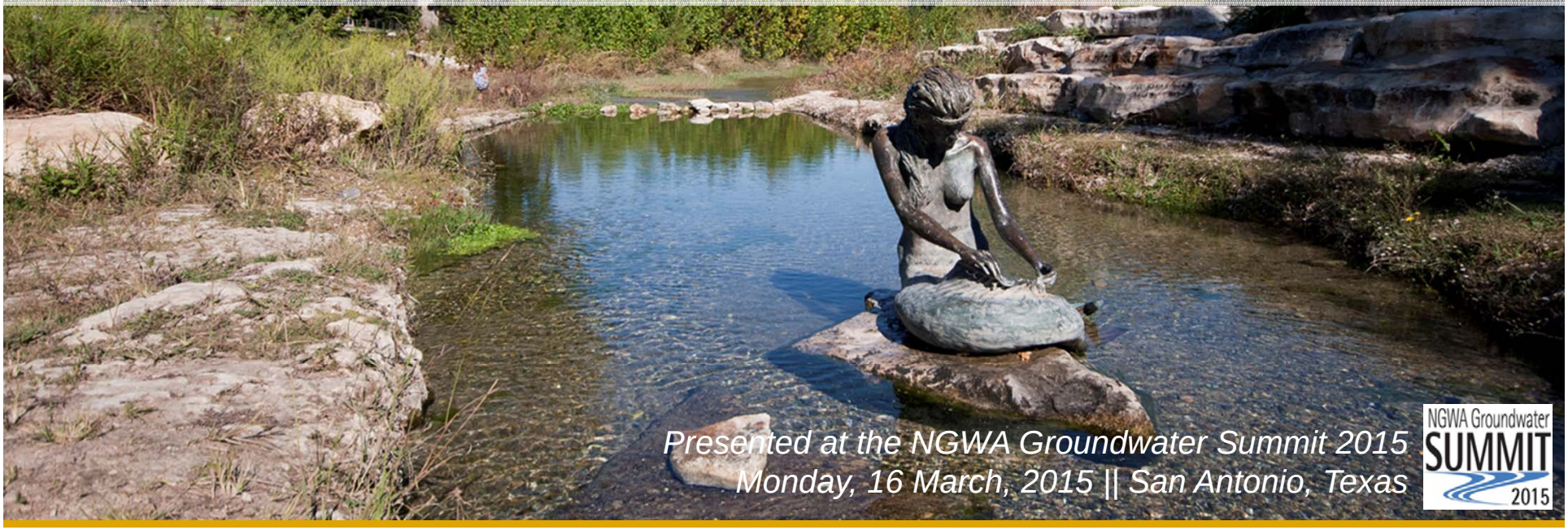
Insights into karst groundwater-stream interactions using dissolved natural radon concentrations, Central Texas



Presented at the NGWA Groundwater Summit 2015
Monday, 16 March, 2015 || San Antonio, Texas

NGWA Groundwater SUMMIT 2015

BAYLOR UNIVERSITY 1845

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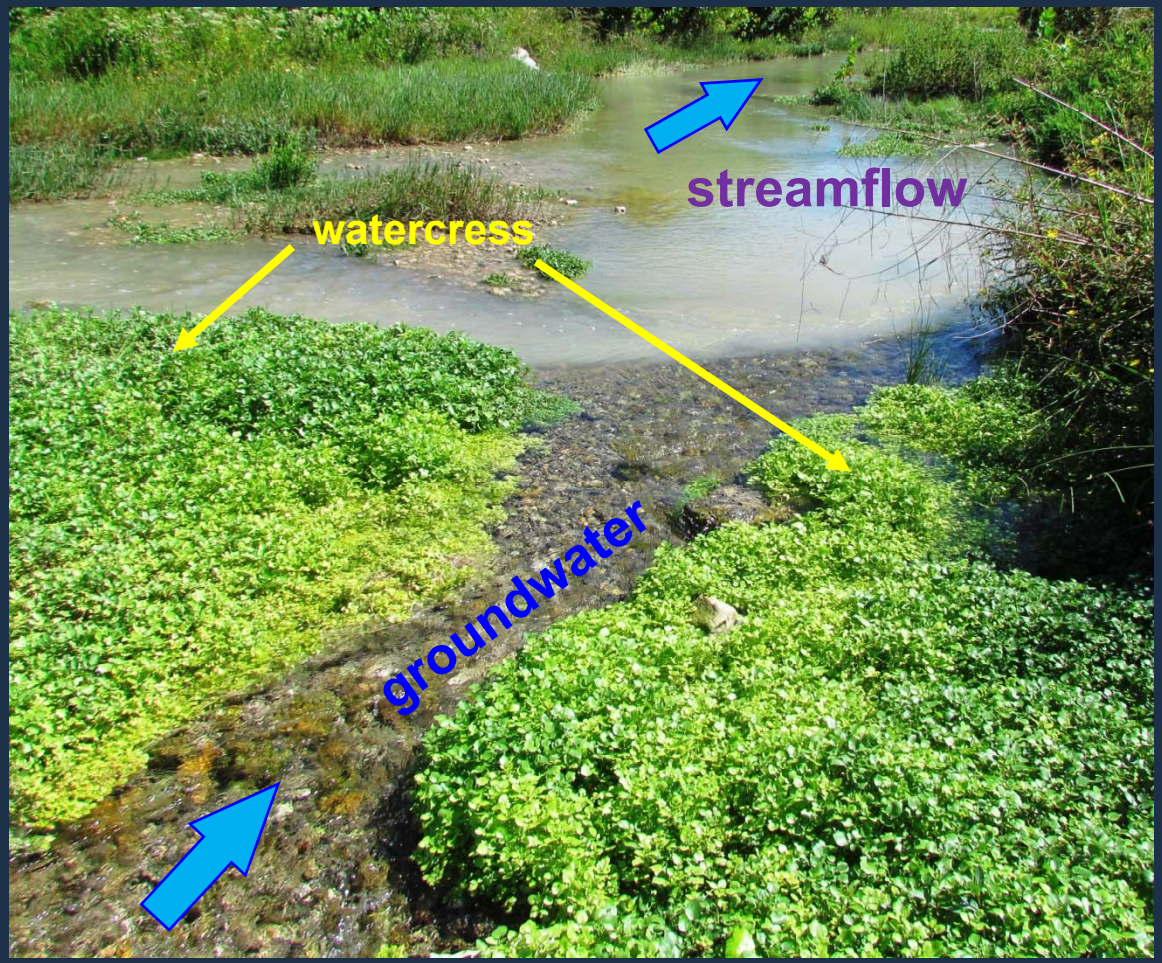
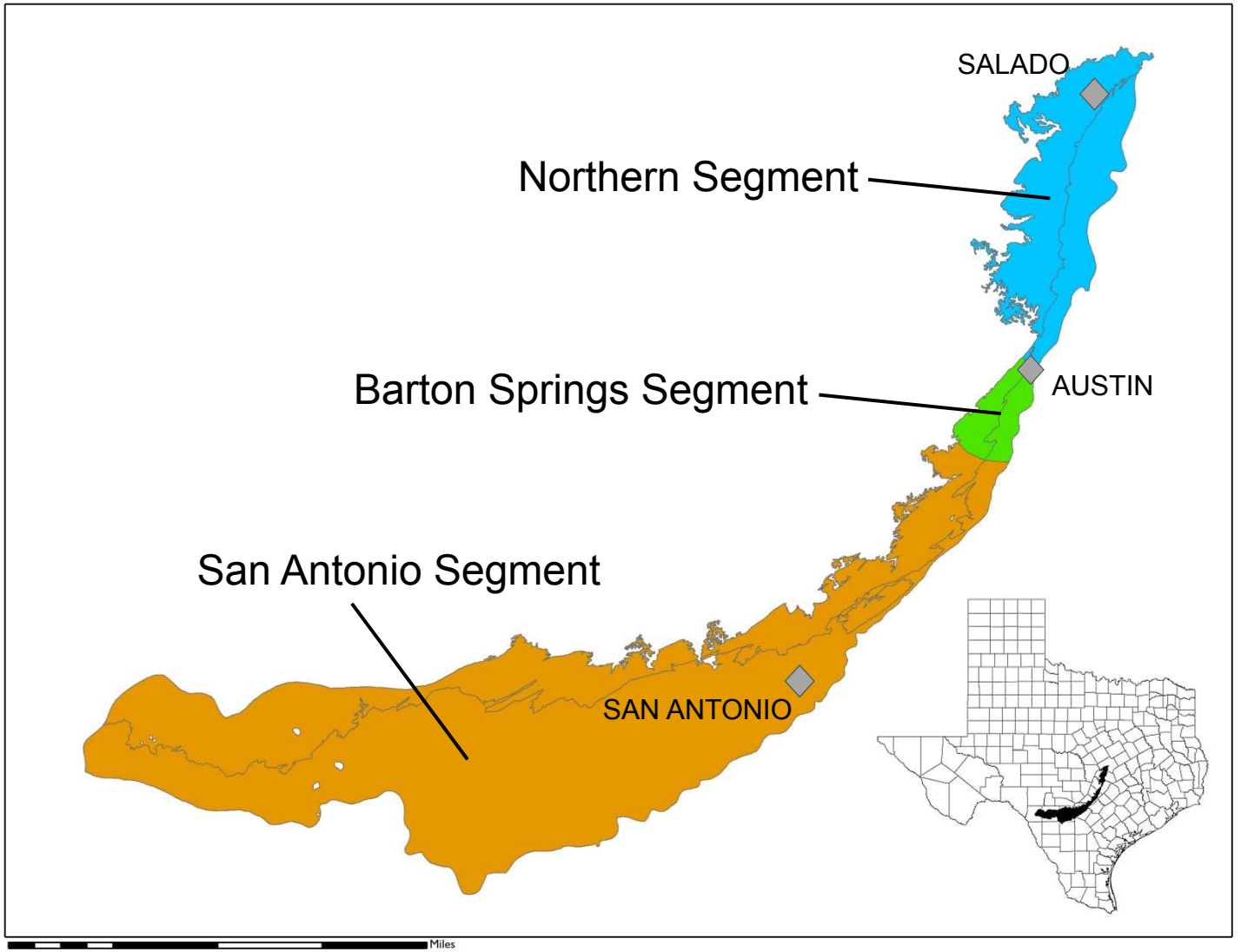
Outline

