

*WWDC Wind/Bighorn River Basin  
Plan,  
Groundwater Study (Level I)*

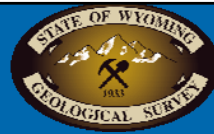
**WSGS – USGS – WRDS 2008-2010**

*Scott Quillinan*

*Geologist*

*Wyoming State Geological Survey (WSGS)*

*Laramie, Wyoming*



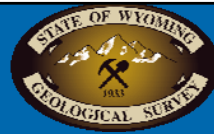
# *Introduction*

## **Wind/Bighorn plan (WBH) Plan II, Groundwater Study (Level I)**

- Commenced in June 2008

## **Cooperative Water Study**

- Wyoming Water Development Commission (WWDC)
- Wyoming Water Development Office (WWDO)
- Wyoming State Geological Survey (WSGS)
- U.S. Geological Survey (USGS)
- Water Resources Data System (WRDS)
- Surface Water Consultant – WWC Engineering, Laramie
- Other interested parties



# ***WBH Groundwater Study Team***

**WWDO** *Project Manager – Jodi Pavlica*

- **WSGS** – Laramie – *Keith Clarey/Paul Tuacher (Energy Compliance)/Scott Quillinan*
- **USGS** – Cheyenne – *Tim Bartos*
- **WRDS** – University of Wyoming – *Steve Gray*

# Major Drainages and Water Bodies, Wind/Bighorn River Basin



WSGS 2009  
Projection: NAD 1983  
UTM Zone 12N



**Data Sources:**

USGS National Hydrography Dataset  
USGS National Elevation Dataset

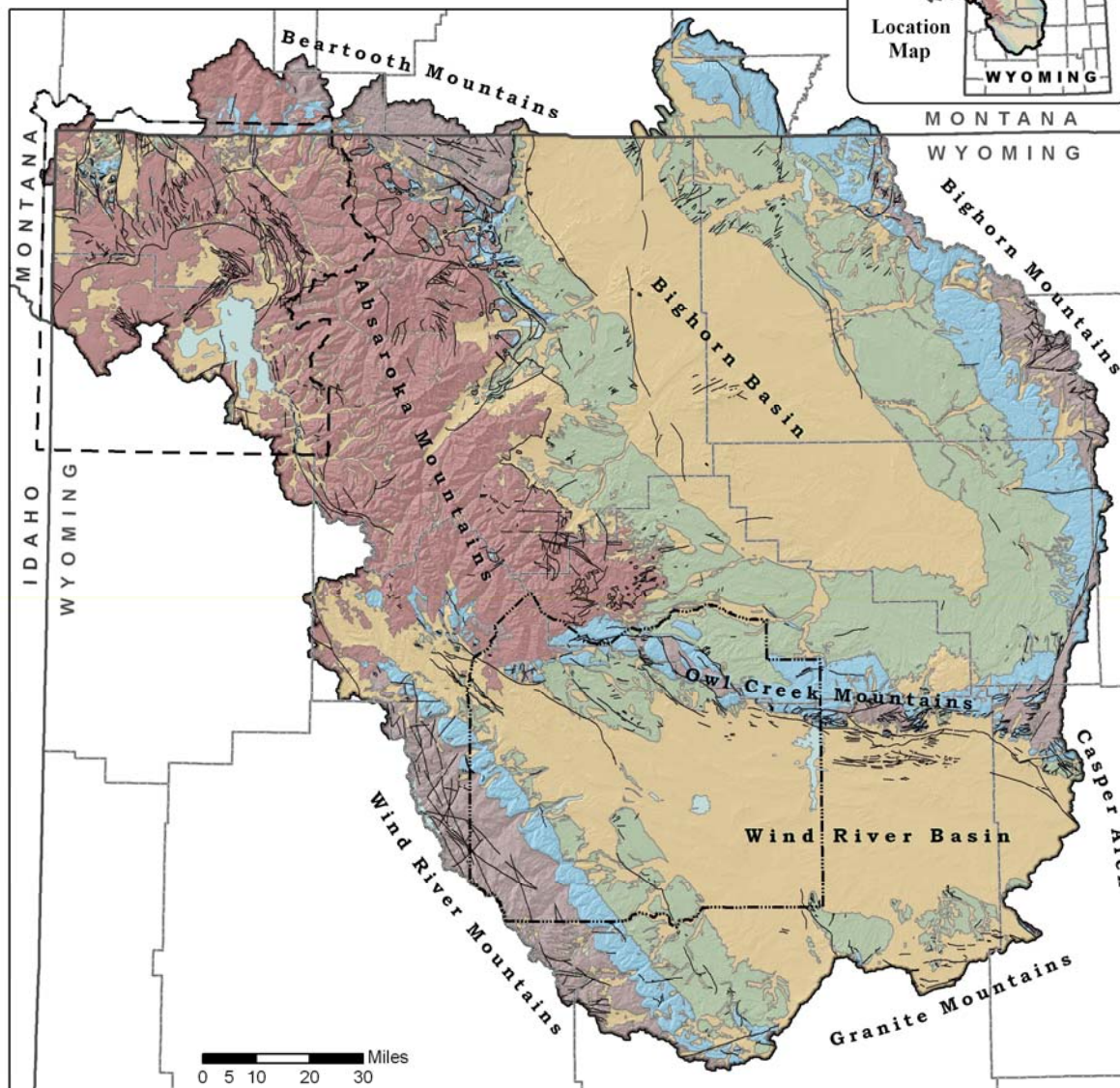
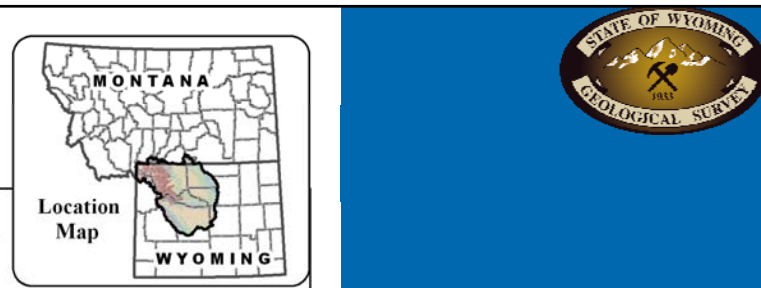
# *WBH Groundwater Study*

