Submarine groundwater discharge off the Suwannee River/estuary

Peter Swarzenski[1], Bill Burnett[2], Kevin Kroeger[1], Chris Reich[1], Ricky Peterson[2], Jason Greenwood[3]

US Geological Survey, St Petersburg[1],

FSU, Tallahassee[2]

SUWANNEE[2] JUNE '05

Talk organization

1-Brief history of SGD

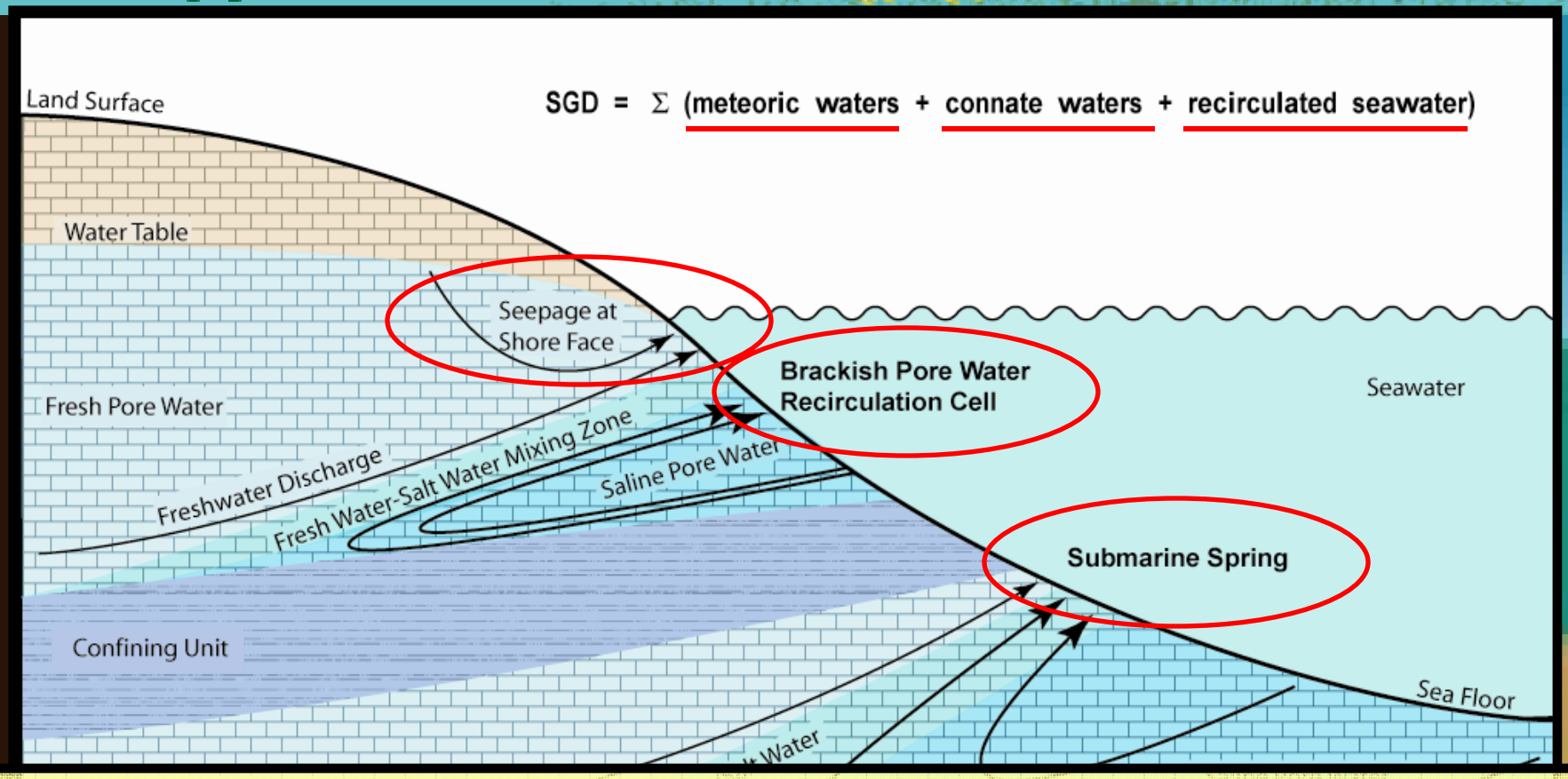
2-Define SGD components, processes, driving forces, and time scales

