Modeling assessment of larger-than-expected inflow to the depleting High Plains Aquifer in Kansas

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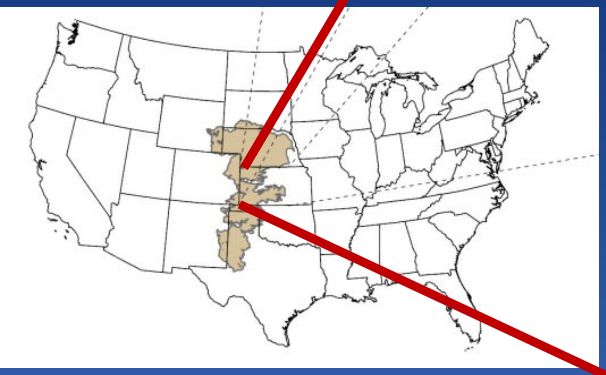
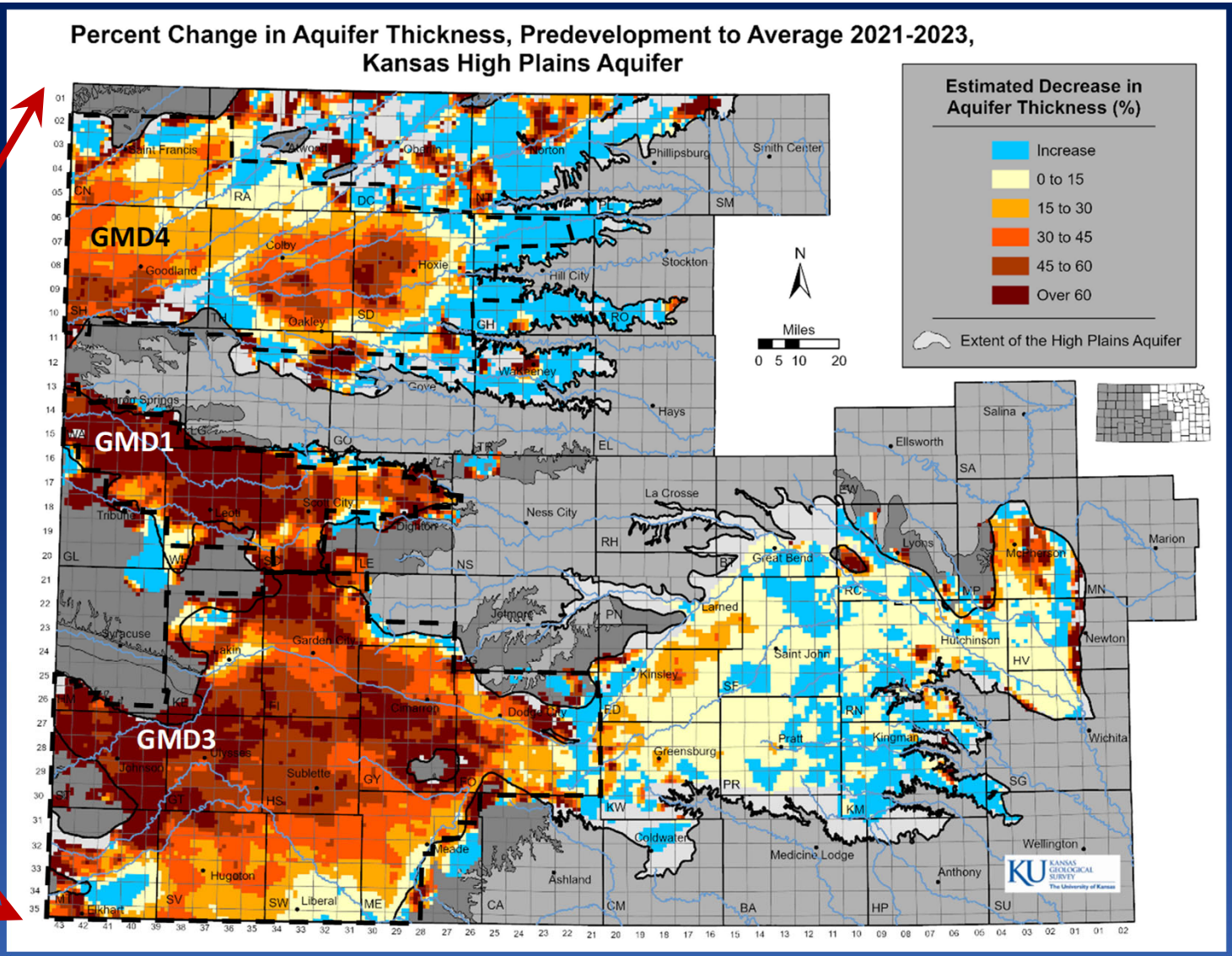
Outline

- Larger-than-expected inflow into Kansas HPA
- GMD3 modeling assessment
  A. District scale
  B. County scale
- Conclusion and future work