- Identify & inventory the aquifers present within the drainage basin area
- Determine 3-dimensional configuration of the aquifers (outcrop areas, geologic structures, & depths)
- Estimate aquifer recharge rates, storage quantities, & discharge rates
- Identify areas with interaction between groundwater & surface water
- Assess the quantity & quality of groundwater available in the aquifers
- Investigate the usage of groundwater in the basin

# *Geologic Setting of the WBH*

- Complex structural basin with folds, faults, & uplifts
  - 35,000 feet of structural relief between the basin and Bighorn mountains
  
- WBH formations range from Precambrian to Quaternary in age
  - Wyoming – 93 GIS geologic units
  - Montana – 43 GIS geologic units

# Geologic Features, Wind/Bighorn River Basin



## Explanation

- Fault, includes buried thrusts
- Yellowstone National Park Boundary
- Wind River Reservation Boundary
- Water and Ice
- Volcanic Rocks

### Major Aquifer Groups

- Cenozoic
- Mesozoic
- Paleozoic
- Precambrian

WSGS 2009

Projection: NAD 1983  
UTM Zone 12N

### Data Sources:

Stoeser, et al. (2005)

USGS National Elevation Dataset

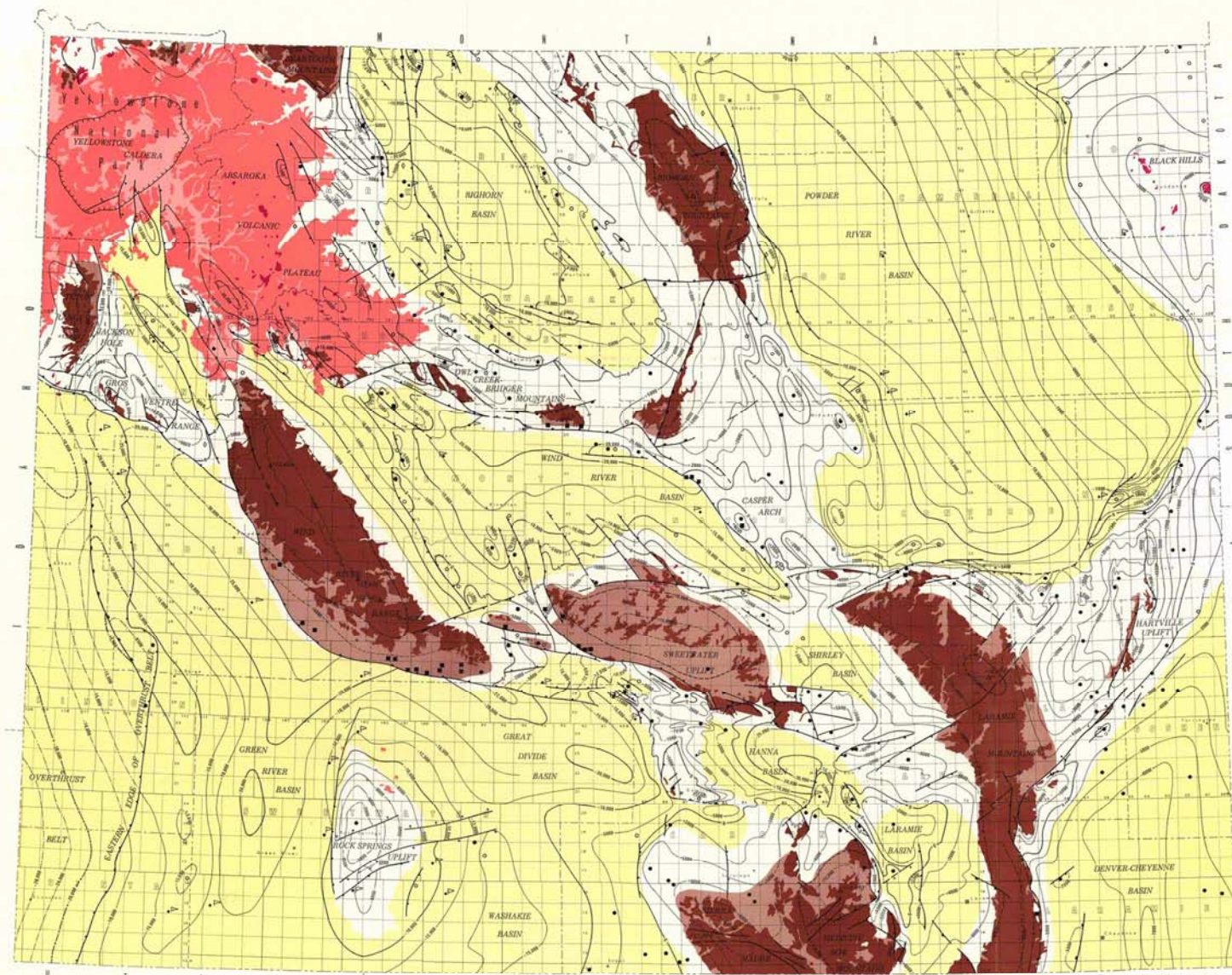


# Precambrian Basement Map - WY

THE GEOLOGICAL SURVEY OF WYOMING  
Gary B. Glass, State Geologist

MAP SERIES 43  
Basement Map of Wyoming

MS-43

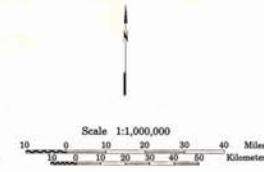


- EXPLANATION**
- Lithologic Units<sup>1</sup>**
- Precambrian rock outcrop.
  - Precambrian rock present in subsurface at shallow depth.
  - Tertiary and Quaternary volcanic rock outcrop.
  - Tertiary and Quaternary volcanic rocks present in subsurface at shallow depths.
  - Tertiary igneous intrusive rocks.
- Faults** (shown where they intersect Precambrian rocks at the surface or at the level of the Precambrian rocks in the subsurface).
- Thrust fault, sawteeth on upthrown side; dashed where inferred.
  - Normal fault, ball and bar on downthrown side; dashed where inferred.
  - High-angle fault, bars on upthrown side; dashed where inferred.
  - Fault, movement unspecified; dashed where inferred.
- Contours**
- Structure contour on top of Precambrian basement, in feet above (+) or below (-) mean sea level. Contour interval varies; heavy contour lines at 10,000-foot intervals.
  - Structure contour in footwall of thrust.
  - Structure contour restored to pre-erosion elevation.
- Data Points**
- Well drilled to the Precambrian.
  - Well drilled into or through the Precambrian.
  - Well drilled to the Cambrian.
  - Well drilled to the Ordovician.
  - Wells critical to interpretation (drilled to units younger than Ordovician).
  - Elevation of Precambrian rocks in some of the highest mountain peaks (in feet).
- Other Boundaries**
- Yellowstone caldera boundary.
  - Major Wyoming basins and overthrust belt<sup>2</sup>.

<sup>1</sup>Outcrop modified from J.D. Love and A.C. Christiansen, 1985, Geologic map of Wyoming, U.S. Geological Survey, scale 1:500,000.

<sup>2</sup>Boundaries of basins modified from R.H. DeBruin and C.S. Boyd, 1991, Oil and gas map of Wyoming, Geological Survey of Wyoming Map Series 35, scale 1:500,000.

The basement map presented here was prepared using all well data, published information, gravity, magnetic, and reflection seismic data available to the author. Numerous cross sections were constructed to aid in interpretation. The Geological Survey of Wyoming and the compiler welcome comments.



Base by U.S. Geological Survey  
Cartography by Phyllis A. Bass  
and Fred H. Porter.

