

***WWDC Bear River Basin  
Plan,  
Groundwater Study (Level I)***

**WSGS – USGS – WWDC - WRDS**

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***Hydrogeologist***

***Wyoming State Geological Survey (WSGS)***

***Laramie, Wyoming***



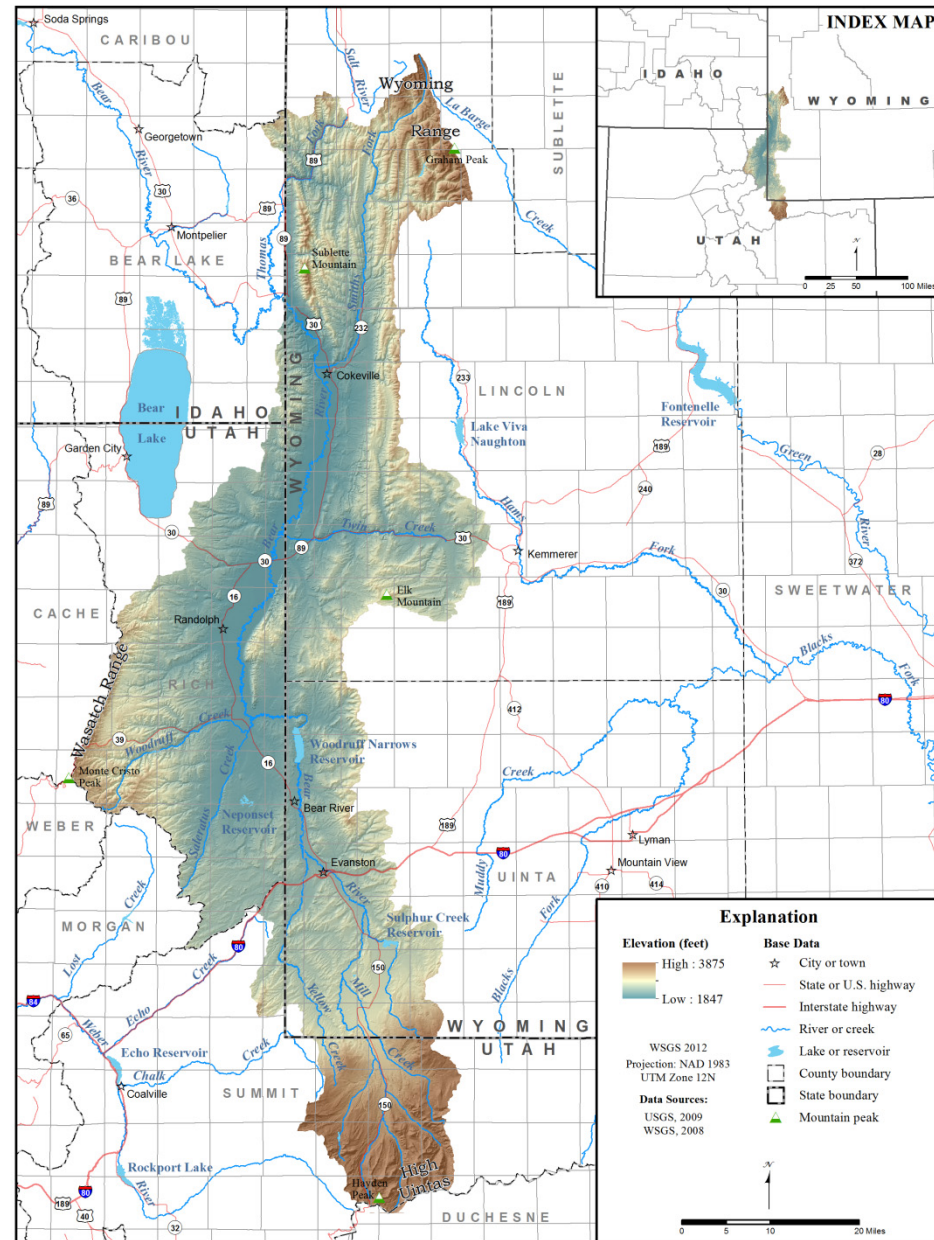
# *Groundwater Study Team*

## **WWDO** *Project Manager – Chace Tavelli*

- *Deputy Director, River Basin Planning – Phil Ogle*
  
- **WSGS** – *Jim Stafford, Tomas Gracias, Seth Wittke and Karl Taboga*
  