Change in Kansas HPA Thickness

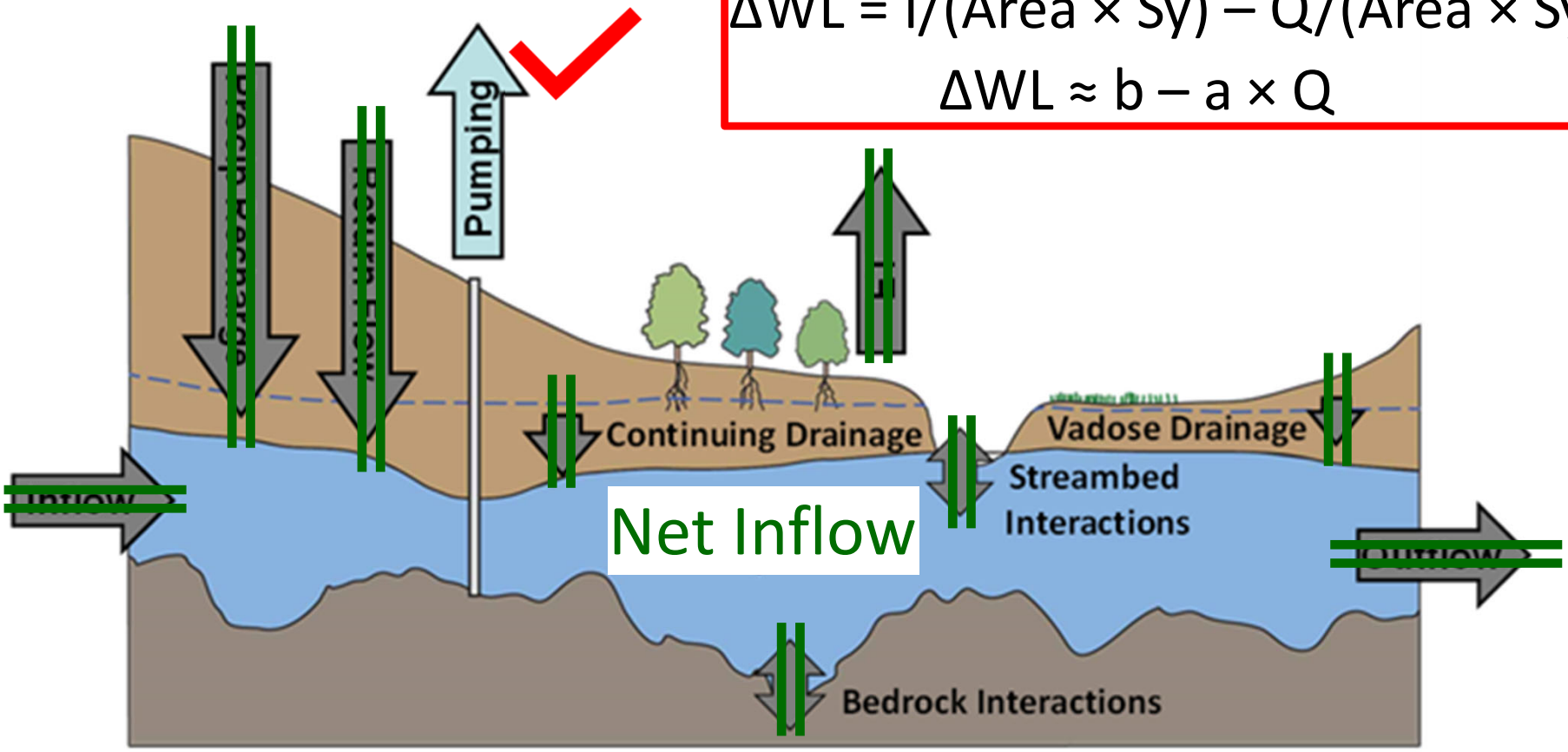




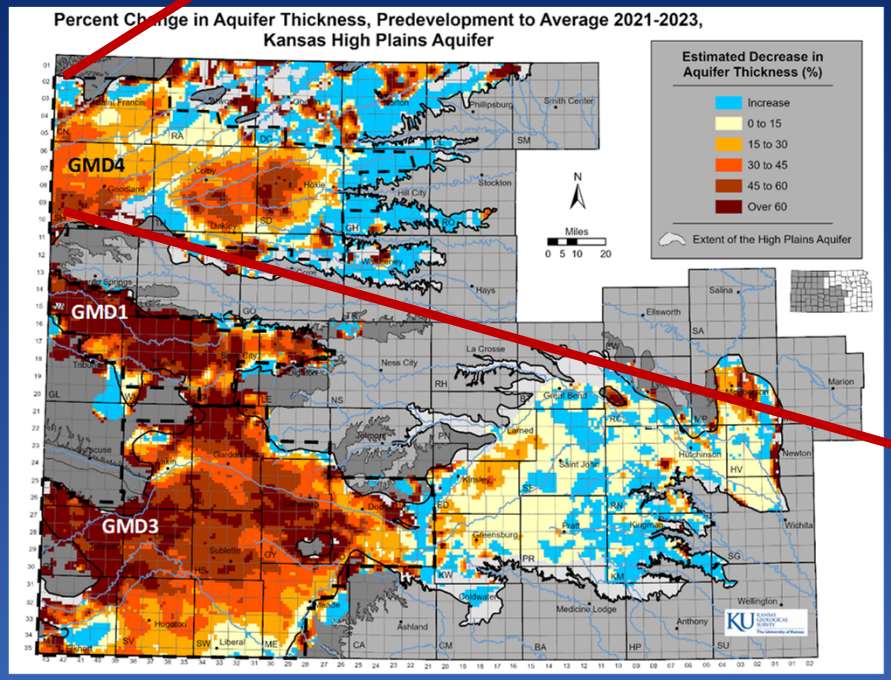
KGS Water Balance Approach

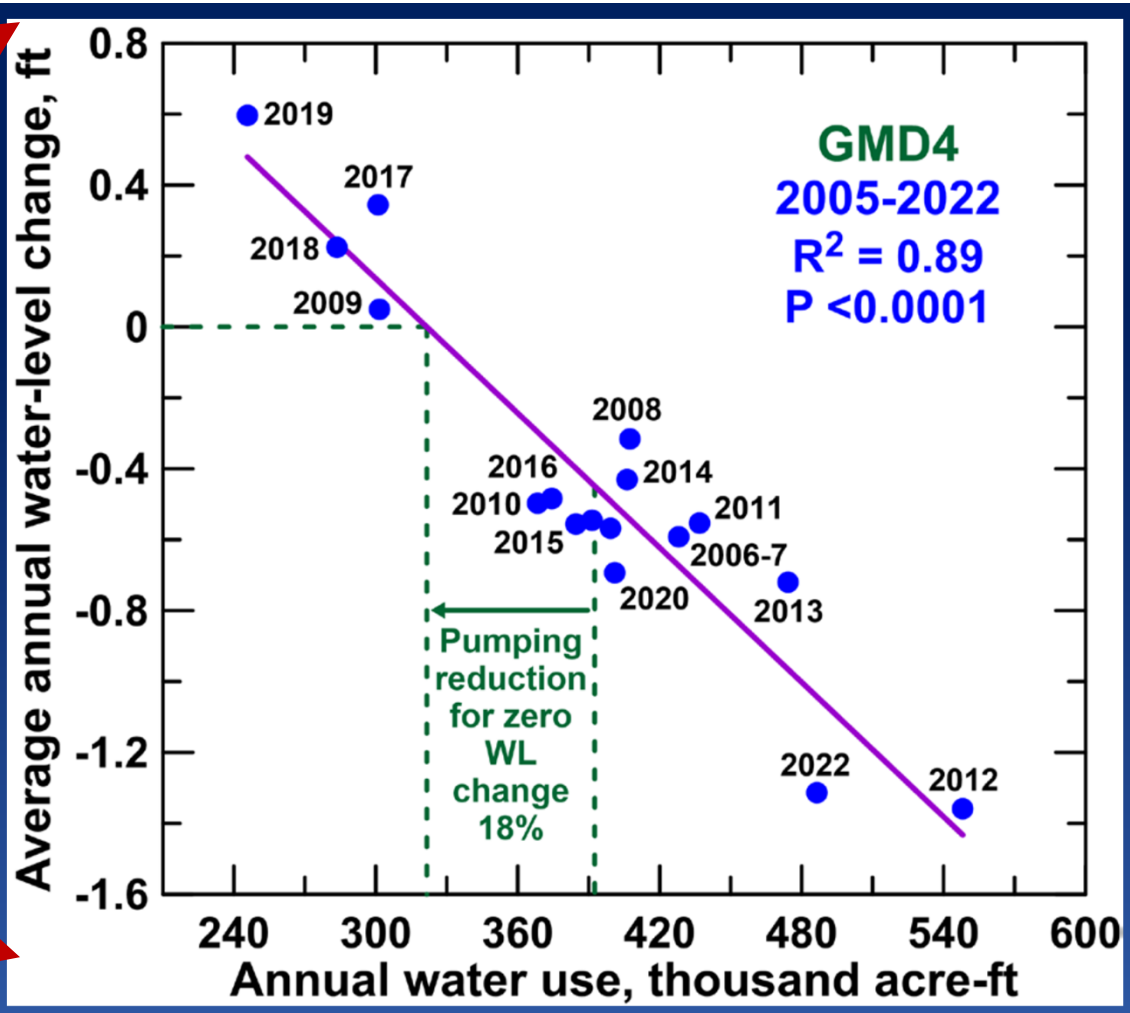
$$\Delta WL = I/(Area \times Sy) - Q/(Area \times Sy)$$