## PRECAMBRIAN BASEMENT MAP OF WYOMING: OUTCROP AND STRUCTURAL CONFIGURATION

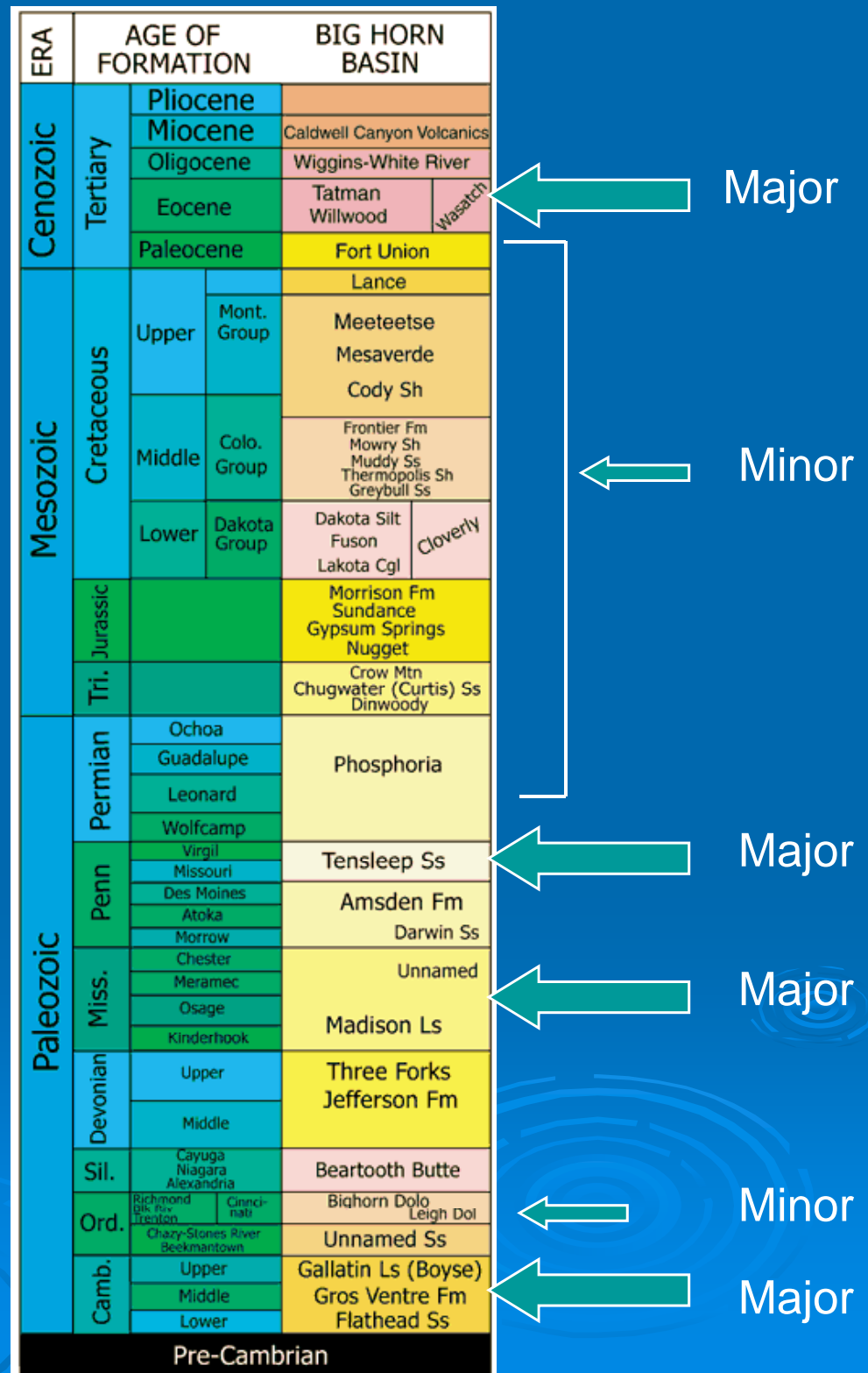
by  
D.L. Blackstone, Jr.  