- **USGS** – *Tim Bartos, Melanie Clark, Laura Hallberg*
  
- **WRDS** – *Chris Nicholson*
  
- **Energy Compliance** – *Paul Taucher*



# Bear 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

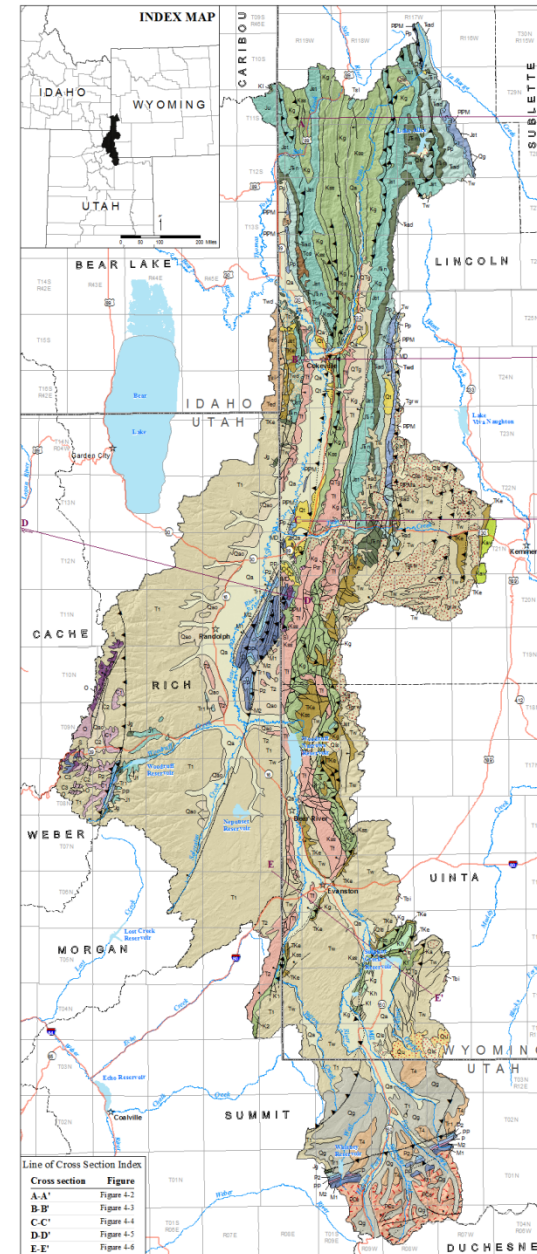


## *Identify the Major Aquifers and Their Extents*

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

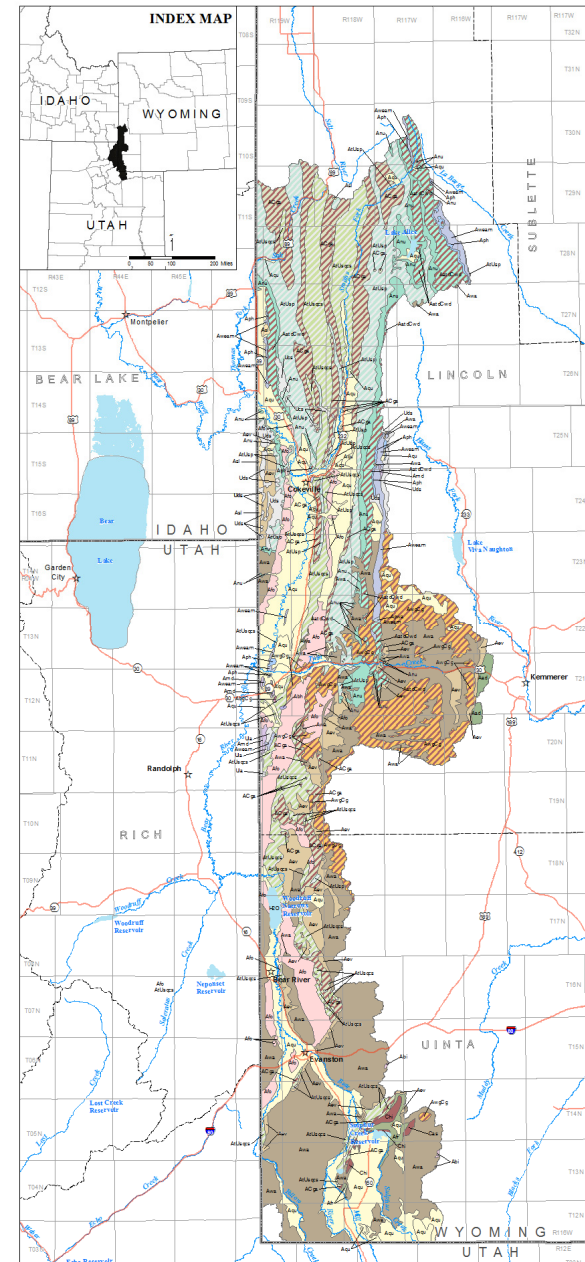
# Plate 1 - Bedrock Geology

- Shows 53 geologic units in Wyoming, Utah, 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