3-SGD tools: ^{222}Rn, Ra isotopes, CH_4, and streaming resistivity profiling

4-Suwannnee River/estuary

5-Conclusions

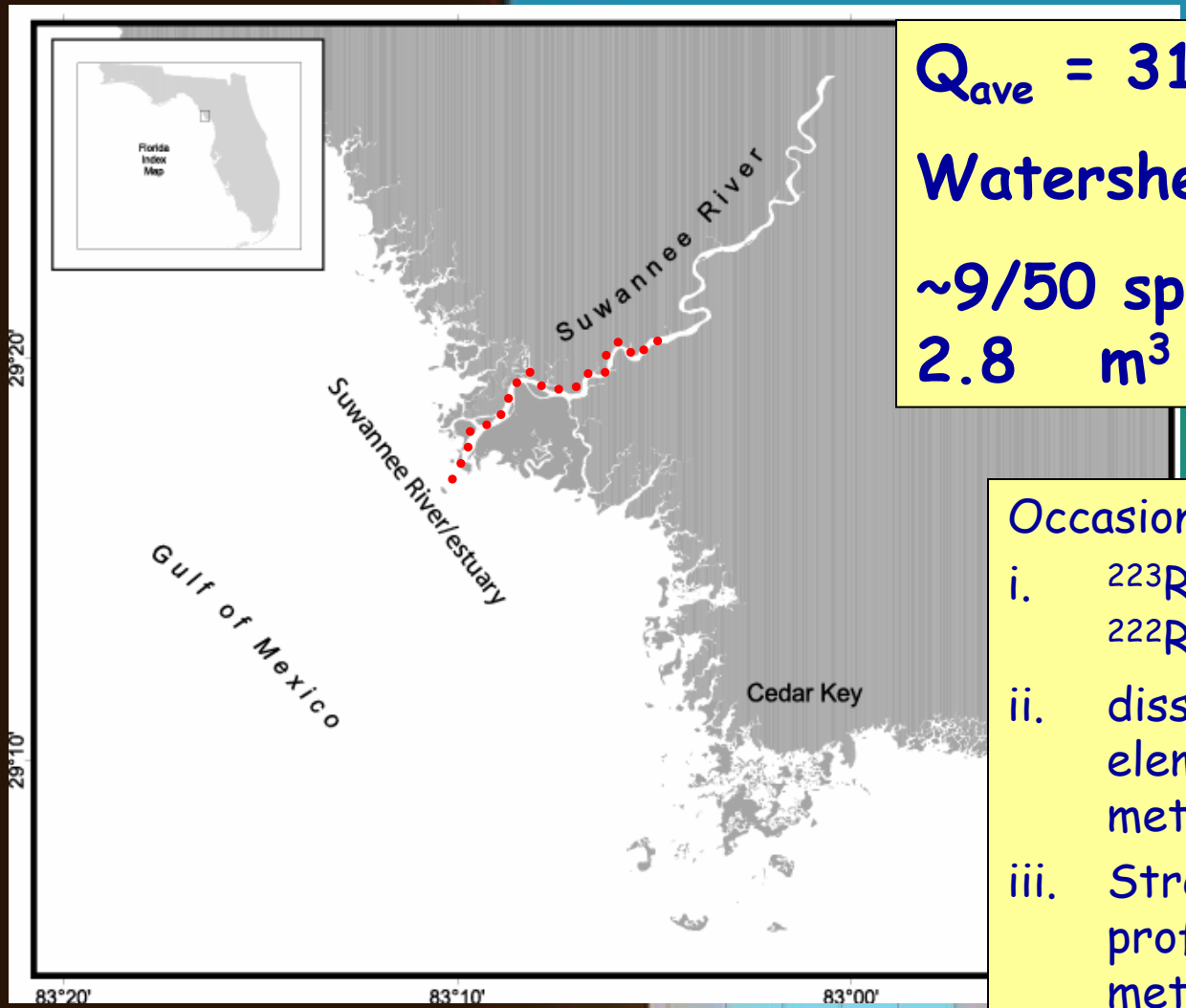
SGD components



Controlling forces:

- Terrestrial – hydraulic gradient (geologic control), CLIMATE
- Marine – tide-driven pumping, wave setup, current-induced topographic flow, convection (e.g., salt fingering), sea-level fluctuations, barrier island effects, etc

Suwannee River/estuary: sampling objectives



Q_{ave} = 311 m^3 s^{-1}

Watershed = 28.5 E3 km^2

~9/50 springs have Q > 2.8 m^3 s^{-1} (source/sink)

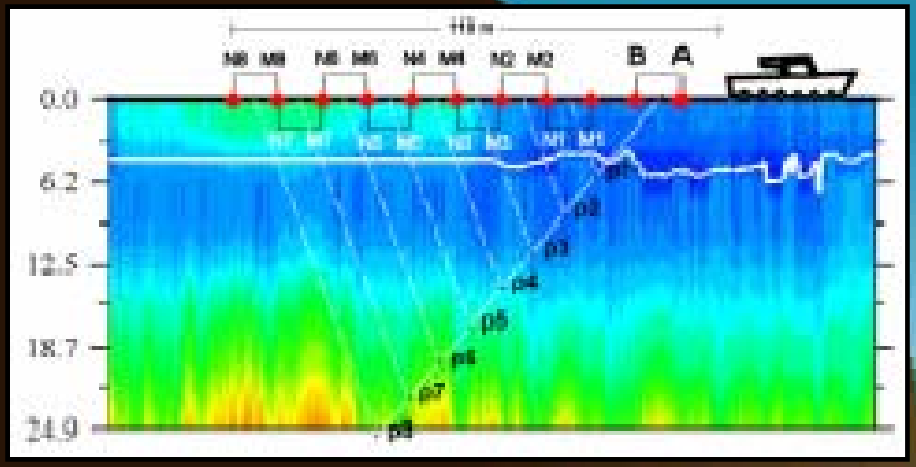
Occasional sampling for:

i. ^{223}Ra, ^{224}Ra, ^{226}Ra, ^{228}Ra, ^{222}Rn

ii. dissolved nutrients, trace elements, salinity, temp., methane

iii. Streaming resistivity profiling, EM seepage meters

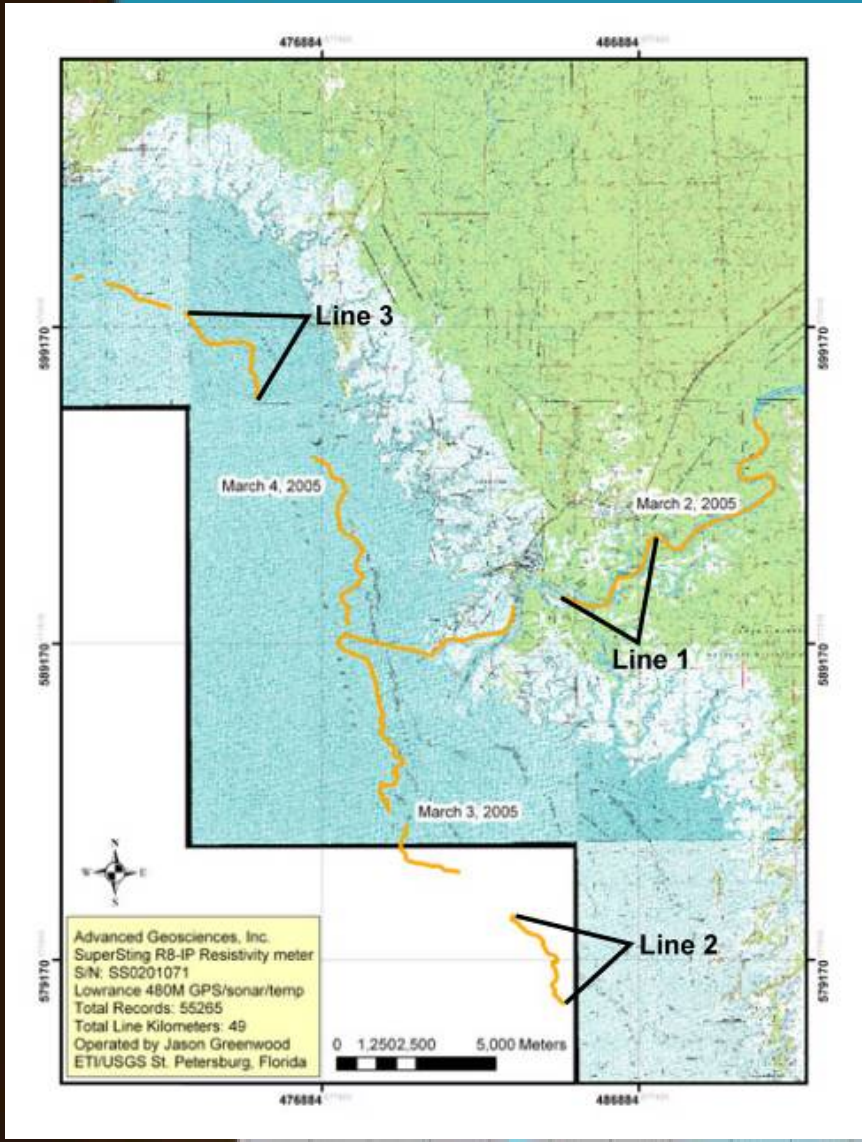
Streaming resistivity profiling in Suwannee River/estuary



