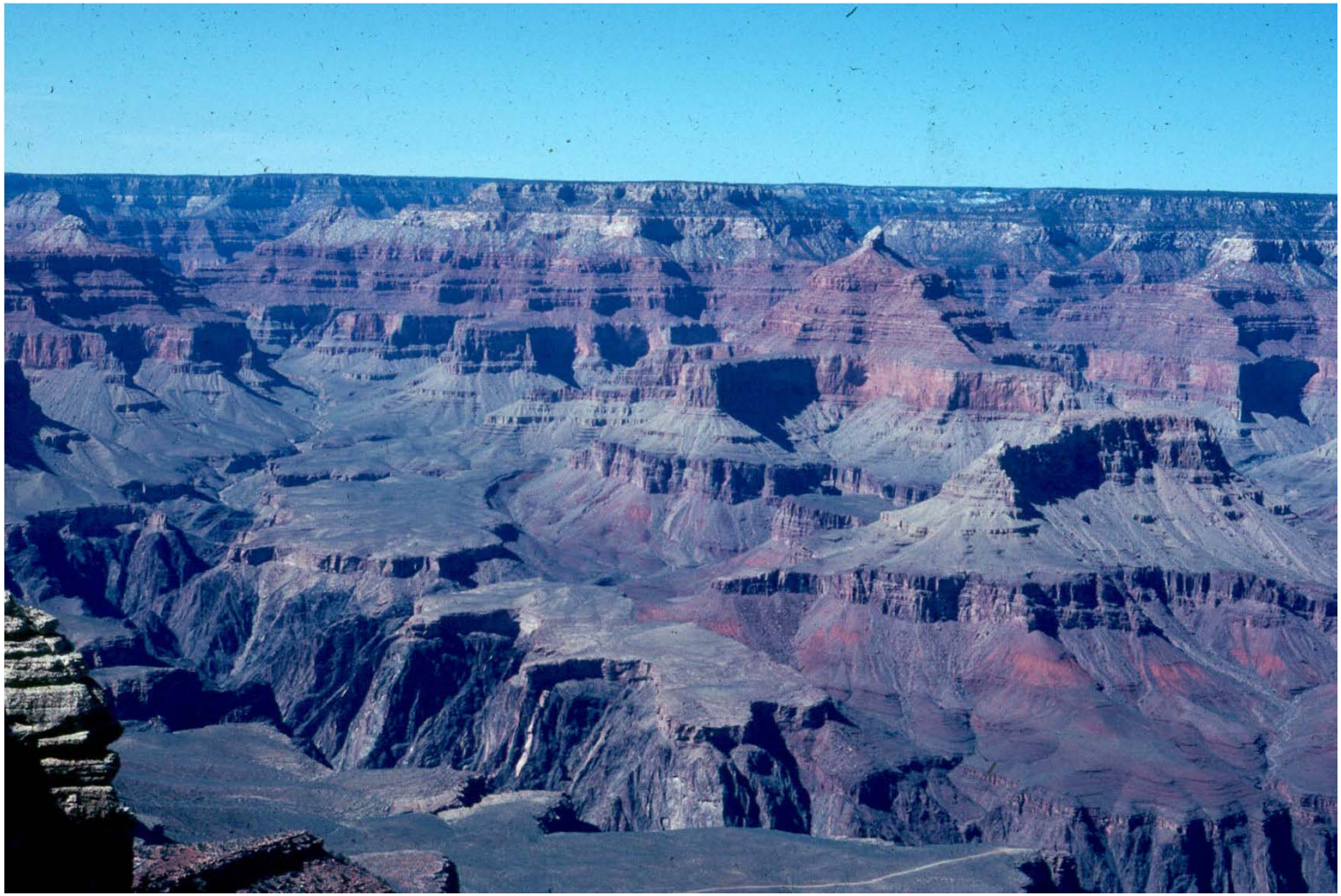
The Earth is Very Old

- Natural Disasters – Result from natural processes that have operated on Earth for the last 4.6 billion yrs.
- Geologists have a unique perspective - We can “see” into the past by studying deposits or structures created by Pre-historic events.
- Large events occur on time scales greater than human lifetimes or human recorded history.
- If an event has occurred in human history it will likely occur again in the near future.

Provide the Long Term Perspective

Water is powerful!

