WWDC Snake/Salt River Basin Plan, Groundwater Study (Level I)

WSGS – USGS – WWDC - WRDS

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Groundwater Study Team

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- **WRDS** – *Chris Nicholson*
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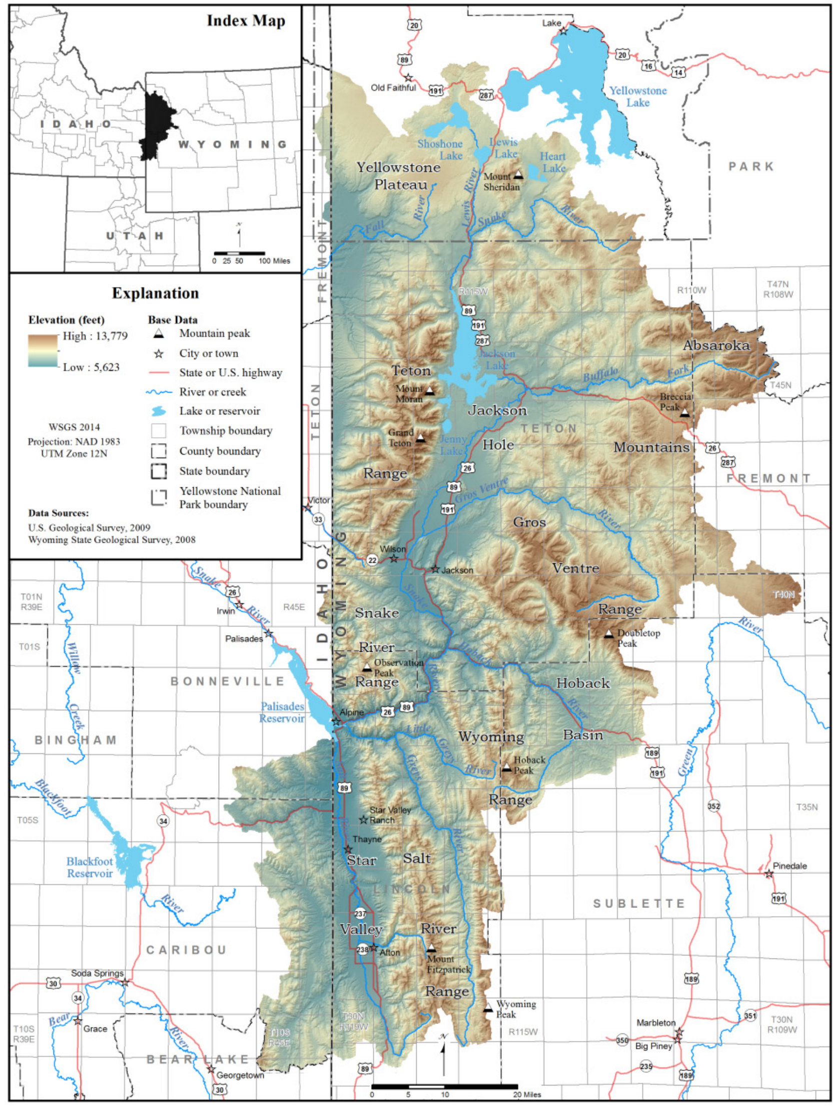
Snake/Salt River Drainage Basin



Tasks

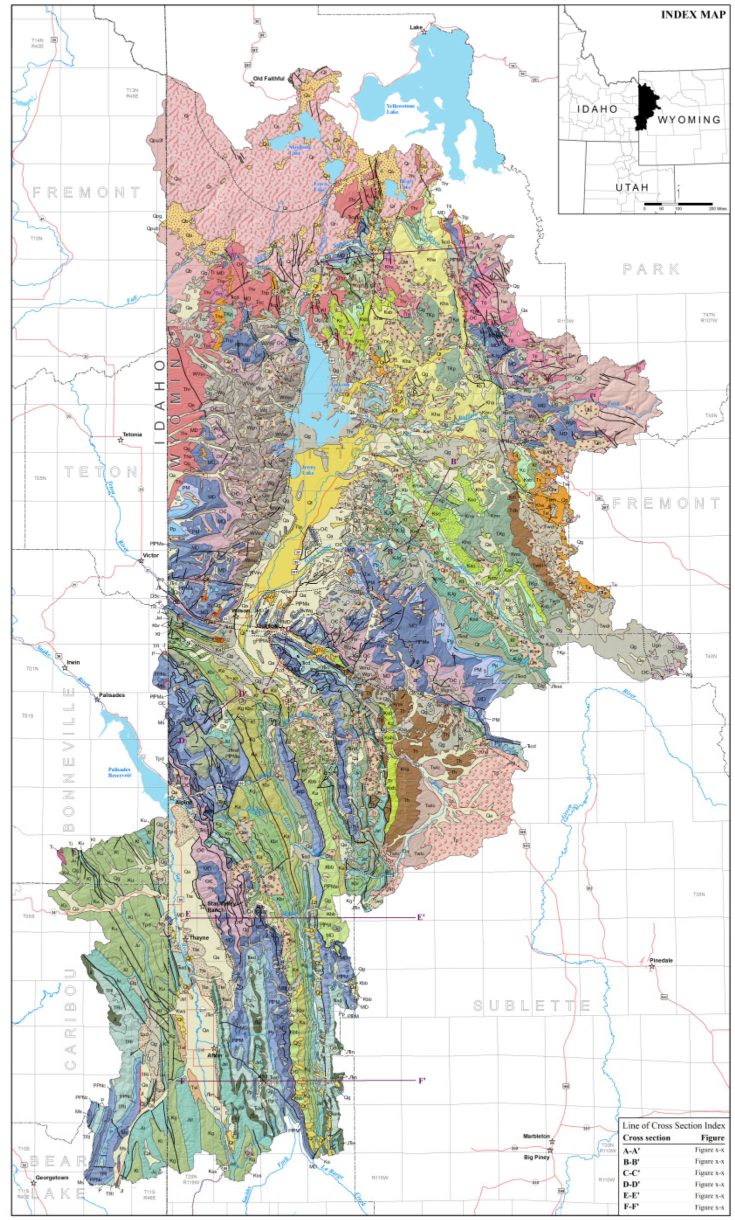
- Identify major aquifers
- Define the three dimensional extents of the aquifers
- Describe aquifer hydrogeologic and chemical properties
- Describe aquifer recharge areas and rates
- Estimate water quantity and safe yield
- Identify and describe existing studies/models
- Identify water development opportunities

Identify the Major Aquifers and Their Extents

- Geologic formations
- Hydrogeologic units (aquifers and confining units)
- Formation thickness
  - Six cross section figures
  - One potentiometric surface/water table map