- Background
  - Groundwater/Surface water interactions in karst
  - Setting
  - Natural radon (Rn-222)
  - Research question
- Methods
- Results
- Conclusions
- Acknowledgements

Groundwater / Surface Water Interactions in Karst Systems



Setting: The Edwards BFZ Aquifer



(I-35 CAC, 2011)

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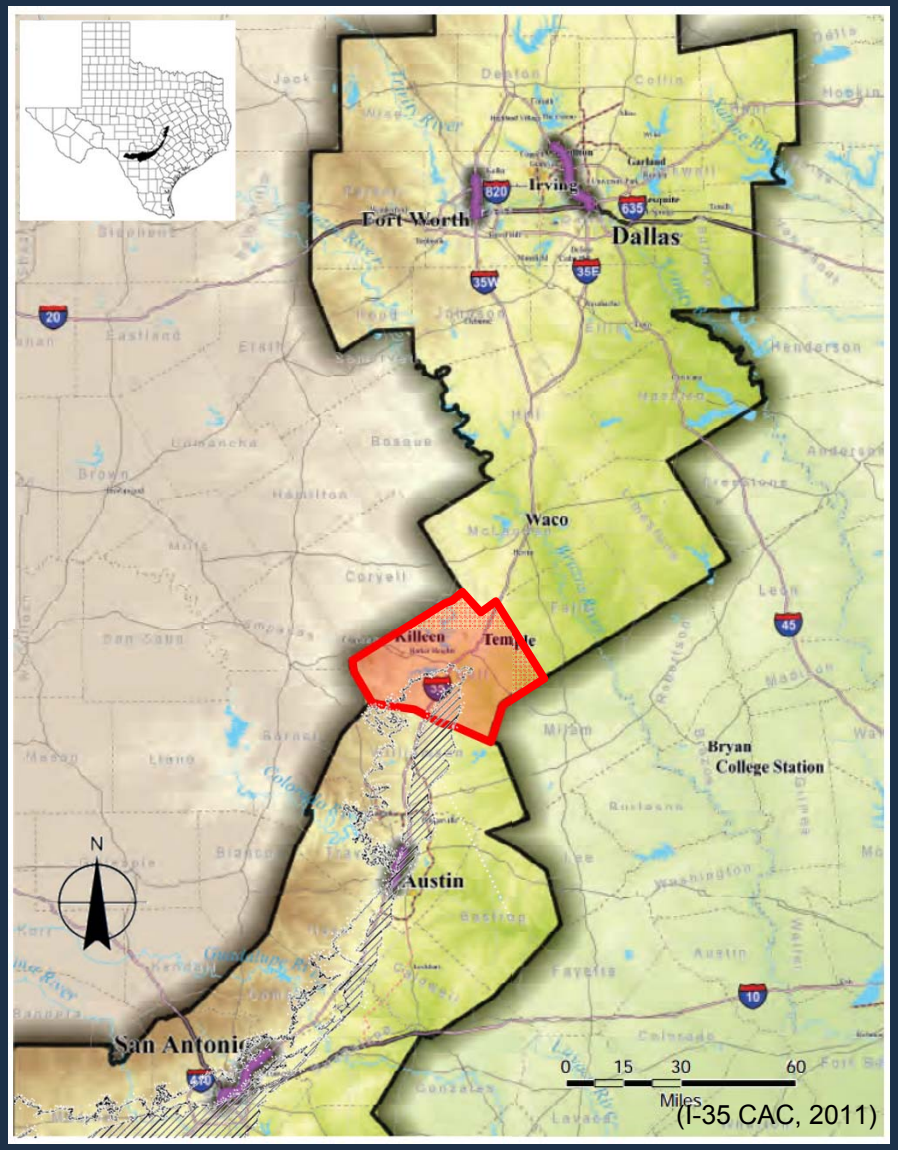
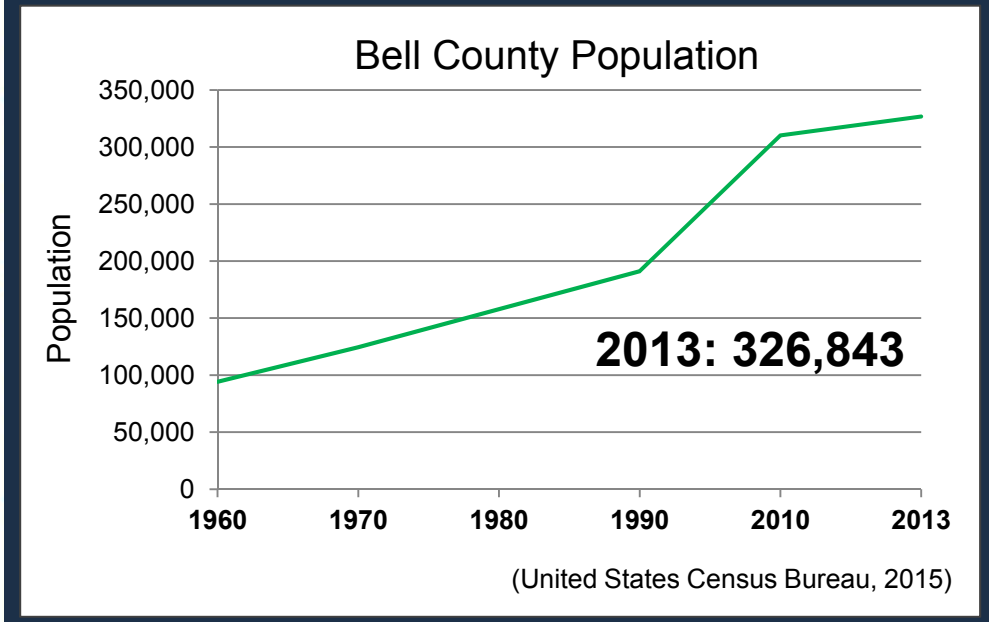