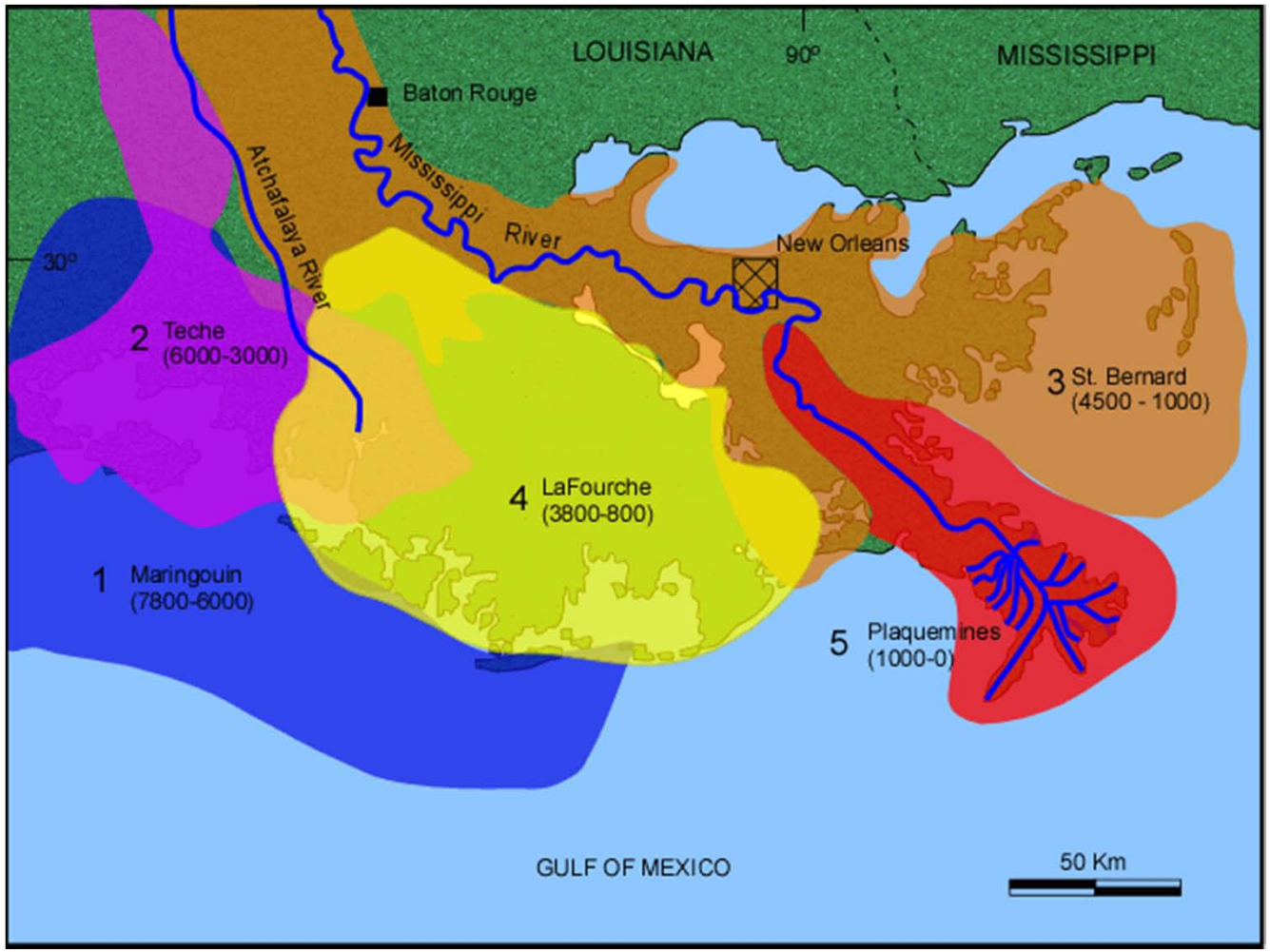
It has the power to erode -



Provide the Long Term Perspective

Water is powerful!

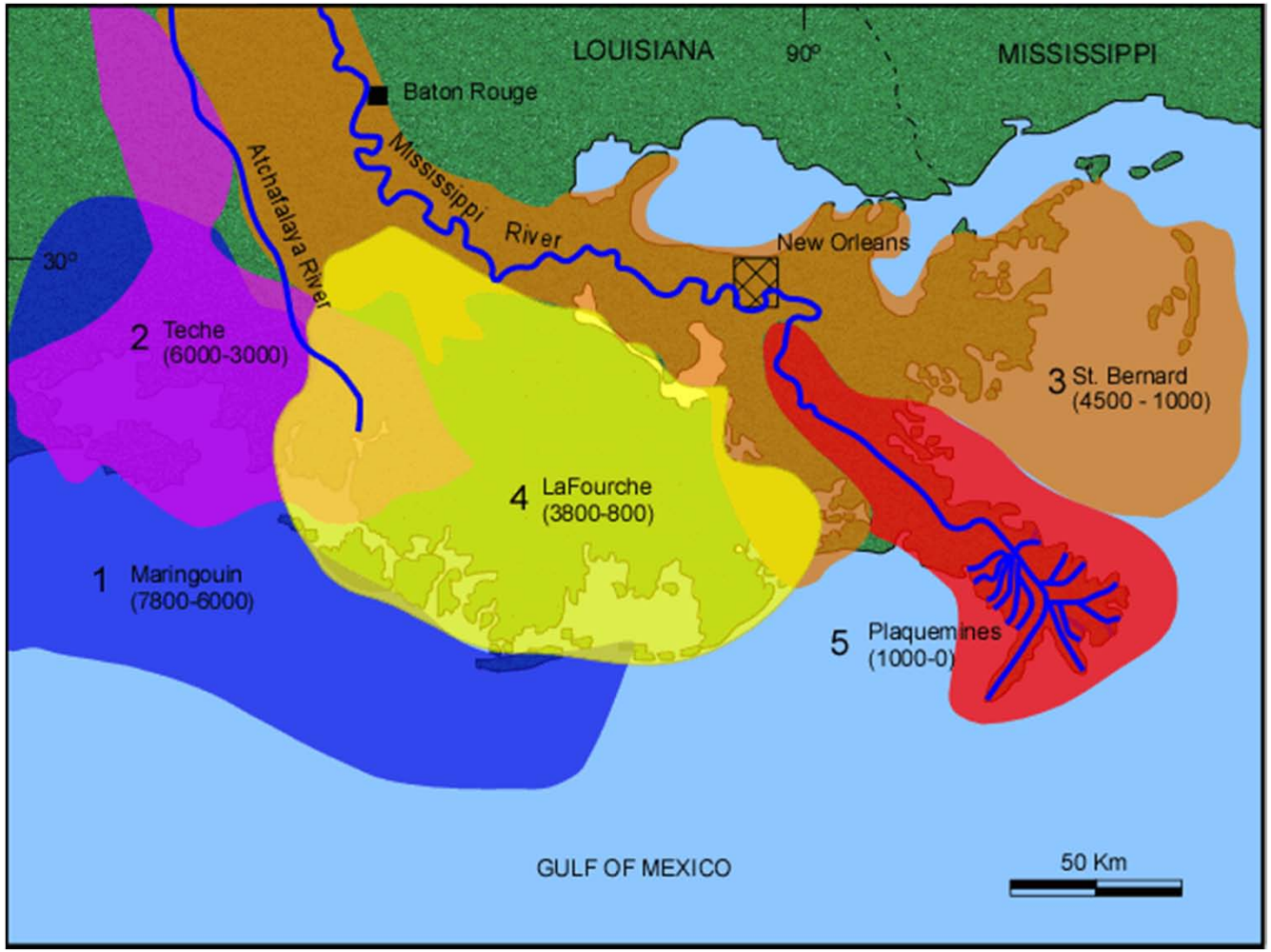
And it has the power to carry and deposit sediment



Provide the Long Term Perspective

Water is powerful!

All of South Louisiana has been created (and partially removed) by water in the last 10,000 years!



Provide the Long Term Perspective

Water is powerful!

Flood control is the constant battle between natural processes and human desires.

In the long run – natural processes will win

The geologist's role is to provide the insight to help us hold off nature for as long we can afford to do so.