1993



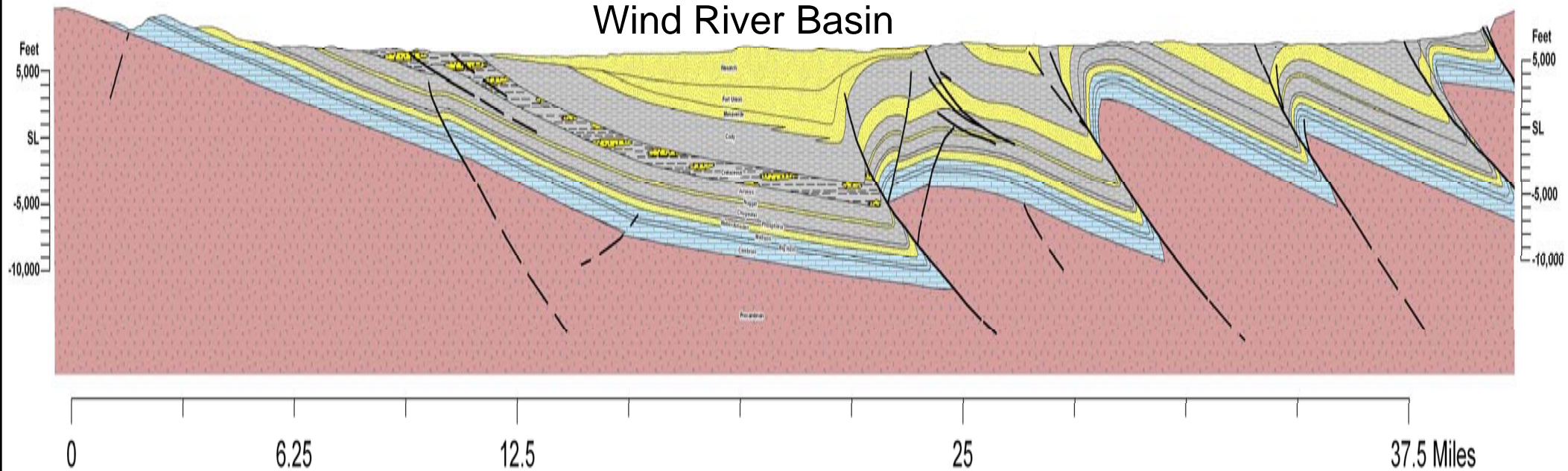
# Wind/Bighorn Basin Stratigraphy

&

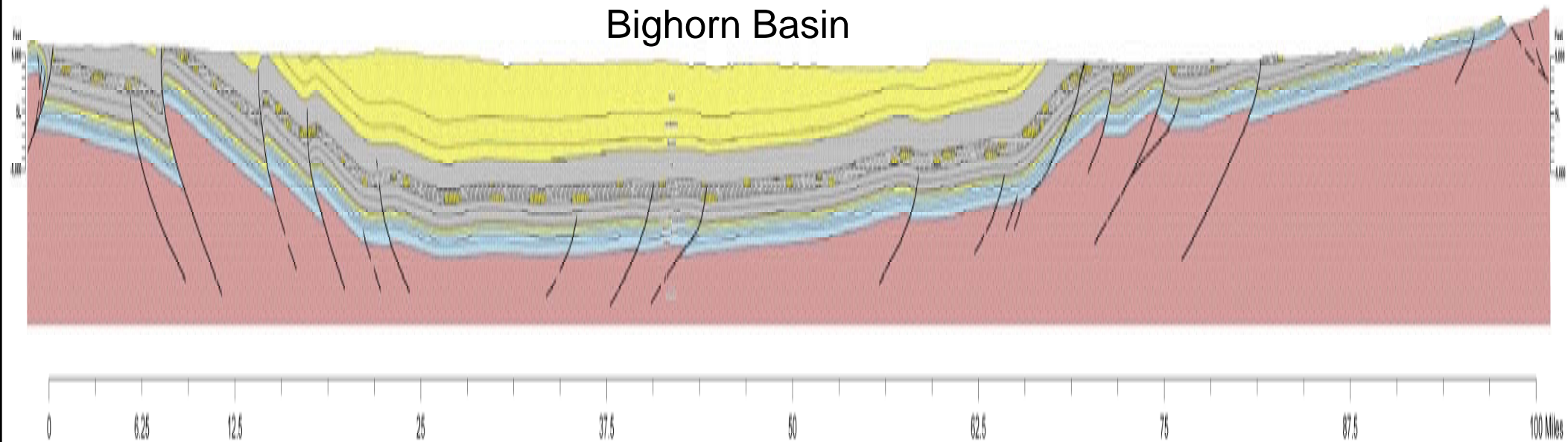