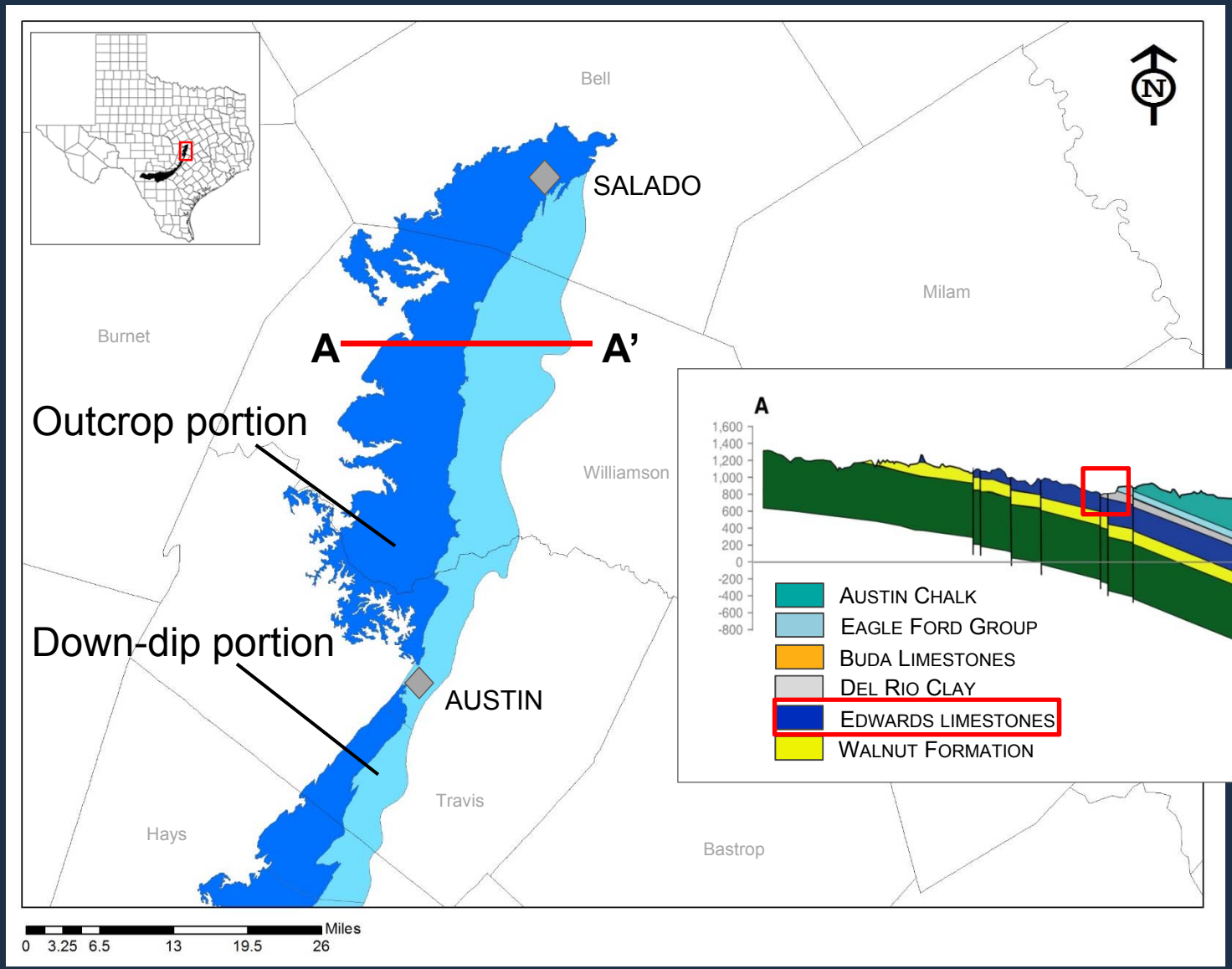
(I-35 CAC, 2011)



(United States Census Bureau, 2015)

What are the impacts of construction and increasing resource demands on the aquifer?

Setting: The Northern Segment, Edwards BFZ Aquifer



Study area: Salado Springs complex

- Historical – stage stop
- Present – local landmark (tourism)
- Habitat for Salado salamander, *E. chisolmensis*
- Local groundwater management measure