Provide the Long Term Perspective

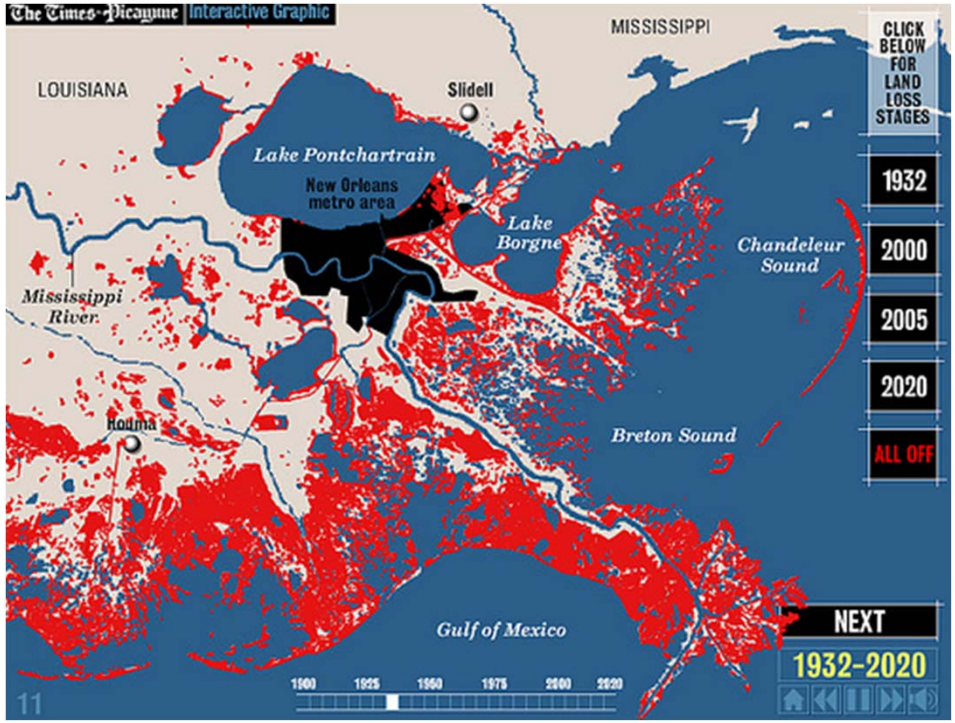
Adverse Consequences of Flood Control

Flood control structures (levees) deprive the delta of sediment

Without sediment supply, land subsides

Subsidence (among other things) results in coastal land loss

Land loss increases susceptibility to flooding from hurricanes



Provide the Long Term Perspective

Sediment is the Key

To hold off coastal erosion we need sediment

Sediment source is the river – it built the coast to begin with!

Geologists can provide the perspective to tell us where to put the sediment or breach the levees so it will do the most good

Provide the Long Term Perspective

Adverse Consequences of Flood Control

Subsidence + Sea Level Rise means we will eventually have to build higher levees

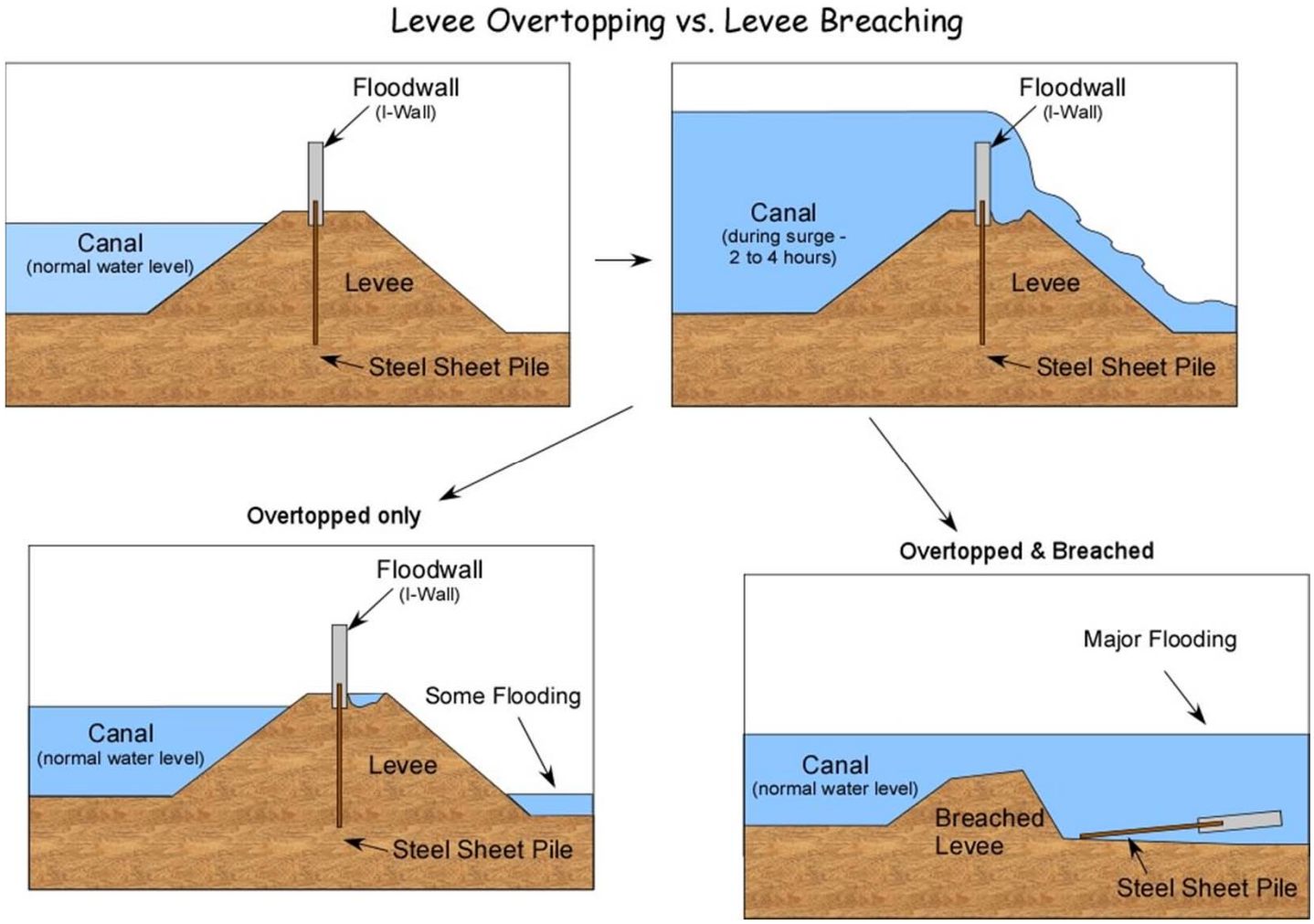
When this becomes cost prohibitive, we will start to lose the battle unless we develop new ideas.

Provide the Long Term Perspective

Water is powerful!

Even with higher levees, they will eventually be overtopped

But, overtopping should be less severe than levee breaching



Provide the Long Term Perspective

Water is powerful!

Katrina taught us that breaches caused by erosion due to overtopping can be catastrophic

Provide the Long Term Perspective

Water is powerful!