- 120/50m streamers
- 2 current/9 potential electrodes
- DGPS
- real-time flow-through system for S/T/pH/DO

- 50+ km surveyed
- High resolution freshwater/saltwater interface contours to a depth of 30m

Streaming resistivity profiling in Suwannee River/estuary



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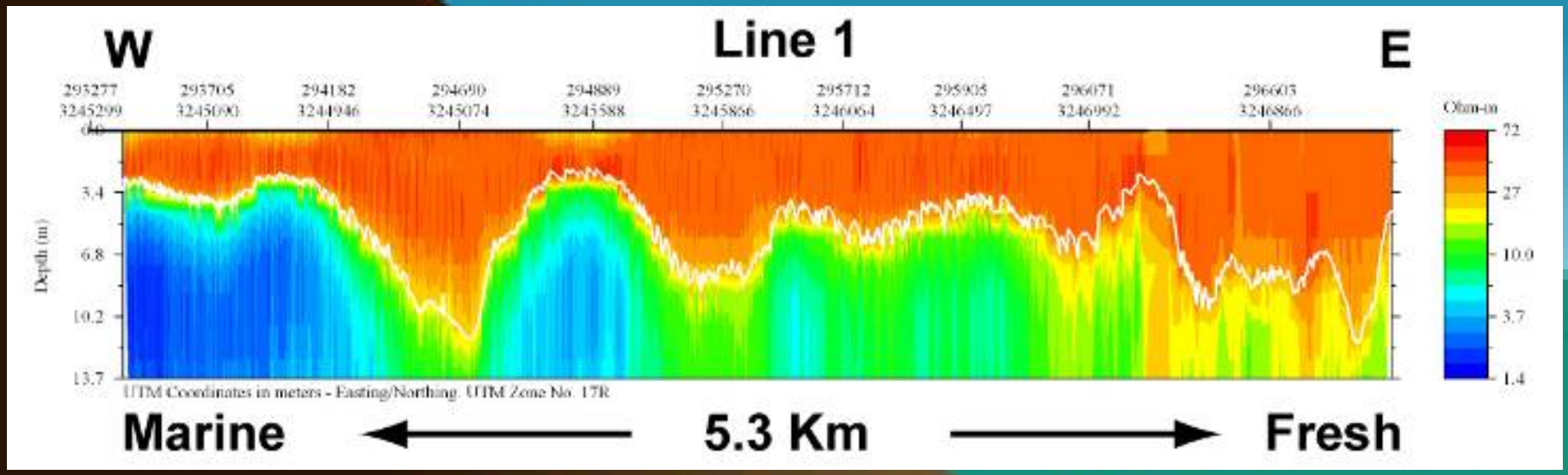