Salado Creek

Anderson

Doc Ber

Little Bubbly Spring

Big Boiling Spring

Spring St

Critchfield Spri

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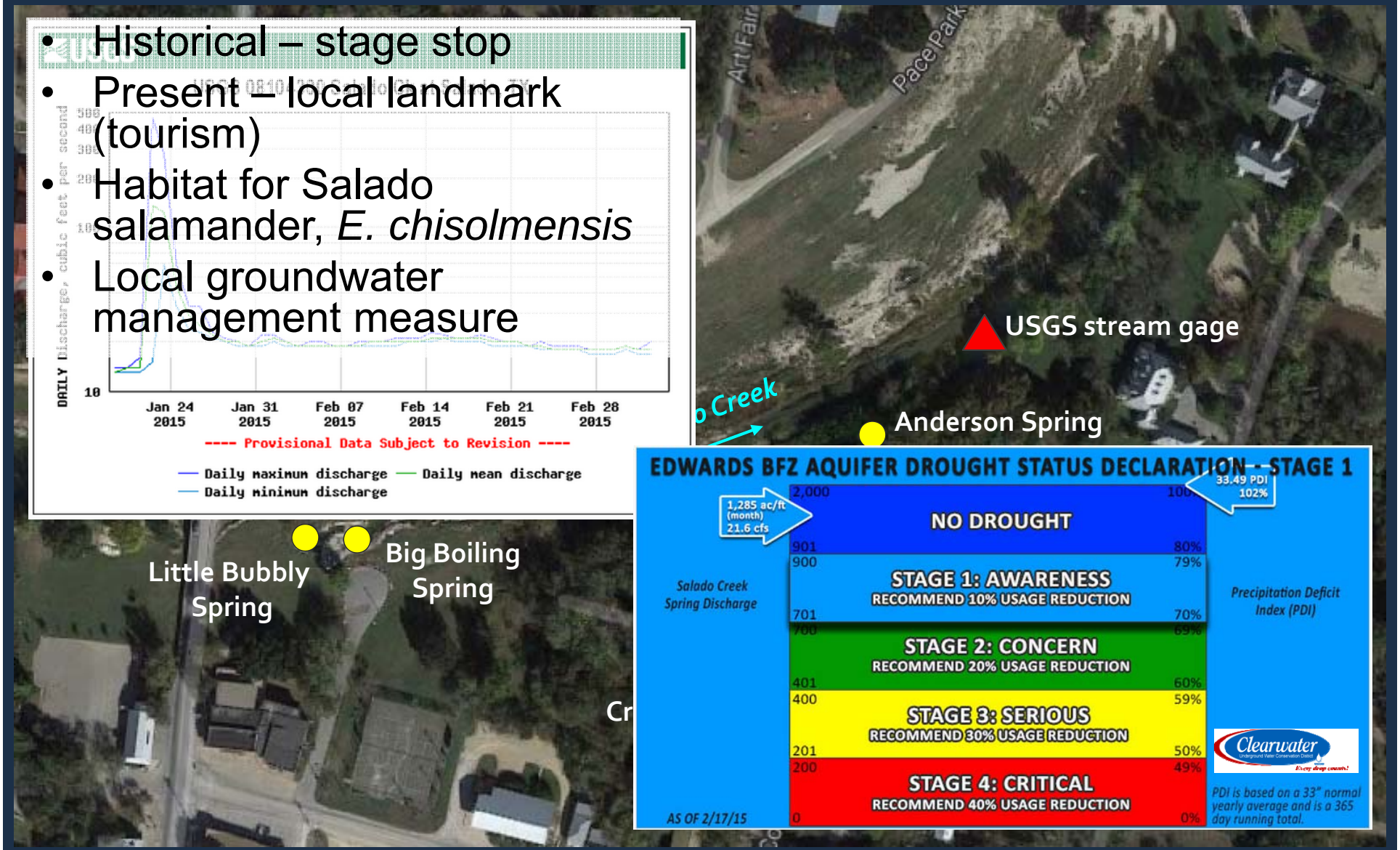
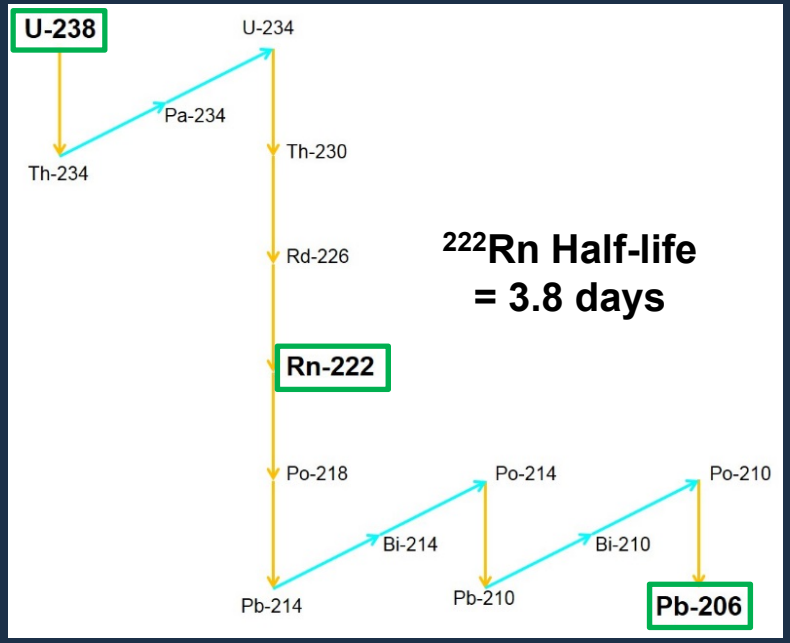
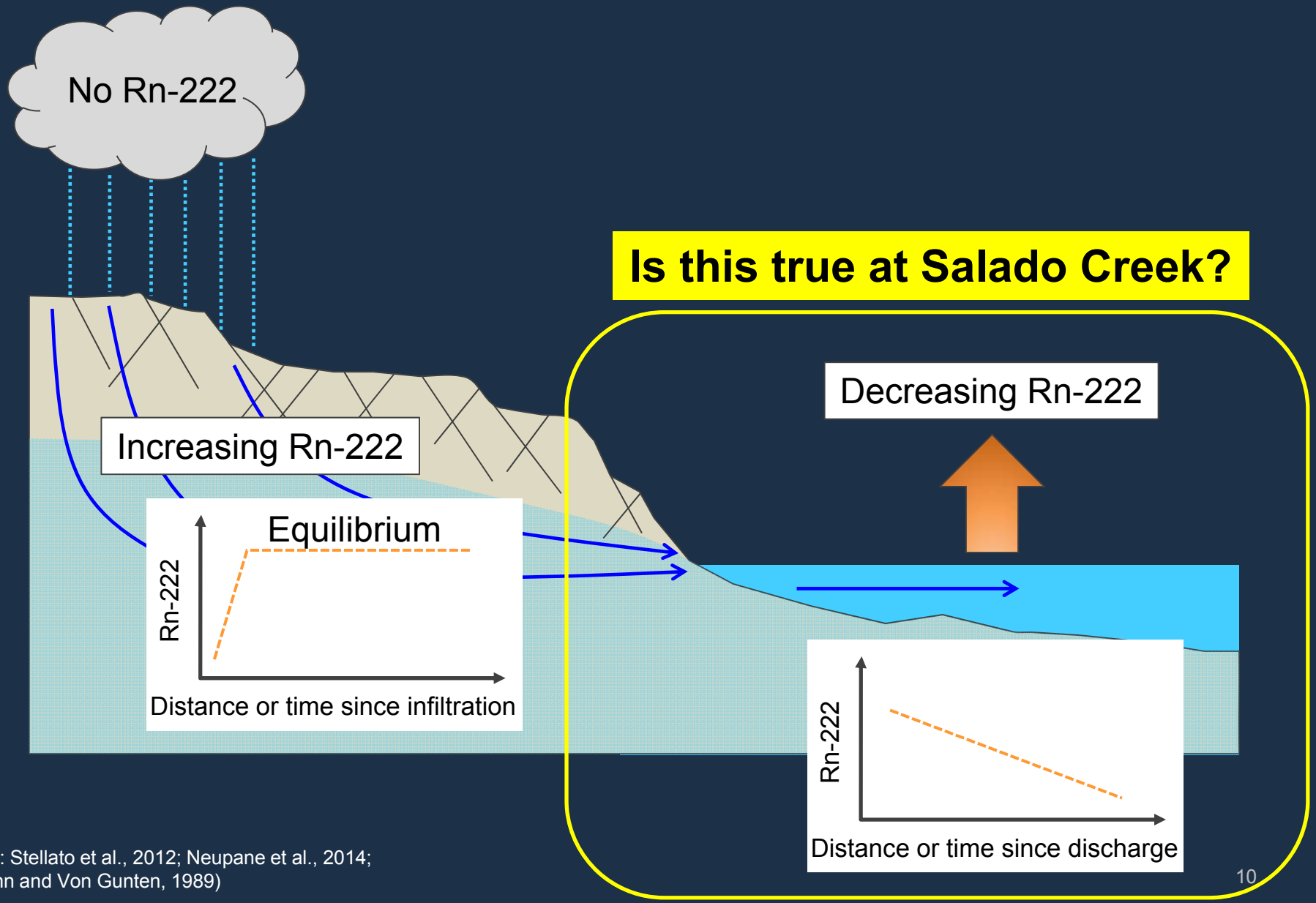