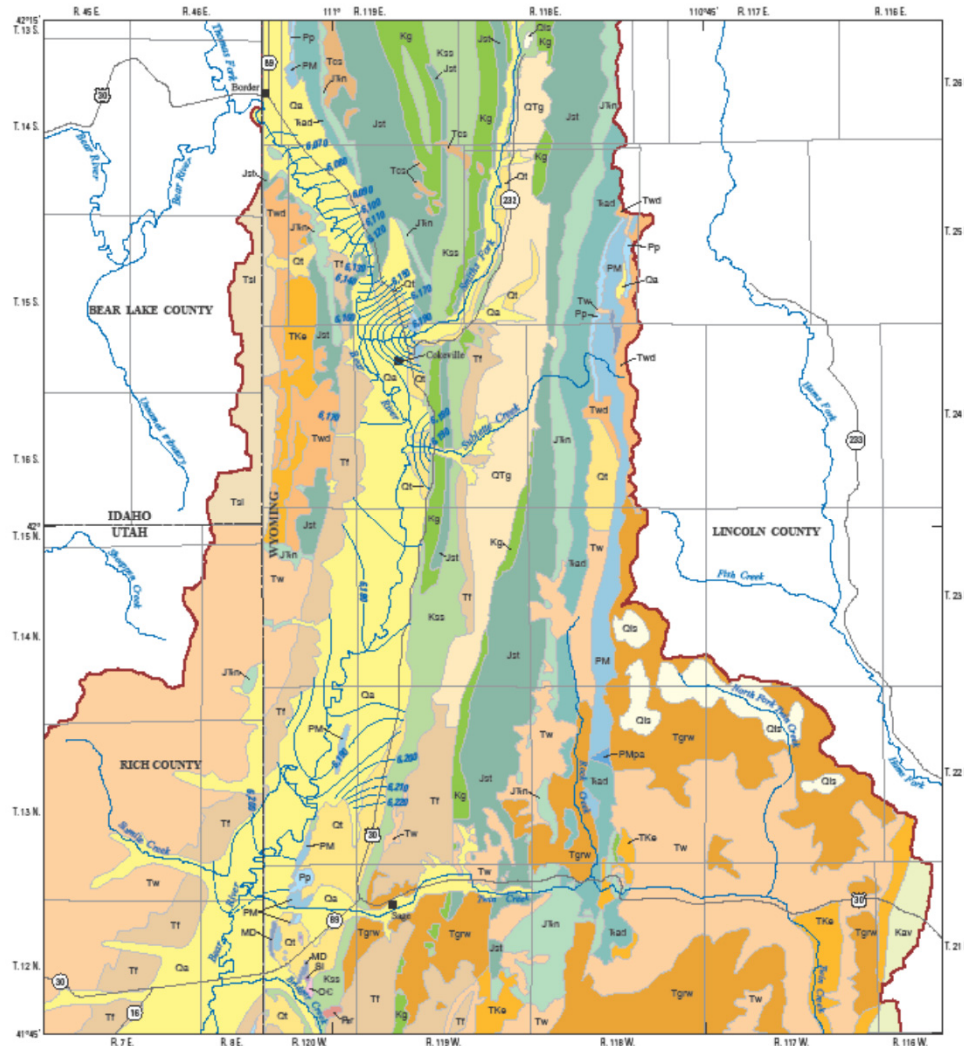






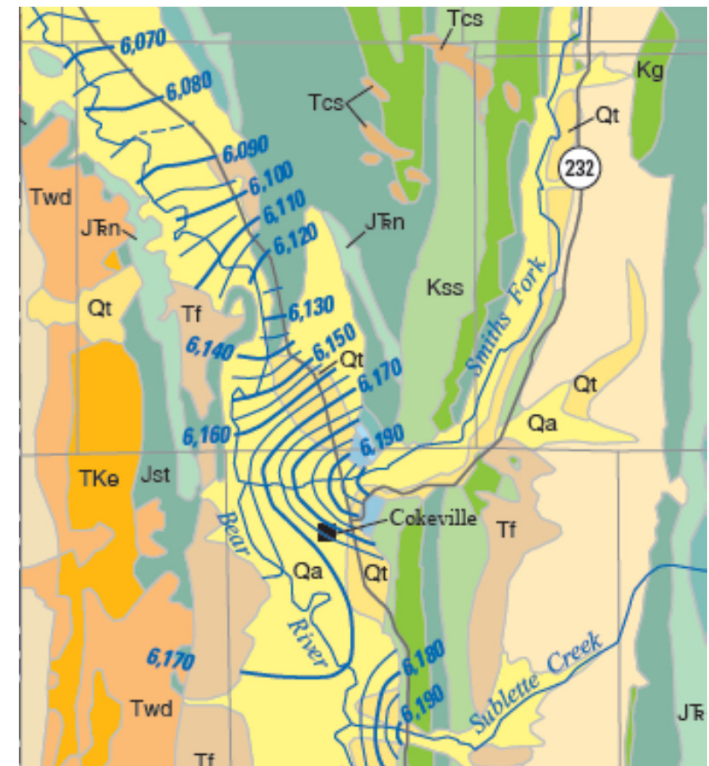


# Potentiometric Surface



Base modified from U.S. Geological Survey digital data, 2012, 1:1,200,000  
Albers Equal area Conic projection  
Standard parallels 29°30'N and 49°30'N, central meridian 111°W  
Geology from Stoeser et al., 2005

EXPLANATION



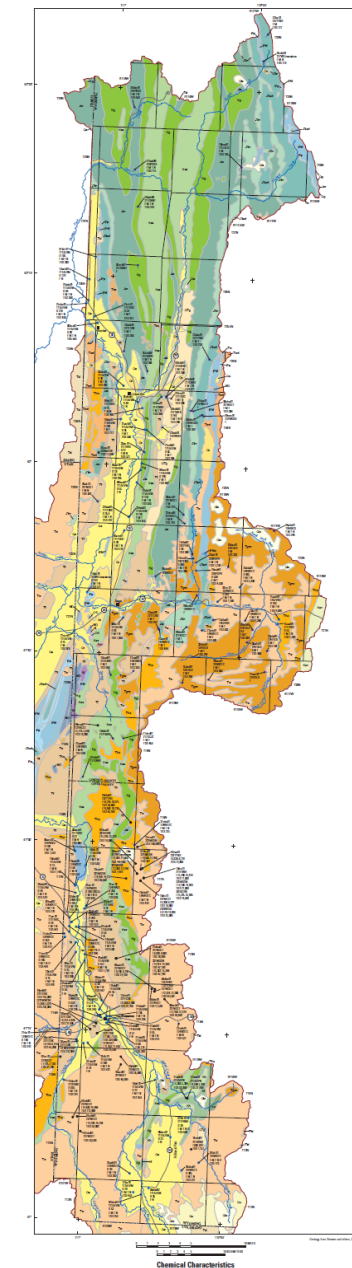
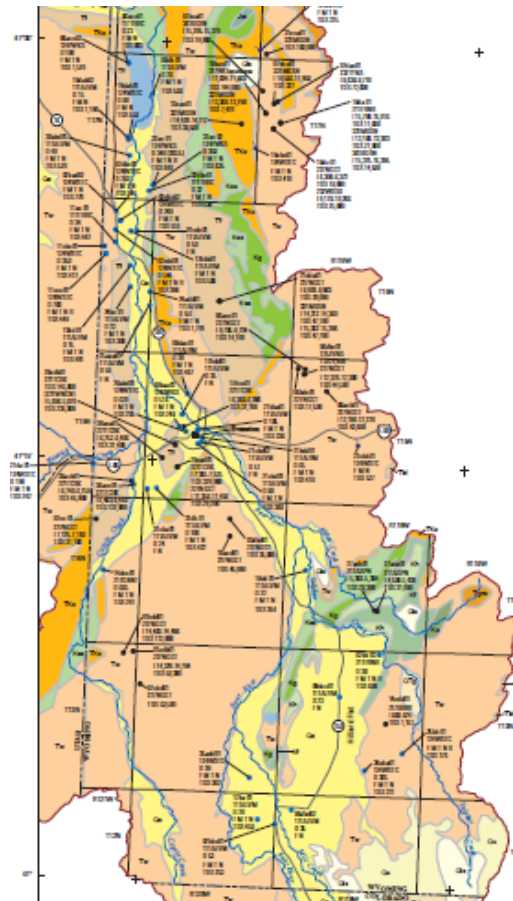


