Estimating Groundwater Recharge Using Soil Moisture Data

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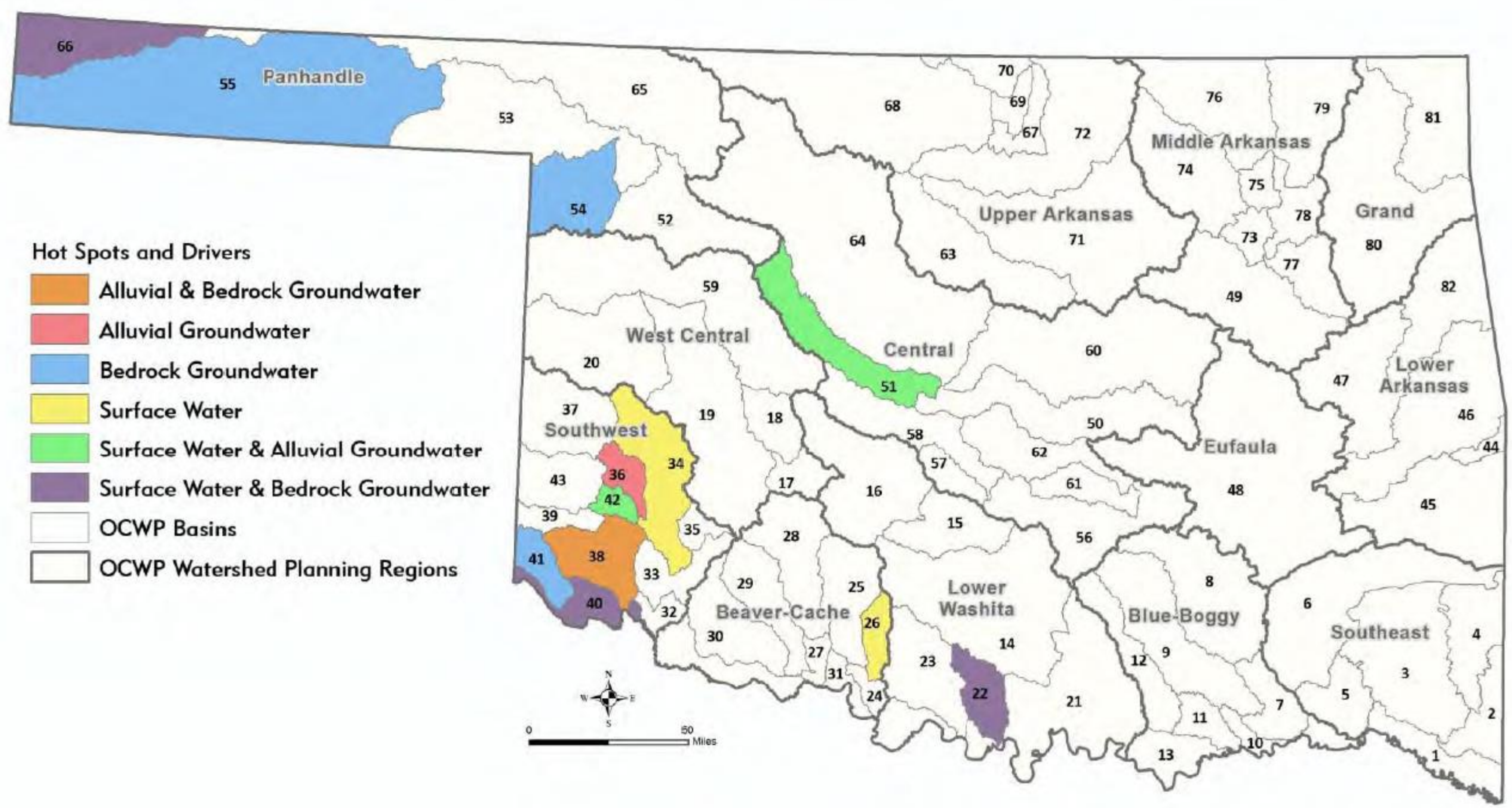
The Challenge