Radon-222

- Naturally-occurring; trace amounts in soils and geology
- Radioactive alpha decay product of radium-226 (uranium-238 series)
- Rapid dispersal from groundwater to atmosphere
- Applications (over short time scales): apparent age estimation, infiltration rates, discharge location and magnitude, fracture aperture estimation, contamination studies



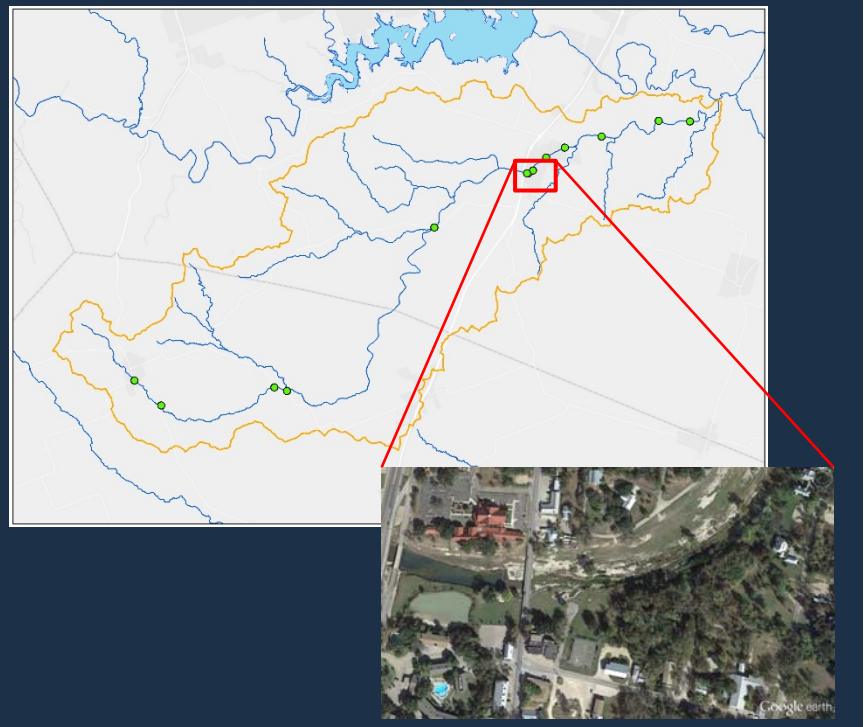
Radon-222 conceptual model



(Ref.: Stellato et al., 2012; Neupane et al., 2014; Hoehn and Von Gunten, 1989)

Methods: field sampling

- Sampling:
  - Zero headspace
  - Sampling depth (~6 in)
- Focused sampling:
  - Salado Creek
  - Salado Springs complex
- Monitoring samples:
  - Big Boiling springs/Salado Creek



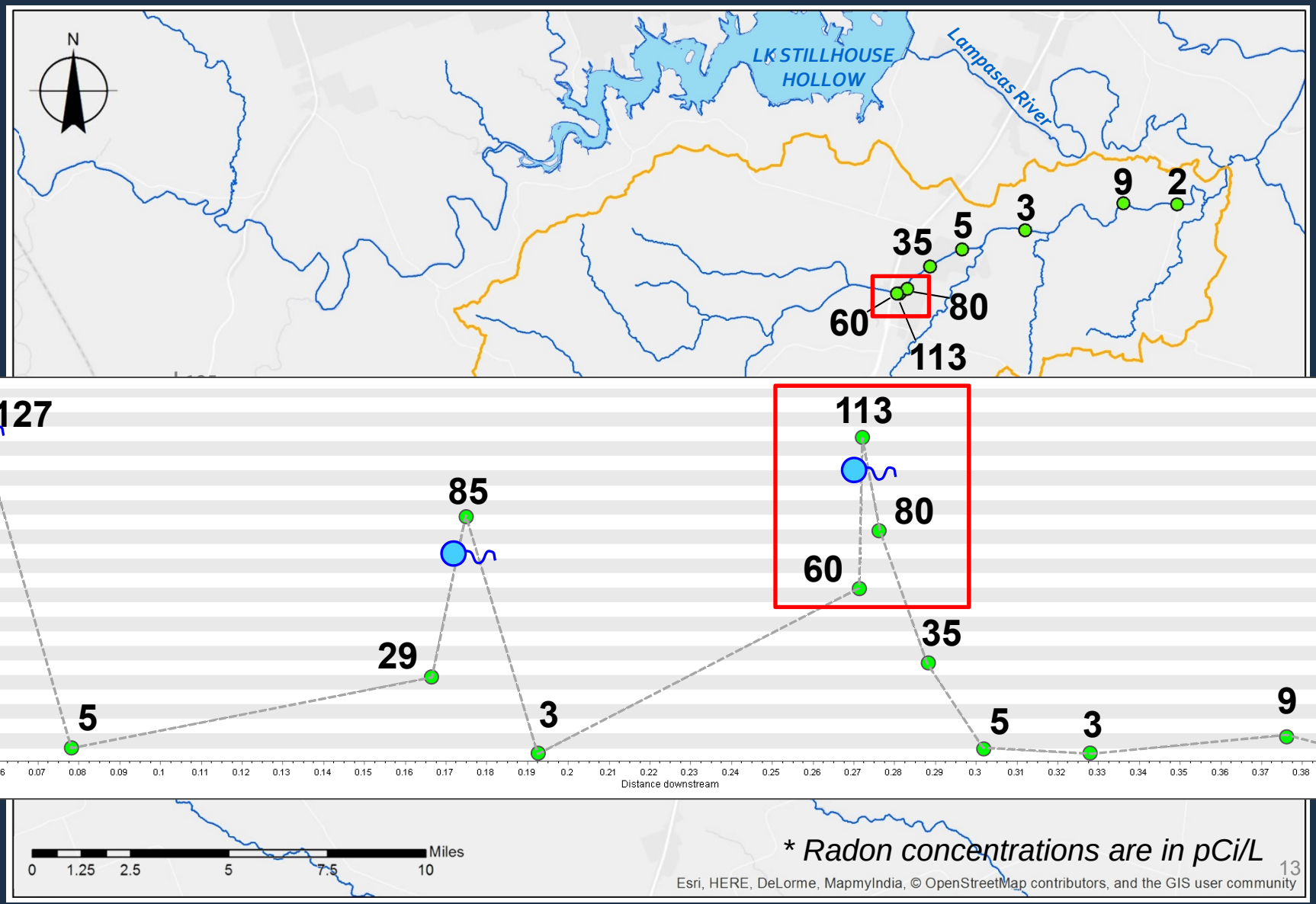
Methods: analysis

- Analysis within 24 hours
- Instrument: RAD7
- Solid state alpha detector
  - Conversion of alpha radiation to an electrical signal

