

# Land Subsidence in Hampton Roads

Summary of USGS Report

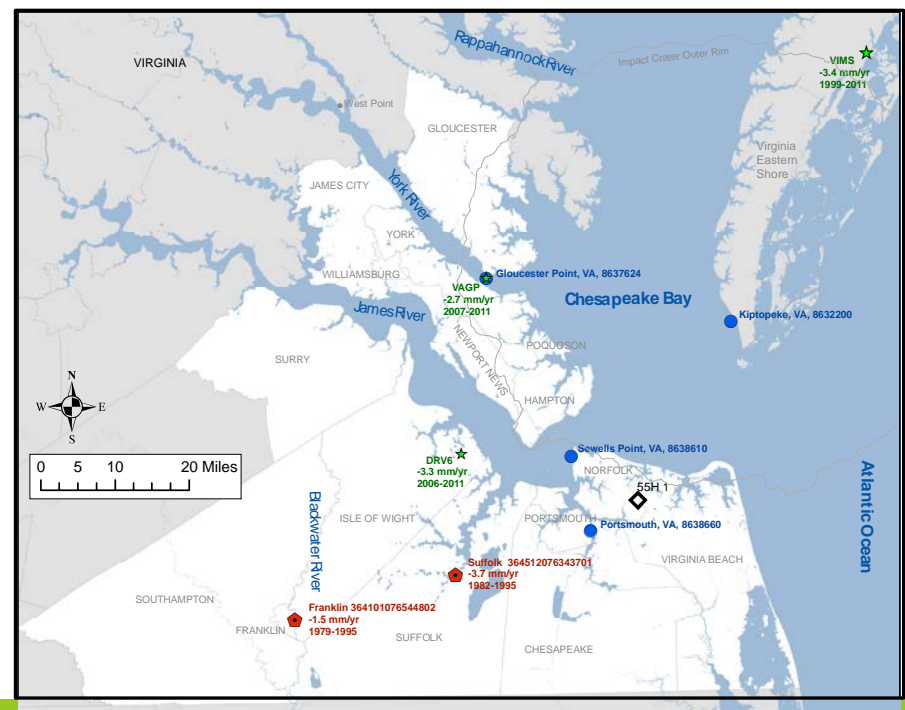
“Land Subsidence and Relative Sea-Level Rise  
in the Southern Chesapeake Bay Region”

Presented to HRPDC Directors of Utilities Committee  
Whitney Katchmark, Principal Water Resources Engineer

January 8, 2014



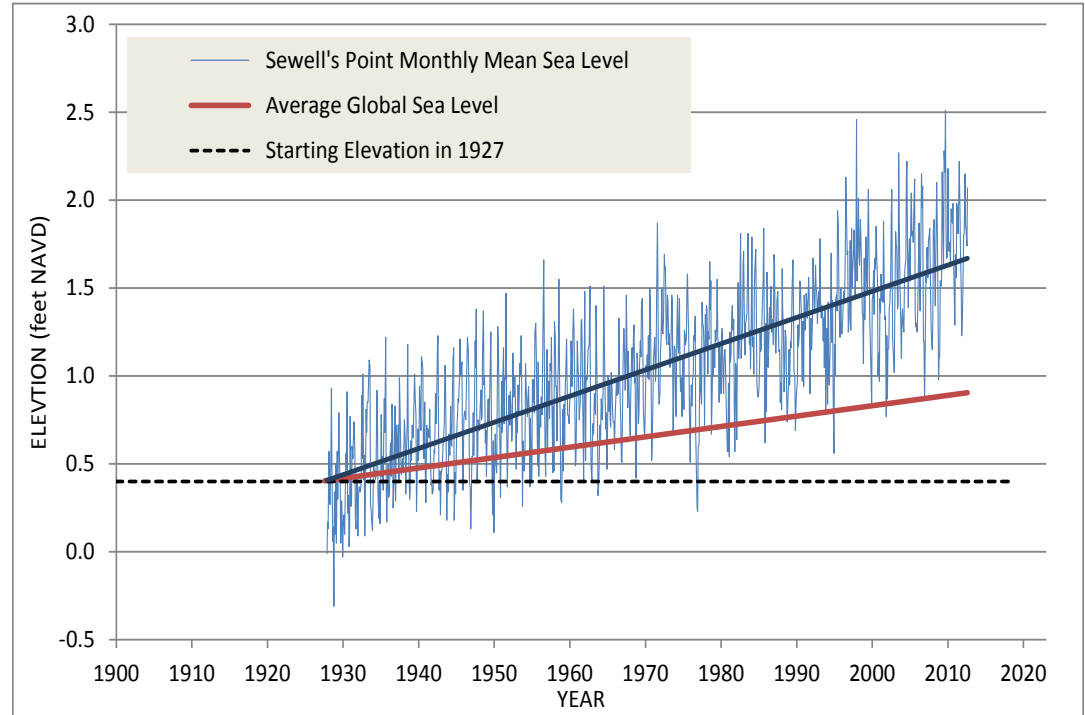
# Measurements of relative sea-level rise at NOAA tidal stations