# Identified Major and Minor Aquifers



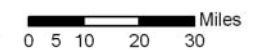
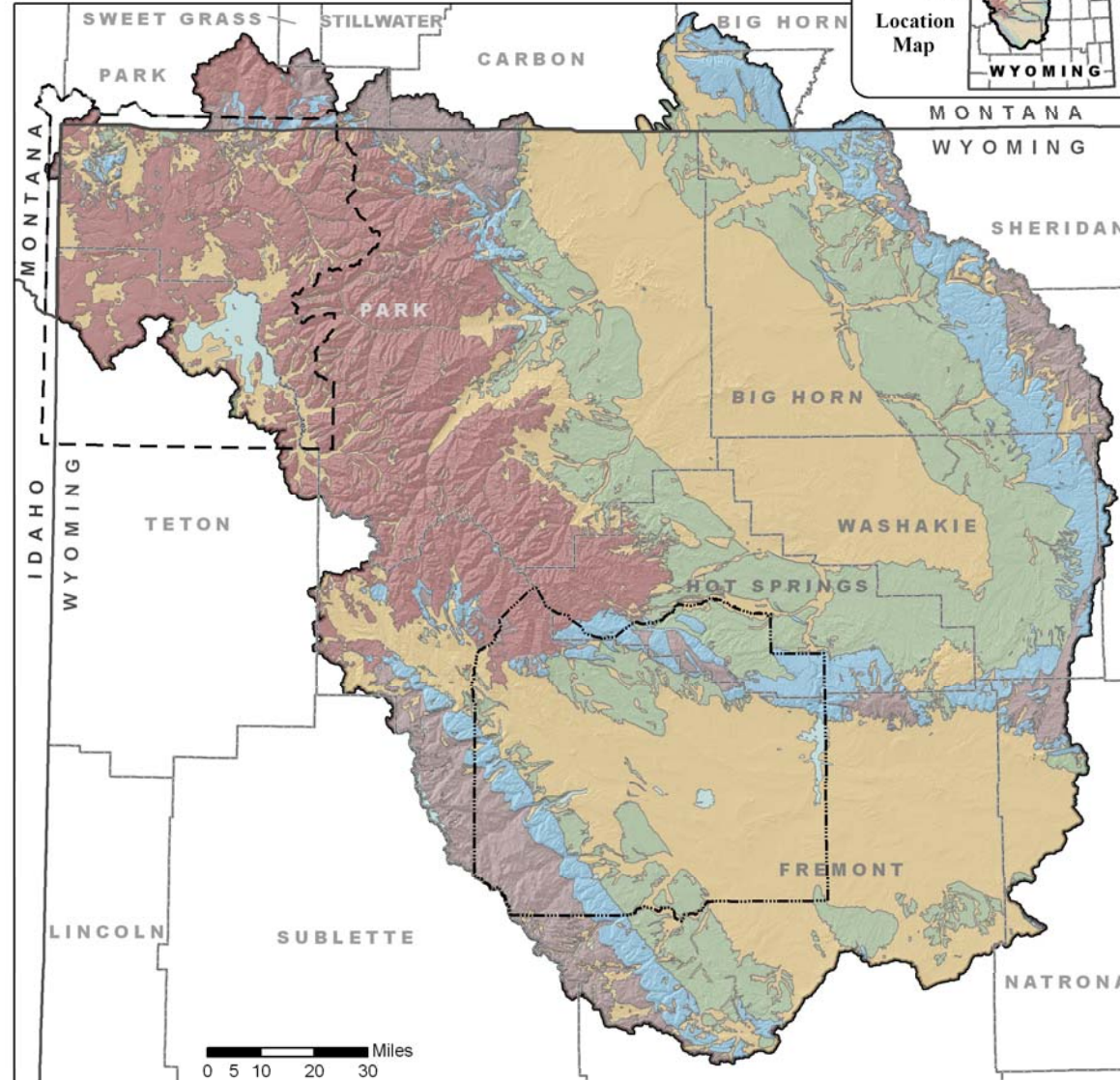
# Wind River Basin