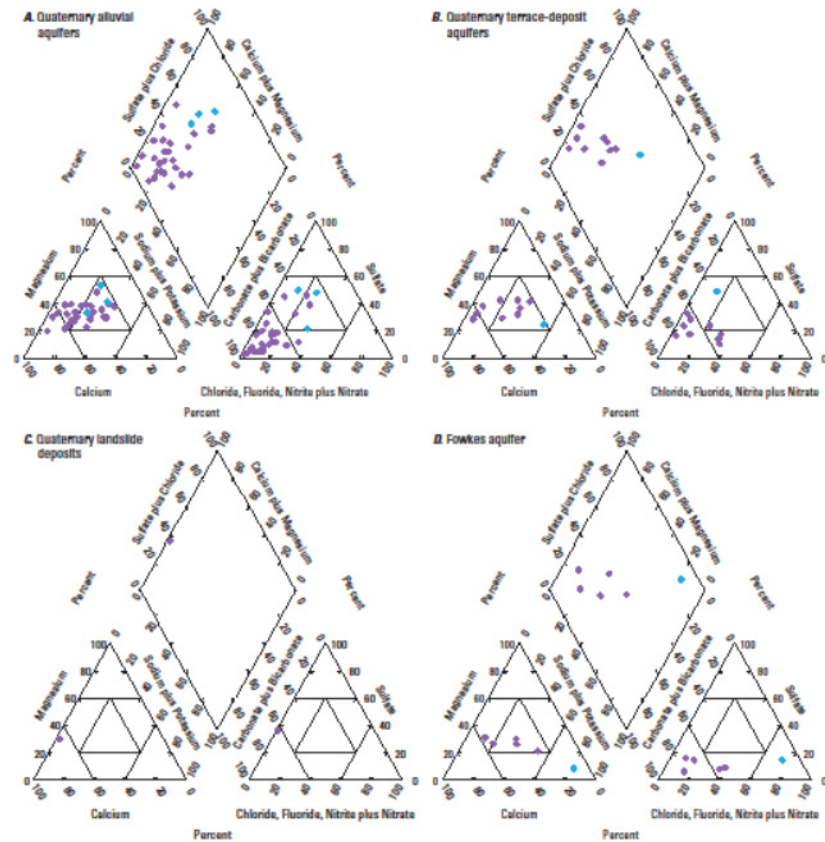
## *Identify Aquifer Hydrogeologic Properties*

- 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
- 31 Trilinear diagrams
- 2 Statistical appendices

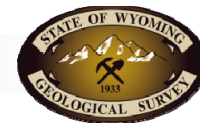




**EXPLANATION**  
 Total dissolved-solids concentration, in milligrams per liter, and U.S. Geological Survey salinity classification (Heath, 1982)

- Less than or equal to 999; fresh
- 1,000–2,999; slightly saline
- 3,000–9,999; moderately saline
- 10,000–34,999; very saline
- Greater than or equal to 35,000; briny

**Appendix C.** Ternary diagrams showing major-ion composition and total dissolved-solids concentrations for environmental groundwater samples, Bear River Basin.