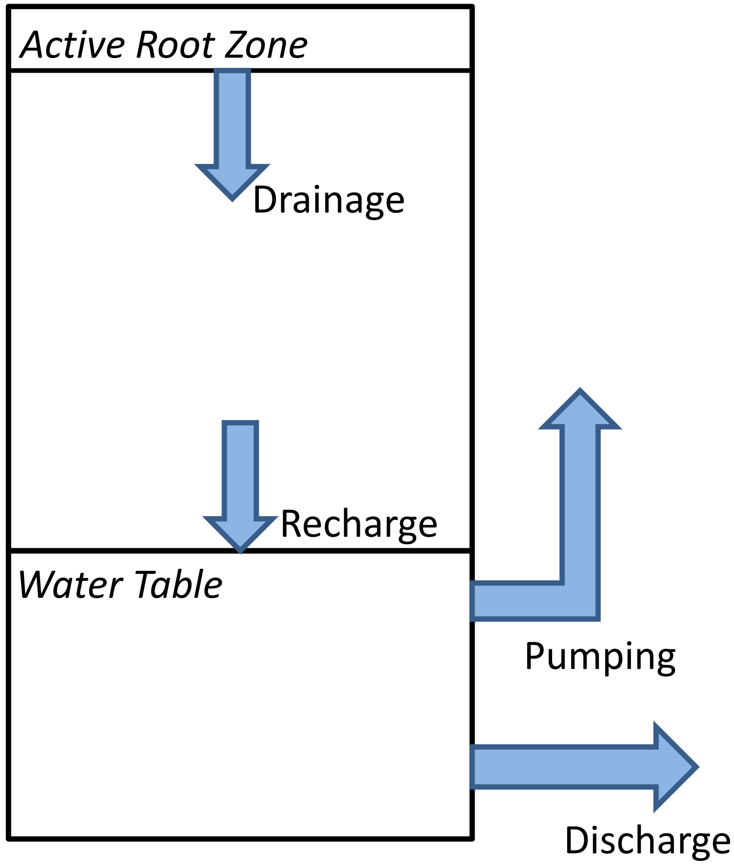
- Sustainability of groundwater resources



Groundwater basins facing the greatest water supply issues (OCWP, 2012)