# Bighorn Basin



# Major Aquifer Groups, Wind/Bighorn River Basin



## Explanation

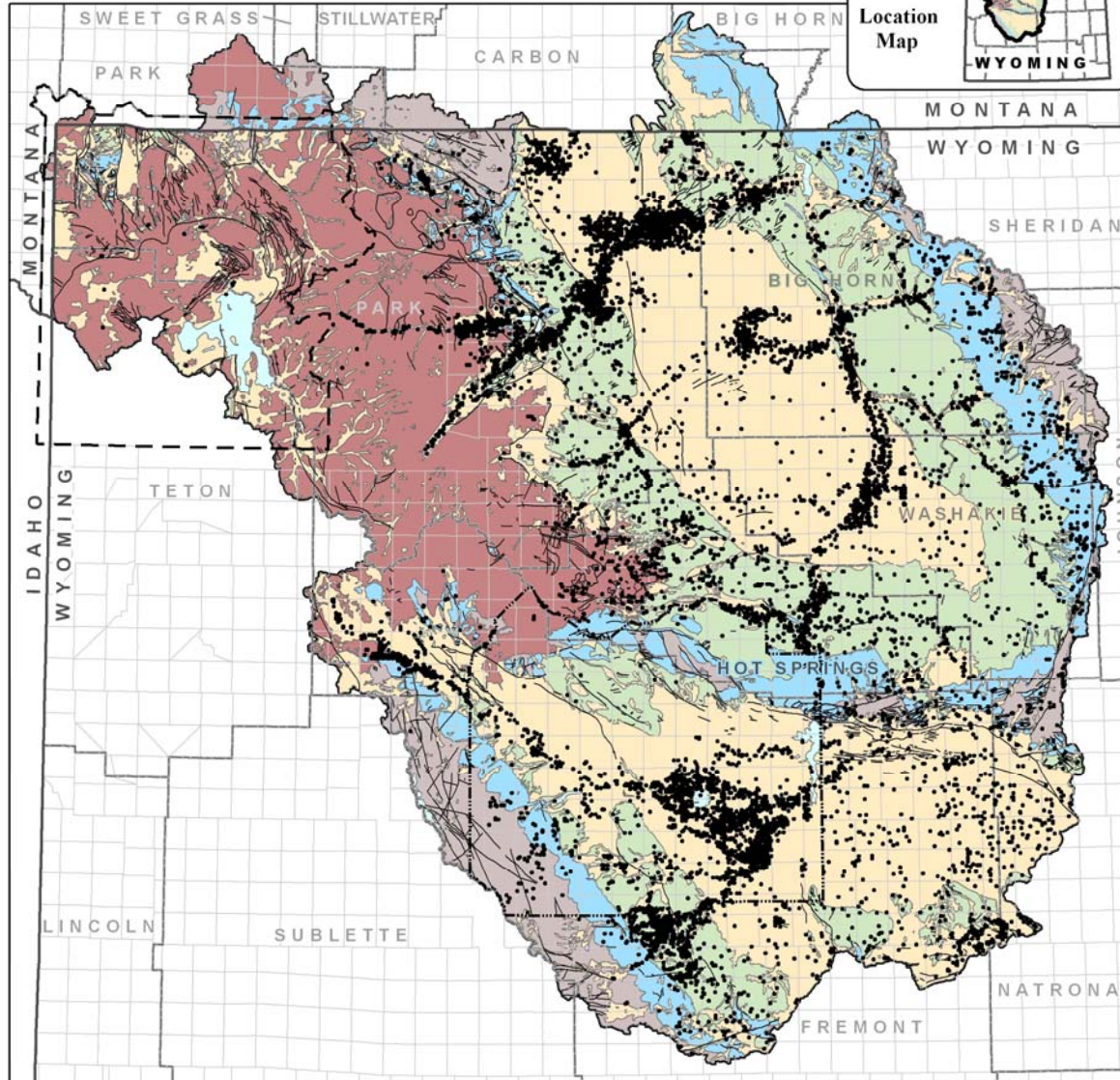
- |                                    |                             |
|------------------------------------|-----------------------------|
| Yellowstone National Park Boundary | <b>Major Aquifer Groups</b> |
| Wind River Reservation Boundary    | Cenozoic                    |
| Water and Ice                      | Mesozoic                    |
| Volcanic Rocks                     | Paleozoic                   |
|                                    | Precambrian                 |