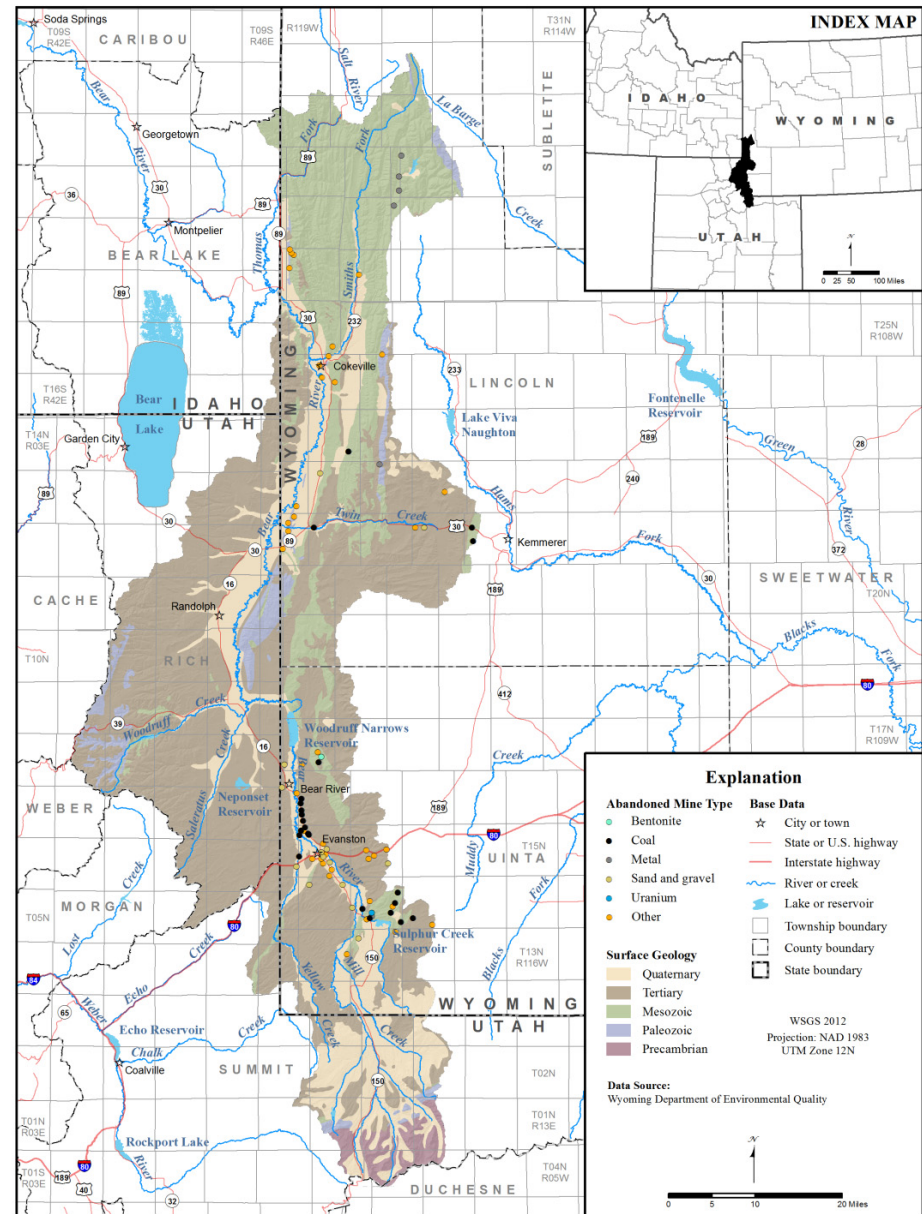
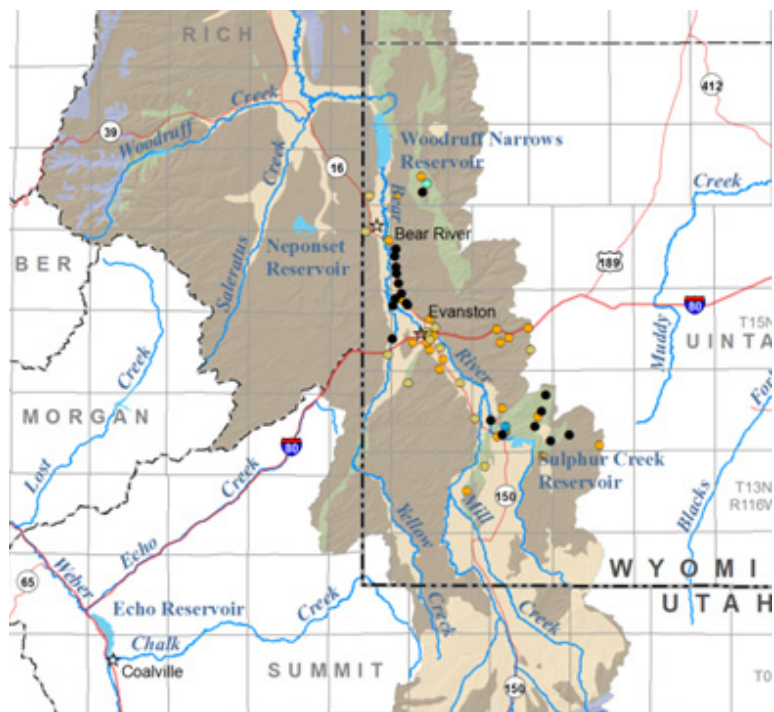