RAD7 with the RAD H2O accessory

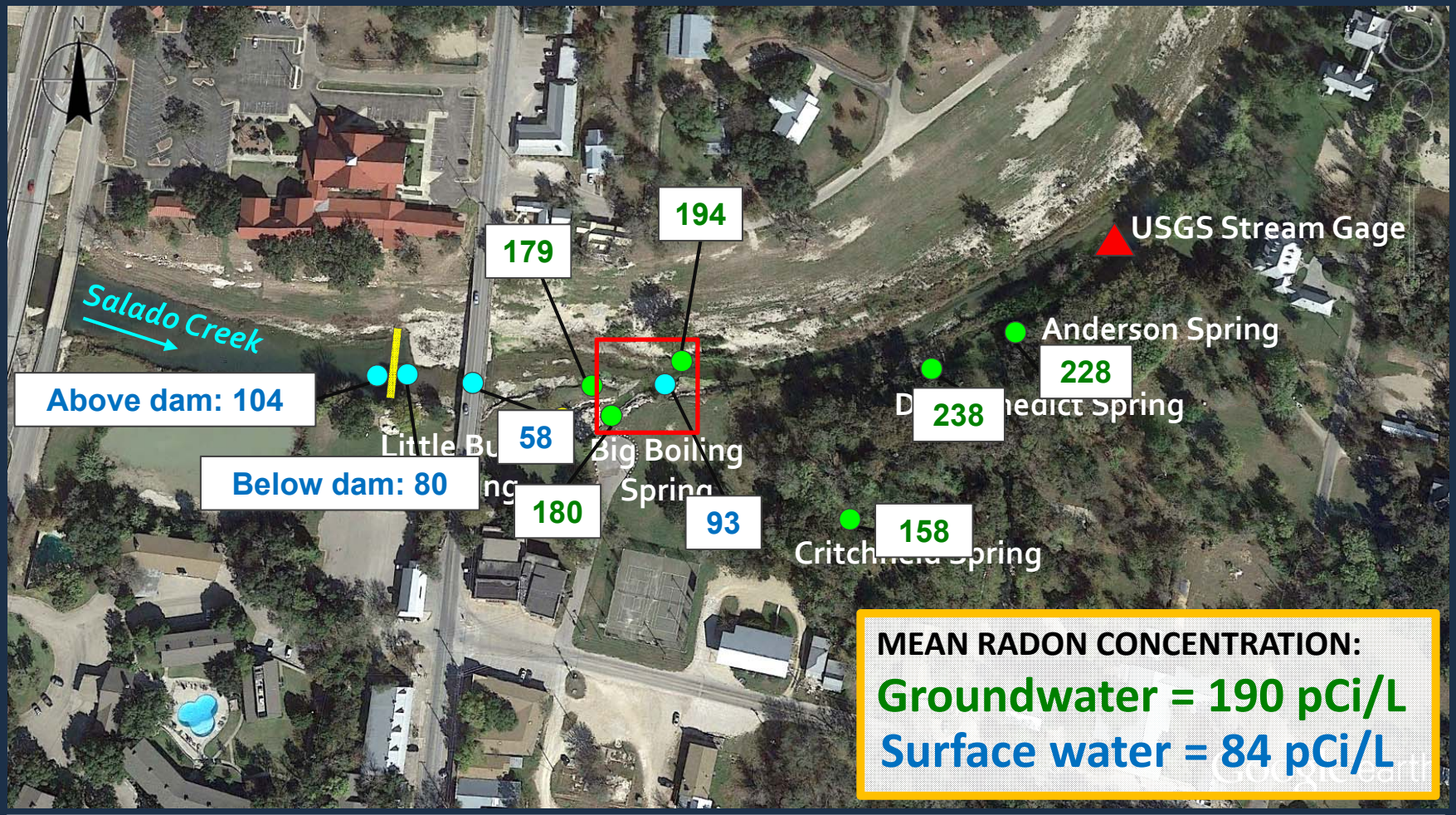
Radon concentration: Salado Creek basin

(May-June 2014)



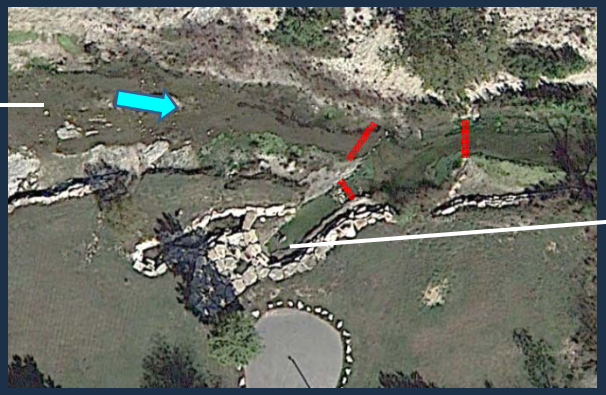
Radon concentration: Salado Springs

(March 2014)