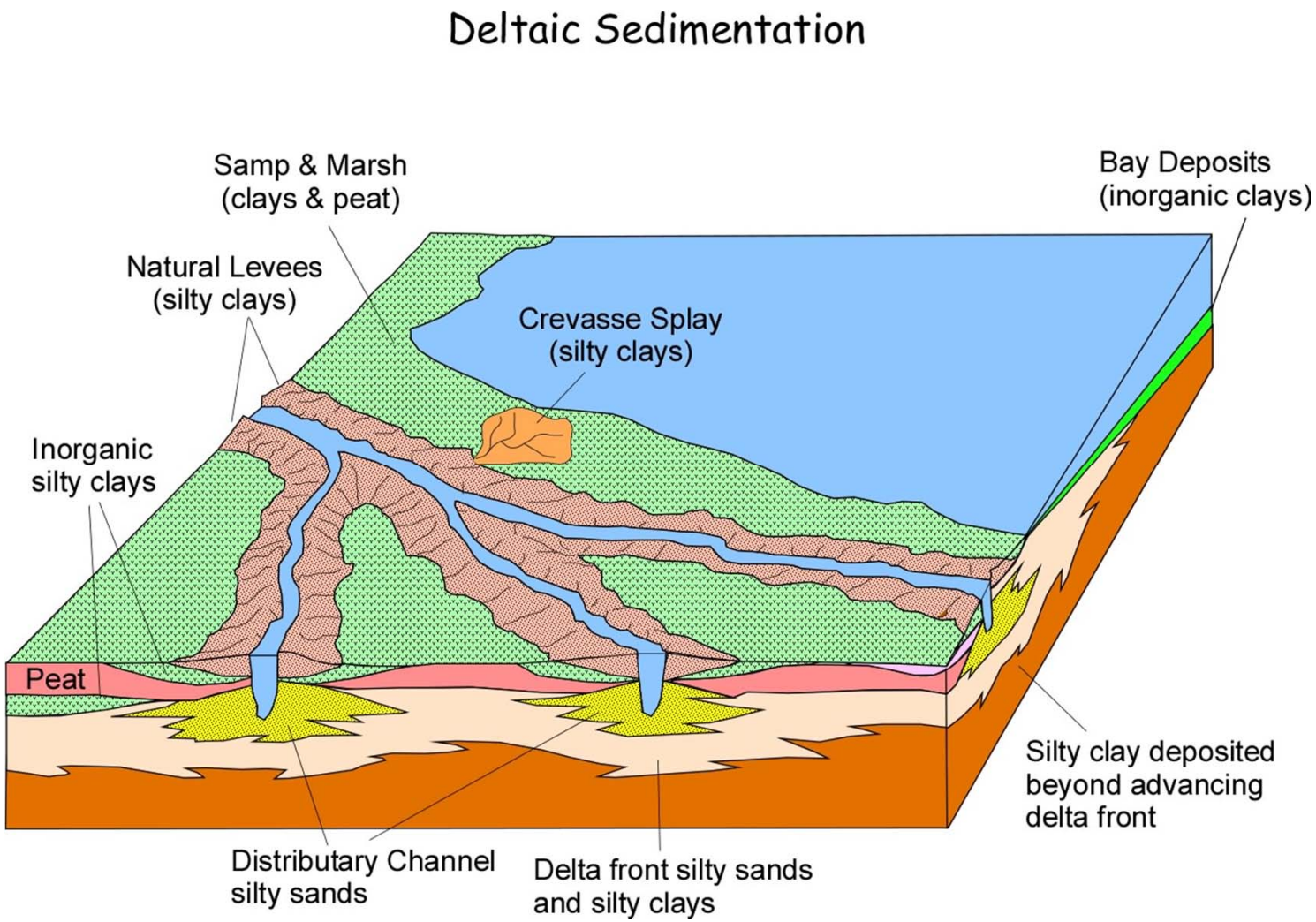
Relatively inexpensive armoring on tops of levees or splash pads at the base of floodwalls help prevent catastrophic failures from overtopping

Perspective on Subsurface Variability

Although geologists often show layering in the subsurface as horizontal layers of uniform thickness, such as we might see in the Grand Canyon …..