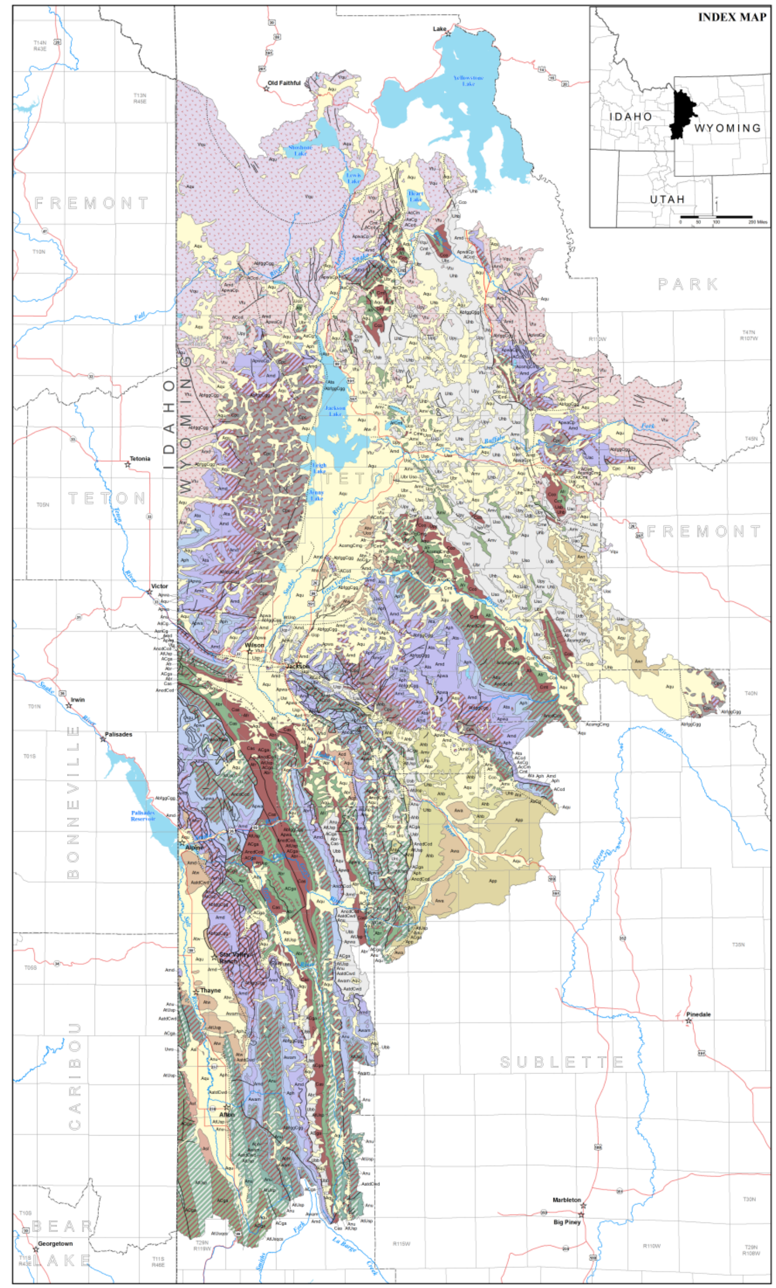
Plate 1 - Bedrock Geology

- Shows 90 geologic units in Wyoming and Idaho.
- Includes two inset maps of geologic structure.
- Descriptions of the geologic units given in Appendix A.