Site name	Period	Rate of relative sea-level rise	
		Measured (mm/yr)	95% Confid Interval (mm)
Kiptopeke	1951–2006	3.5	±0.42
Gloucester Point	1950–2006	3.8	±0.47
Sewells Point	1927–2006	4.4	±0.27
Portsmouth	1935–2006	3.8	±0.45
<b>Average</b>		<b>3.9</b>	<b>±0.40</b>

# High rate of relative sea level rise in Hampton Roads

- Relative sea level rise in region is 3.9 mm/year compared to global average of 1.8 mm/year.
- Land subsidence was theorized to be the reason regional rates are roughly 2x greater than global average.
- USGS report summarizes available measurements of land subsidence.



*Tidal stations measurements of sea levels do not distinguish between water that is rising and land that is sinking.*

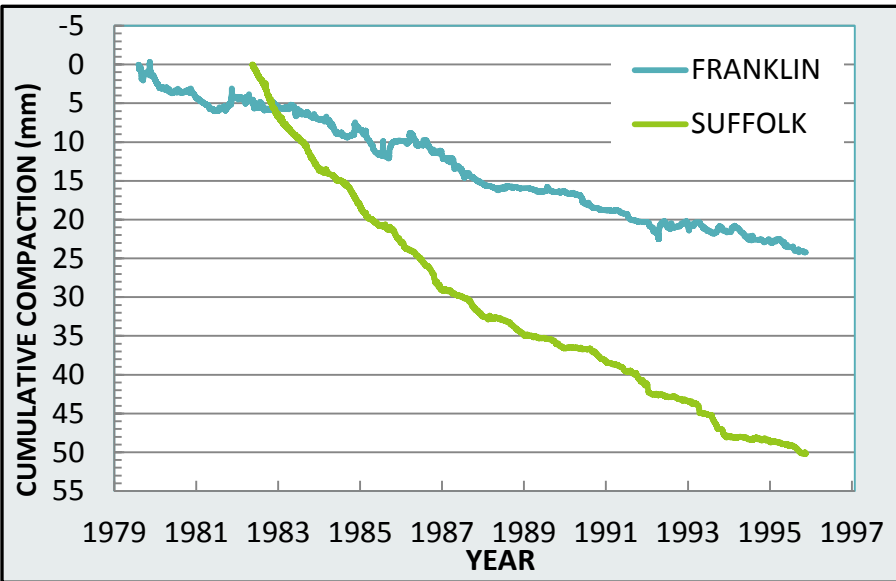
# Measurements of land subsidence in Hampton Roads

What was measured	Monitoring technique	Number of stations	Period	Average Rate (mm/year)
Aquifer compaction	Extensometer	2	1979-1995	-2.6
Land subsidence	Geodetic survey	17	1940-1971	-2.8
Land subsidence	Fixed GPS	3	2006-2011	-3.1