$$\Delta WL \approx b - a \times Q$$



GMD4 Water Balance Analysis

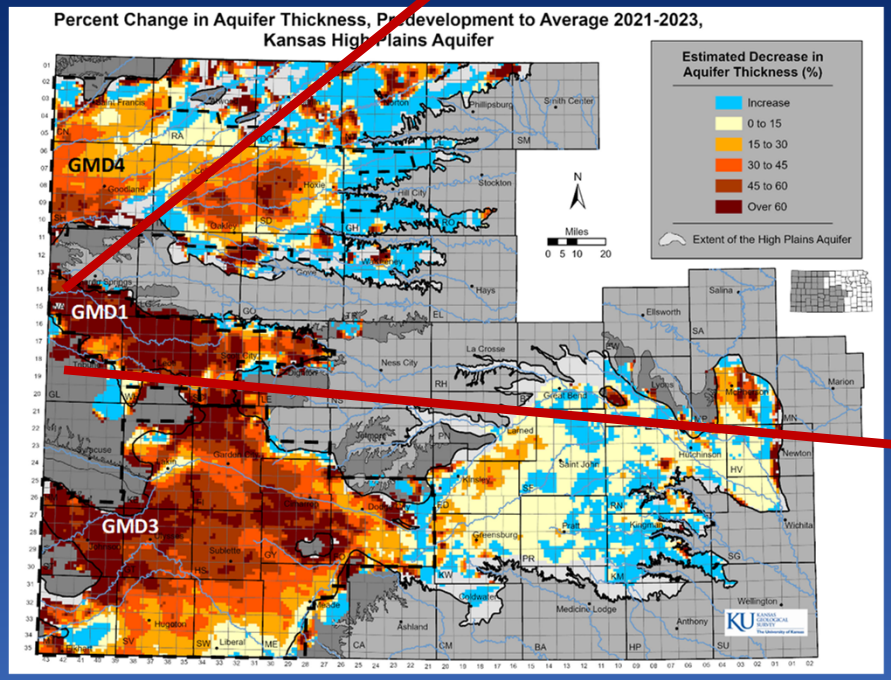


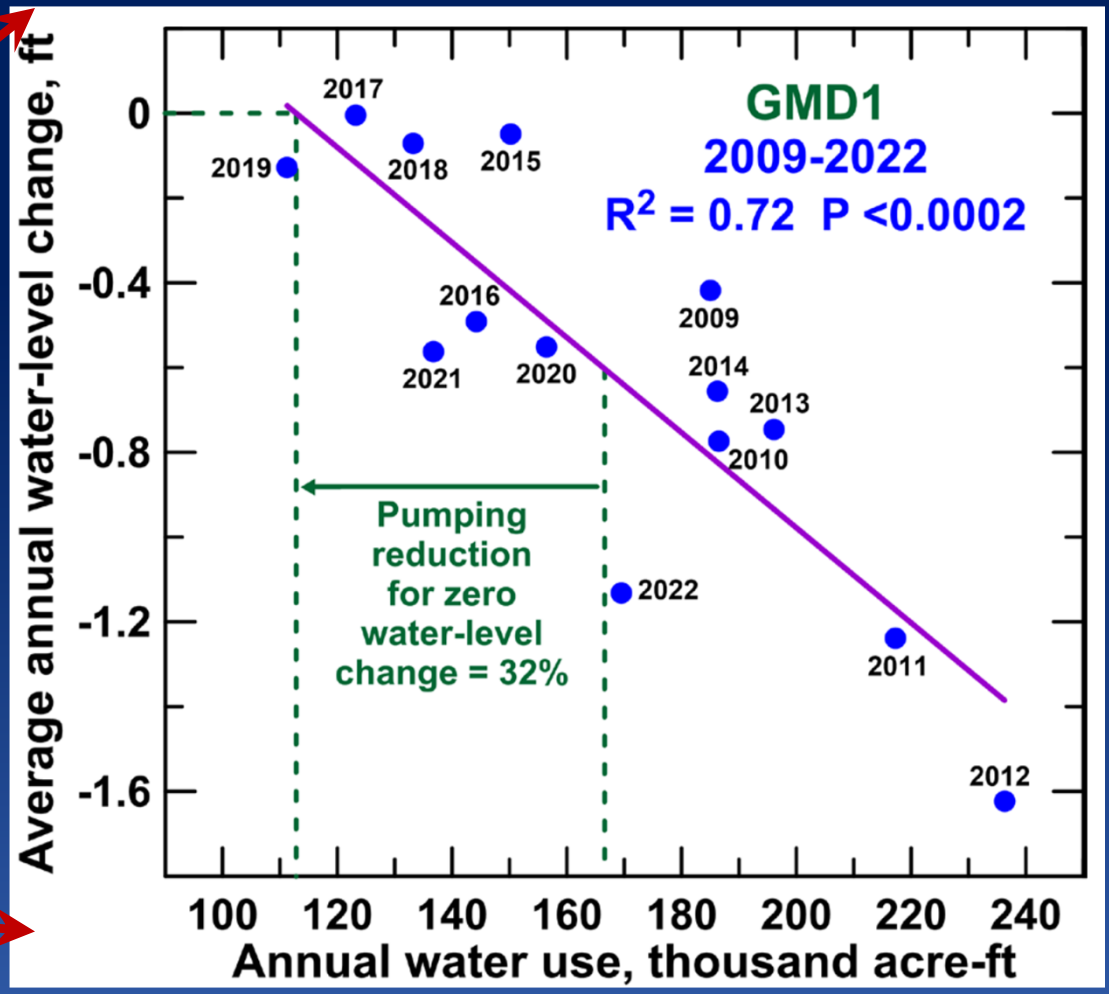


Net Inflow 3.3 cm/yr

Precip Recharge 1.7 cm/yr

GMD1 Water Balance Analysis

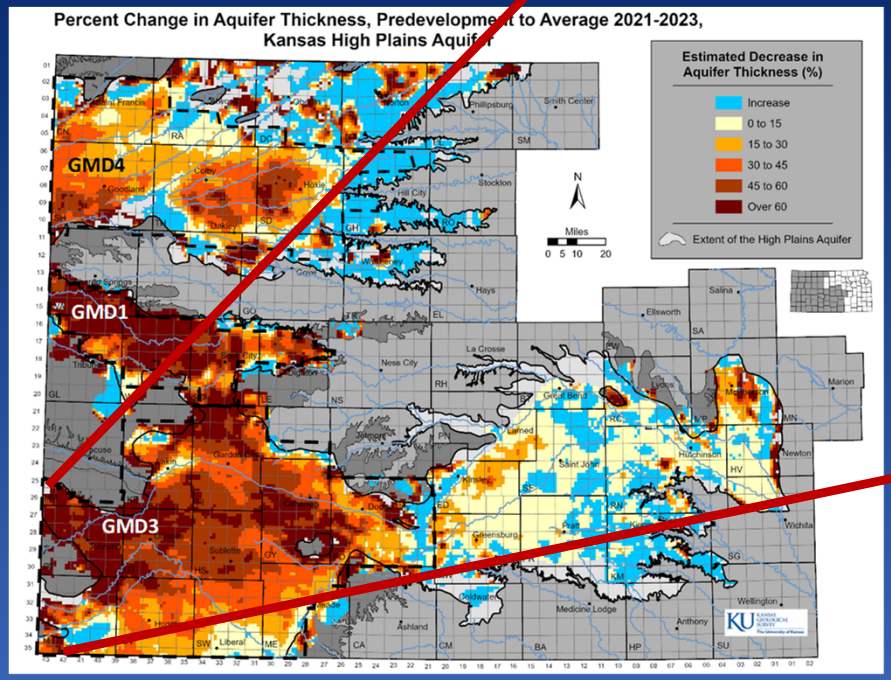


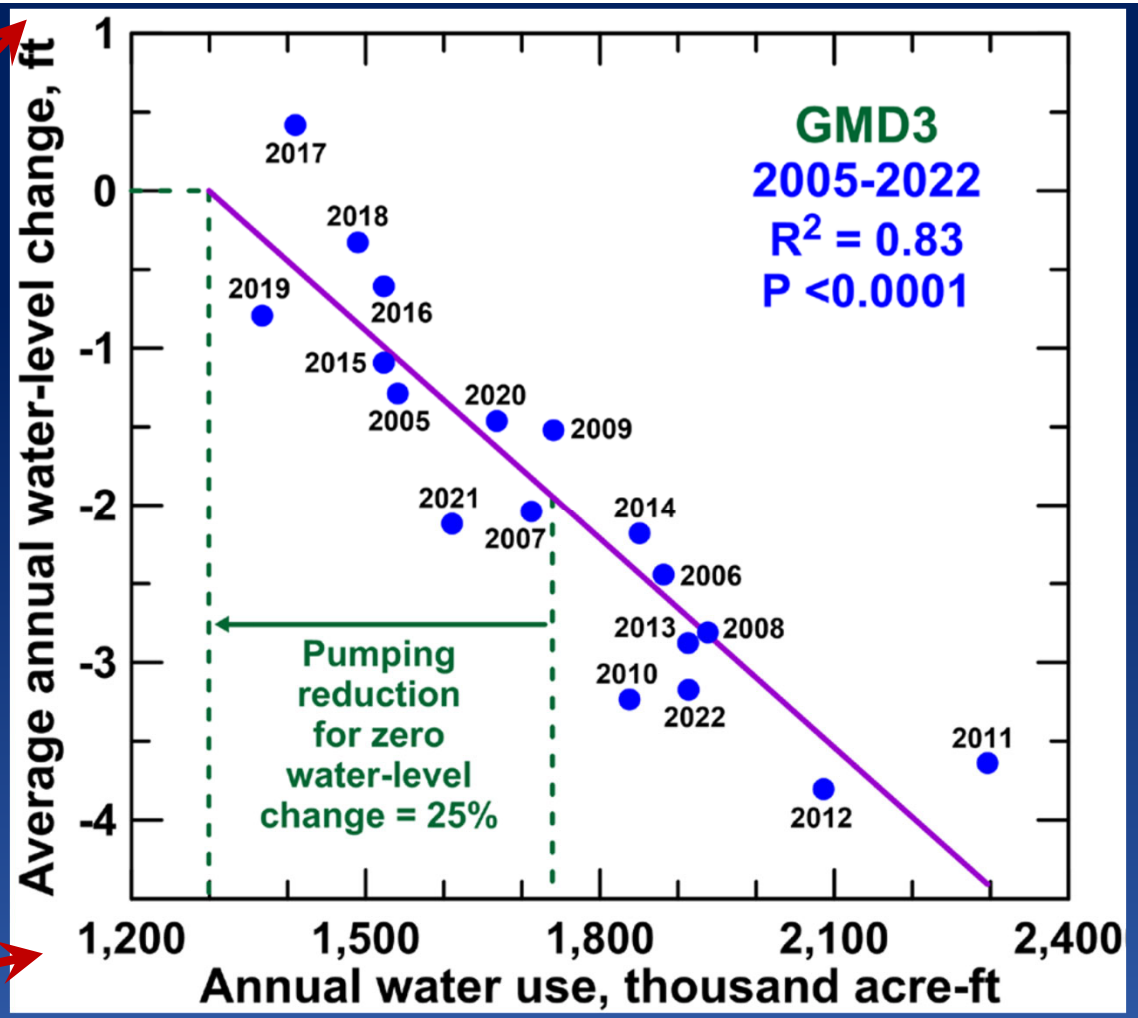


Net Inflow 3 cm/yr

Precip Recharge 1.3 cm/yr

GMD3 Water Balance Analysis





Net Inflow 8 cm/yr

Precip Recharge 2.5 cm/yr