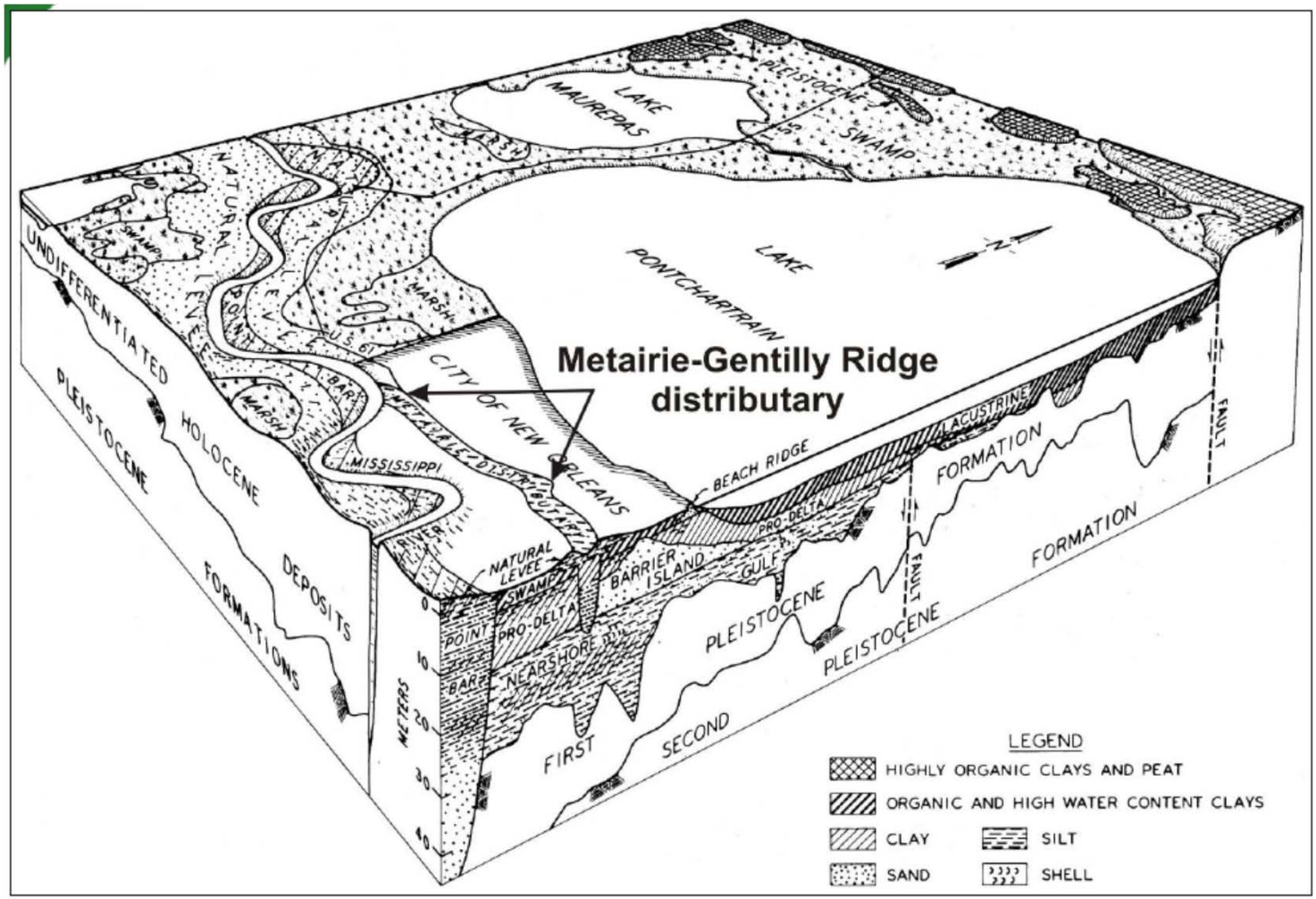
Perspective on Subsurface Variability

Deltaic sedimentary layering, such as we have in Louisiana, is much more complex!



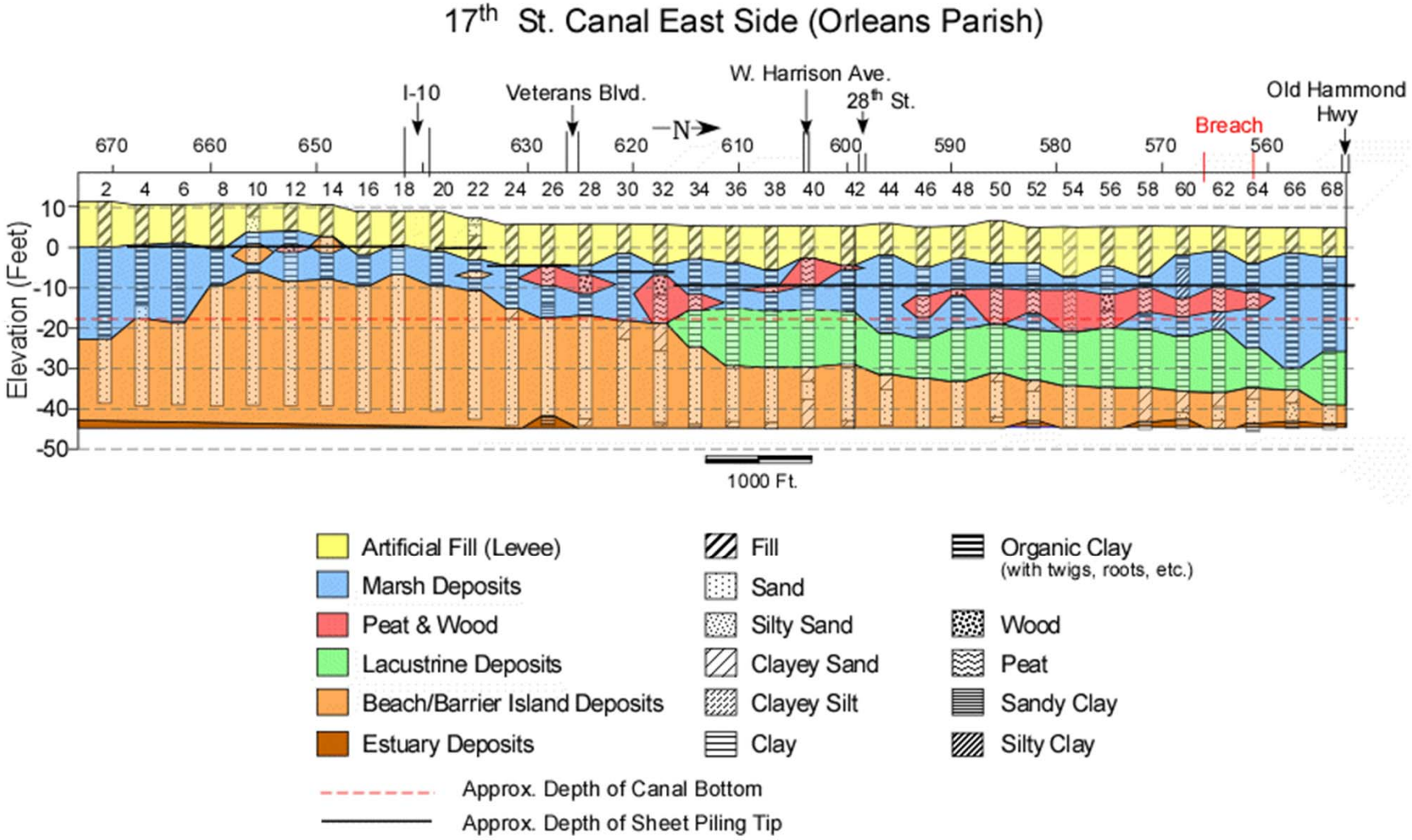
Perspective on Subsurface Variability

Different rock/soil layers are cut by channels, layers interfinger with one another, and layers change character horizontally on scales of a few feet.