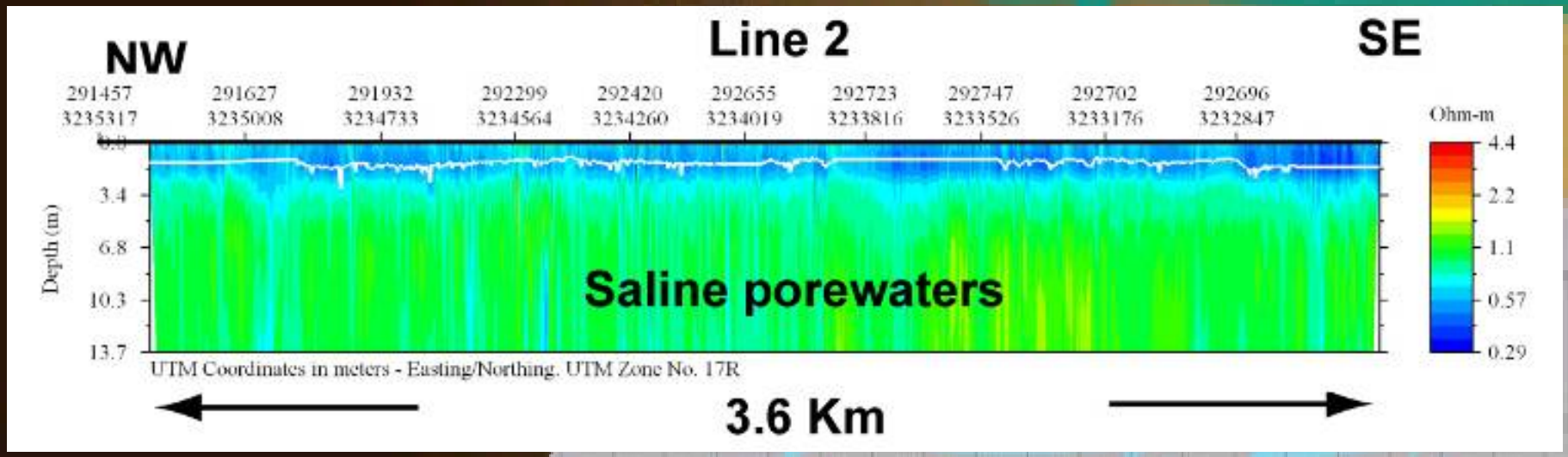

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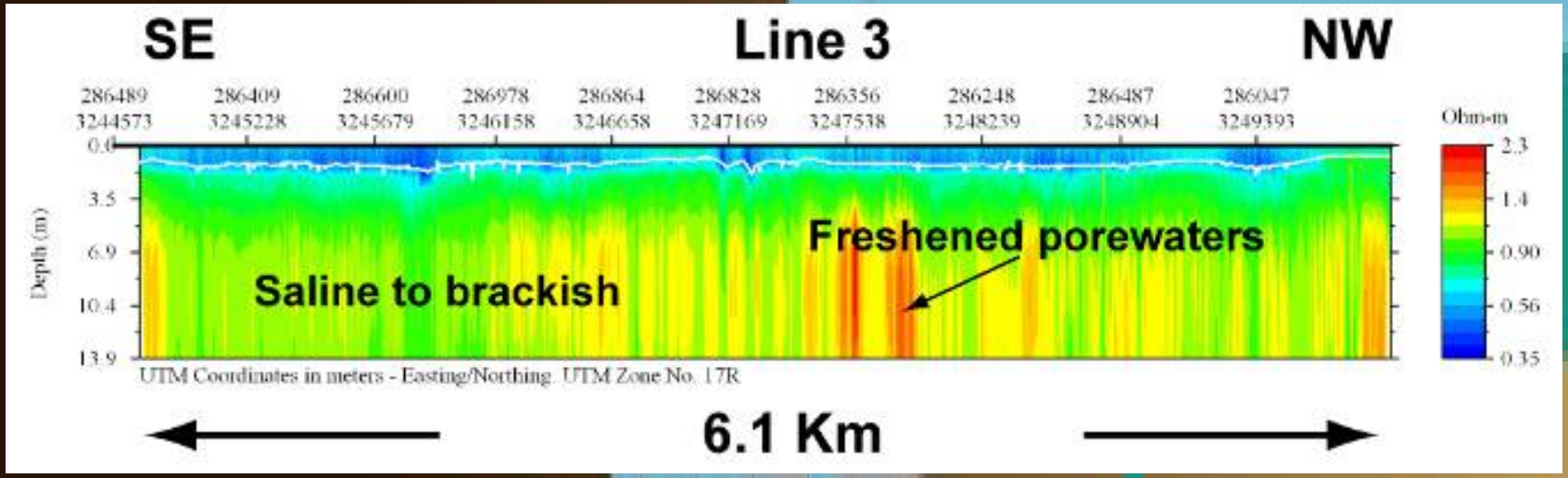
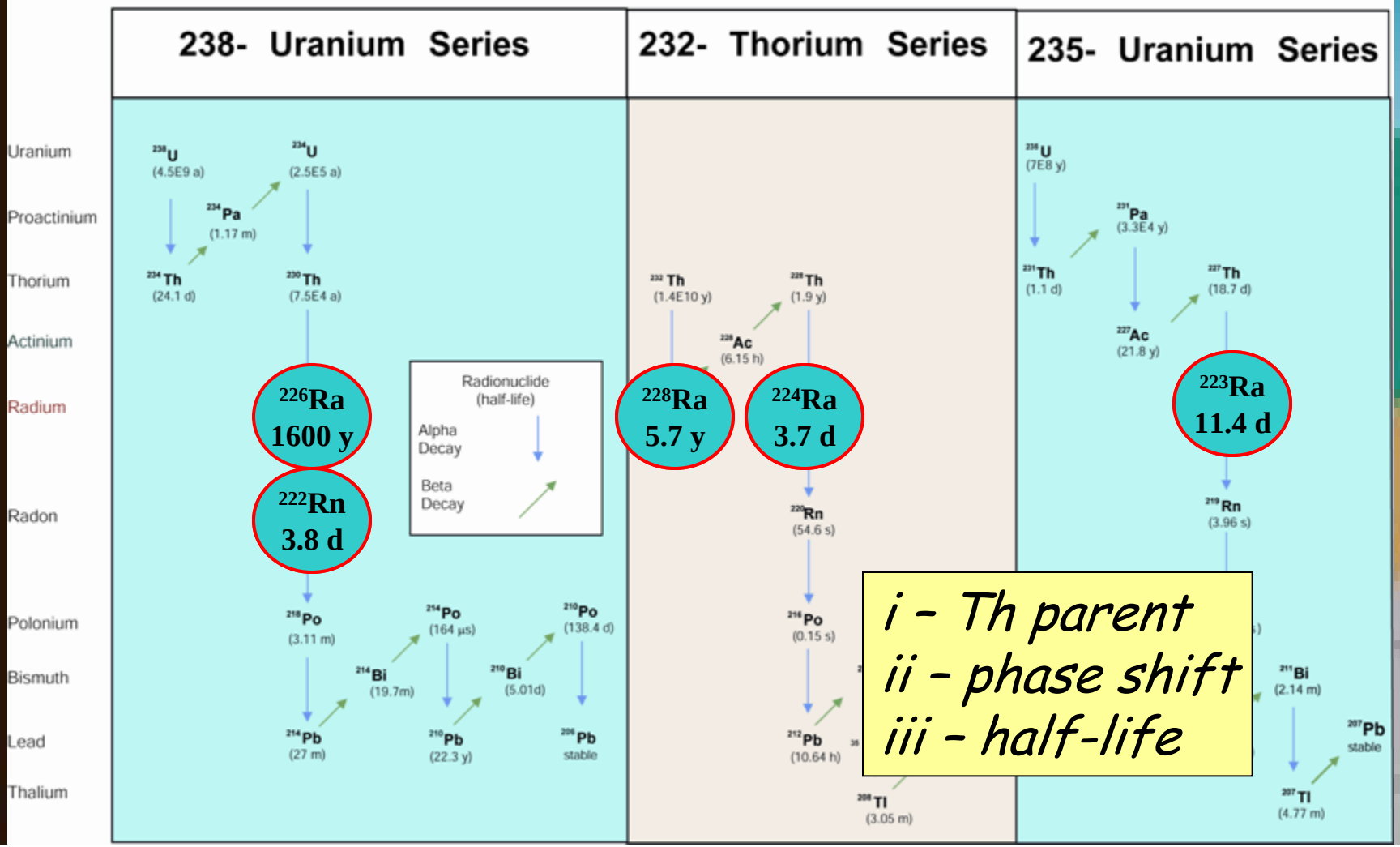


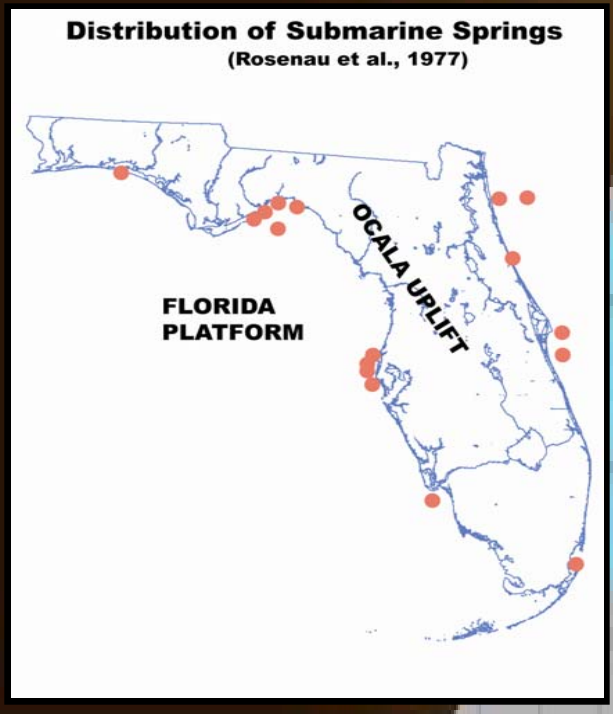
Measurement of SGD - tracers

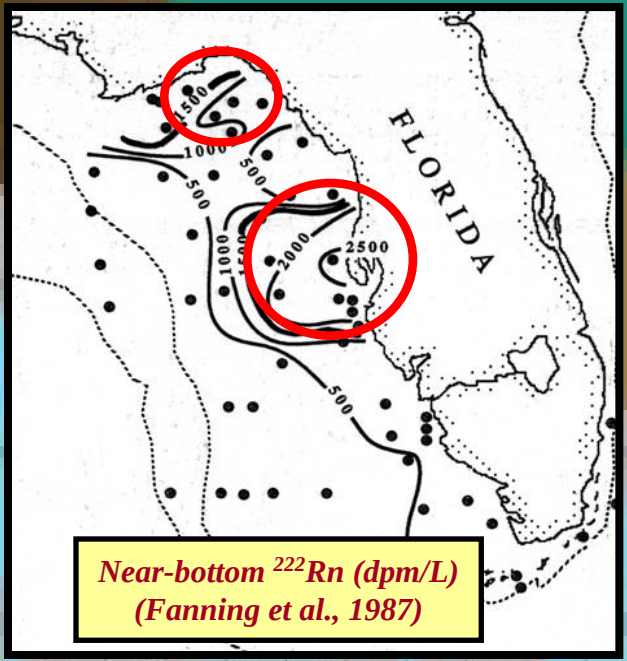
Geochemical tracers (Rn and Ra isotopes)