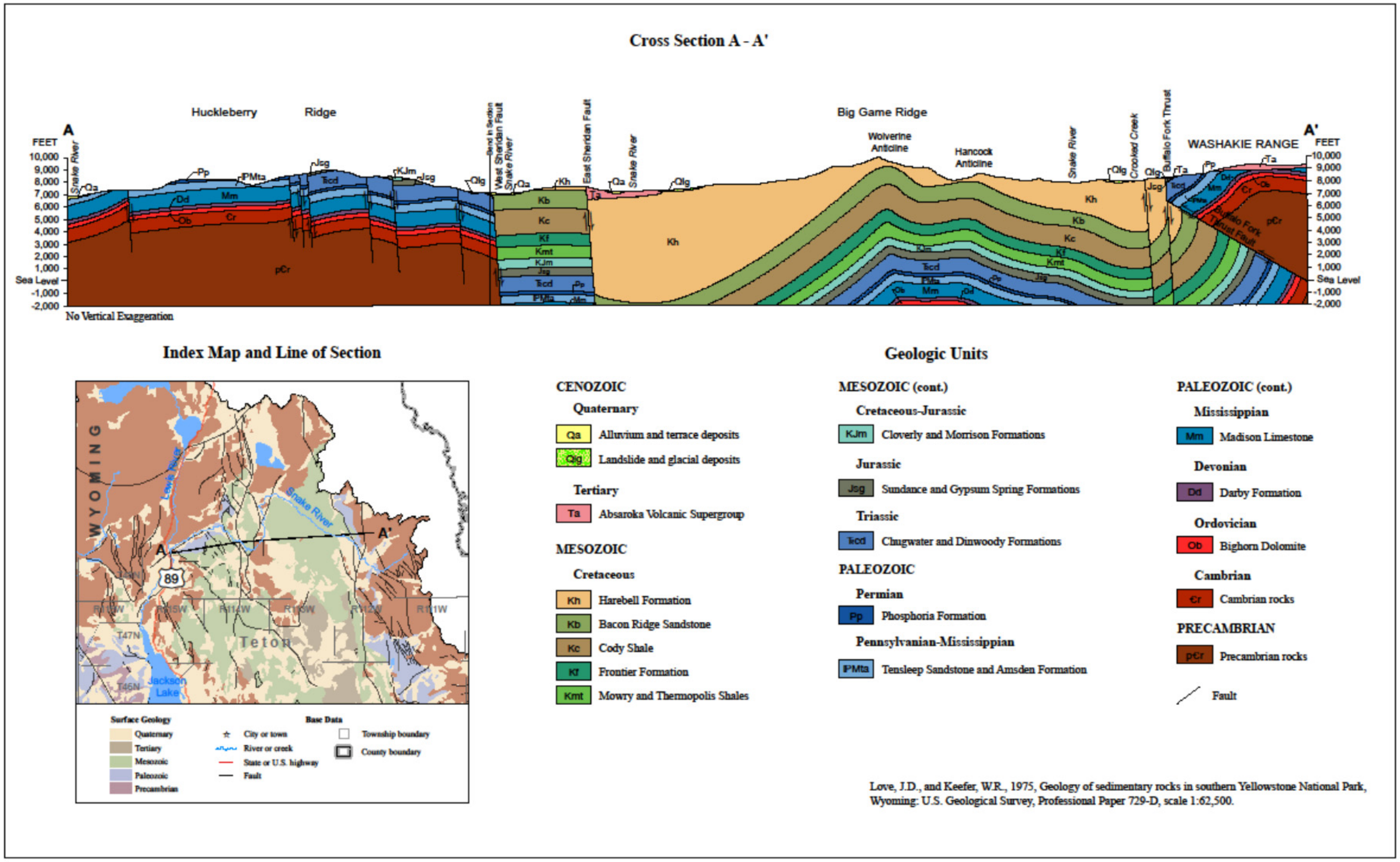


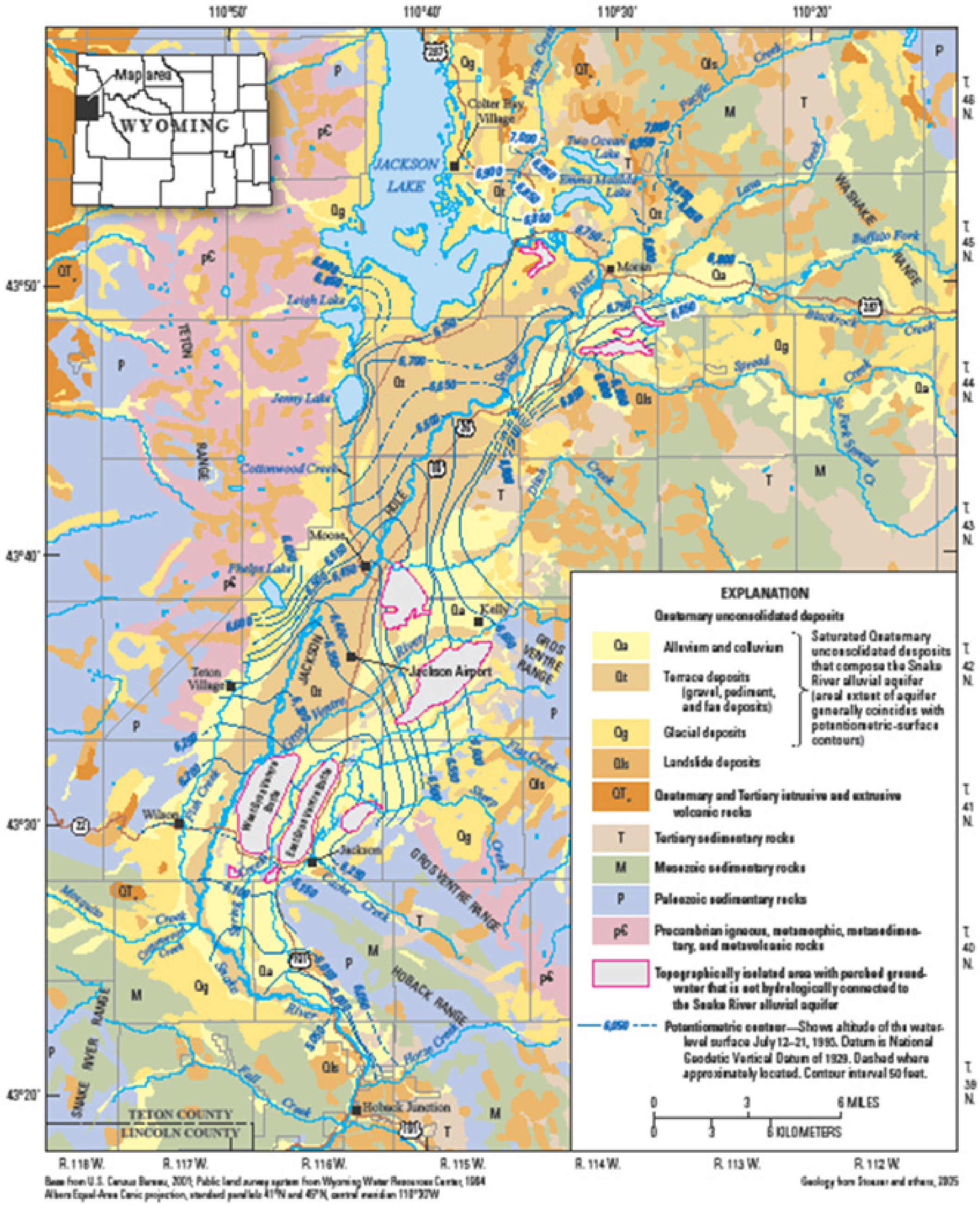
Hydrogeology Plate

- Confining units in dark red
- Aquifers in all other colors



Cross Section





Potentiometric Surface

Identify Aquifer Hydrogeologic Properties

- USGS examined physical hydrogeologic properties in Chapter 7
- Statistical analysis of water quality from over 160 water samples
- Mapped and described potential contaminant sites identified from WDEQ and WOGCC data.

Environmental and Produced Water Samples

- Compare water quality to state and federal regulatory standards
- 43 Trilinear diagrams
- 2 Statistical appendices