* *Radon concentrations are in pCi/L*

Radon concentration: seasonal patterns



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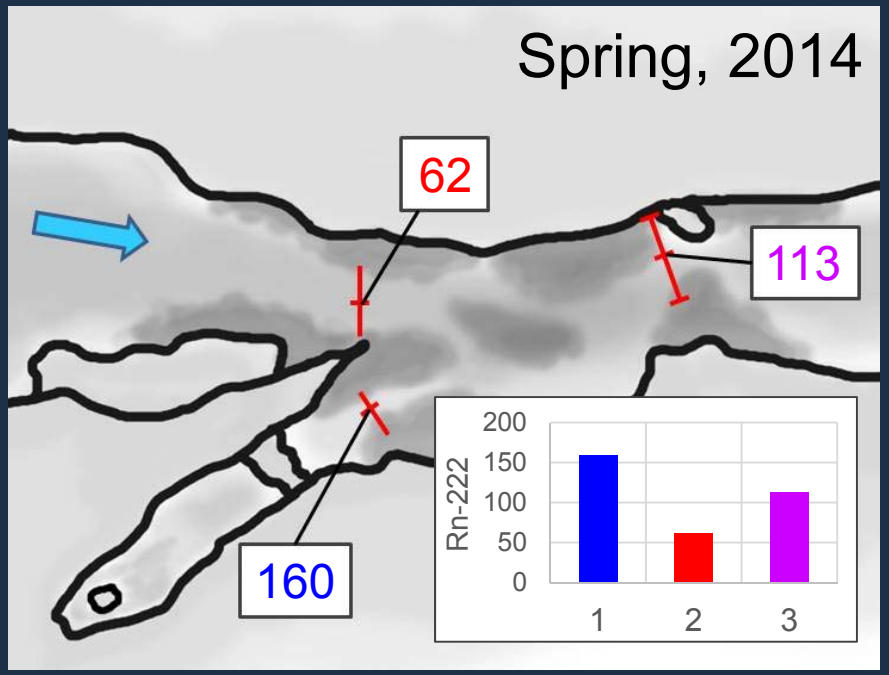
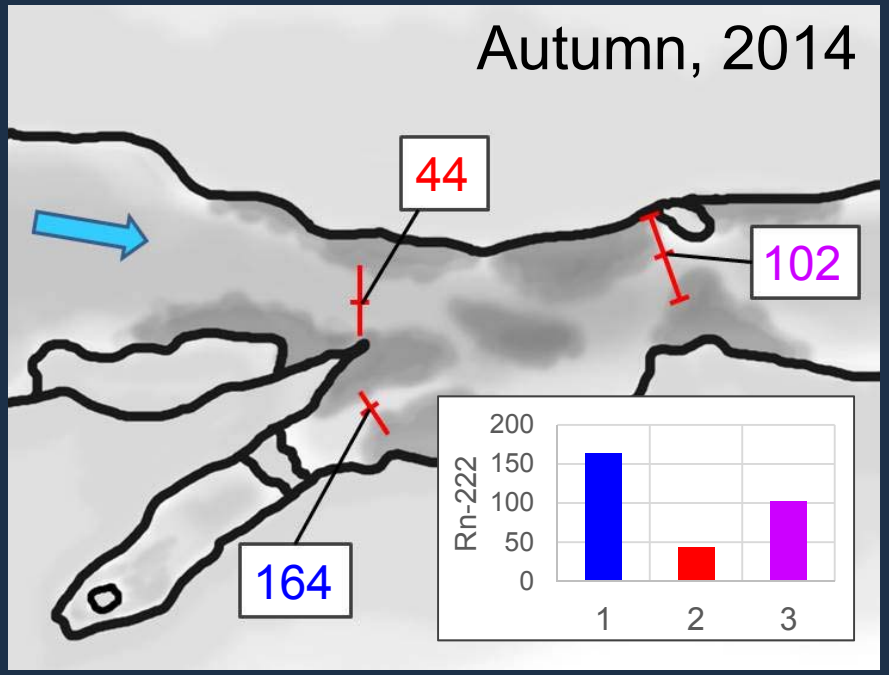




Radon concentration: seasonal patterns

Season	Modeled GW flow (cfs)	Observed GW flow (cfs)
Spring 2014	3.23	1.64
Autumn 2014	1.79	1.1

$$\frac{Q_{GW}}{Q_m} = \frac{C_m - C_{SW}}{C_{GW} - C_{SW}}$$

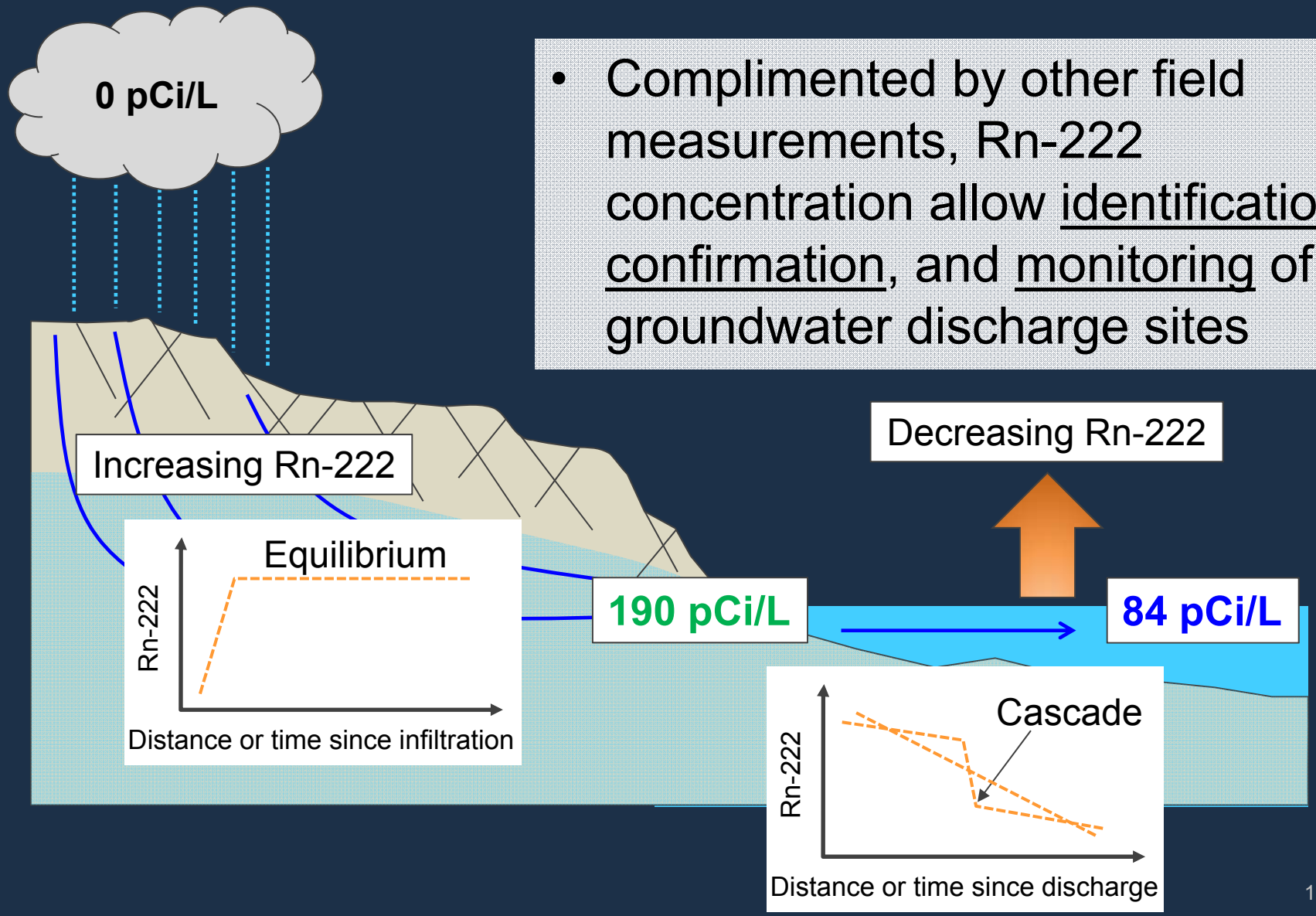
(Lee and Hollyday, 1991)

Salado Creek

Big Boiling Springs

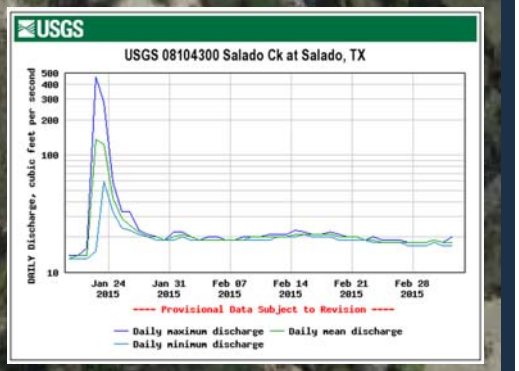
1. Clear difference between groundwater and surface water Rn-222 concentrations at downtown Salado