Advantages of ^{222}Rn

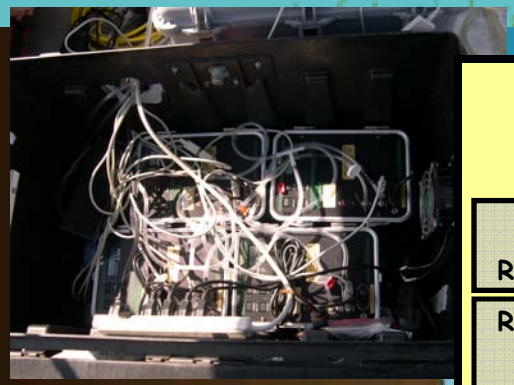
- Very high activity in GW (<6,000 dpm L^{-1})
- Low activity in seawater (2 - 5 dpm L^{-1})
- Conservative, inert (Noble gas)
- Dissipates relatively quickly (half life = 3.8d; short memory)
- Can now measure ^{222}Rn continuously – good temporal resolution

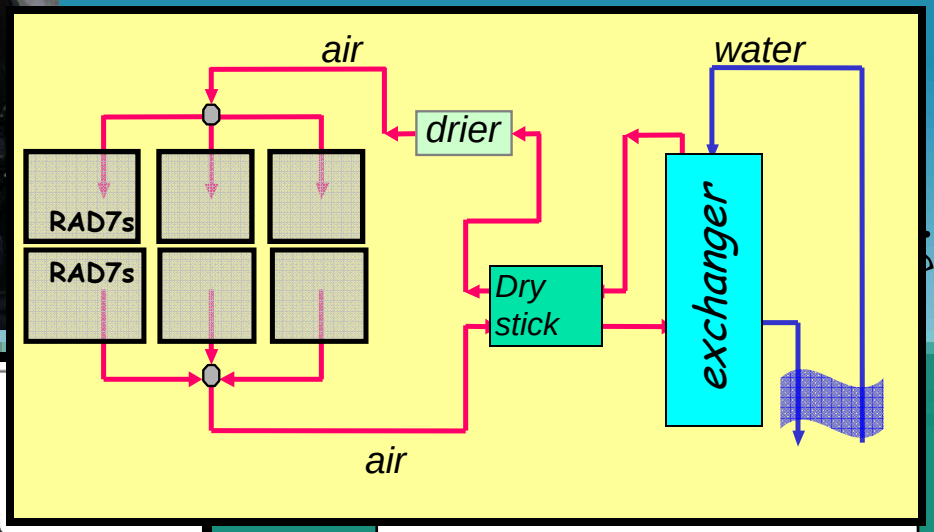


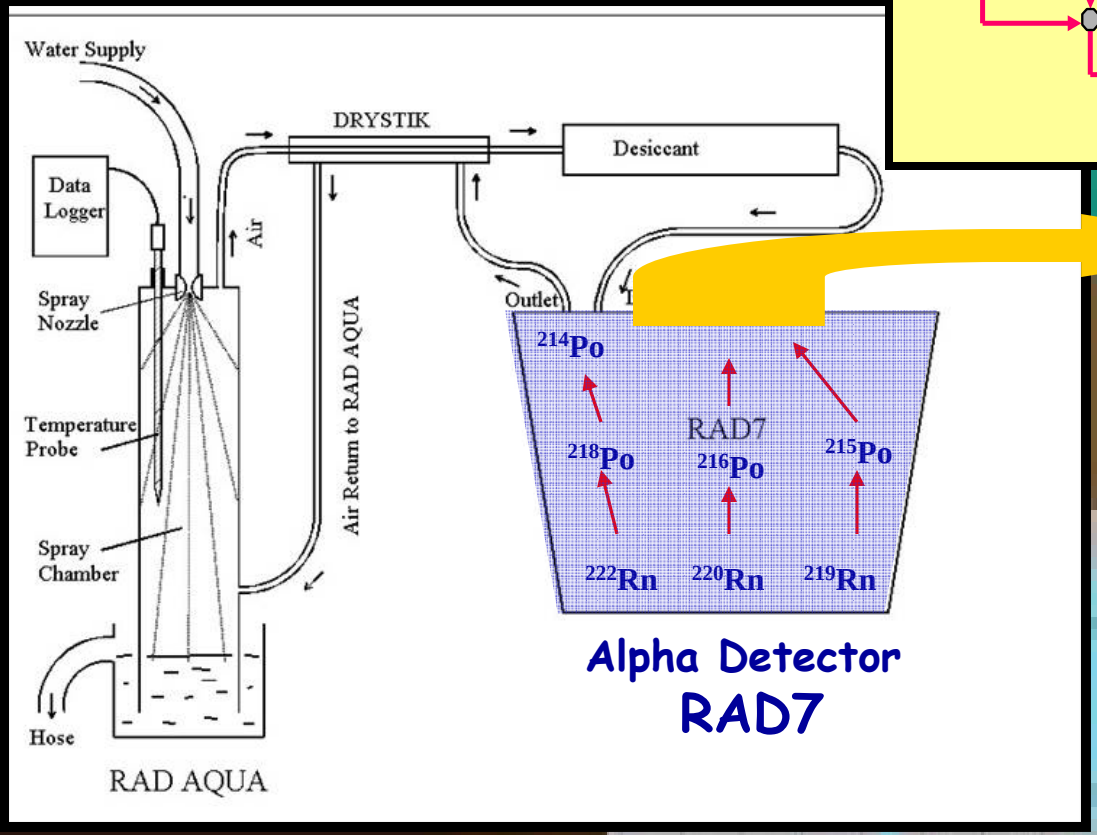


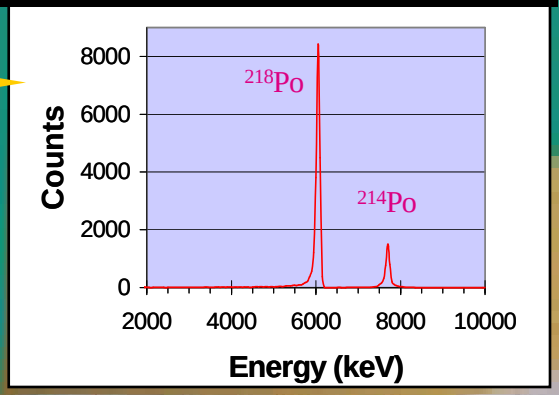
Near-bottom ^{222}Rn (dpm/L)
(Fanning et al., 1987)