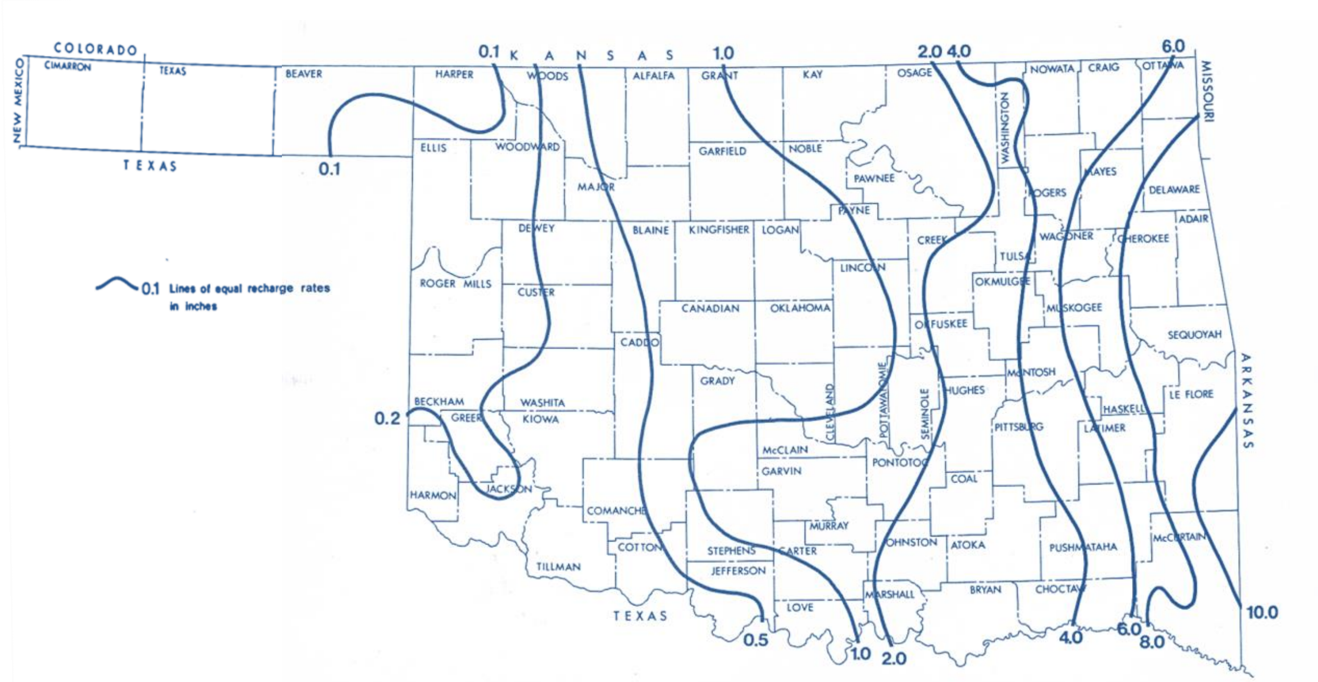
Groundwater Balance

- To maintain groundwater levels, outputs (pumping, discharge) must not exceed inputs (precipitation, irrigation).
- Pumping < recharge for sustainable supply
- **In order to prevent overuse, reliable recharge estimates are needed.**



Current Recharge Data

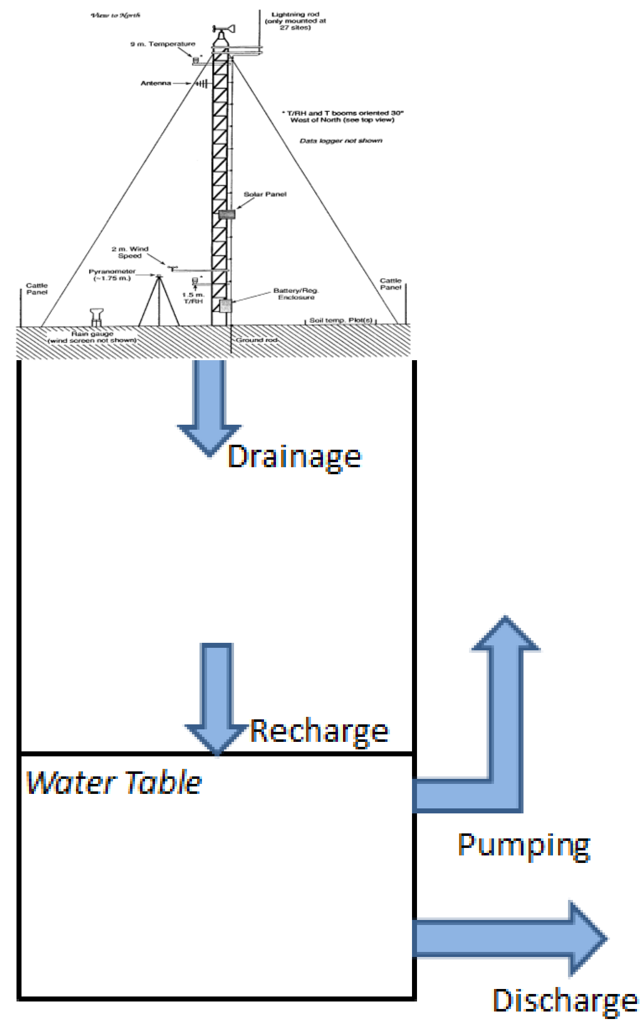
- Most recent publication of state-wide recharge rates is over 30 years old.
- Many studies have focused on recharge in specific groundwater systems, but no state-wide estimates exist.