WSGS 2009  
 Projection: NAD 1983  
 UTM Zone 12N  
**Data Sources:**  
 Stoesser, et al (2005)  
 USGS National Elevation Dataset

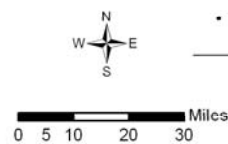
# *Percentages of WBH Map Area*

- **Cenozoic Aquifer System**
  - 42%
- **Mesozoic Aquifer System**
  - 20%
- **Paleozoic Aquifer System**
  - 10%
- **Precambrian Aquifer System**
  - 7.3%
- **Volcanic**
  - 19%

# Wells in Wyoming Permitted by the Wyoming State Engineer's Office (WSEO), Wind/Bighorn River Basin



## Explanation

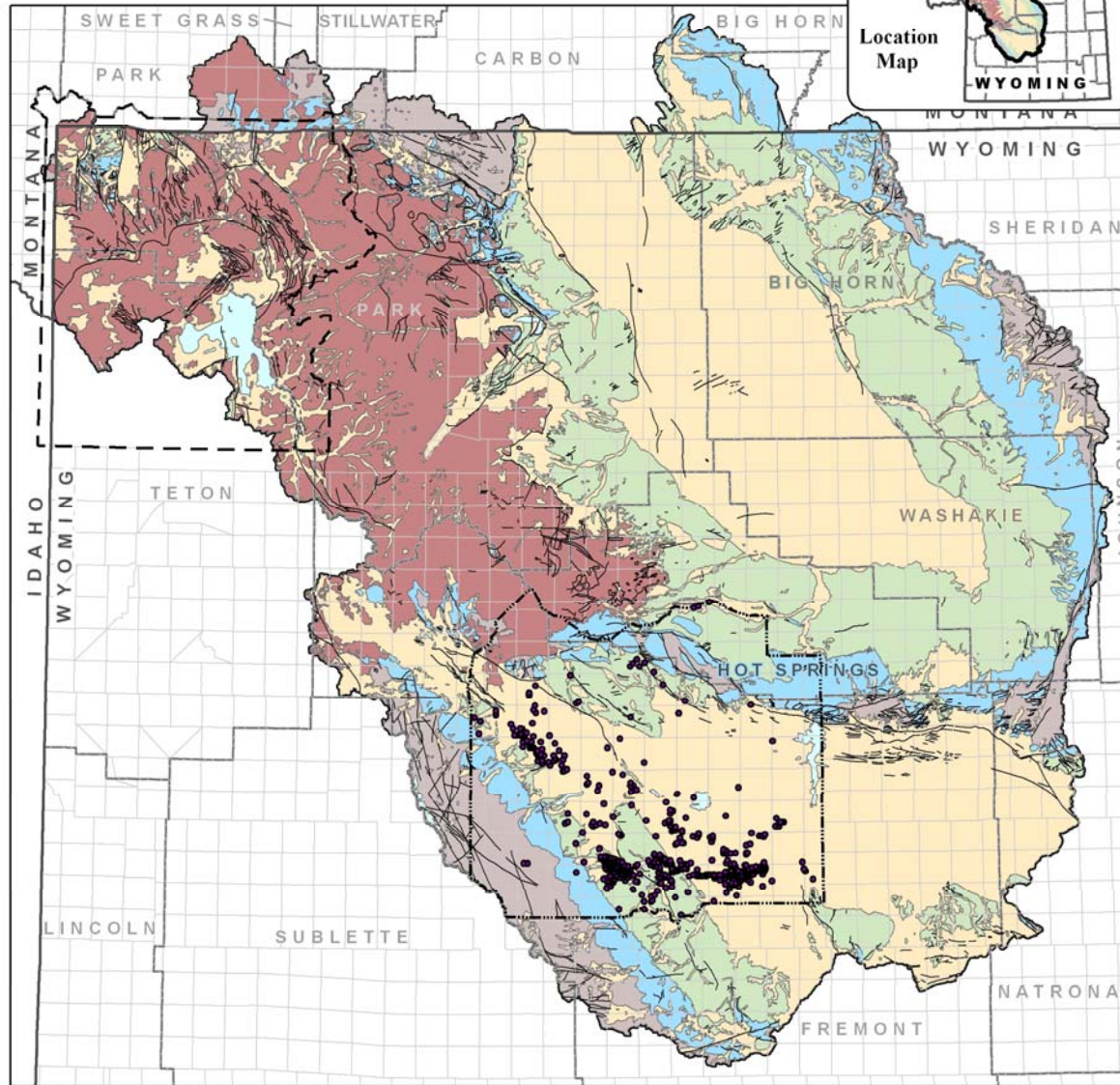


- WSEO Well
- Fault
- ⌞ Yellowstone National Park Boundary
- ⌞ Wind River Reservation Boundary
- Water and Ice
- Volcanic Rocks