Continuous ^{222}Rn measurements



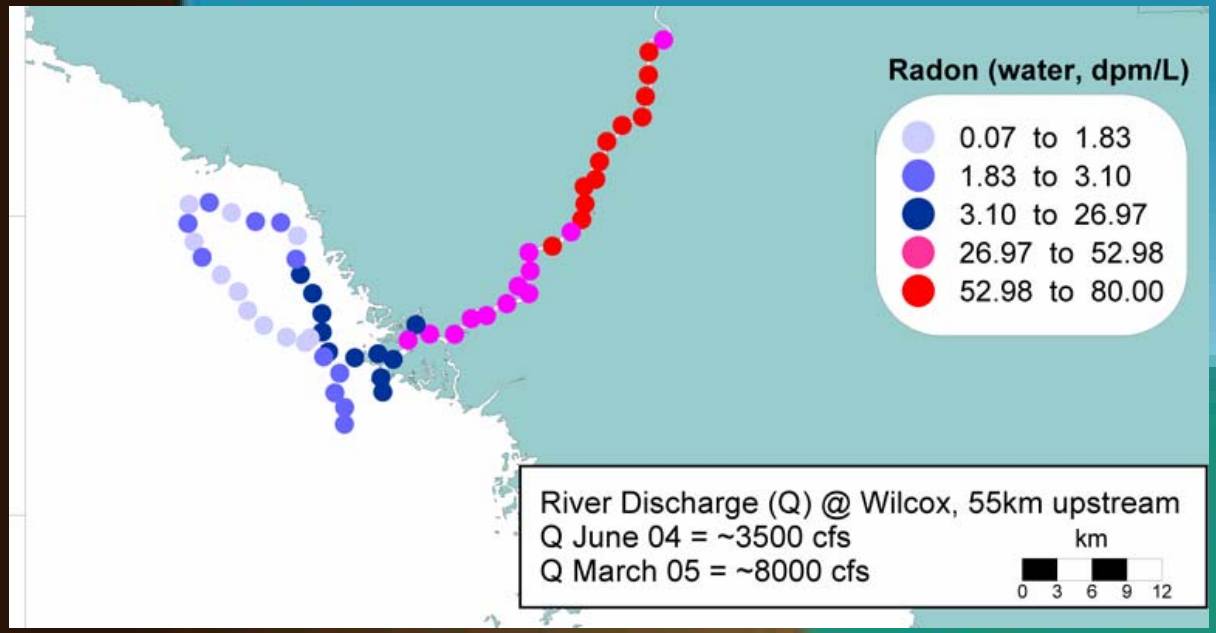


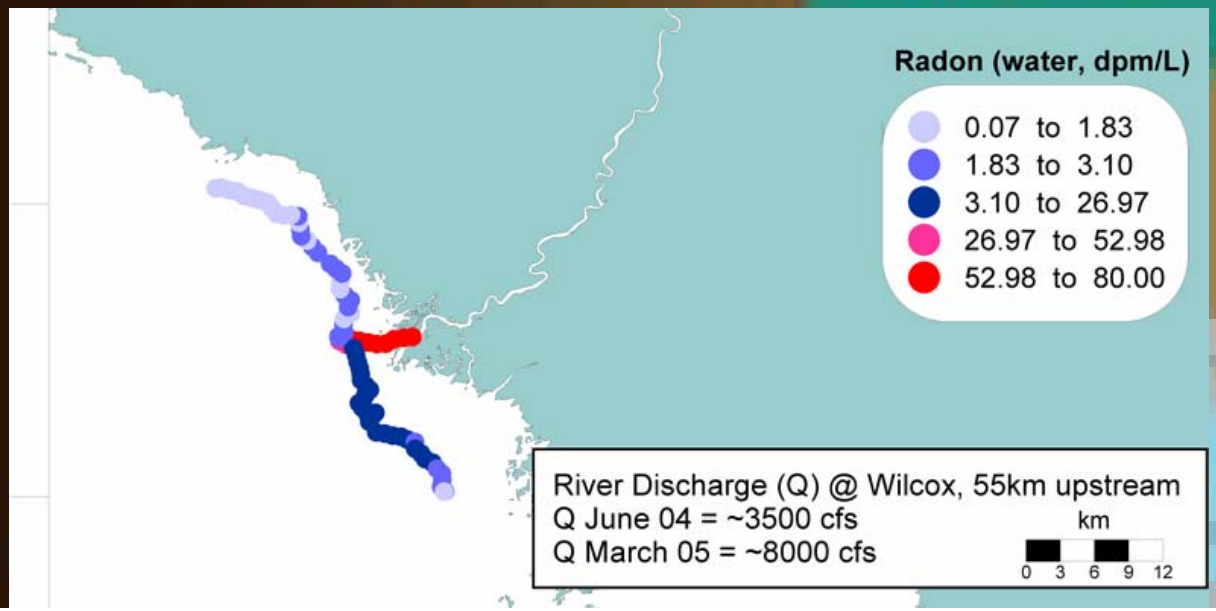




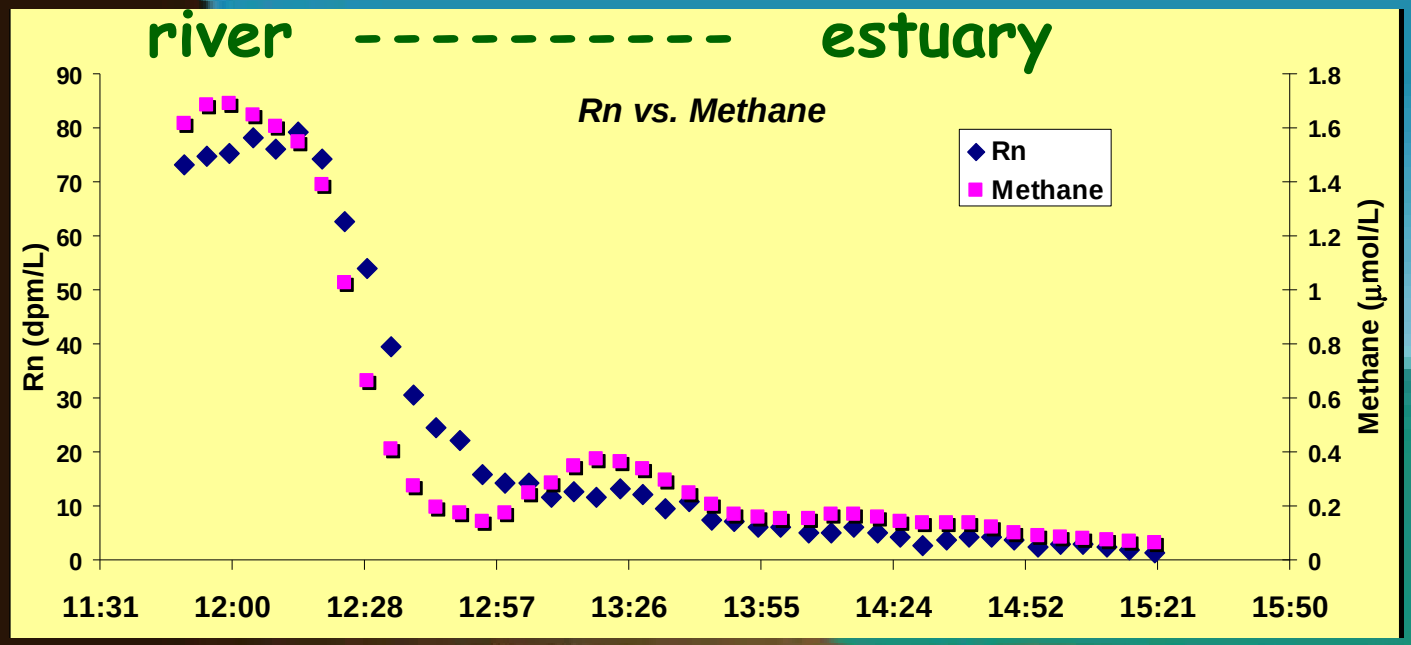
after Burnett et al.