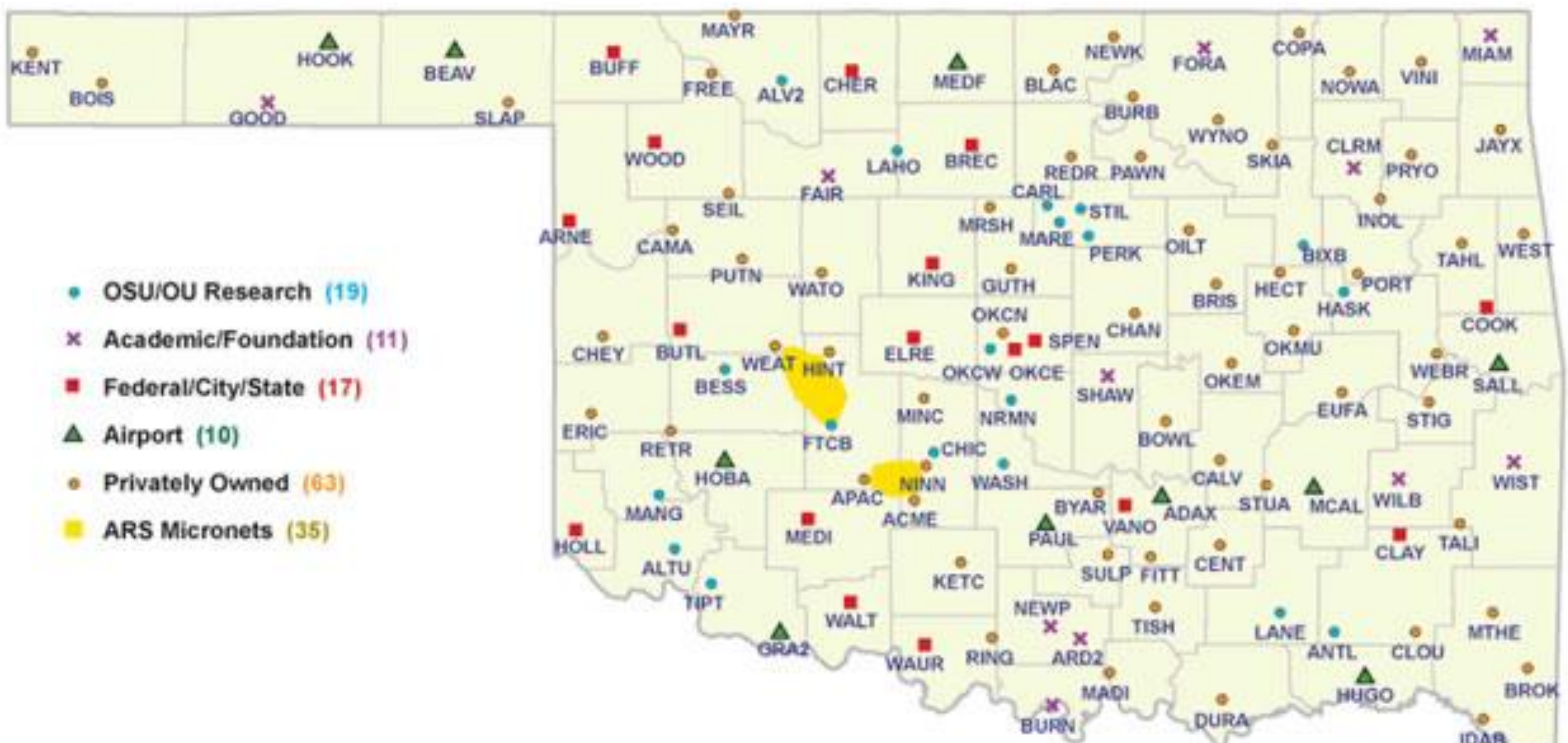
Our Approach

- Soil moisture data and soil properties collected from Oklahoma Mesonet sites can be used to estimate site-specific drainage rates.