- Complimented by other field measurements, Rn-222 concentration allow identification, confirmation, and monitoring of groundwater discharge sites



2. Rn-222 concentrations at Salado Springs support stream gauge site

- No major groundwater addition after Salado Springs
- Additional geochemical and dye trace data indicate spring connectivity
- Stream gauge location is suitable for aquifer monitoring



USGS stream gage

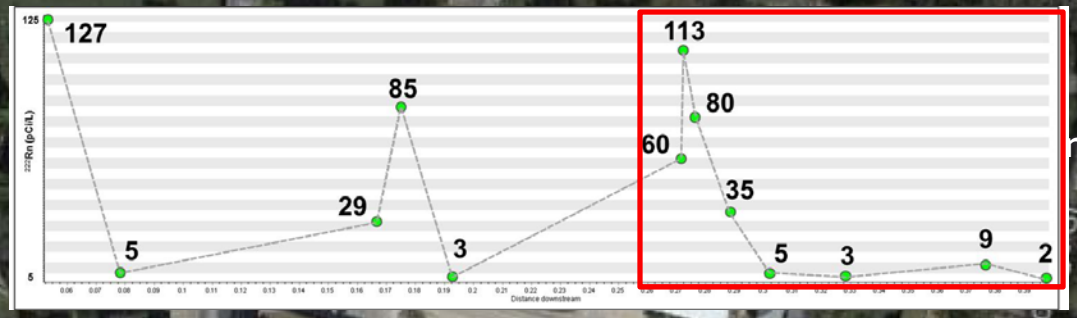
Salado Creek

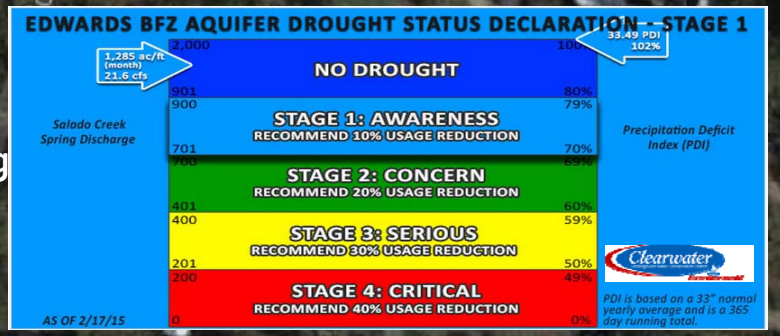
Anderson Spring

Doc Benedict Spring

Little Bubbly Spring

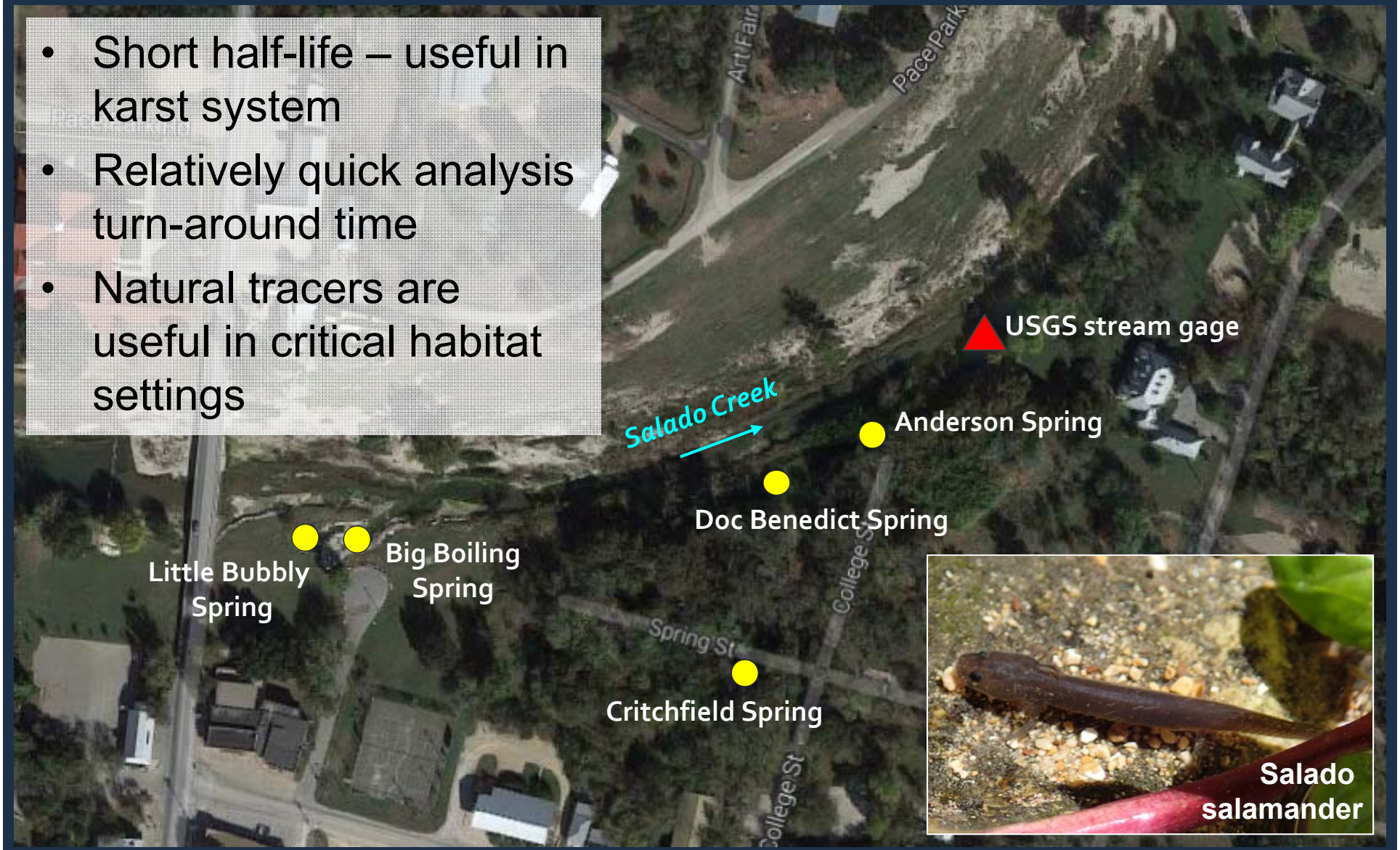
Big Boiling Spring





3. The use of Rn-222 as a natural tracer is relevant in a critical habitat setting

- Short half-life – useful in karst system
- Relatively quick analysis turn-around time
- Natural tracers are useful in critical habitat settings



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Clearwater Underground Water Conservation District

Village of Salado

THE STATE OF TEXAS BELL COUNTY

USGS science for a changing world

U.S. FISH & WILDLIFE SERVICE

national ground water association

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- Photo credits: P. Diaz, S. Wong, J.C. Yelderman Jr.