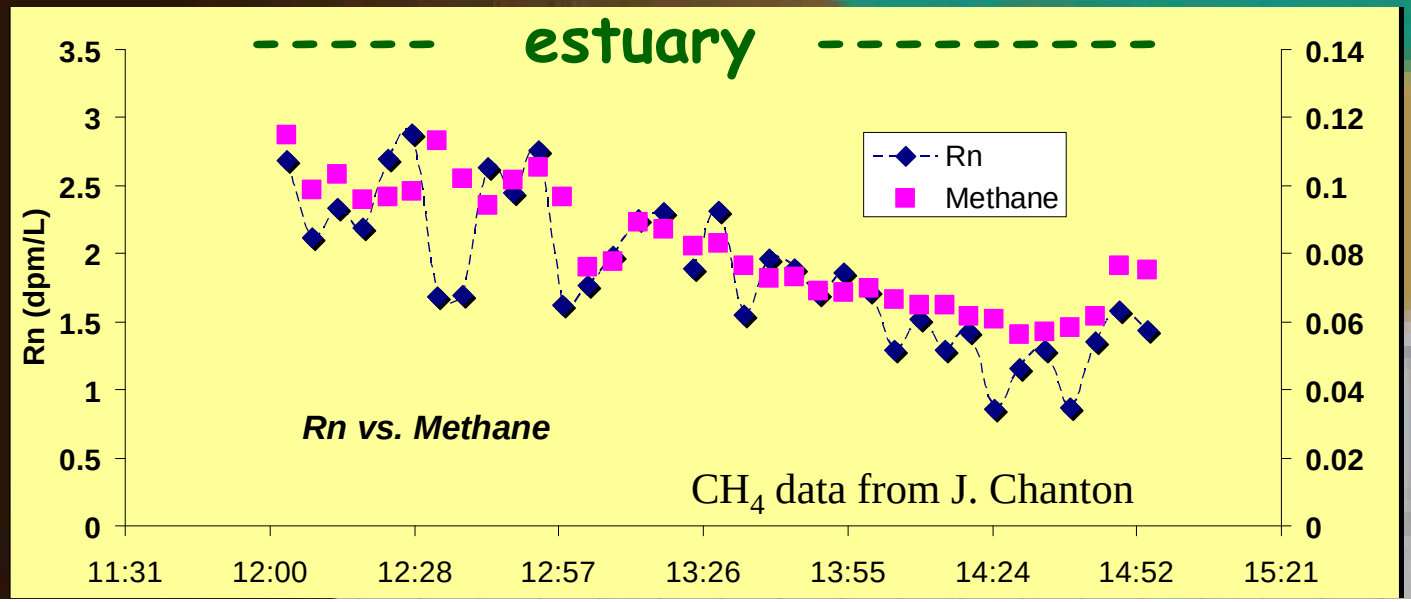
Continuous ^{222}Rn measurements





Continuous $^{222}Rn/CH_4$ measurements





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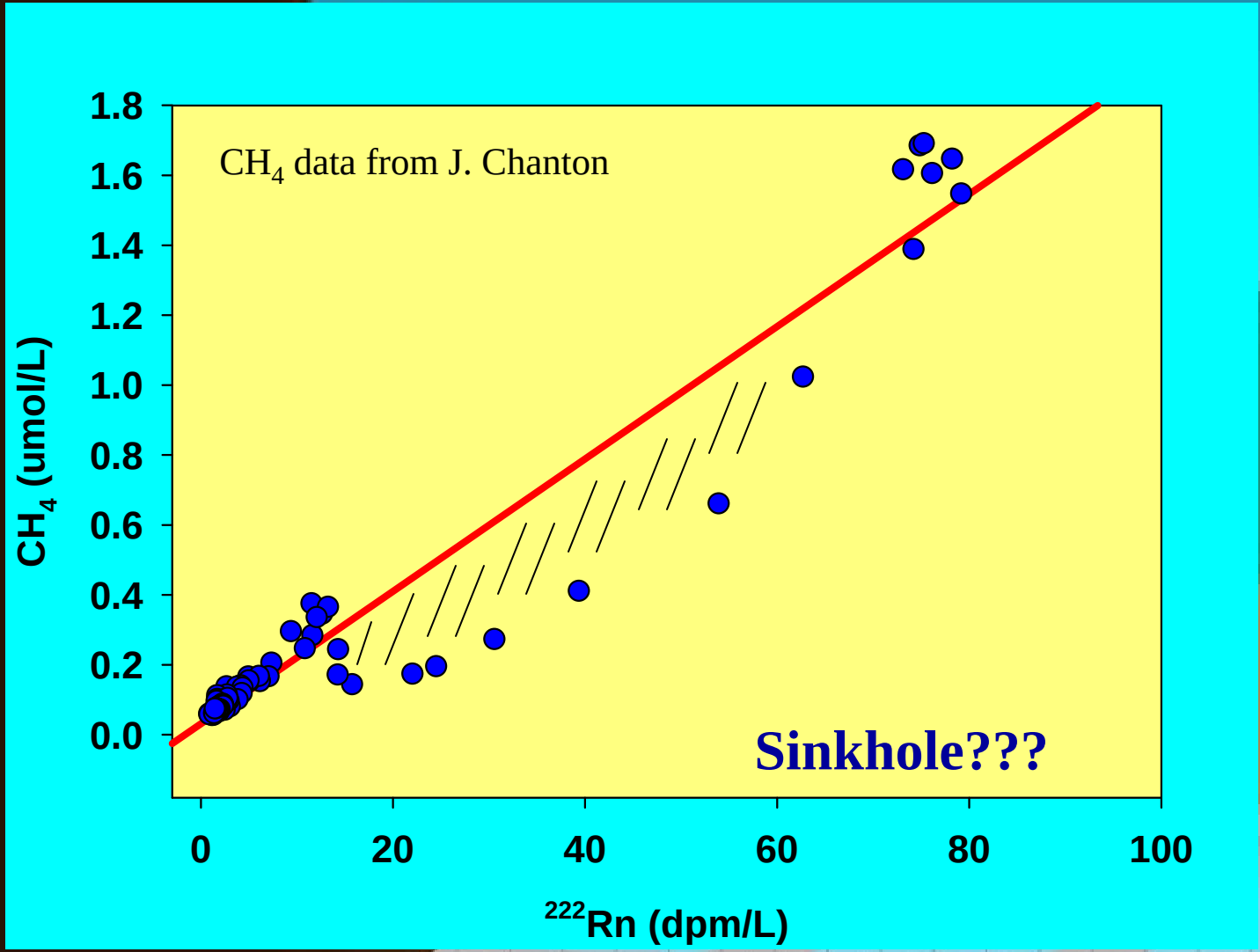