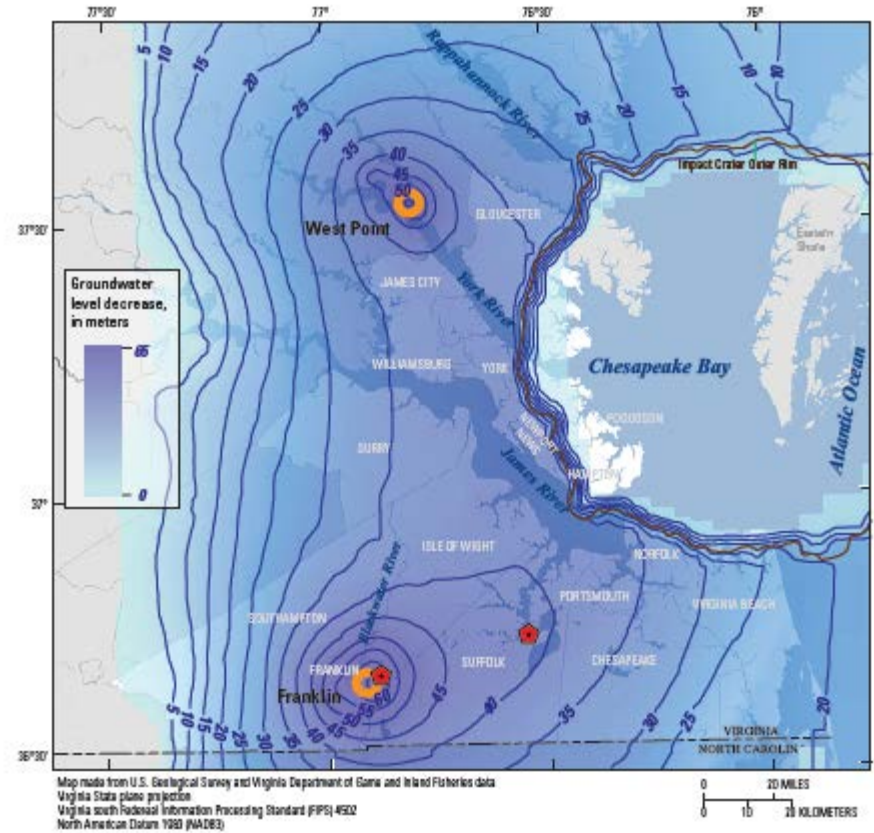
“There are some inconsistencies between measured subsidence rates, which are expected given the variety of data, the different times of measurement, and the multiple locations measured. However, the data paint a clear overall picture of land subsidence in the region during the past 75 years.

Relative sea level rise has been 3.5 to 4.5 mm/yr. Land subsidence, measured to be 1.1 to 4.8 mm/yr, causes more than half the relative sea level rise. Aquifer compaction estimated to be 1.5 to 3.7 mm/yr can explain the majority of observed land subsidence.”