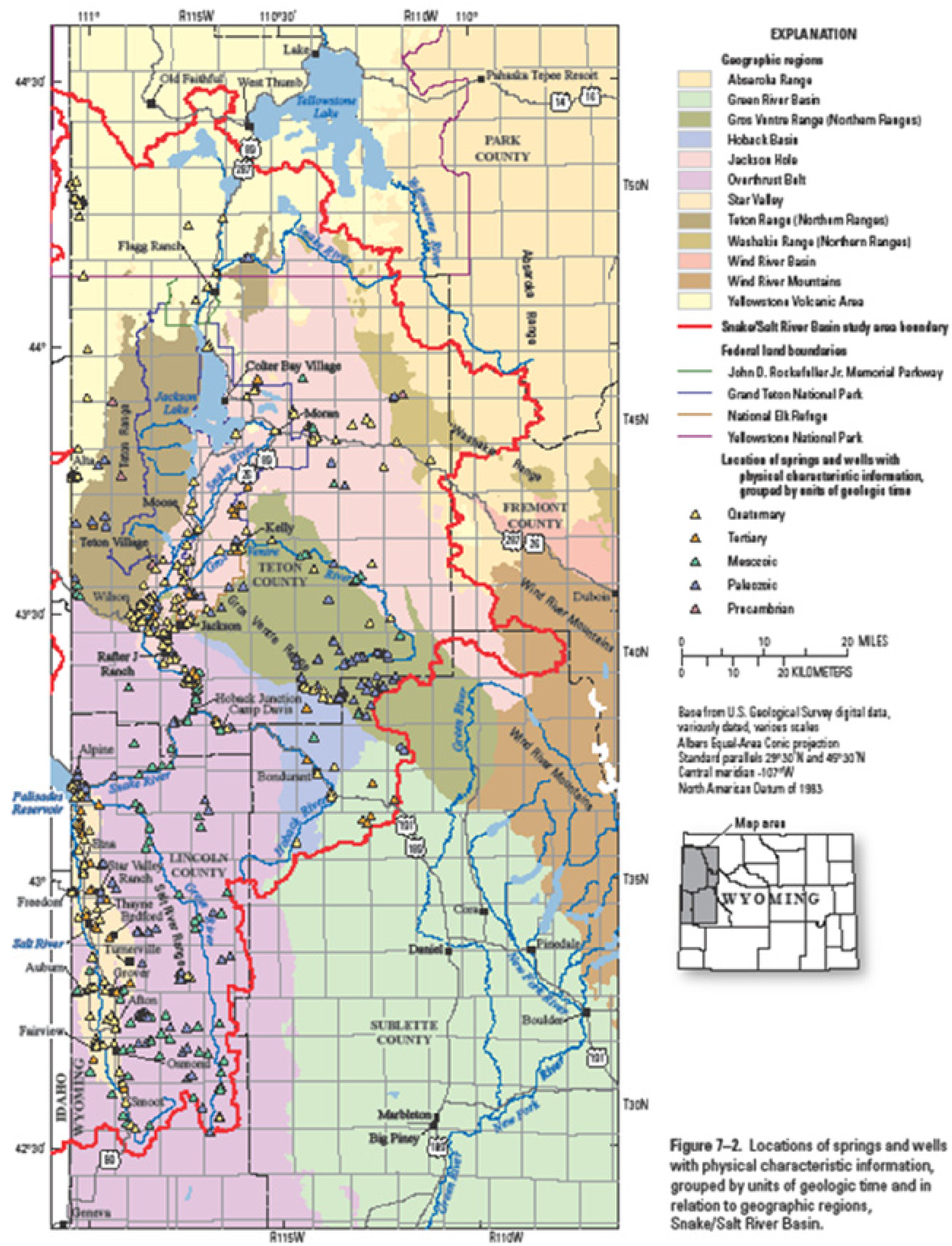
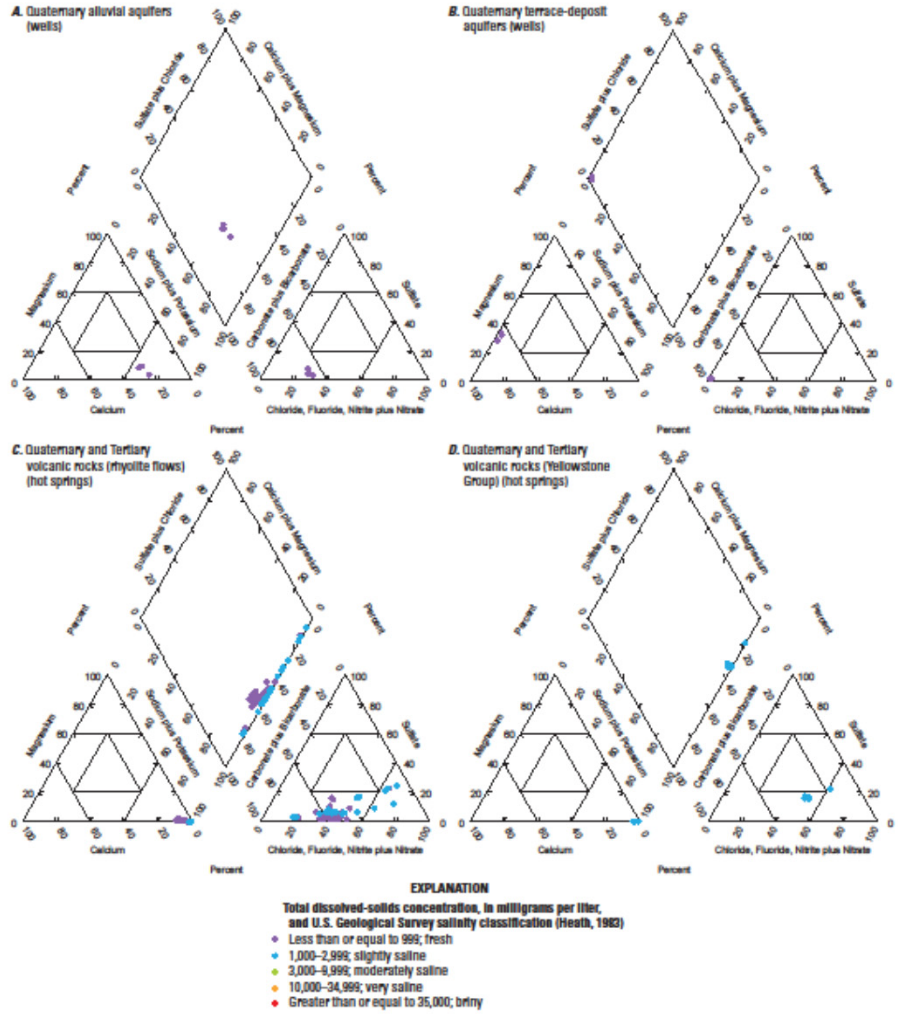


Figure 7–2. Locations of springs and wells with physical characteristic information, grouped by units of geologic time and in relation to geographic regions, Snake/Salt River Basin.