SGD rate comparisons: LOX

Site	Geology	SGD rate	N flux	P flux
		(L m^{-2} d^{-1})	(µmol m^{-2} d^{-1})	(µmol m^{-2} d^{-1})
Nauset Marsh, MA	sandy sediment	-	24,000-72,000	NA
Elizabeth River, VA	coastal plain	21.3	4,500	160
Florida Bay, FL	limestone	19.3	301	0. 58
Southern Chesapeake Bay	alluvium	-	<53,000	<410
Tumon Bay, Guam	carbonate karst aquifer	-	1340	12
Inner Kahana Bay, Hawaii	alluvium	-	920	37
Middle Kahana Bay, Hawaii	alluvium	-	160	9
North Inlet, South Carolina	sand, gravel, and clay	31.5	2,400	900
Crescent Beach Spring, FL	limestone and dolomite	42.5*	NA	NA
Port Royal Sound	limestone and coastal plain	28.7	6,700	500
Pettaquamscutt, RI	metasedimentary rock	11.5	400	30
Loxahatchee River estuary, FL	**sandy sediment**	**20-75**	**63-1063**	**69-379**
Rhode Island Point Judith	sand and gravel	6.8	1,840	3

Guebuem and Swarzenski, Accepted, 2005

Conclusions

- All four SGD methods (CH_4, tidal prism, Ra, EM seepage meter) provide internally consistent results;
- Near continuous ^{222}Rn results confirm most gw discharges upstream;
- Streaming resistivity profiling results provide information as to the position/extent of the freshwater/ saltwater interface;

Current SGD Research

Submarine Groundwater Discharge - Mozilla Firefox

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http://home.earthlink.net/~smeylan/usgs/researchprojects/researchprojectsindex.html

Getting Started Latest Headlines

USGS science for a changing world

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Submarine Groundwater Discharge

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Current and Future SGD Research Projects

Current SGD projects at USGS are primarily focused on the first-order questions of the locations and rates of discharge, as well as studies of nutrient delivery from SGD (Figure 1). These include:

Delmarva Peninsula

- Characterization of submarine extensions of surficial aquifers in Delaware and Maryland beneath coastal bays, especially Indian River Bay and Chincoteague Bay, including determination of the contribution of SGD to eutrophication (2000-present)

Florida

- *Indian River Lagoon:* estimating the contribution of SGD to the lagoon using radium isotope measurements (1999-2001).
- *Biscayne Bay:* Characterization of SGD rates and hydrogeologic control thereof (1998-present).
- *Crescent Beach Spring:* geological and geochemical characterization of a large submarine spring located approximately 4 km from shore (1998-2000).
- *Tampa Bay:* determination of the quantity and quality of freshened ground water discharging to the bay and its possible impacts on seagrass health (2001-present).
- *Loxahatchee River Estuary:* Determining the contribution of SGD to the estuary as part of the South Florida Water Management District's Everglades restoration (2003-2005).

North Carolina

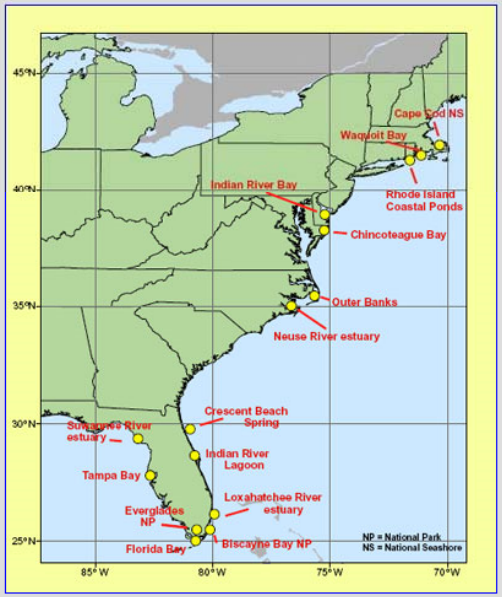
- *Outer Banks:* characterization of the thickness of fresh-water lenses beneath the barrier islands, and the salinity of deep ground water flowing beneath adjacent Albemarle Sound and Pamlico Sound (2001-2004).
- *Neuse River Estuary:* study of the geologic controls on the rates and locations of SGD, drawing upon other investigations, especially at Marine Corps Air Station Cherry Point (2003-2005).

Massachusetts

- *Waquoit Bay National Estuarine Research Reserve:* testing of new instruments to detect SGD, including a boat-based radon mapping system, in an area used as a natural laboratory for previous SGD studies by other investigators (2004-present).
- *Cape Cod National Seashore:* characterization of the role of SGD in eutrophication of the Nauset Marsh and Pleasant Bay systems, with special attention to impacts on seagrasses (2004-present). Water and nutrient fluxes and denitrification rates are all being assessed.

Mediterranean Sea

- *Israel:* use of various tools to develop an estimate of total SGD along the entire Mediterranean coast of Israel, along with academic collaborators (2004-present).



1. US east coast map depicting selected USGS SGD project sites.

Possible future research areas and topics:

- *Alaska:* investigation of SGD in regions with intense seasonality, active glaciation, permafrost; study of the role of SGD in water and nutrient delivery (nitrate and iron) to the N. Pacific Ocean.
- *Hawaii:* assessment of SGD to fringe coral reef ecosystems, and study of the style of discharge from fractured rock aquifers and lava tubes.
- *Yucatán Peninsula:* determination of interconnections between ocean waters and the cenote ring associated with the Chicxulub impact crater; the area has been chosen as a prime candidate for a coordinated study of chemical fluxes in the GEOTRACES program and was recently featured in a National Geographic article.

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