- Working hypothesis- drainage ≈ recharge



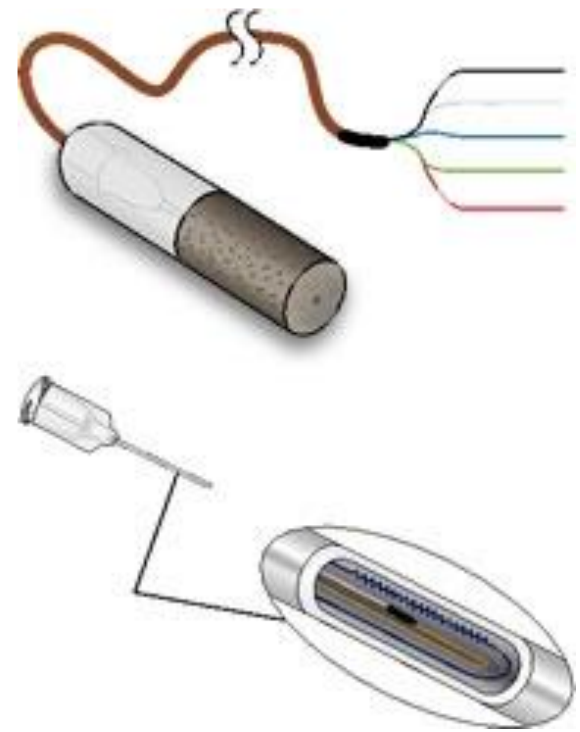
Oklahoma Mesonet



CS 229–L Soil Moisture Sensors

- Measure change in temperature of thermocouple inside ceramic case

- Inverse relationship between soil moisture and temperature change



Converting Soil Moisture Data to Drainage Rates

- Convert Mesonet soil moisture data to matric potential (Illston et al., 2004)

$$\Psi_m = -c\exp(a\Delta T_{ref})$$

- Use Van Genuchten equation to convert these matric potentials, using site-specific soil hydraulic properties, to soil volumetric water content for each site (van Genuchten, 1980)

$$S_e = [1 + (-\alpha\,\Psi_m)^n]^{\,m}$$

- Use daily volumetric water content at the 60cm depth to determine daily hydraulic conductivity values (Schaap et al., 2001)

$$K(S_e) = K_0 S_e^{\,L}\{1-[1-S_e^{\,n/(n-1)}]^{1-1/n}\}^2$$

Our Goals

- Determine the *site-specific* level of agreement between Mesonet-based drainage estimates and recharge estimates from independent sources.
- Determine the *regional* level of agreement between Mesonet-based drainage estimates and recharge estimates from independent sources.

Mesonet-estimated Drainage

Table 1: Median annual precipitation and median annual drainage at 60 cm for the Mesonet sites above three Oklahoma aquifers from 1996 through 2012. For comparison, prior published estimates of groundwater recharge for these aquifers are also shown.

Aquifer	Sites	Precip.	Drainage	Recharge	Source
		mm	mm yr^{-1}	mm yr^{-1}	
Roubidoux	3	1097.3	226.1	2.3-45.7	USGS (2009)
Antlers	5	1092.2	71.1	152.4	Hart and Davis (1981)
Arkansas River	5	1023.6	200.7		
Vamoosa-Ada	3	962.7	104.1	38.6	D'Lugosz (1986)
Garber-Wellington	3	911.9	68.6	53.3	Pettyjohn and Miller (1982)
Rush Springs	5	746.8	73.7	71.1	Tanaka and Davis (1963)
Ogallala	8	508.0	27.9	27.9	OWRB (2011)

Independent Estimates

- Site-specific long term average drainage rates will be estimated by the *unsaturated* zone chloride mass balance (uzCMB) method.

$$P \cdot Cl_{rain} = R \cdot Cl_{uz}$$

- Soil cores have been collected from Fort Cobb, Slapout, and Arnett.