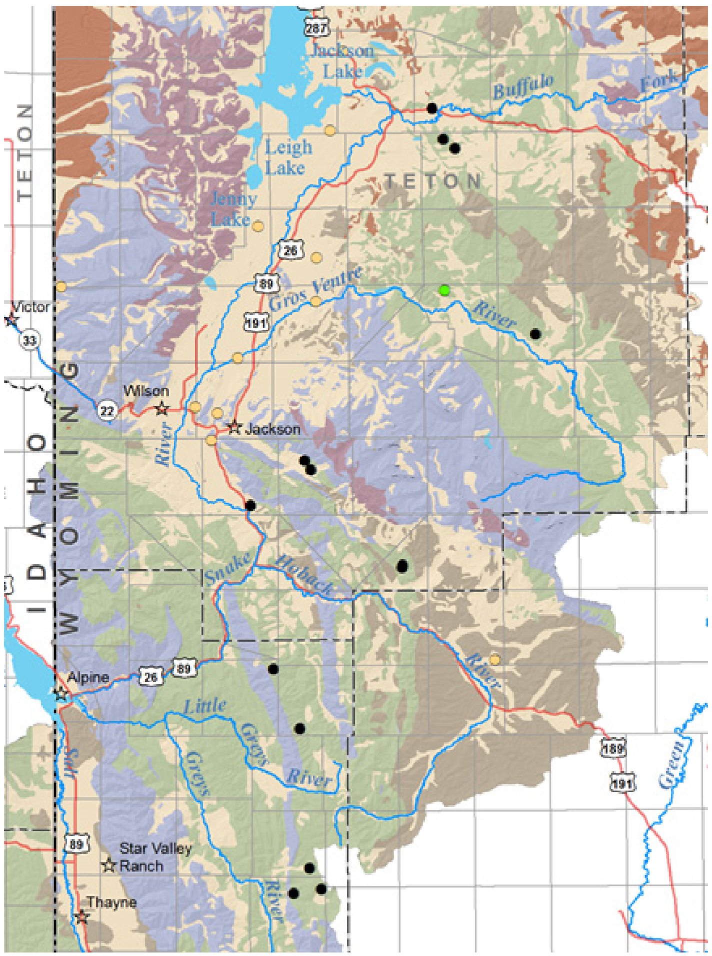


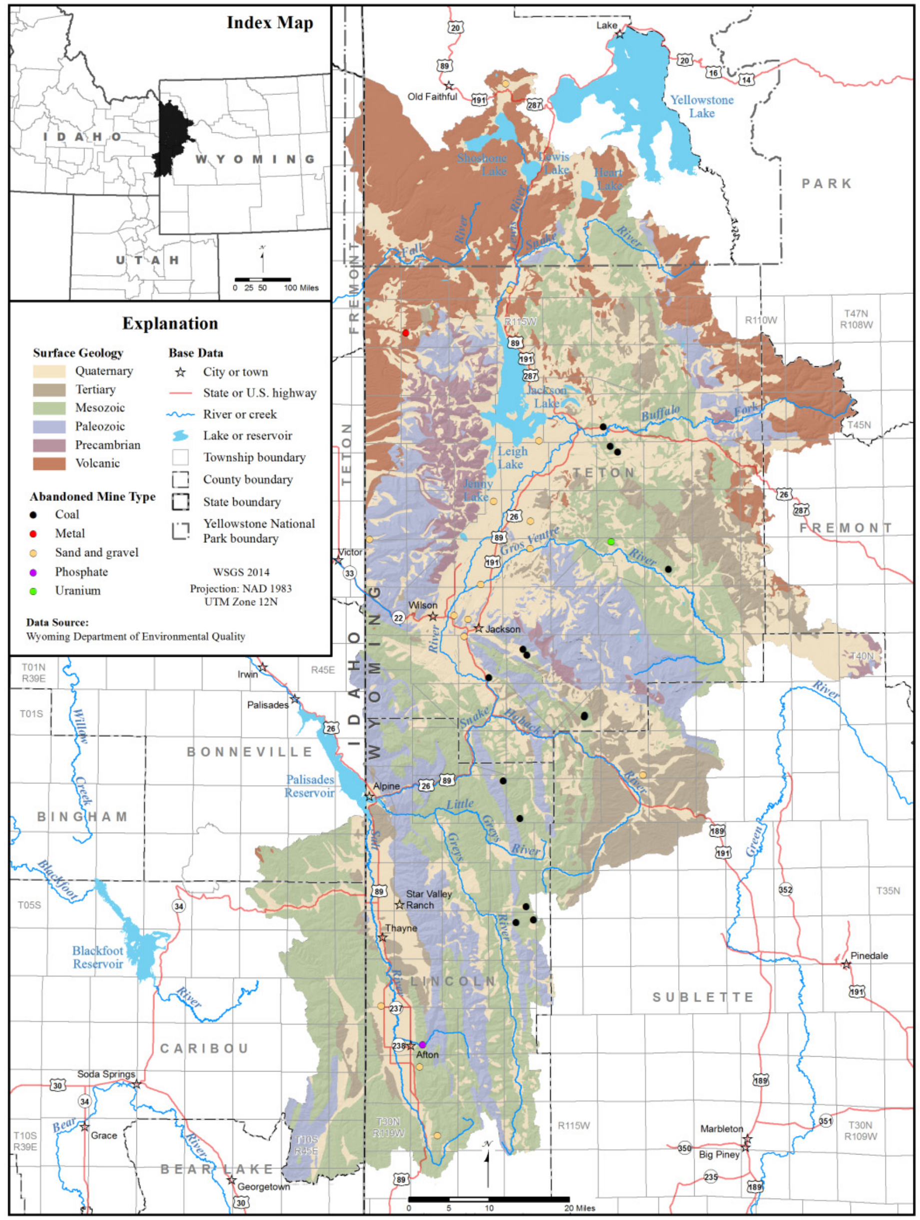
Appendix F–1. Trilinear diagrams showing major-ion composition and dissolved-solids concentrations for groundwater samples from wells and springs in the Yellowstone Volcanic Area, Wyoming.

[--, not applicable; µS/cm, microsiemens per centimeter. Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter]

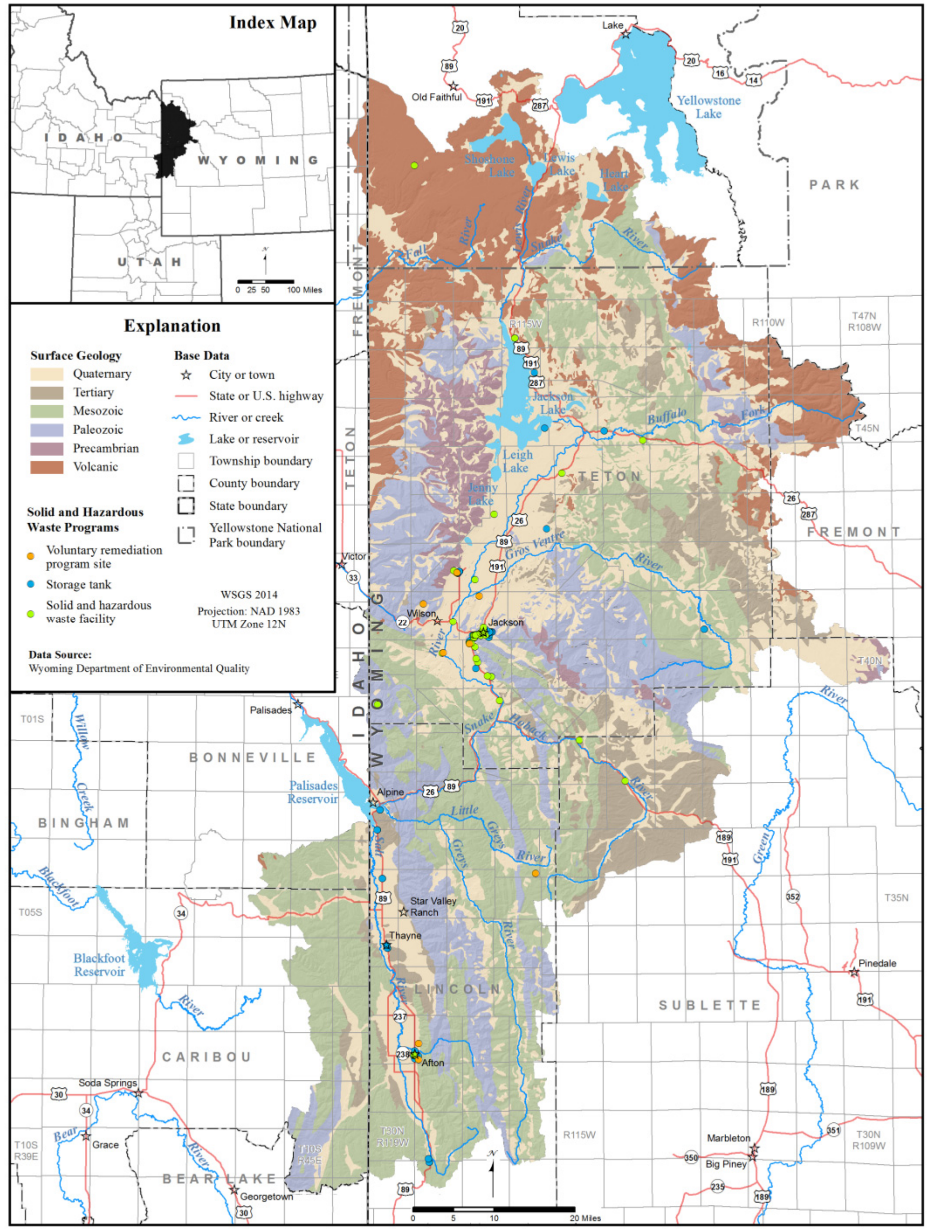
Geologic unit	Constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Madison Formation—Continued	Silica	7.5	8.6	10.3	20.0	24.0	12
	Sulfate	3.3	9.3	17.0	27.0	560	13
	Dissolved solids	181	209	216	245	920	13
	Ammonia (as N)	--	0.020	0.020	0.030	--	5
	Nitrate+nitrite (as N)	--	0.080	0.20	0.92	--	11
	Phosphorus, unfiltered (as P)	--	0.006	0.009	0.020	--	8
	Boron	--	14.4	20.0	27.8	--	7
	Iron	--	3.0	60.0	140	--	7
	Manganese	--	0.85	20.0	80.0	--	7
	Alpha radioactivity (picocuries per liter)	--	1.2	2.7	6.8	--	6
	Gross beta radioactivity (picocuries per liter)	--	2.0	4.0	6.3	--	5
	Radium-226 (picocuries per liter)	--	0.92	1.2	2.7	--	4
	Uranium, natural	--	1.3	2.1	2.8	--	4