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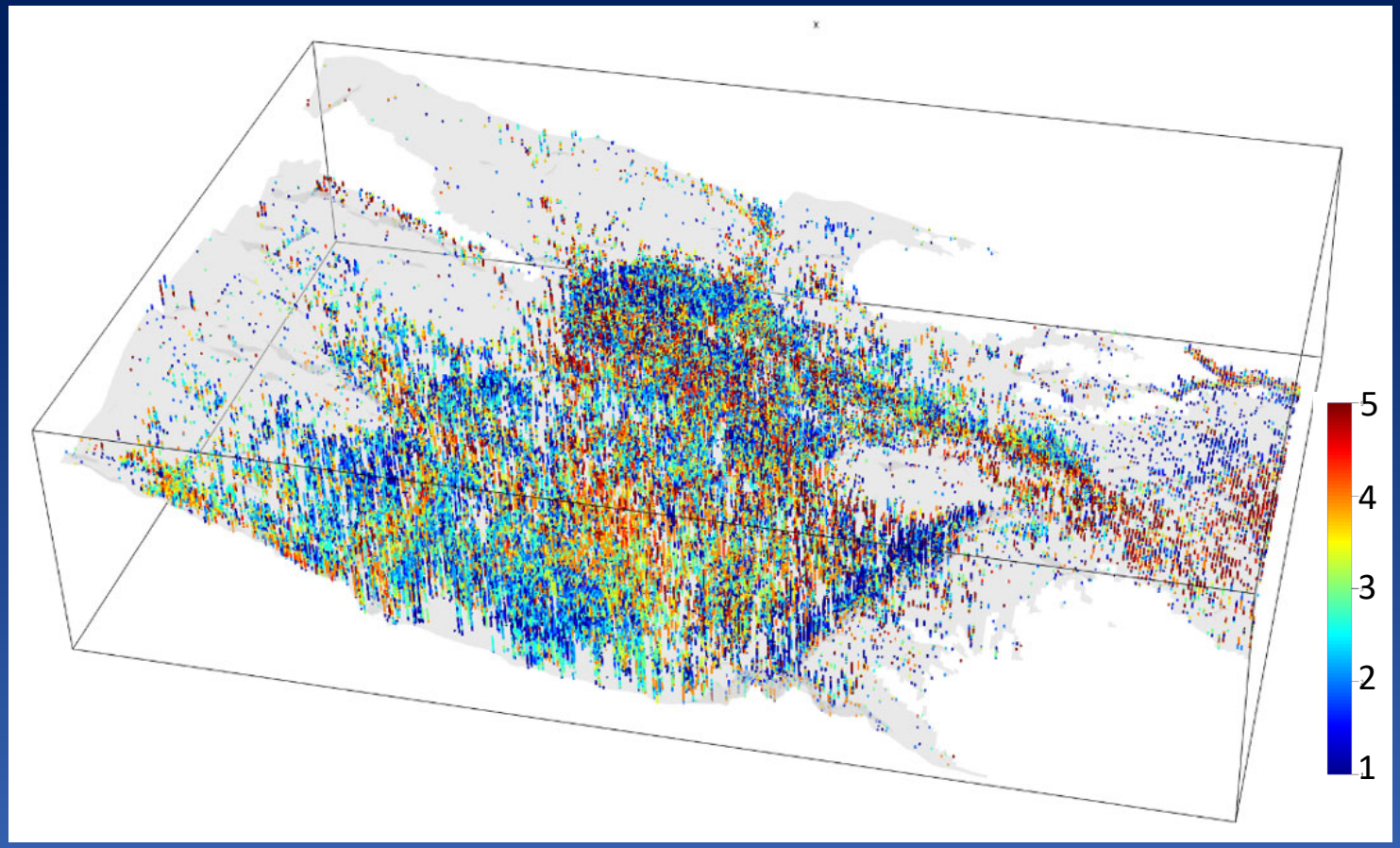
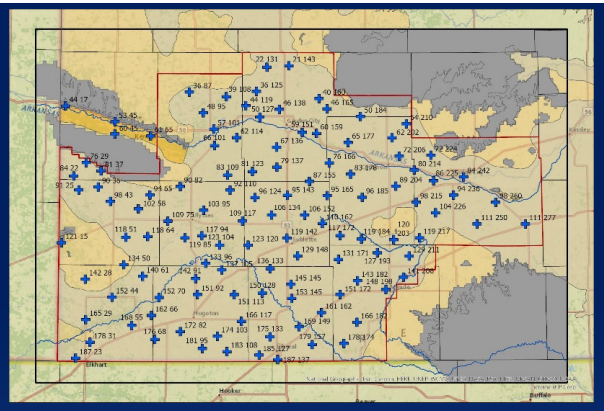
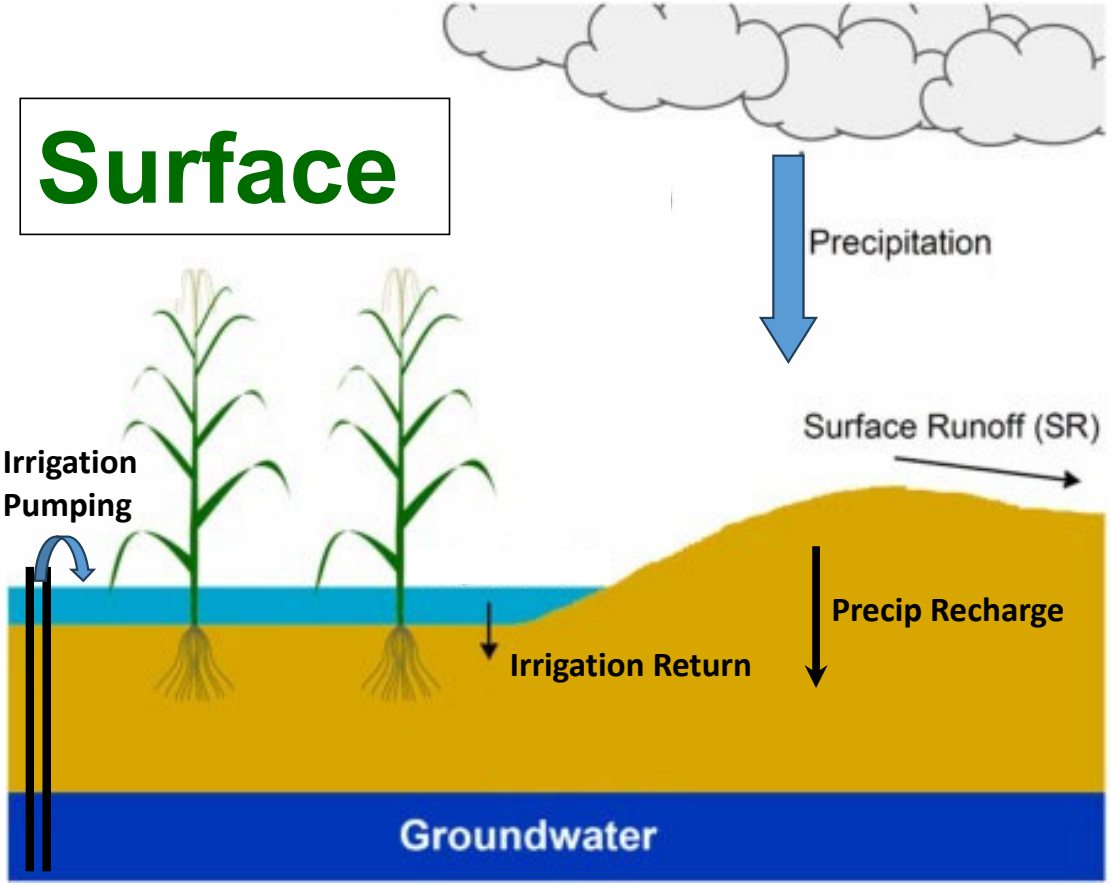
GMD3 Model Assessment



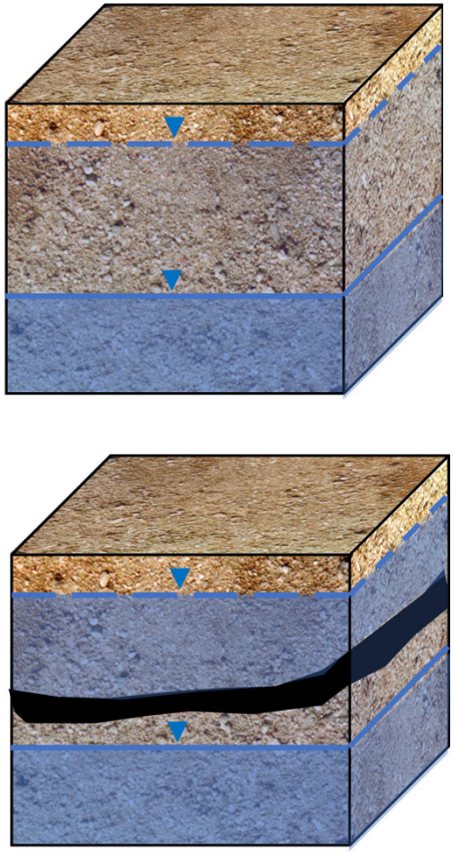


- Each well segmented into regular 10- foot intervals.
- Compute the proportion of each category within each interval.
- 5 (dark red) for highest permeability.
- 1 (dark blue) for lowest permeability materials.