# Measurements of Aquifer compaction in Hampton Roads



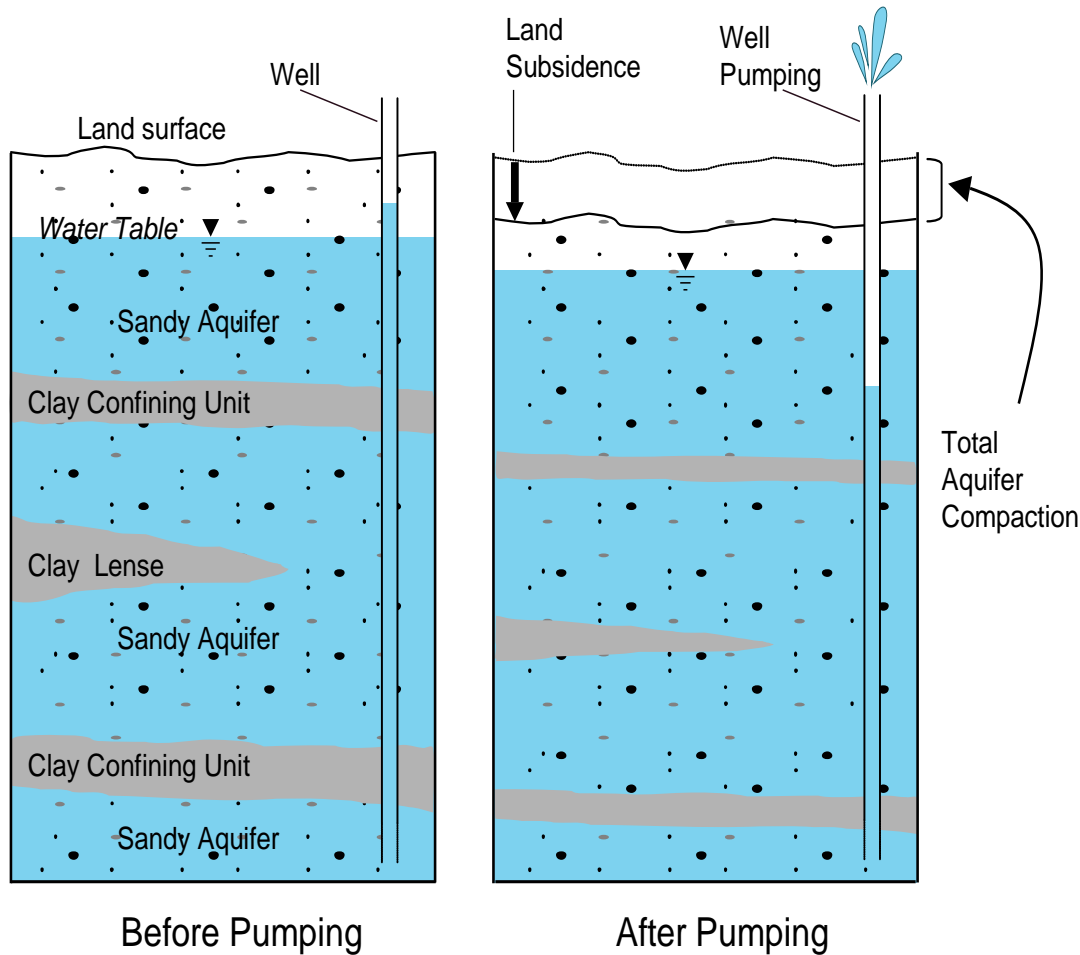
- Equipment was installed in two locations and monitored for roughly 15 years.
- Measurements in Franklin showed 24 mm of compaction (0.9 inches)
- Measurements in Suffolk showed 50 mm of compaction (2 inches)



Monitoring locations were chosen because they are near the largest groundwater withdrawal in region.