Abandoned Mine Lands



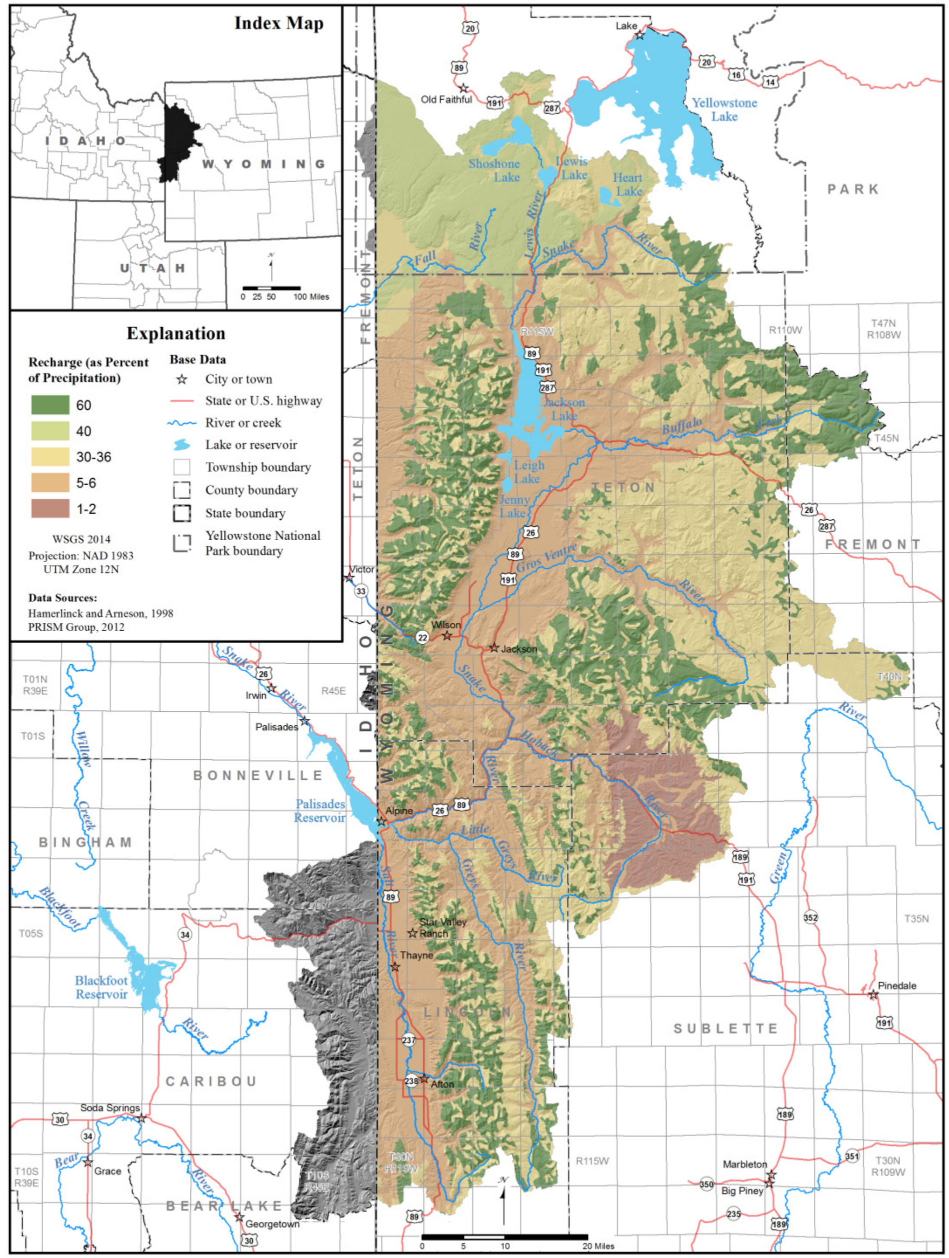


Solid and Hazardous Waste Disposal Sites



Identify Aquifer Recharge Areas and Rates

- Highest recharge areas in green shades
- Low recharge areas in browns

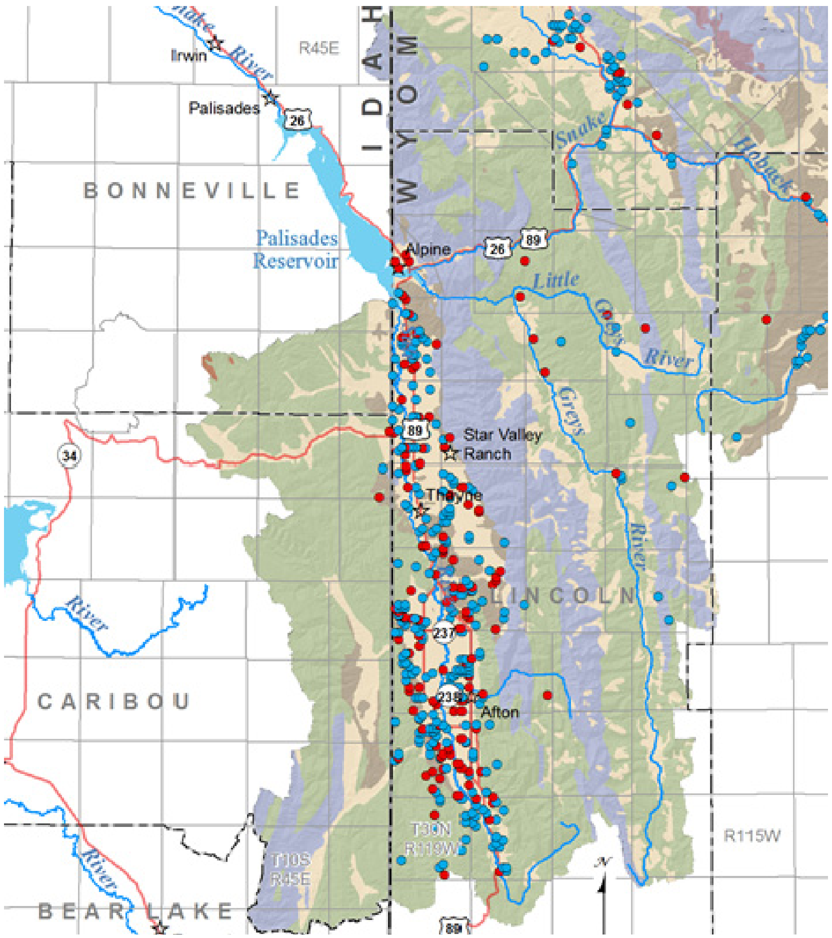


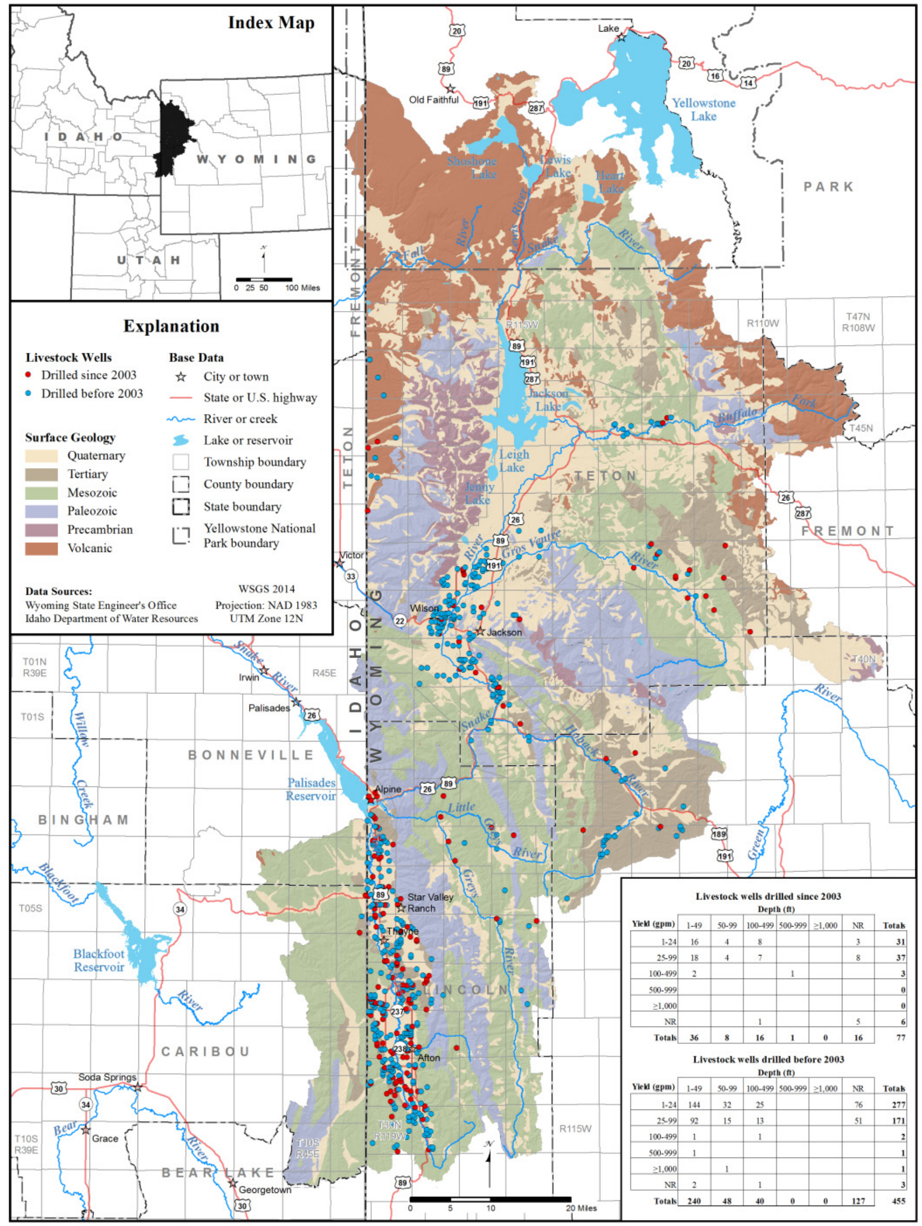
Estimate Water Quantity and Safe Yield

- Provide a basin wide water balance (mass balance model)
- Maps of basin groundwater uses
- Discussion of “safe” vs “sustainable” yield

Water balance statistics		**Volume (ac-feet)**	**% Precip.**
[1]Average annual precipitation (1981 - 2010)		9,137,300	---
[2] Net surface water outflows	-	4,600,000	50.1%
[3] Total consumptive use (surface water and groundwater)	-	9,800	0.1%
[3] Reservoir evaporation	-	72,200	0.8%
[3] Estimated recharge volume	-	1,706,300	19.0%
Basin-wide evapotranspiration	=	2,749,600	30.0%
[1] PRISM, 2012			
[2] USGS, 2012	Sanford and Selnick, 2013	4,150,900 ac-feet	
[3] WWDO, 2012			

SEO Livestock Wells





Livestock wells drilled since 2003

Yield (gpm)	Depth (ft) 1-49	50-99	100-499	500-999	≥1,000	NR	Totals
1-24	16	4	8			3	31
25-99	18	4	7			8	37
100-499	2			1			3
500-999							0
≥1,000							0
NR			1			5	6
Totals	36	8	16	1	0	16	77

Livestock wells drilled before 2003

Yield (gpm)	Depth (ft) 1-49	50-99	100-499	500-999	≥1,000	NR	Totals
1-24	144	32	25			76	277
25-99	92	15	13			51	171
100-499	1		1				2
500-999	1						1
≥1,000		1					1
NR	2		1				3
Totals	240	48	40	0	0	127	455

"Safe Yield" – An Evolving Concept

Lee (1915): "the limit to quantity of water that can be withdrawn regularly and permanently without dangerous depletion of the storage reserve."