## 14 Appendix 2a

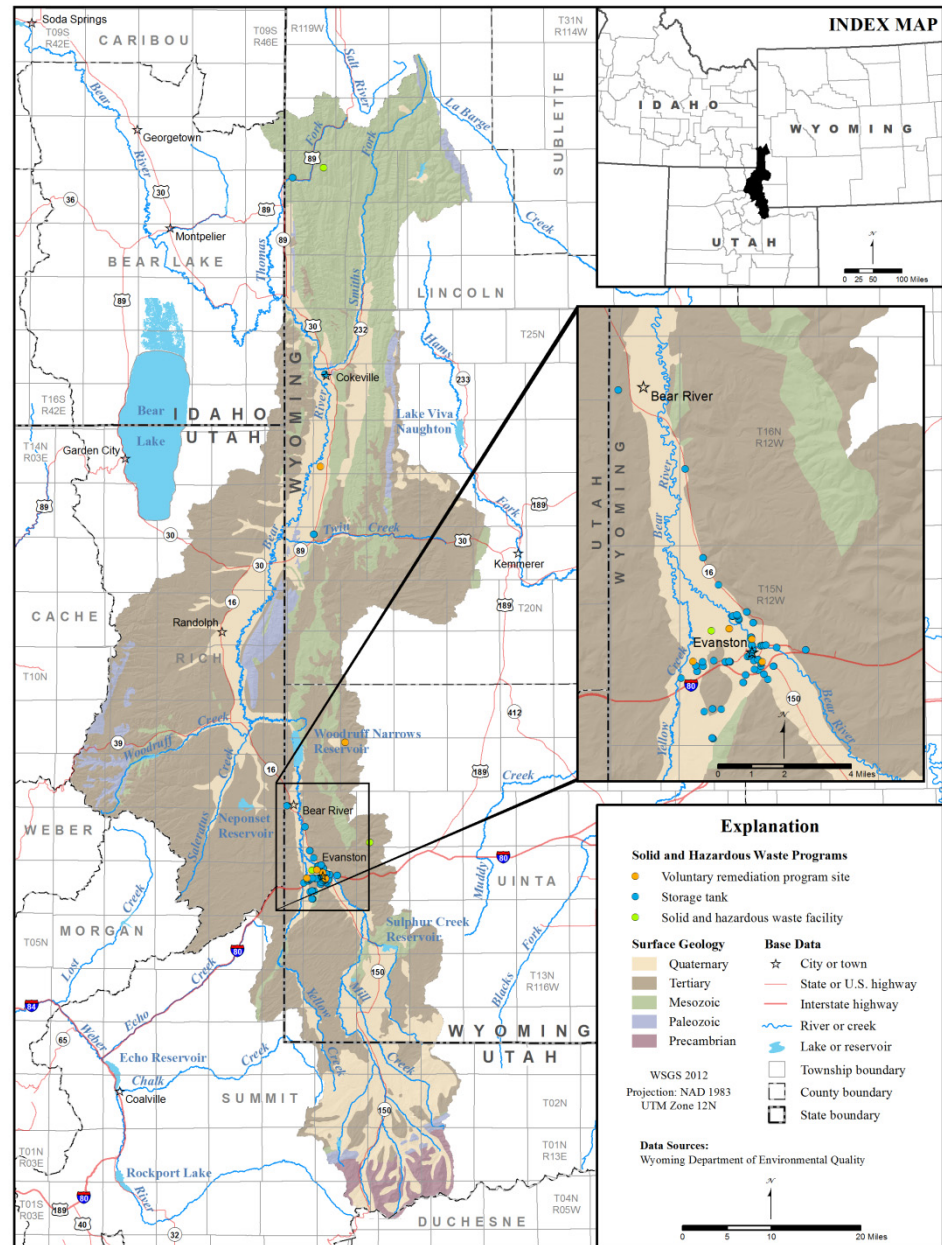
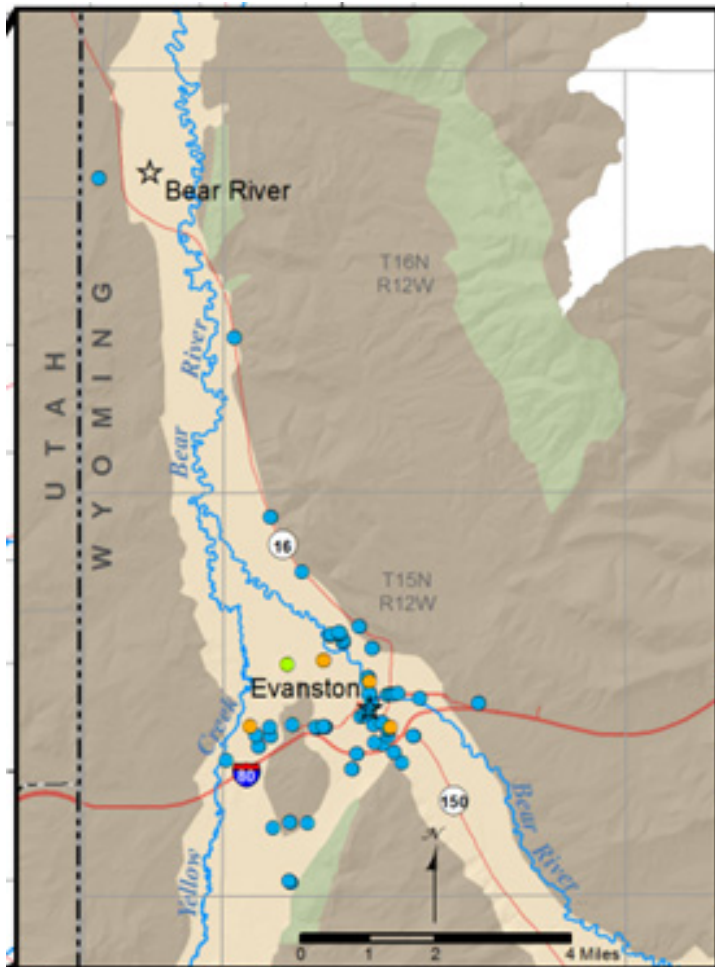
[--, not applicable;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter. Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter]