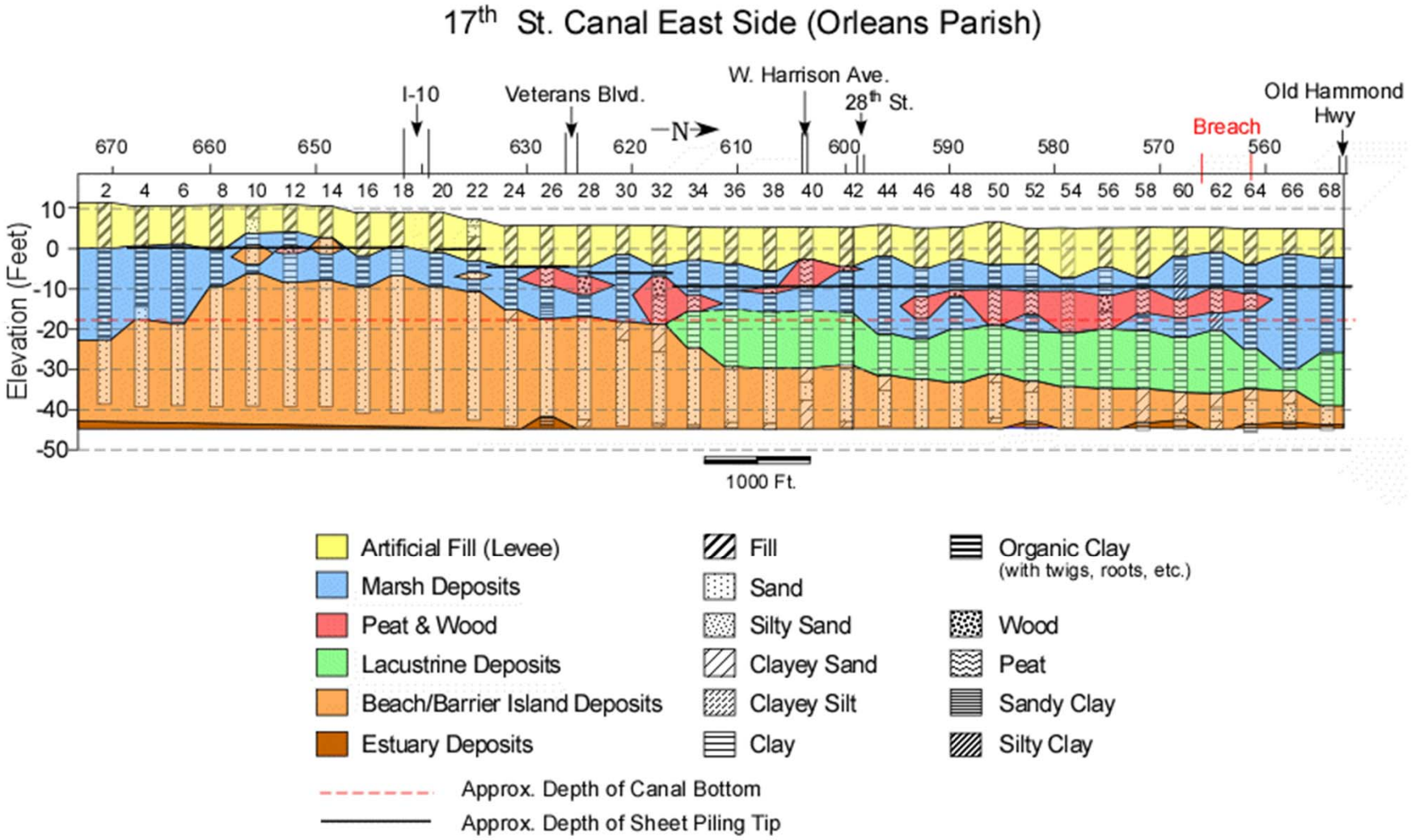
Perspective on Subsurface Variability

The complexity is seen in cross-sections based on boreholes usually spaced a few hundred feet apart, but this will not show variability on a scale of a few feet.



Perspective on Subsurface Variability

Since floodwall designs are based on the strength of the soils, and strengths may vary laterally, the variability must be taken into account



Perspective on Subsurface Variability

Since it is cost prohibitive to drill boreholes spaced a few feet apart, other measures must be undertaken to account for the variability.

Engineers take the variability into account by designing flood control structures to have a factor of safety, F_s, greater than 1

$$F_s = \text{Strength/Expected Forces}$$

If $F_s < 1$, the forces are greater than the strength – structure will fail

If $F_s > 1$, the strength is greater than the forces - structure is stable

To account for possible errors in knowledge of the strength or forces, USACE specifies minimum F_s of 1.3 (thus allowing for a 30% error).

Perspective on Subsurface Variability

F_s = Strength/Expected Forces

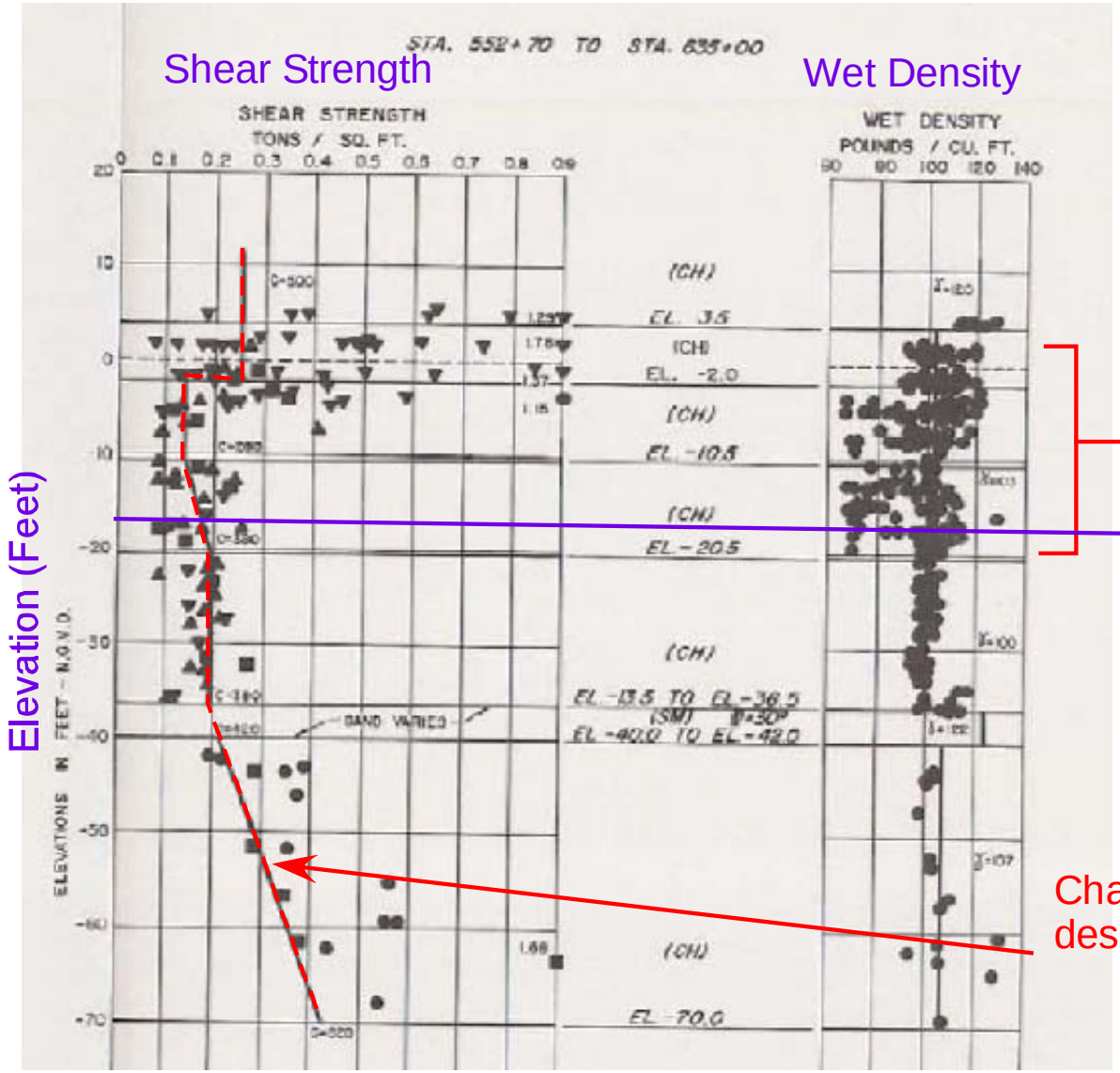
If the variability of the soils is more than 30% along a section between boreholes, as it might be because of variability in the type, strength, or water content of the soils, then a minimum F_s of 1.3 is not adequate.