Meinzer (1923): "the rate at which ground water can be withdrawn from an aquifer for human use without depleting the supply to such an extent that withdrawal at this rate is no longer economically feasible."

Misconceptions Related to “Safe Yield”

- Groundwater withdrawals from wells and springs are “safe” as long as they do not exceed the amount of annual recharge.
- Safe yield (average annual recharge) can be determined by developing a water balance.

Water in (Recharge) = Water out (Discharge) + Change in aquifer storage (long term assumed to be 0)

Or, simply

Recharge = Discharge

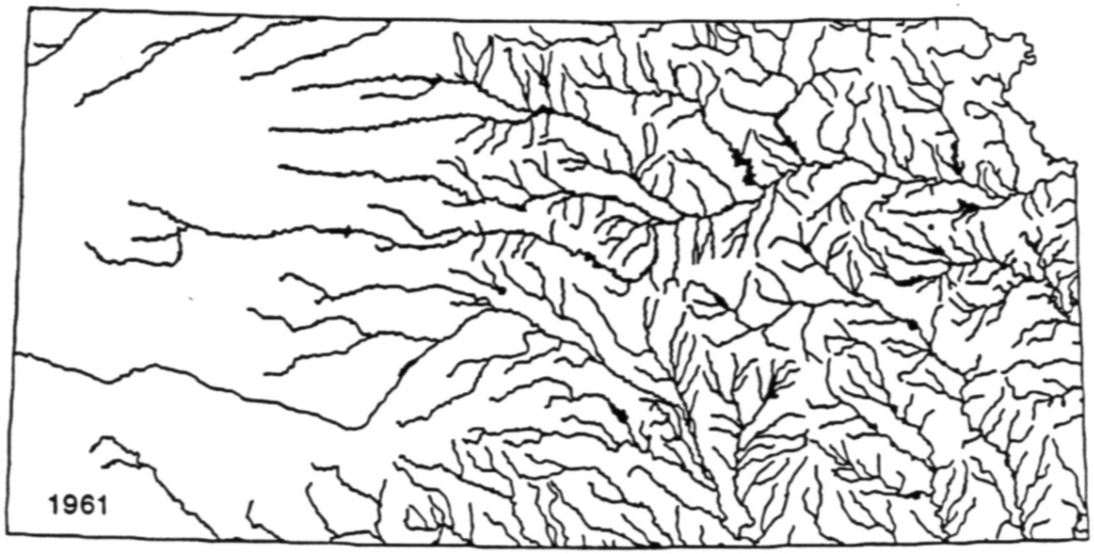
Pre-development: Natural discharges to springs and streams reach dynamic equilibrium with recharge volumes.

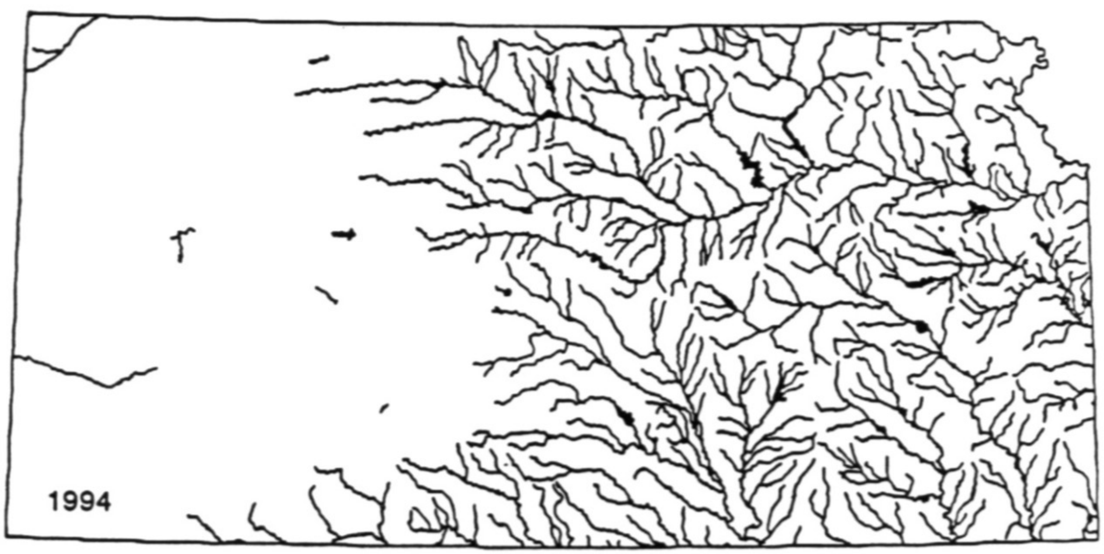
Under development: Groundwater volumes extracted from wells and developed springs result in reduced natural discharges to streams.

Perennial streams in Kansas

1961 and 1994

(Angelo, 1994)





It's unlikely that a basin scale value of safe yield can be calculated accurately, because:

- Heterogeneity – Any drainage basin is a complex system of aquifers and confining units that possess high levels hydrogeologic heterogeneity.

- Scale - A regional water balance analysis may mask unacceptable groundwater depletions on the local level.

Sustainable water systems

- American Society of Civil Engineers - “… those designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental and hydrological integrity.”

Estimating Sustainable Yields

Mandel and Shiftan (1981)

1. Determine mean annual recharge.
2. Identify the first unacceptable affect that will occur as water levels are lowered.
3. Define the quantitative relationship between water levels and the timing and extent of the unacceptable affect(s).
4. Determine minimal acceptable water levels for the aquifer.
5. Calculate the rate of natural discharge that will result when a new state of dynamic equilibrium consistent with the minimal water levels is established.
6. The sustained yield is the difference between Steps 1 and 5.
7. *Monitor, review and reevaluate frequently.*

Identify Water Development Opportunities

WSGS reviewed WWDC water development projects (2003 and later) in 8 communities in the basin.

Future water development projects will focus on alluvial, late Tertiary (Salt Lake, Teewinot, Wasatch), early Mesozoic (Twin Creek, Nugget) and late Paleozoic (Madison, Tensleep) aquifers .

Identify Existing Studies

- USGS identified over 250 previous studies in this report.
- WSGS reviewed 38 WWDC studies in Appendix B

Summary

Once published, you will be able to access the 2014 Snake/Salt River Basin groundwater report online:

WWDC website

http://waterplan.state.wy.us/plan/snake/snake-plan.html

WSGS website

http://www.wsgs.uwyo.edu/Research/Water-Resources/River-Basin-Plans.aspx

Or search “Snake/Salt River Basin Report”

Thank you, questions?

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