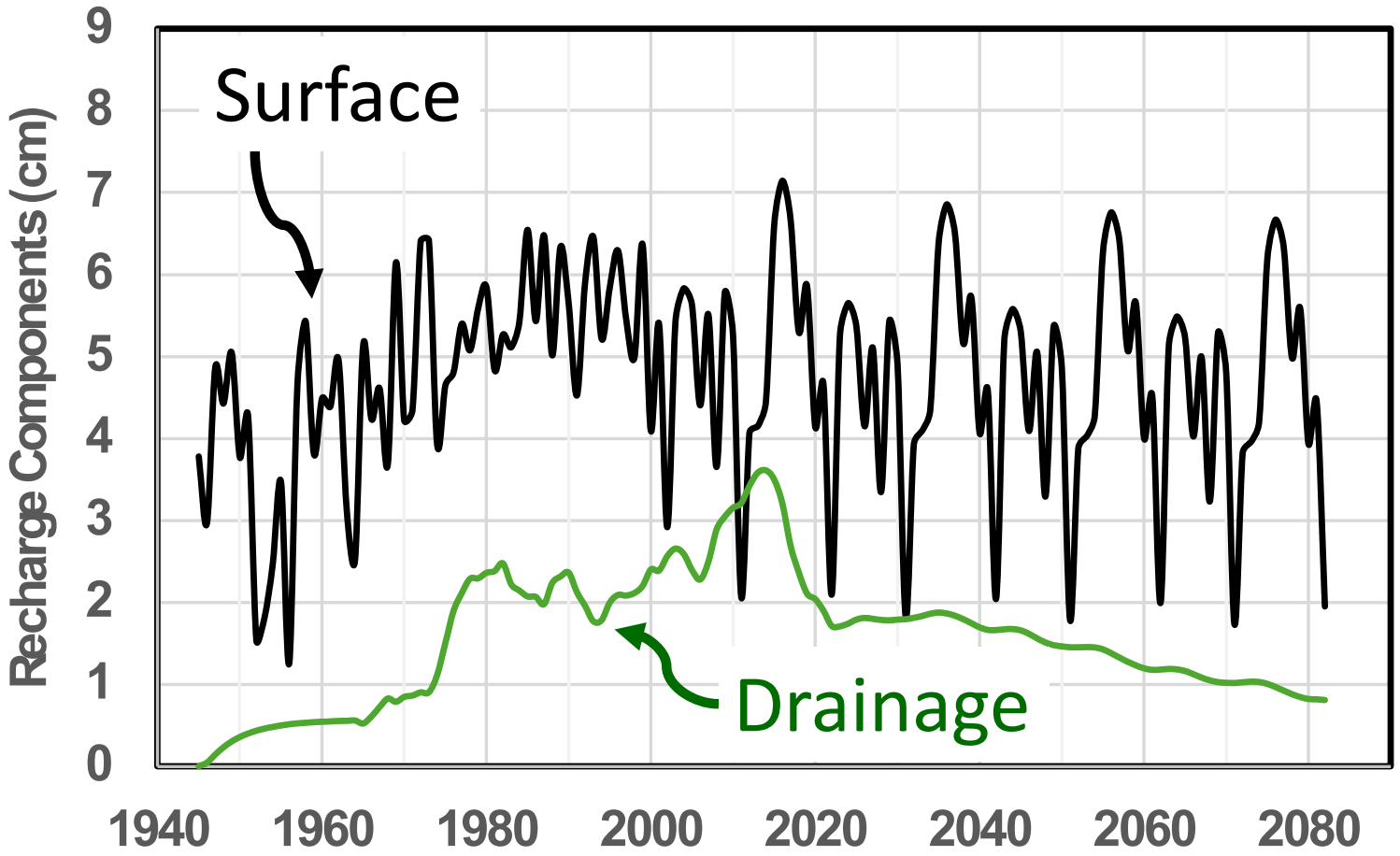
Two Major Recharge Components



Drainage delayed by silts and clays

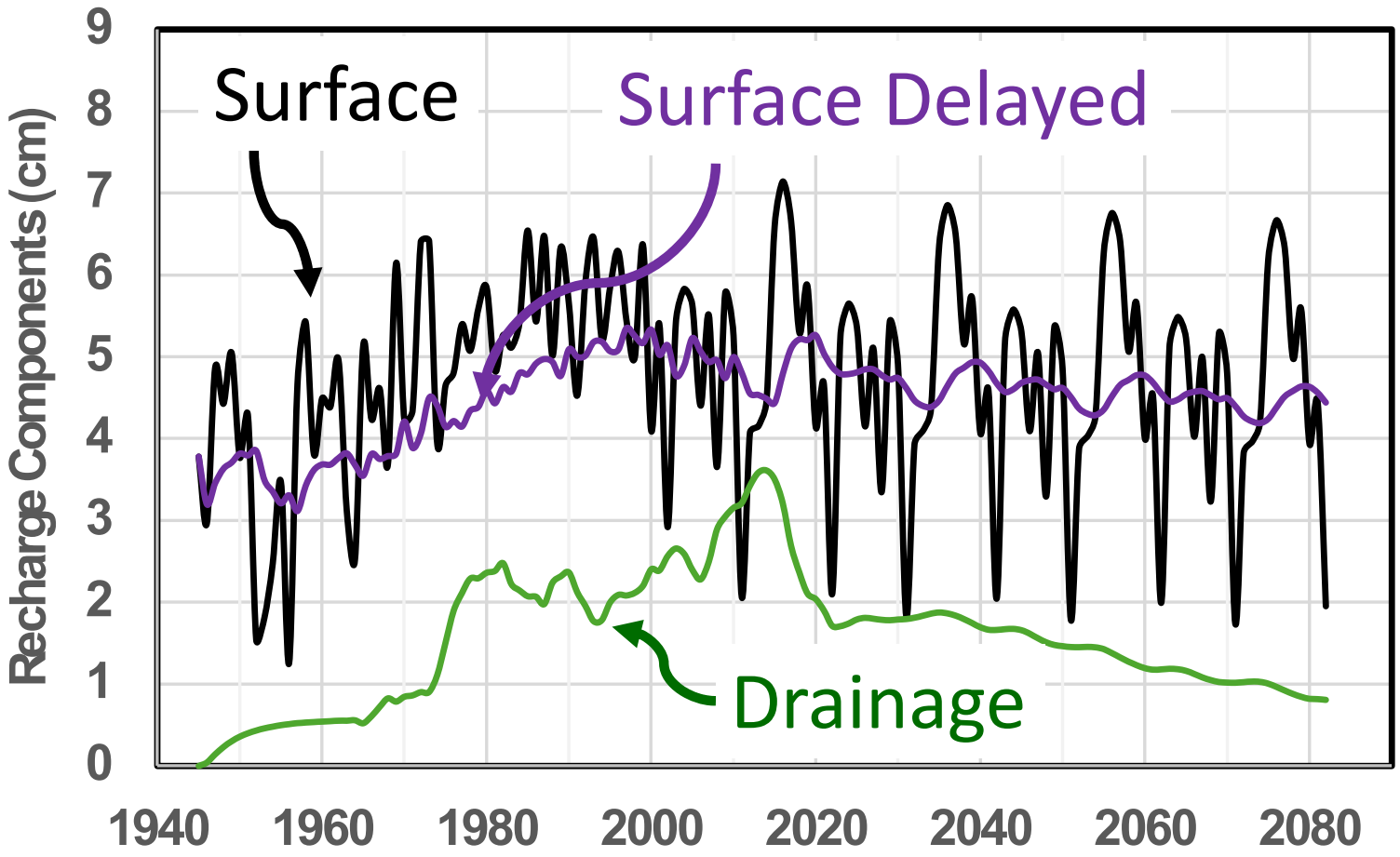


Two Major Recharge Components Simulated in GMD3



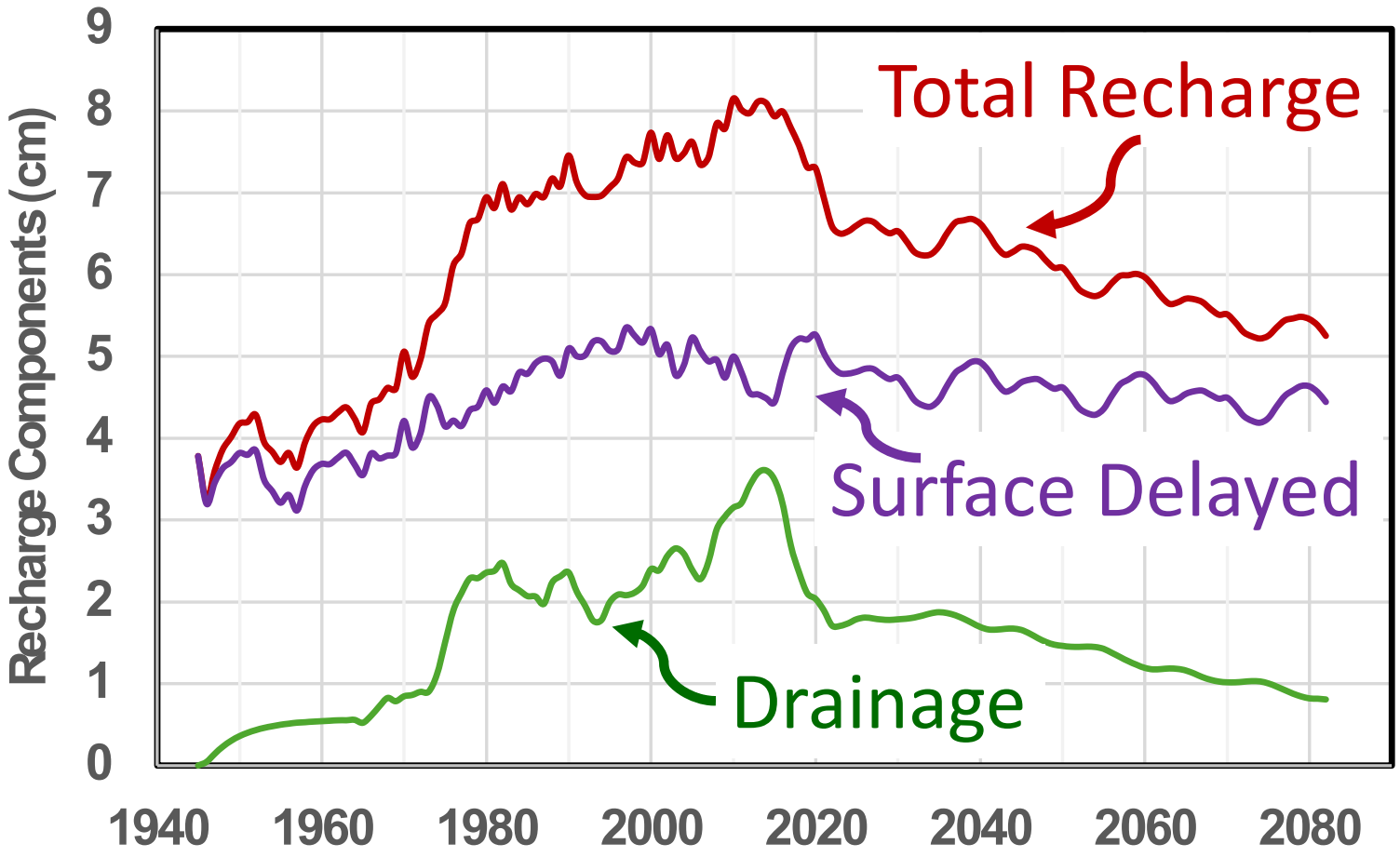
- District average
- ≤2020, historical
- ≥2001, future
- Future climate repeats 2001-2020
- Two main components: recharge from surface and lagged drainage

Surface recharge delayed in vadose zone



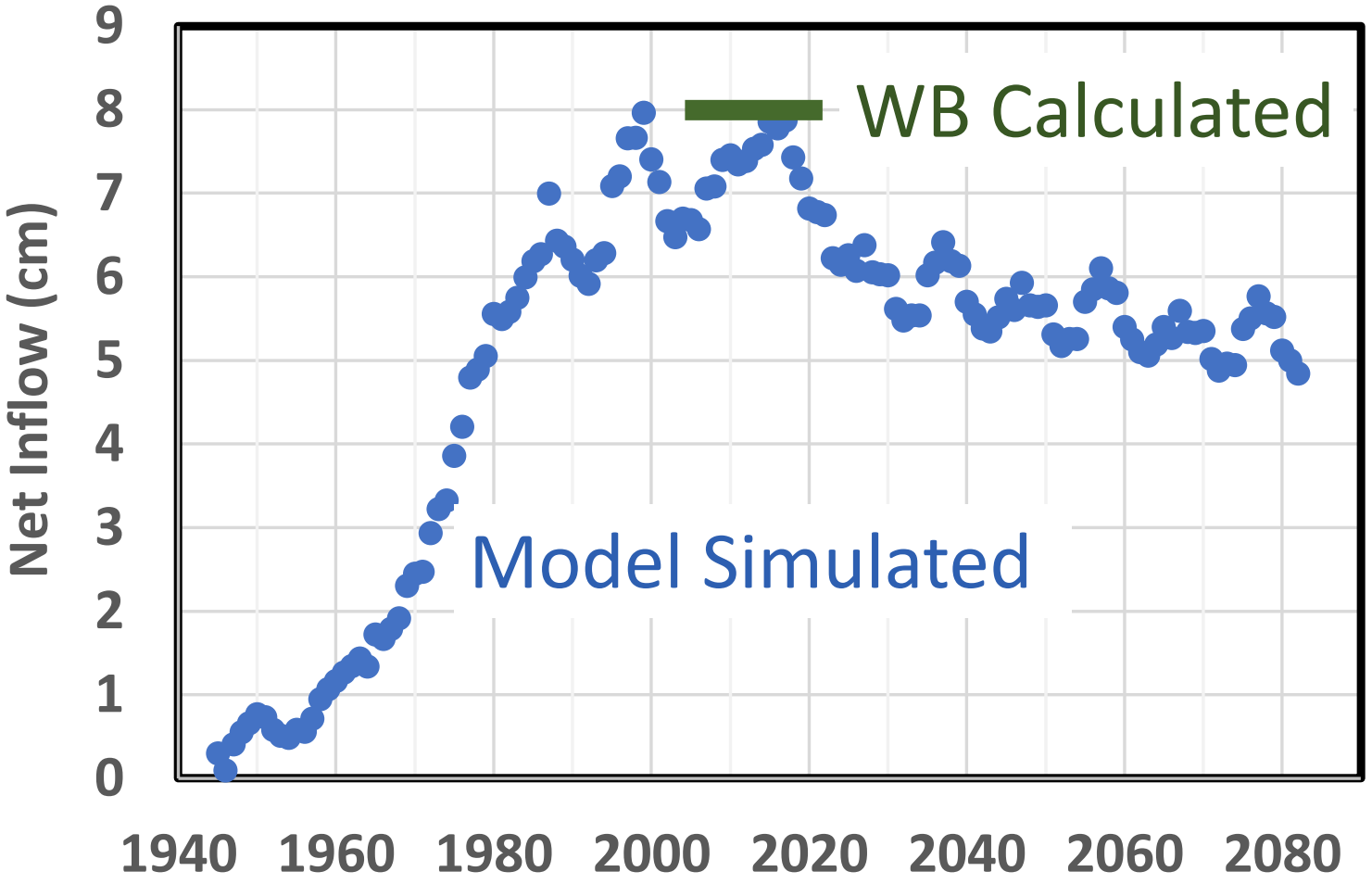
- District average
- ≤2020, historical
- ≥2021, future
- Future climate repeats 2001-2020
- Two main components: recharge from surface and lagged drainage