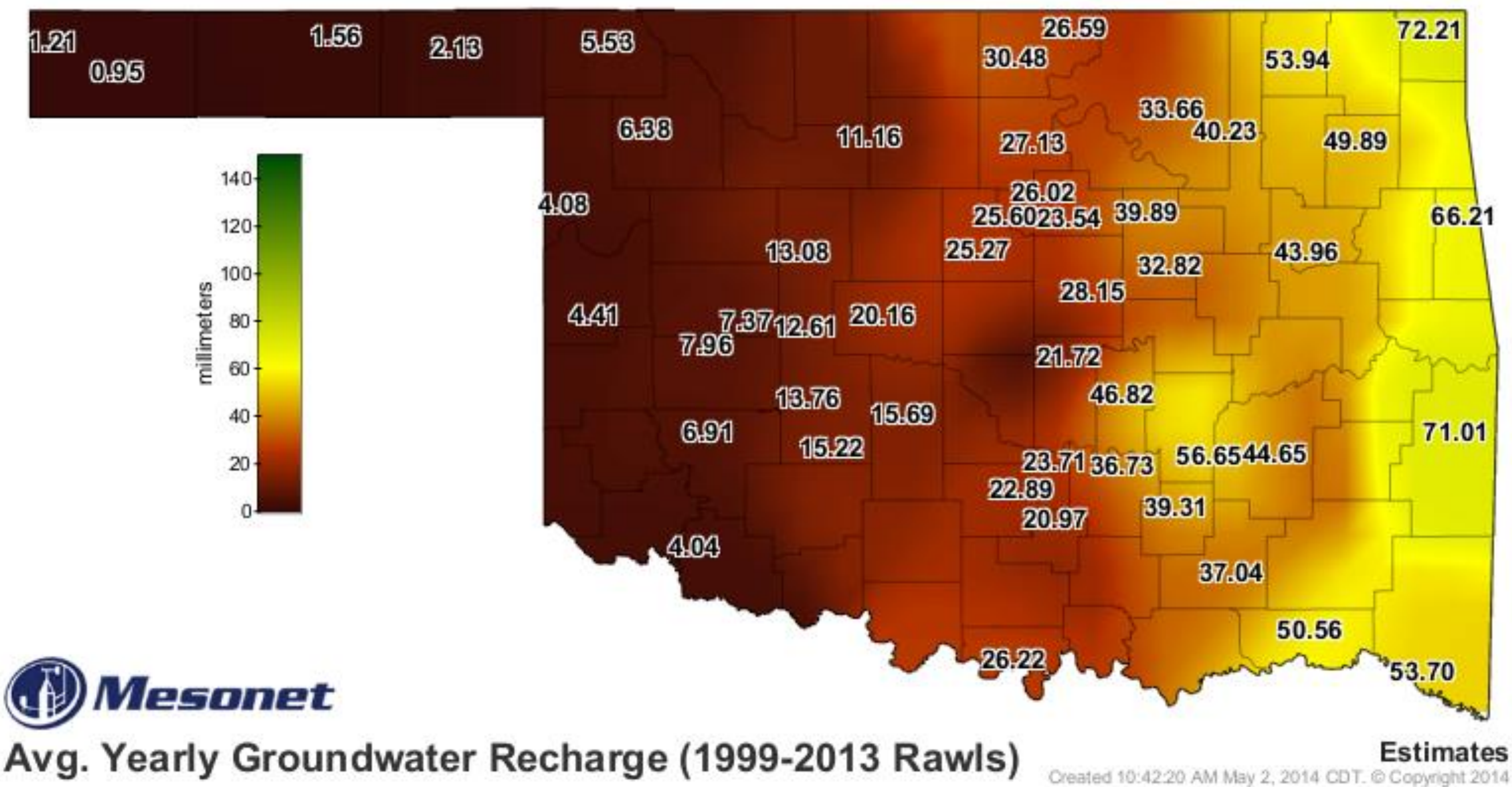
Chris Hobbs (NRCS) collecting a soil core at the Slapout site. March 20, 2014