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

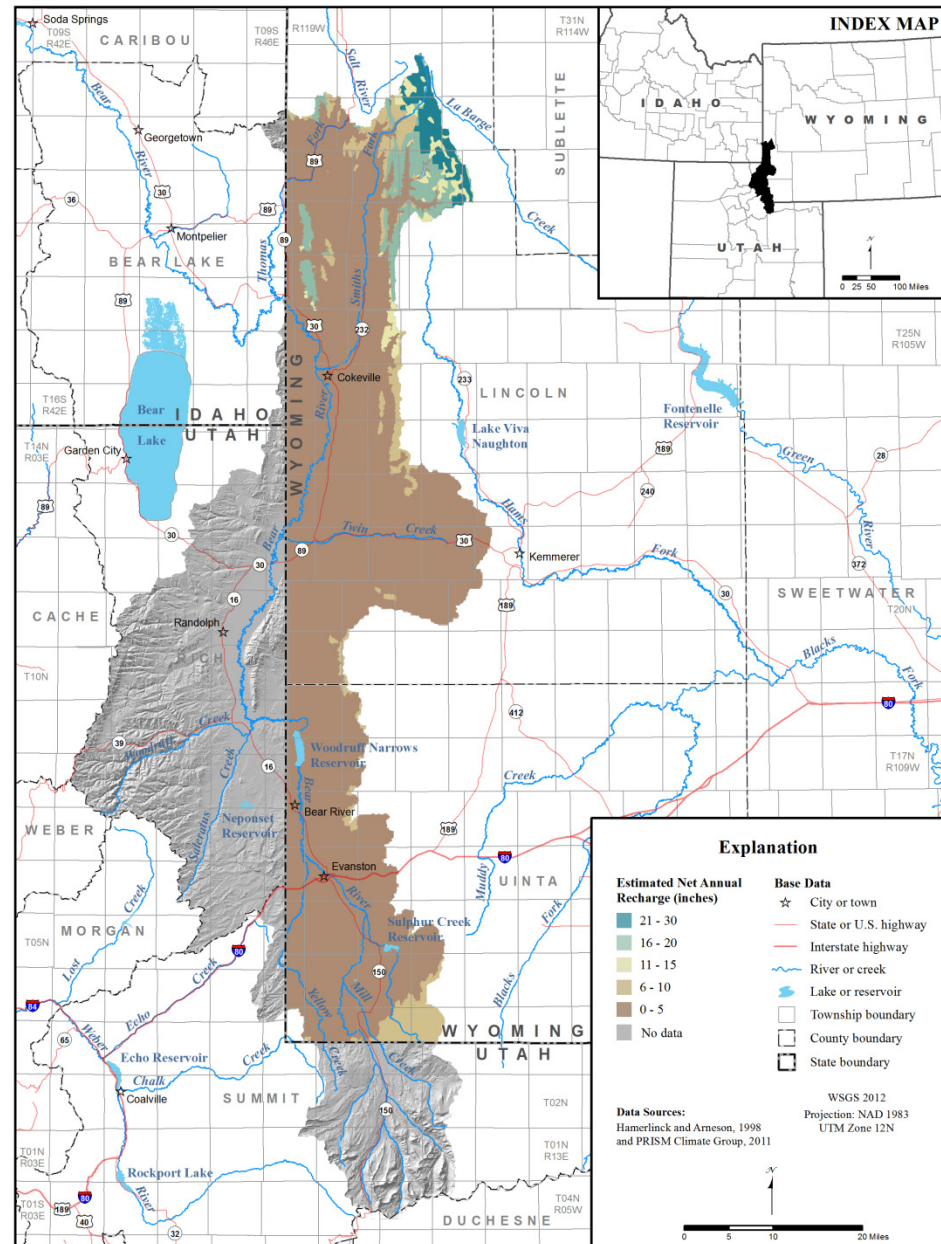


# Solid and Hazardous Waste Disposal Sites



# Identify Aquifer Recharge Areas and Rates

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







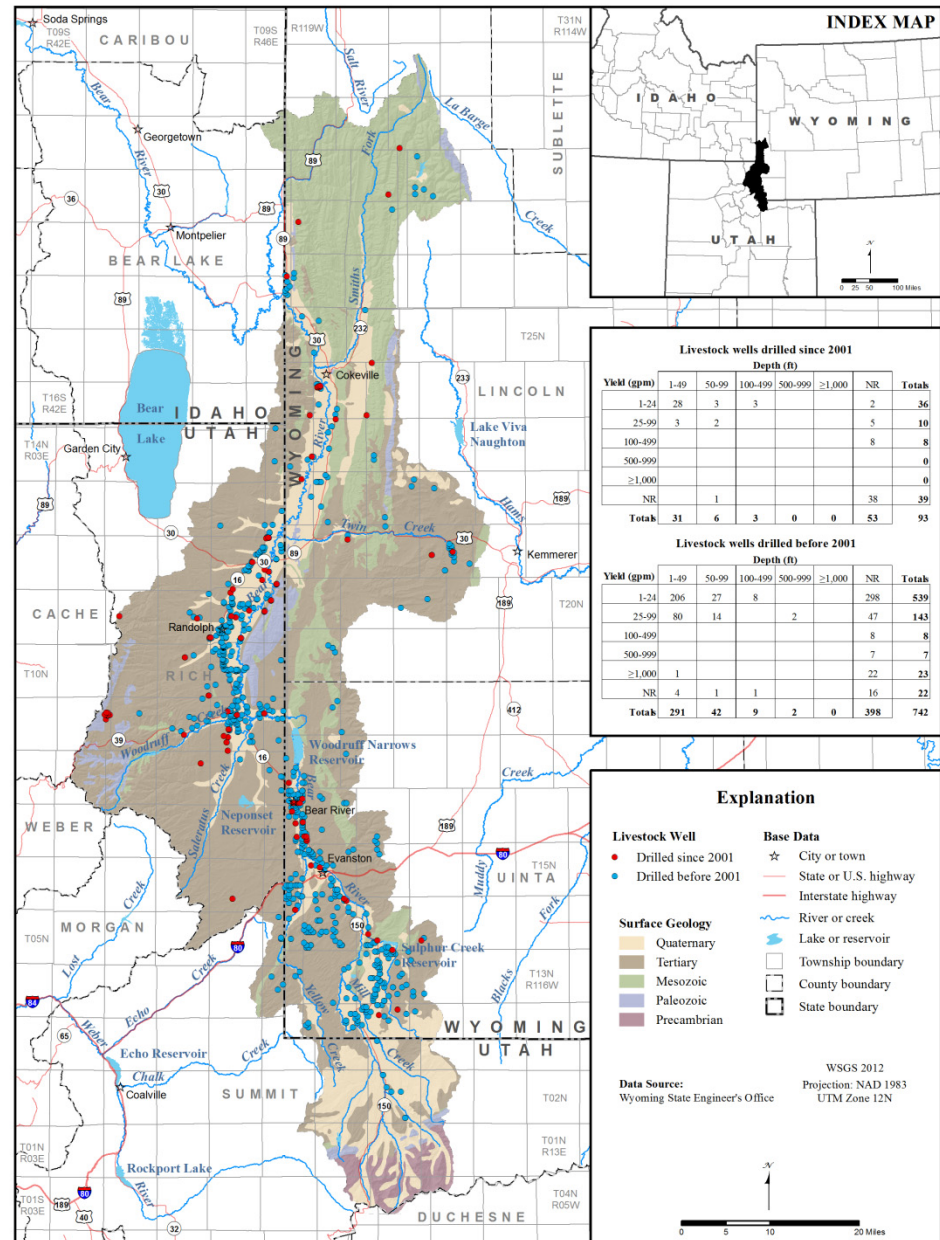
## *Estimate Water Quantity and Safe Yield*