Total aquifer recharge



- **Lagged drainage slowly declining after 2040**
- **Total recharge steady at 6.5 cm between 2020 and 2040, then slowly decreases to 5.3 cm in 2080**

GMD3 Simulated versus WB-calculated Inflow



- **Model showed inflow peaked between 1995 and 2020 (about 7.1 cm)**
- **The inflow would quickly drop to 6 cm from 2020 to 2030, followed by a gradual decline to 5 cm in 2080.**
- **The KGS WB analysis of 2005-2022 data showed inflow of 8 cm.**

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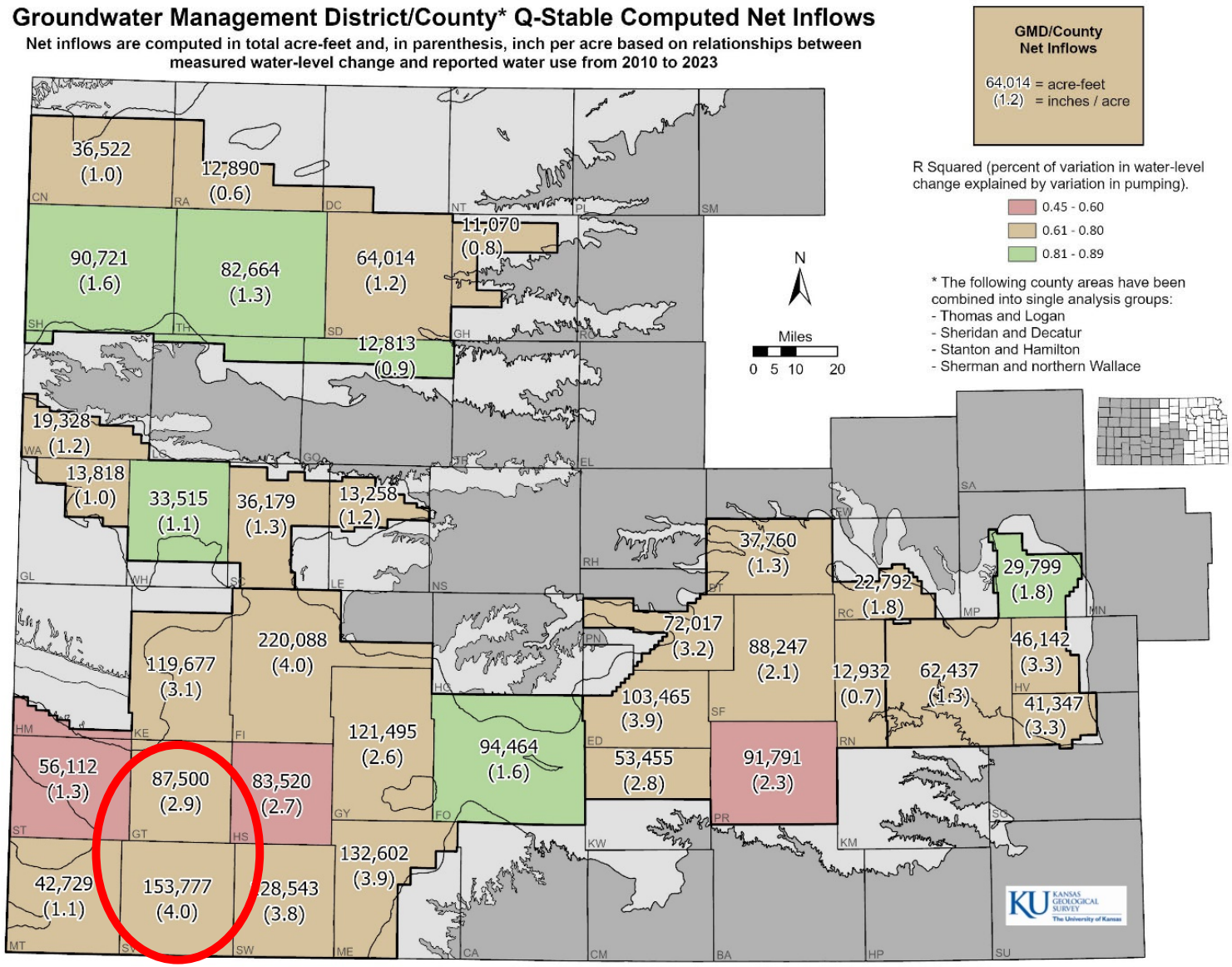
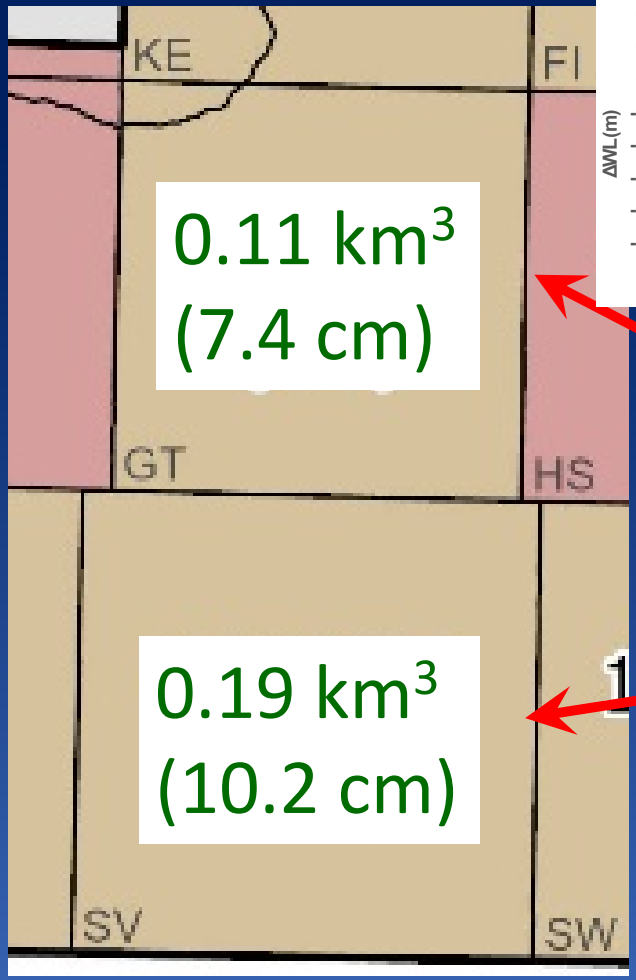


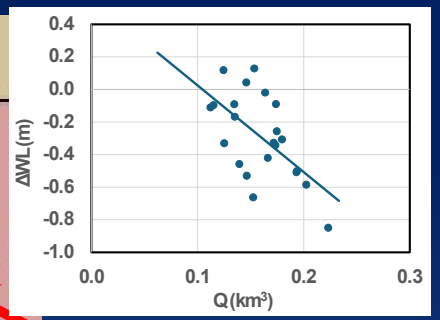
Net Inflow in Local Areas

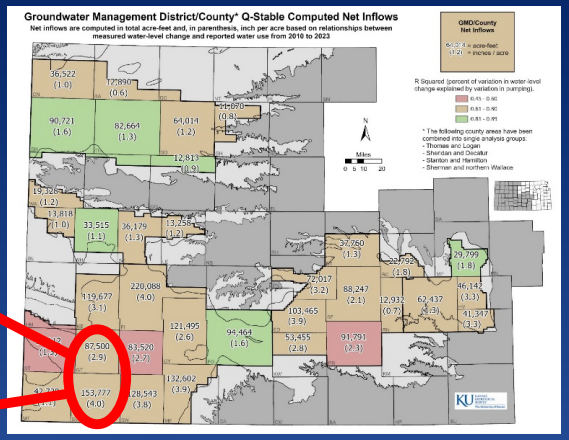
- **The KGS WB analysis of 2010-2023 data indicated significant variability in aquifer net inflow between counties.**