The Katrina levee/floodwall failures, showed us that the variability in soil strength under some levees in New Orleans is greater than 30%.

Geologists can provide a reminder that a minimum F_s of 1.3 is not adequate to protect lives and property.

Perspective on Subsurface Variability

Shear Strength and Density of Samples Along 8,200 Foot Section of 17th St. Canal



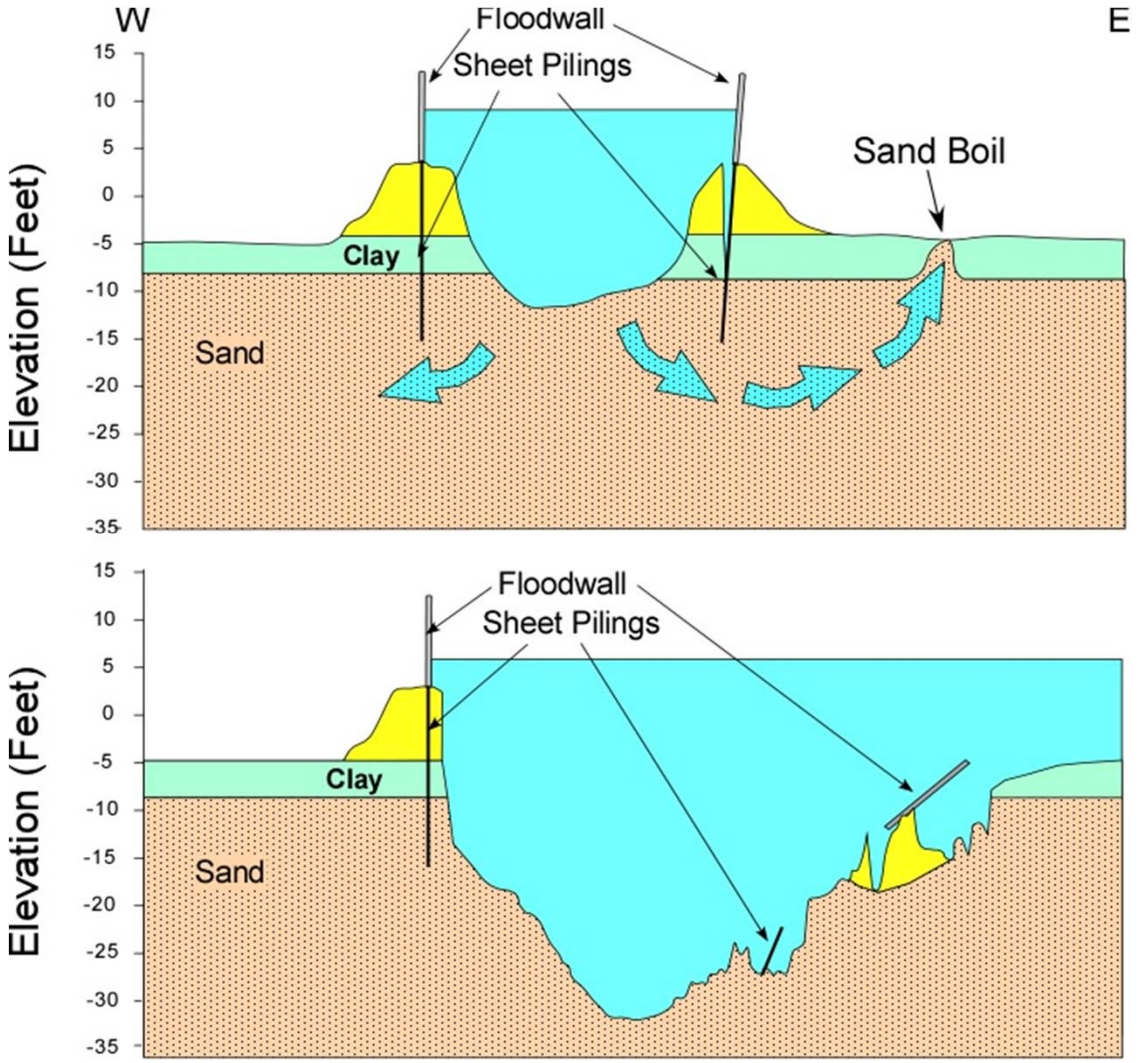
From USACE Design Memorandum 20, 1990 (17th St. Canal)

Link Between Science & Engineering

Some Other Reminders

(Things that everyone should know, but often forget)

Sand **is** permeable to water



Link Between Science & Engineering

Some Other Reminders

(Things that everyone should know, but often forget)

Despite the fact that the 100 year flood/storm has only a 1% chance of occurring each year, the probabilities do accumulate over time.

The probability of a certain-size flood occurring during any period can be calculated using the following equation:

$$P_t = 1-(1-P_e)^n$$

where P_t is the probability of occurrence over the entire time period, n,

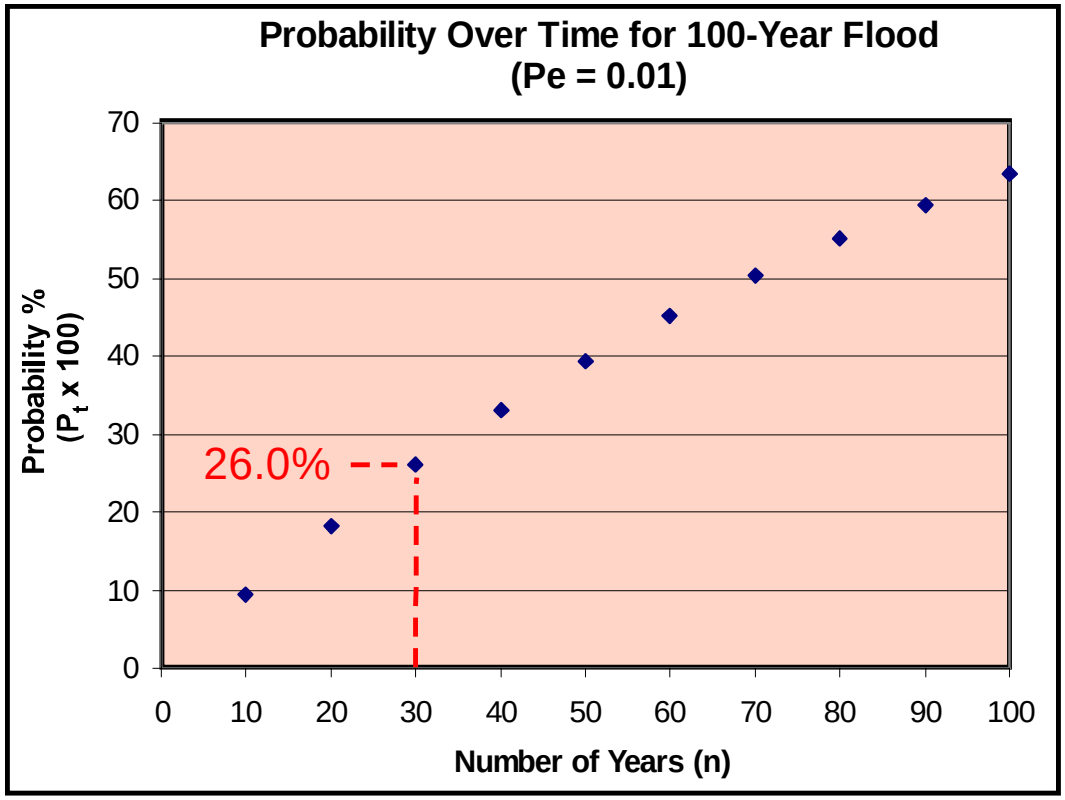
and P_e is the probability of occurrence in any year.

Link Between Science & Engineering

Some Other Reminders

$$P_t = 1-(1-P_e)^n$$

Using this relation, the probability of a 100 year flood occurring in 30 years (the lifetime of the average home mortgage) is 26.0%!



Link Between Science & Engineering

Some Other Reminders

The chain always breaks at its weakest link!

You cannot meaningfully extrapolate a single data point to the rest of the universe (or levee or floodwall, etc.)!

Beware of complacency!

Link Between Science & Engineering

Some Other Reminders

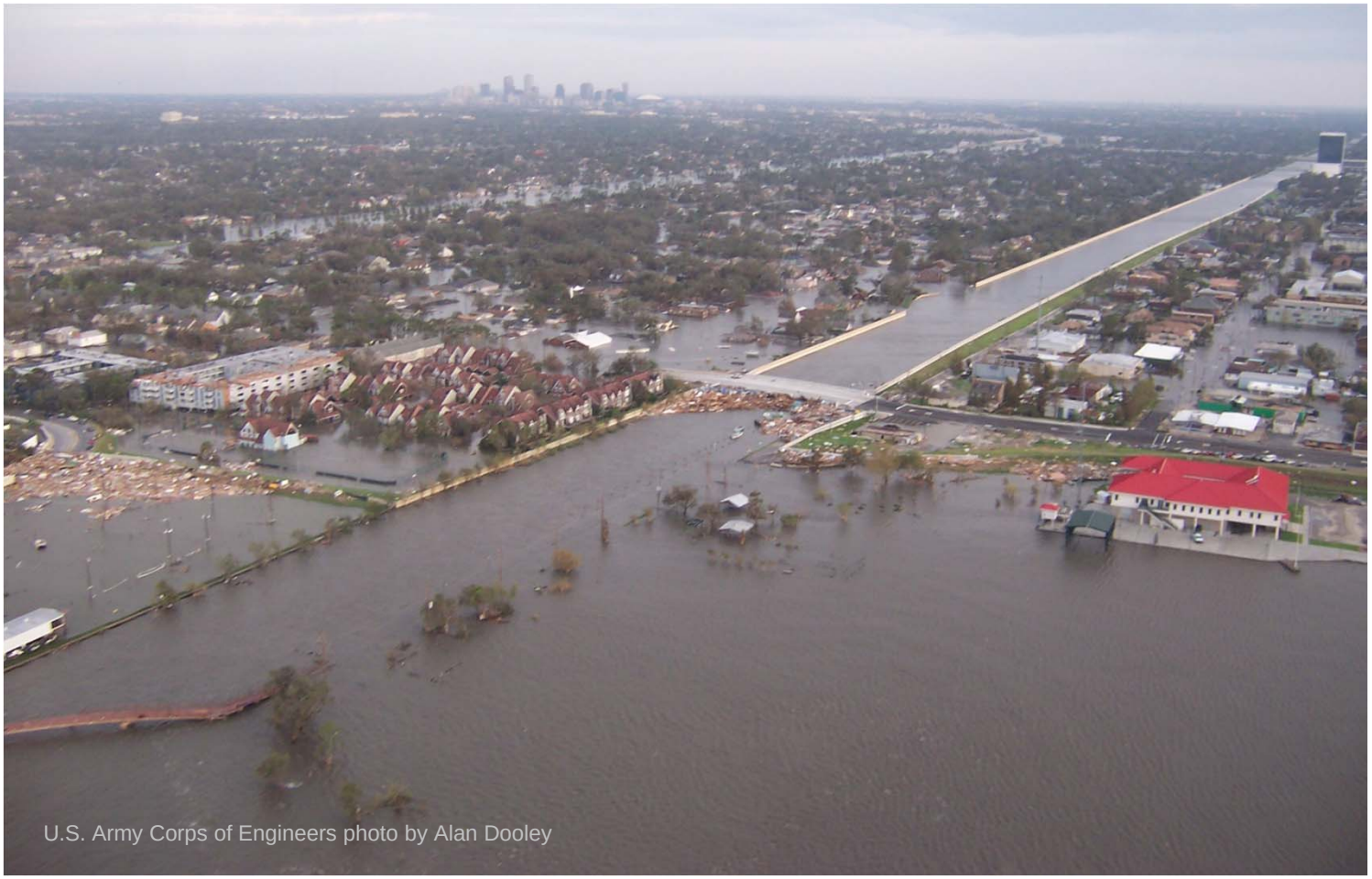
Beware of complacency!

“There hasn’t been a major oil spill in over 20 years”

“There hasn’t been a major nuclear power plant accident in over 25 years”

“There hasn’t been a tsunami that produced waves as high as 30 feet since 869 AD.”

Role of Geologists in Flood Control



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