Current uzCMB Results

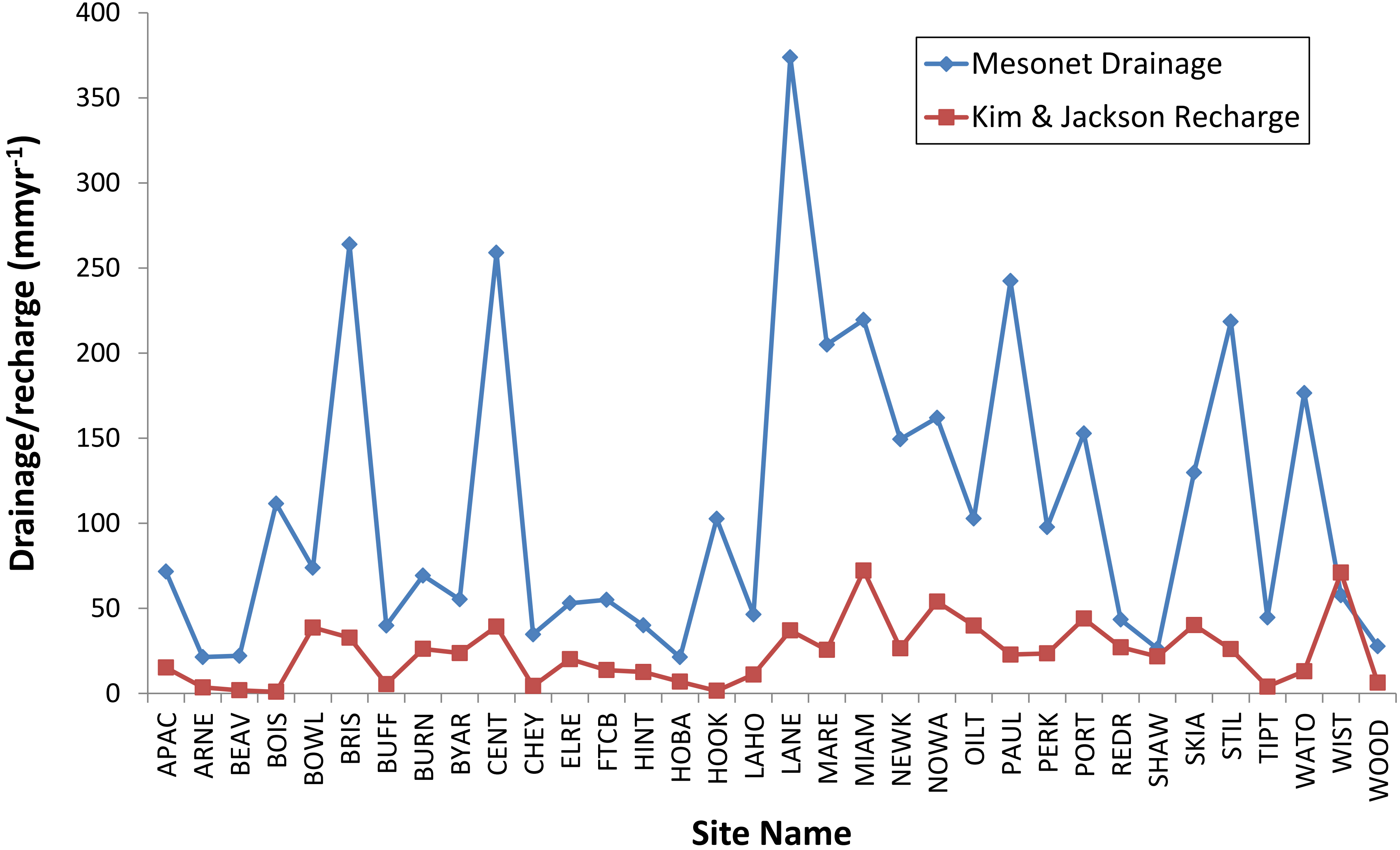
- Results show very low recharge rates
- Possible sampling error at FTCB
- Shallow cores at SLAP

Site	Aquifer	Sample Depth	Recharge	Mesonet Estimate
		m	mm yr^{-1}	mm yr^{-1}
Arnett	Ogallala	5.5	0.45	21.4
Slapout	Ogallala	3.7	0.5	31.4
Fort Cobb	Rush Springs	7.6	0.16	55