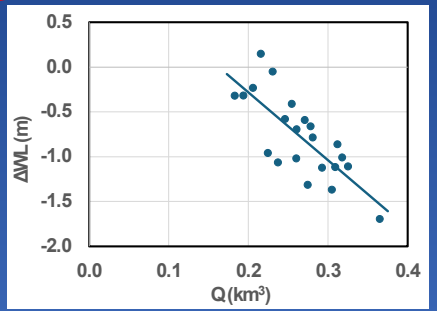
Net Inflow in Local Areas

- **GT: Grant County**
- **SV: Stevens County**



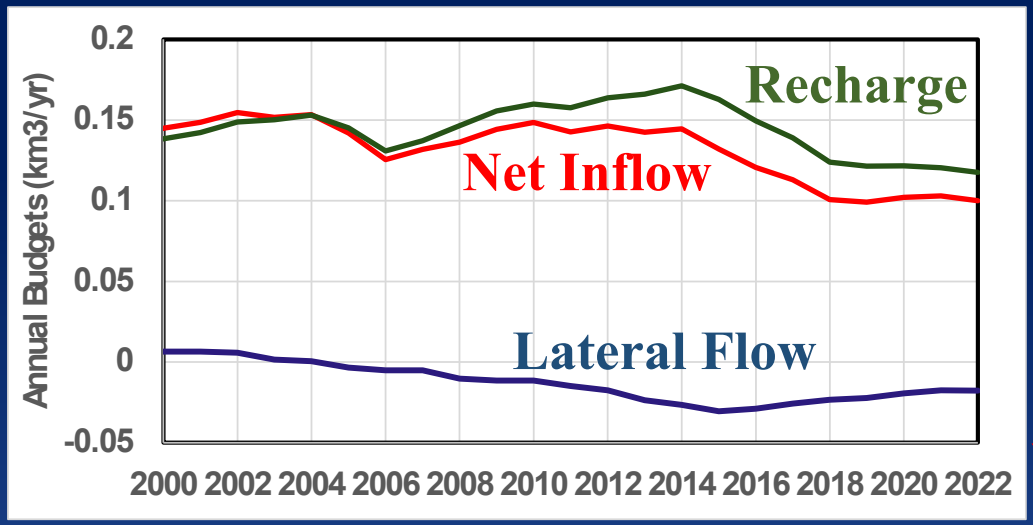




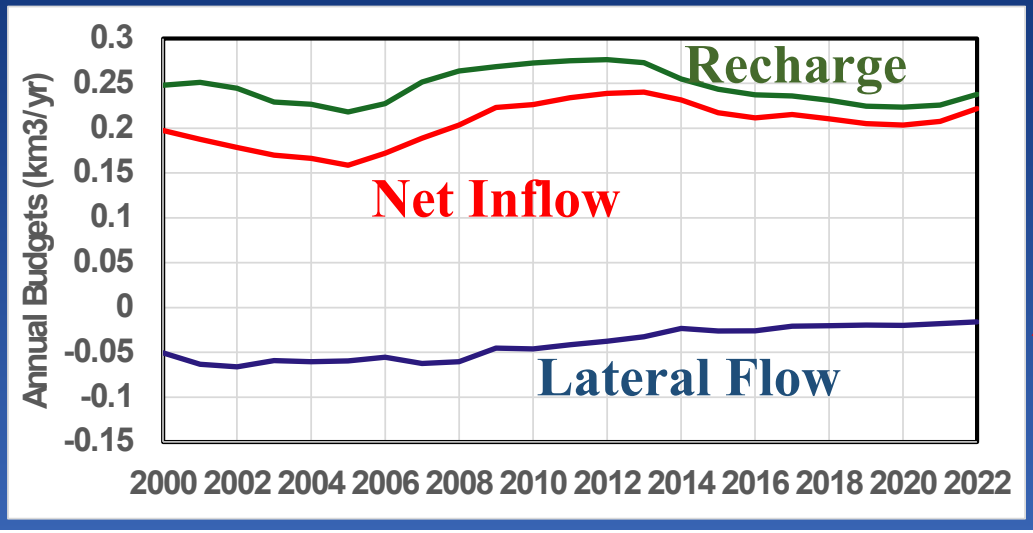


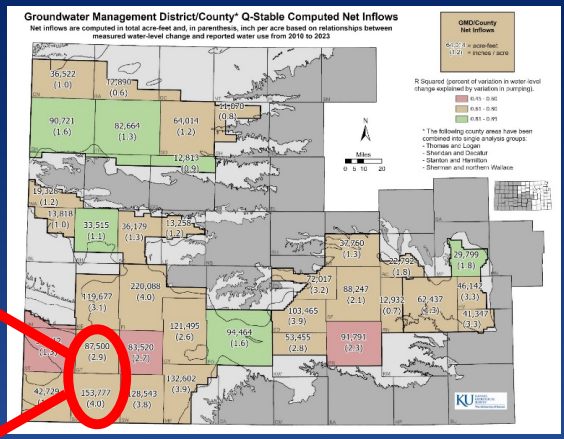
Net Inflow in Local Areas: Impacts of lateral flow

Grant



Stevens





Conclusion and Future Work

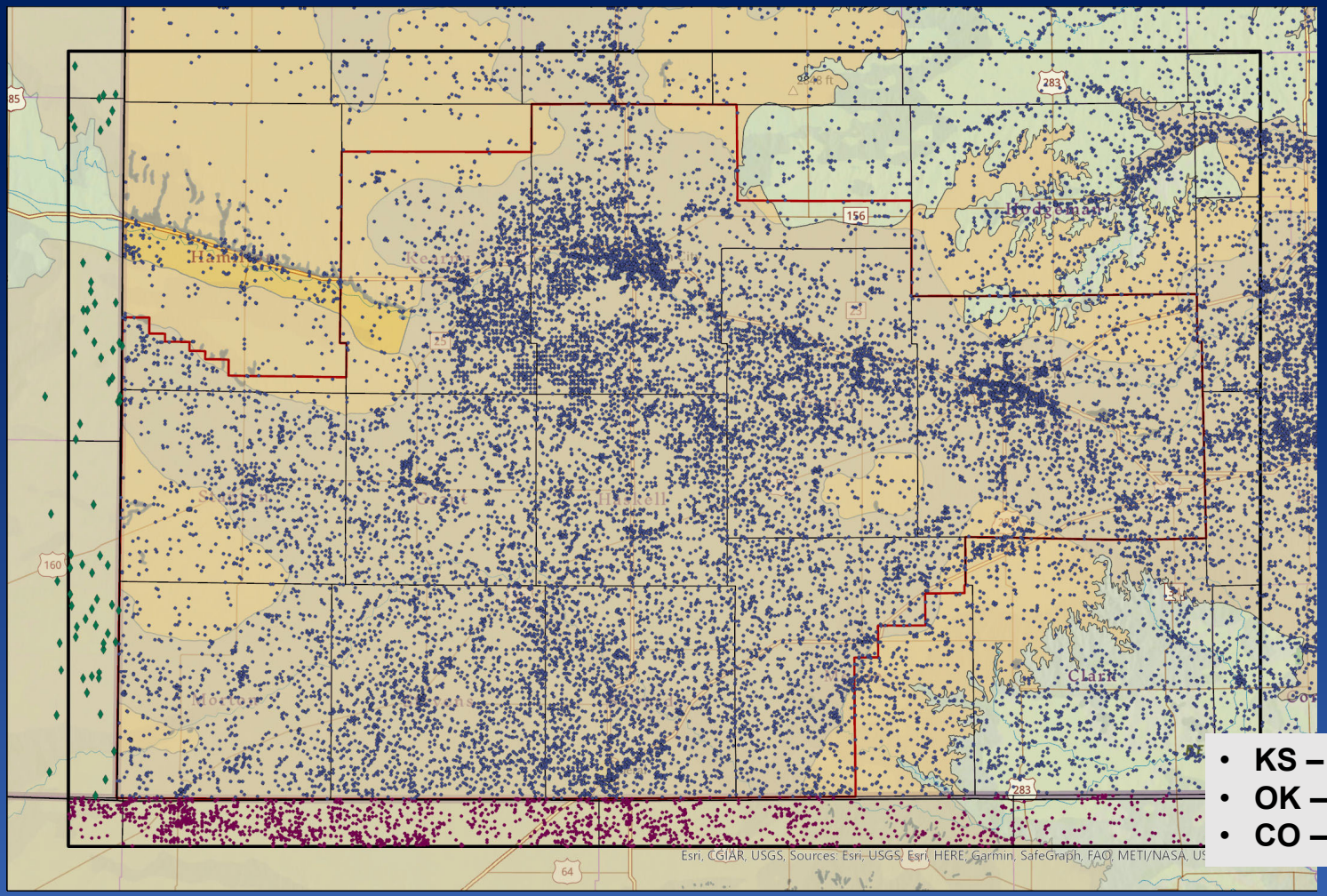
- At the regional level, modeling indicates HPA net inflow has two major sources: recharge from land surface and drainage delayed by low-permeability sediments.
- At the county level, the impacts of lateral flow may be significant. If so, they should be considered in local water resources management programs.
- Further works are needed to investigate different sources of HPA net inflow under different field conditions.

Acknowledgements

- Kansas Water Office, Kansas Water Plan, and Kansas Groundwater Management Districts.

Questions?

Lithology Data Sources – GMD3 Model



- **Driller logs vary in quality!**

- **KS –** Water Well Completion Records
- **OK –** Water Resources Board
- **CO –** Well Permits

Not all forms/logs are created equal

Excellent

USE TYPEWRITER OR BALL POINT PEN-PRESS FIRMLY, PRINT CLEARLY.

WATER WELL RECORD
KSA 82a-1201-1215

T R EW sec 1/4 1/4 1/4 No.