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



<b>Water balance statistics</b>		<b>Volume (ac-feet)</b>	<b>% Precip.</b>
<sup>1</sup> Average annual precipitation (1981 - 2010)		1,398,195	---
<sup>2</sup> Net surface water outflows	-	163,255	11.7 %
<sup>3</sup> Total consumptive use (surface water and groundwater)	-	4,250	0.3%
<sup>3</sup> Reservoir evaporation	-	5,361	0.4%
<sup>3</sup> Estimated recharge volume	-	188,968	13.5%
Basin-wide evapotranspiration	=	1,036,361	74.1 %
<sup>1</sup> PRISM, 2012			
<sup>2</sup> USGS, 2012			
<sup>3</sup> WWDO, 2012			

# SEO Livestock Wells





## *“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)

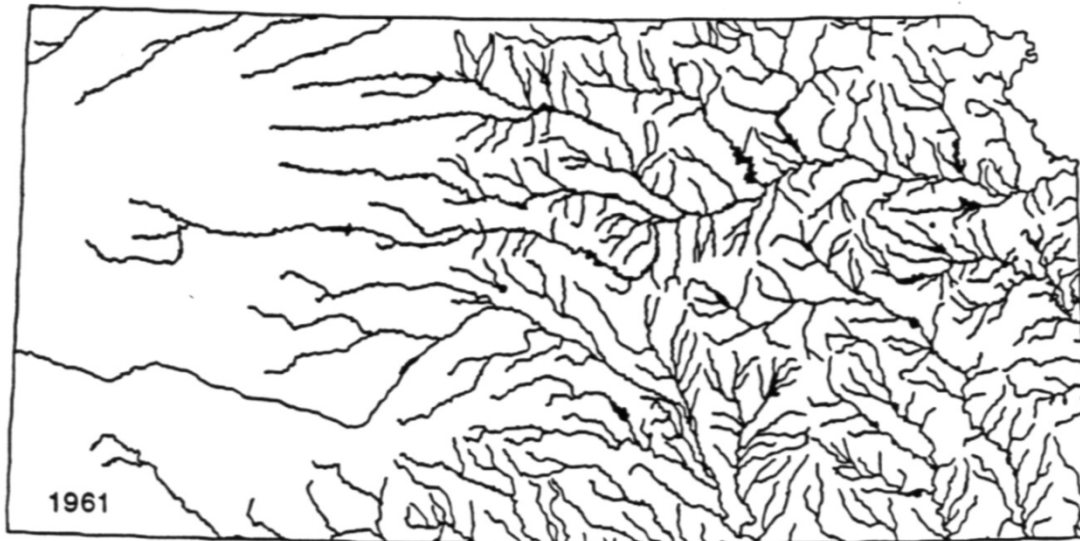
Or, simply

Recharge = Discharge



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

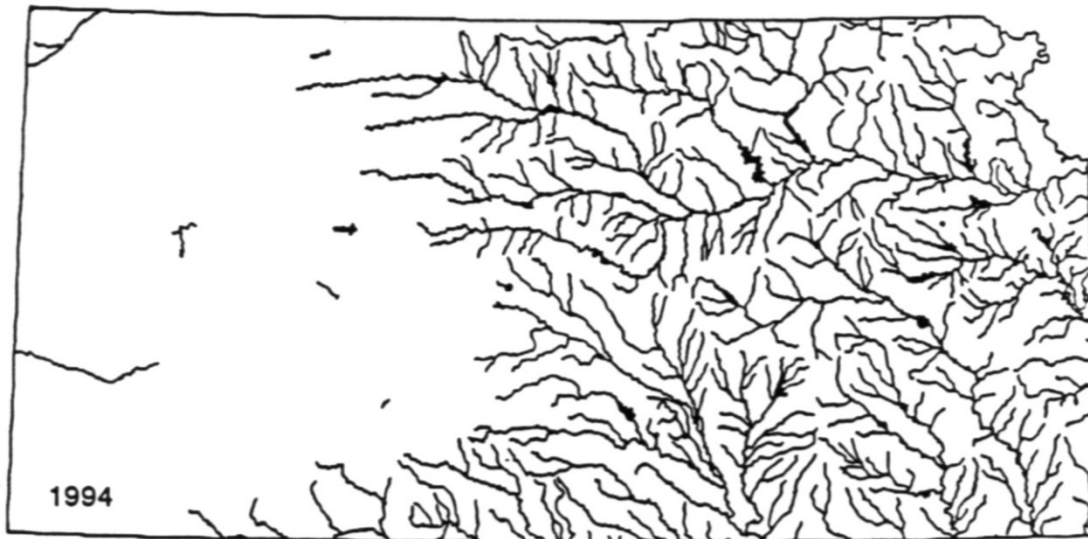
Under development: Groundwater volumes extracted from wells and developed springs result in reduced natural discharges to streams.



## 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*

Future water development opportunities in the Bear River Basin are subject to the provisions of the Amended Bear River Compact of 1978.

WSGS reviewed WWDC water development projects (2005 and later) in the basin.

- North Uintah County (Trihydro, 2003)
- Evanston/Bear River regional water system (Sunrise Engineering, 2005)



## *Identify Existing Studies*

- WSGS and the USGS identified almost 200 previous studies in this report.
- WSGS reviewed 14 WWDC studies in Appendix B



## *Summary*

The Bear River Basin groundwater report can be accessed online:

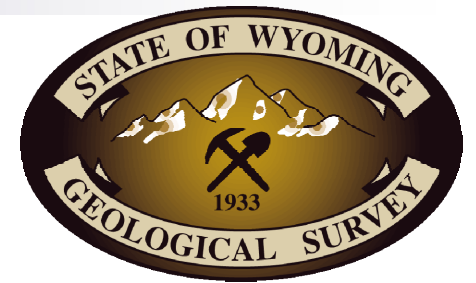
### WWDC website

<http://waterplan.state.wy.us/plan/bear/bear-plan.html>

### WSGS website

<http://www.wsgs.uwyo.edu/Research/Water-Resources/BRB/Default.aspx>

Or search “Bear River Basin Report”



***Thank you, questions?***

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