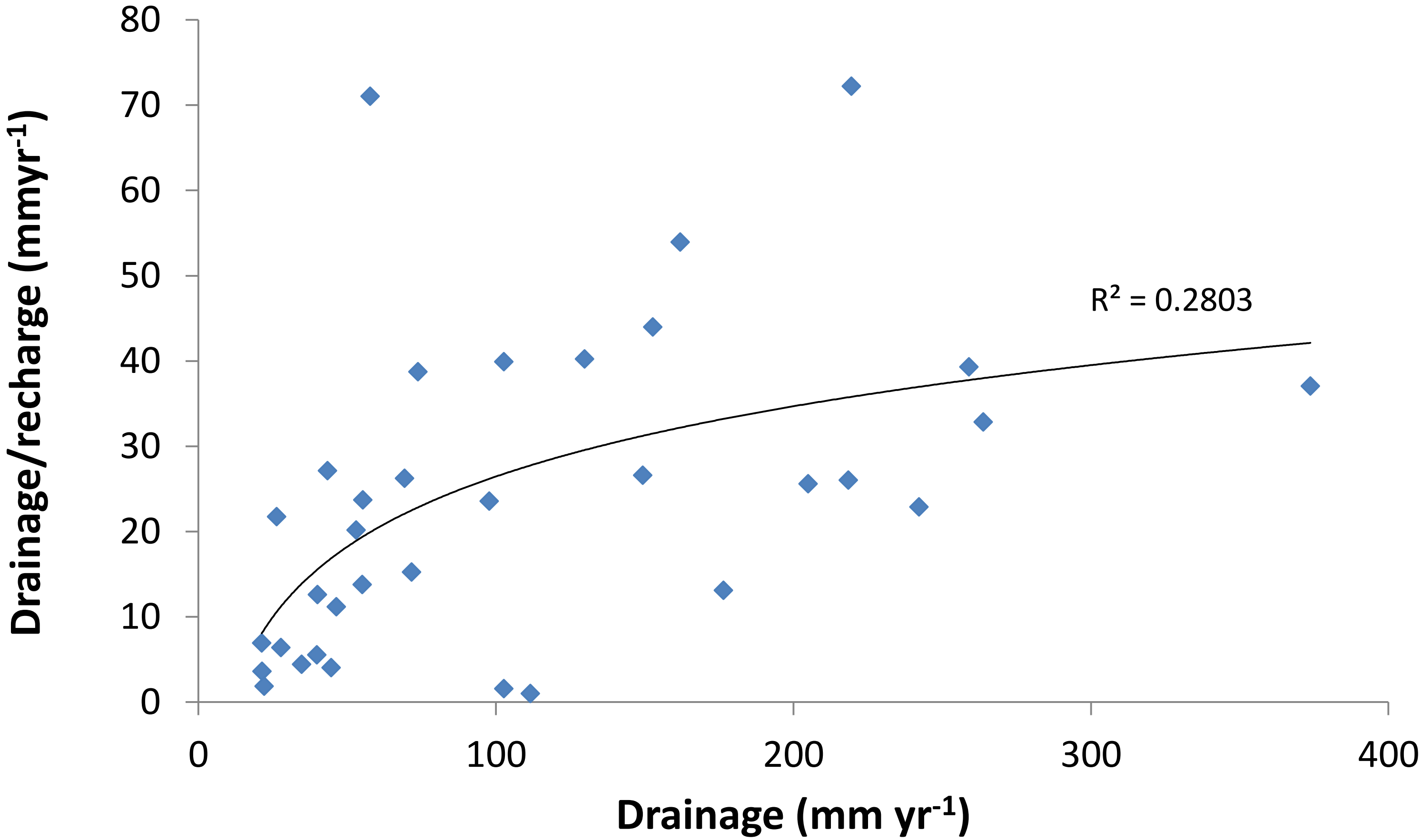
Kim and Jackson Recharge Model



Mesonet Drainage v. Kim & Jackson Recharge



Mesonet Discharge v. Rawls Recharge



Conclusion

- Mesonet-based drainage rates are generally near or higher than previous recharge estimates
- Not confident in uzCMB method results
- Future work
  - Additional uzCMB samples
  - szCMB for regional recharge rates
  - Large-scale recharge map

Questions