Kansas State Dept. Of Health
(Water Well Contractors)
Forbes-Bldg. 740
Topeka, Kansas 66620

1 Location of well:	County	Township name	Fraction	Section number	Town number	Range number
	Haskell		NW, NW, NW	19	29S	31W

Distance and direction from nearest town or city: 6 miles E, 1 N and ½ E of Sublette
Street address of well location if in city:

3 Owner of well: Mike Sherwood
Address: Sublette Kansas

Locate with "X" in section below: N, W, E, S, 1 Mile

Sketch map: Well drilled near test hole 1-75 which is located 120' S of NW corner of NE¼, Sec. 19, T29S, R31W Haskell County, Kansas

4 Well depth: 425 ft. Date of completion 7-23-75
Well diameter 28 in.

5 ☐ Cable tool ☐ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☐ Jetted ☐ Bored ☒ Reverse rotary

6 Use: ☐ Domestic ☐ Public supply ☐ Industry ☒ Irrigation ☐ Air conditioning ☐ Commercial ☐ Test well ☐

7 Casing: Material Stl Height: above/below
Threaded ☐ Welded ☒ Surface 12 in.
Diam. 16 in. to 258 ft. depth Weight 37 lbs./ft.
in. to ft. depth Drive shoe? ☐ Yes ☒ No

2 Type and color of material	From	To
Top soil	0	4
Tan clay with fine sand	4	45
Fine sand and clay	45	70
Fine sand	70	80
Sandy tan clay and sand	80	105
Fine to medium sand	105	140
Fine to coarse sand medium gravel	140	225
Yellow clay with sand streaks	225	245
Blue clay	245	258
Medium sand and gravel	258	328
Blue clay	328	345
Fine to medium sand and gravel	345	358
Blue clay	358	380
Sandy tan clay and sand	380	395
Medium sand to coarse gravel clay streaks	395	425
Sandy tan clay little fine sand	425	500

(Use a second sheet if needed)

8 Screen: Manufacturer Foster, Brown, Cook
Type Millslot, Louver wire wrap Dia. 16"
Slot/gauze 1/8" Length 167
Set between 258 ft. and 425 ft.
Fittings:
Gravel packed ☒ Yes ☐ No Size range of material 1.2mm to 9mm

9 Static water level: 195 ft. below land surface Date 8-23,75

10 Pumping level below land surfaces: No test
ft. after hrs. pumping g.p.m.
ft. after hrs. pumping g.p.m.
Estimated maximum yield g.p.m.

11 Water sample submitted: ☐ Yes ☒ No Date

12 Well head completion: ☐ Pitless adapter ☒ Inches above grade

13 Well grouted? ☒ Yes ☐ No
☐ Neat cement ☒ Bentonite ☐
Depth: From 0 ft. to 10 ft.

14 Nearest source of possible contamination: unk
ft. Direction Type
Well disinfected upon completion? ☒ Yes ☐ No

15 Pump: ☐ Not installed
Manufacturer's name Peerless
Model number HP Volts
Length of drop pipe 240 ft. capacity 1400 g.p.m.
Type: ☐ Submersible ☒ Turbine ☐ Jet ☐ Reciprocating ☐ Centrifugal ☐ Other

Poor

USE TYPEWRITER OR BALL POINT PEN-PRESS FIRMLY, PRINT CLEARLY.

WATER WELL RECORD
KSA 82a-1201-1215

Kansas Department of Health and Environment-Division of Environment
(Water well Contractors)
Topeka, Kansas 66620

1. Location of well:	County	Fraction	Section number	Township number	Range number
	HASKELL	NW NE 1/4 1/4 NW 1/4	14	T 27 S	R 31 E/W

2. Distance and direction from nearest town or city: 8 mi. East 12 mile N of Sublette
Street address of well location if in city:

3. Owner of well: Floyd Frank
R.R. or street: Rt. 1 Box 42
City, state, zip code: Copeland, Kansas 67837

4. Locate with "X" in section below: N, NW, NE, W, E, SW, SE, S, 1 Mile

Sketch map:

6. Bore hole dia. 9 in. Completion date
Well depth 220 ft. 6/28/78

7. ☐ Cable tool ☒ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☐ Jetted ☐ Bored ☐ Reverse rotary

8. Use: ☒ Domestic ☐ Public supply ☐ Industry ☐ Irrigation ☐ Air conditioning ☐ Stock ☐ Lawn ☐ Oil field water ☐ Other

9. Casing: Material Plts Height: Above or below
Threaded ☐ Welded gl Surface 14 in.
RMP ☐ PVC ☒ Weight lbs./ft.
Dia. 5 in. to 160 ft. depth Wall Thickness: Inches or
Dia. in. to ft. depth Gage No. 0.258

5. Type and color of material	From	To
OVERBURDEN	0	90'
SAND + GRAVEL	90	220

(Use a second sheet if needed)

10. Screen: Manufacturer's name PEERLESS
Type P.V.C. Dia. 5in.
Slot/gauze 1/16 Length 60'
Set between 160 ft. and 220 ft.
ft. and ft.
Gravel pack? yes Size range of material 1/8 in.

11. Static water level: mo./day/yr.
90 ft. below land surface Date 6/28/78

12. Pumping level below land surfaces:
ft. after hrs. pumping g.p.m.
ft. after hrs. pumping g.p.m.
Estimated maximum yield g.p.m.

13. Water sample submitted: mo./day/yr.
☐ Yes ☒ No Date

14. Well head completion:
☐ Pitless adapter 14 Inches above grade

15. Well grouted? yes
With: ☒ Neat cement ☐ Bentonite ☐ Concrete
Depths From 3 ft. to 13 ft.

16. Nearest source of possible contamination:
ft. Direction Type
Well disinfected upon completion? ☒ Yes ☐ No

17. Pump: ☒ Not installed
Manufacturer's name
Model number HP Volts
Length of drop pipe ft. capacity g.p.m.
Type: ☐ Submersible ☐ Turbine ☐ Jet ☐ Reciprocating ☐ Centrifugal ☐ Other

18. Elevation:
Topography: ☐ Hill ☐ Slope ☒ Upland ☐ Valley

19. Remarks:
17. Well to be completed by Dunham Drilling Co. Copeland, Kansas

20. Water well contractor's certification:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
T & W Watermell Service 142
Business name License No.
Address PO Box 816 Liberal KS
Signed C.D. Watermell Date 11/24/78
Authorized representative

Forward the white, blue and pink copies to the Department of Health and Environment

Form WWC-5

27 31E 14 NW NE NW

Hydraulic Conductivity (K) and Specific Yield (Sy) Calculation from Lithology

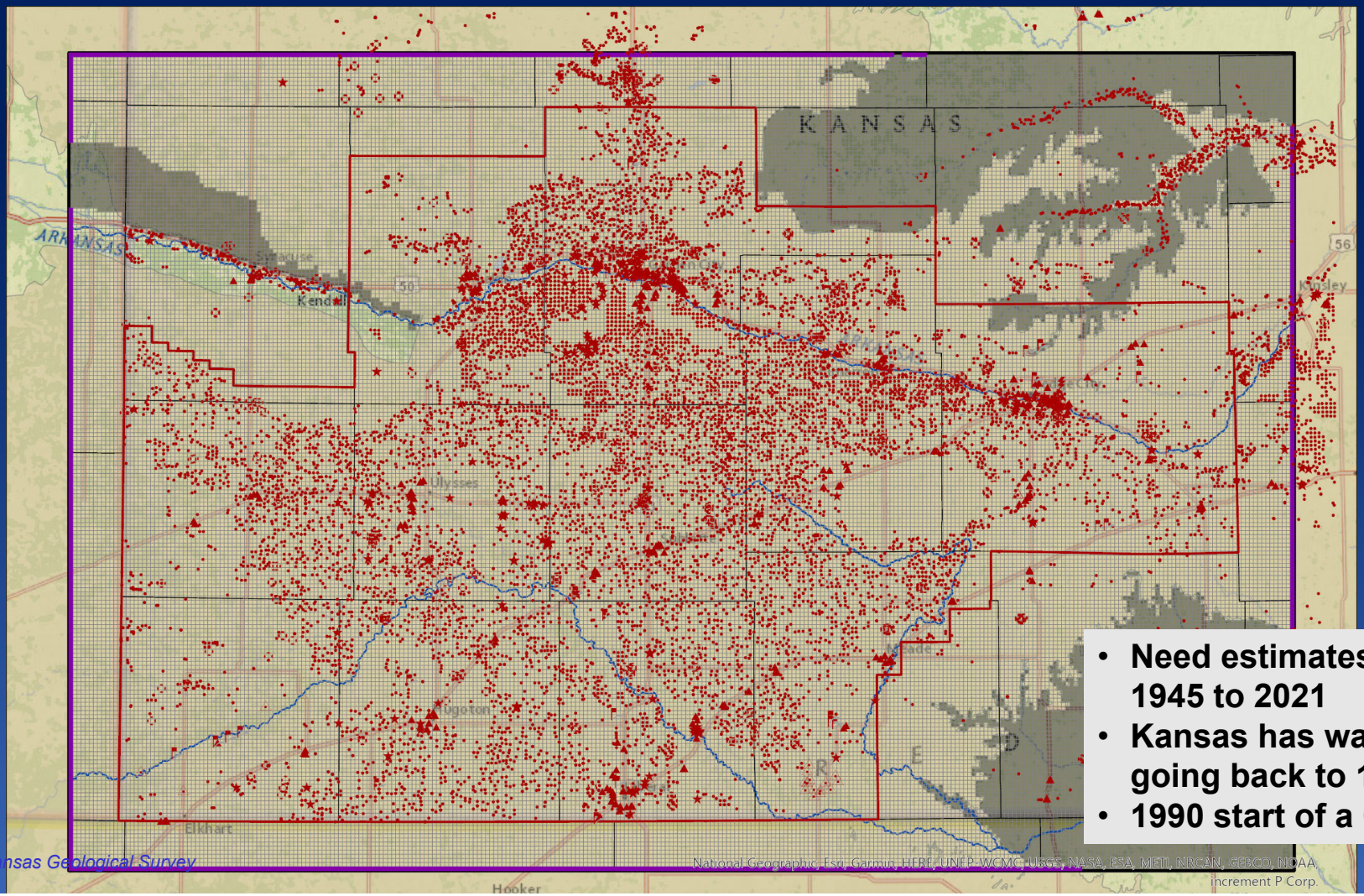
A) Categorize lithologic description into 5 categories:

1: clays, 2: clays and silts, 3: silts and sands, 4: sands, 5: sands and gravels

B) Assign representative K and Sy values to each category. **The lithologic K values are adjusted during model calibration; the Sy values are estimated using the KGS water balance approach.**

C) Using Kriging to populate the K and Sy values from the lithologic log locations onto the entire model grid.

GMD3 Groundwater Right Wells



- Need estimates of pumping from 1945 to 2021
- Kansas has water use records going back to 1958.
- 1990 start of a QA/QC program.

GMD3 All Recharge Components