# Why do groundwater withdrawals cause subsidence?

## LAYERED AQUIFER SYSTEM

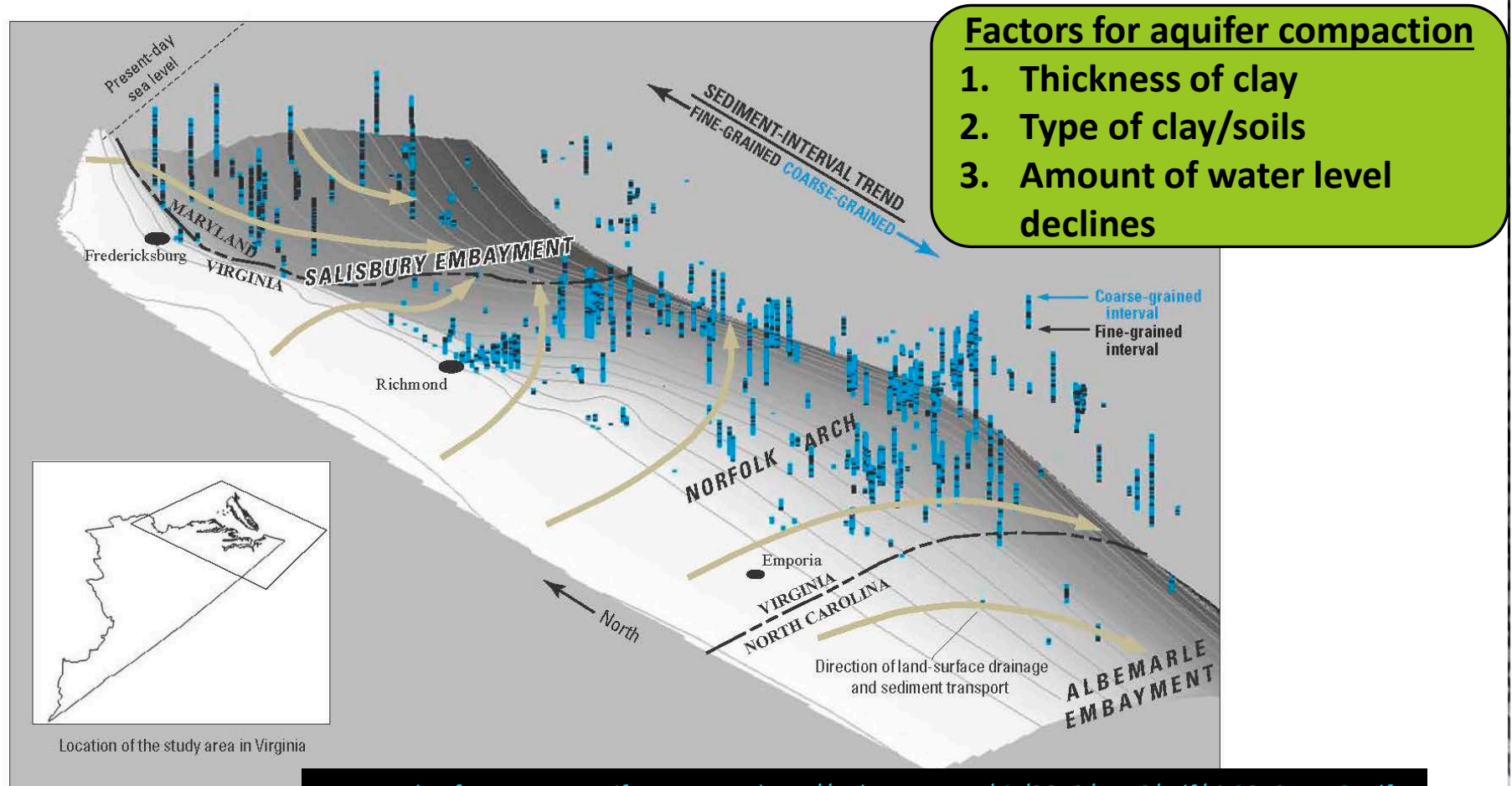


In Hampton Roads, aquifer system is a stack of sand and clay layers.

Pumping from aquifers reduces water pressure in the clay layers and allow them to compress.

# Why should we identify the causes of land subsidence?

- Future rate of land subsidence may not be constant.
- Aquifer compaction will not occur at the same rate across the region.



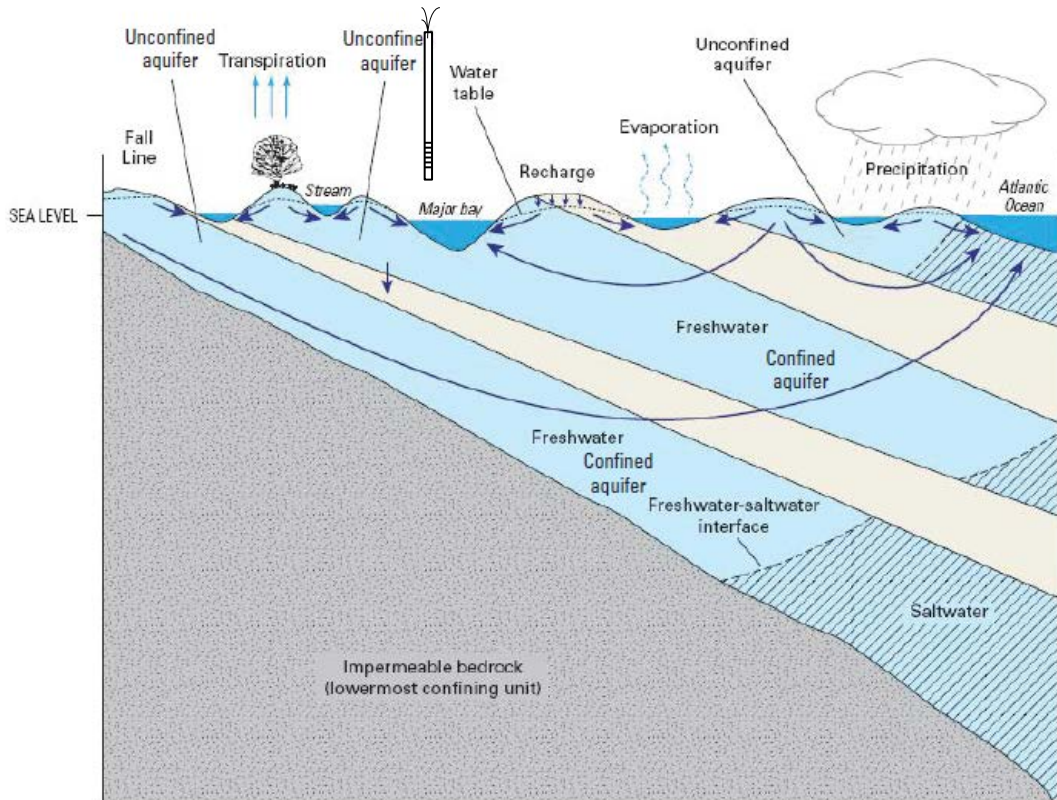
New study of Potomac Aquifer system - <http://pubs.usgs.gov/sir/2013/5116/pdf/sir2013-5116.pdf>

# HRPDC Recommendations

- Support DEQ's budget to incorporate land subsidence into the existing groundwater model.
- Encourage studies of sea level rise impacts and recurrent flooding to consider variable rates of land subsidence.

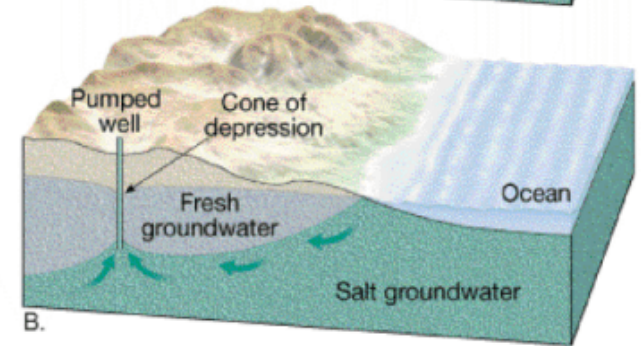
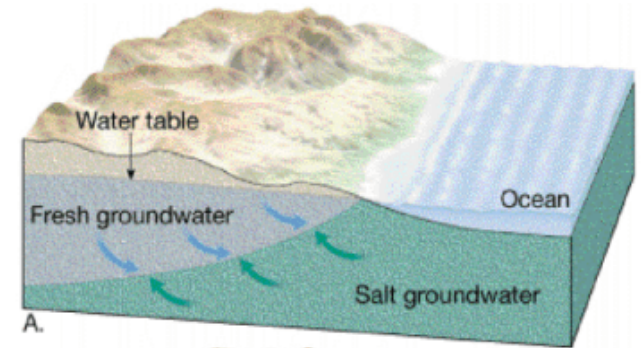


# Saltwater Intrusion Illustrations



Not to scale

Modified from Leahy and Martin (1993)



## EXPLANATION

- Aquifer**
- Confining unit**
- Ground-water flow paths—**  
Shows general direction of ground-water flow