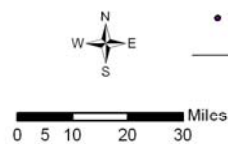
- Major Aquifer Groups**
- Cenozoic
  - Mesozoic
  - Paleozoic
  - Precambrian

WSGS 2009  
 Projection NAD 1983  
 UTM Zone 12N  
**Data Sources:**  
 Stoeser, et al (2005)  
 Wyoming State Engineer's Office,  
 Cheyenne, Wyoming

# Tribal Wells on the Wind River Indian Reservation, Wyoming



## Explanation



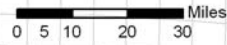
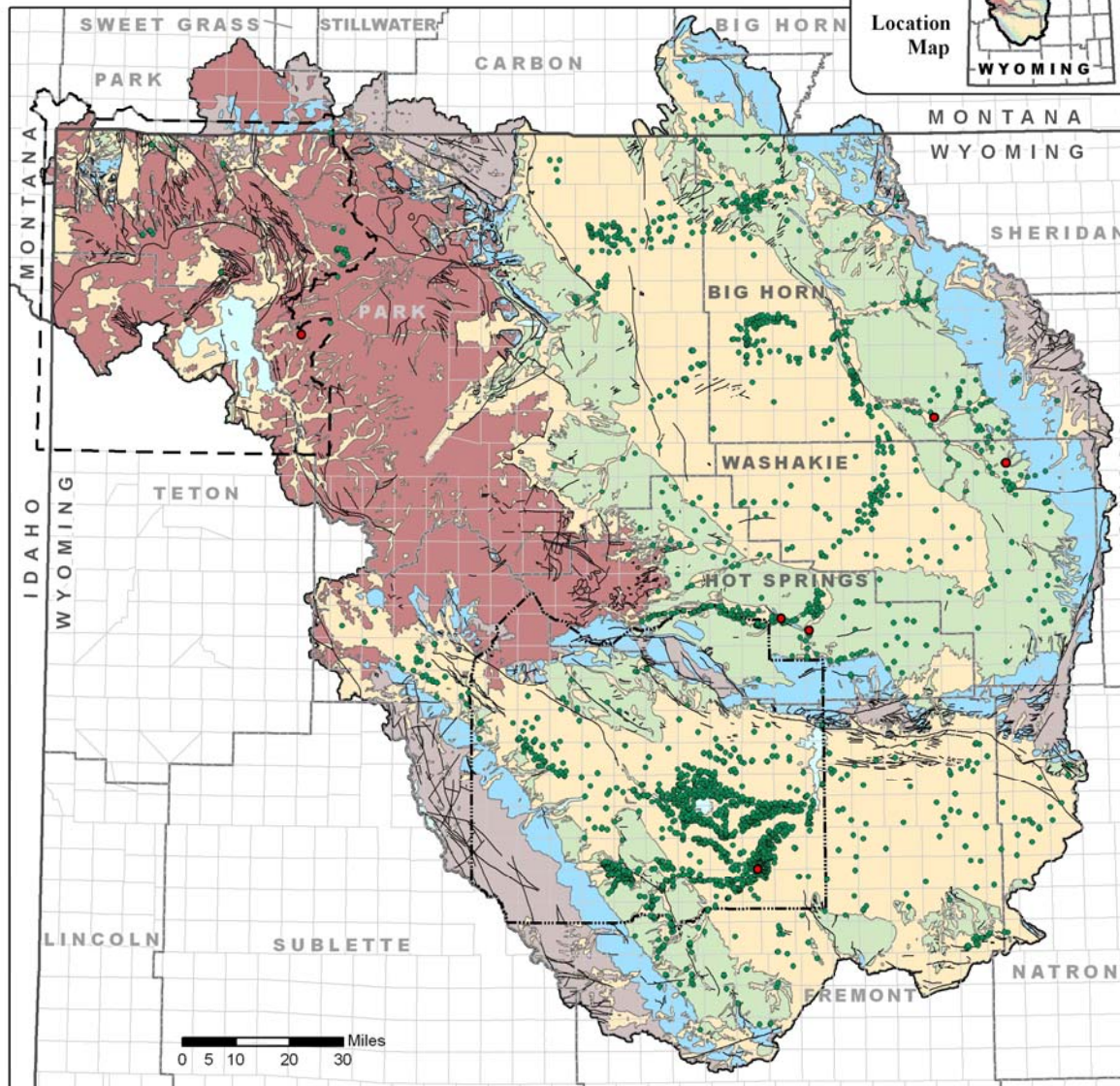
- Tribal Well
- Fault
- ⎓ Yellowstone National Park Boundary
- ⎓ Wind River Reservation Boundary
- Water and Ice
- Volcanic Rocks

- Major Aquifer Groups**
- Cenozoic
  - Mesozoic
  - Paleozoic
  - Precambrian

WSGS 2009  
Projection: NAD 1983  
UTM Zone 12N

**Data Sources:**  
Stoeser, et al. (2005)  
Wyoming State Engineer's Office,  
Cheyenne, Wyoming

# U.S. Geological Survey Groundwater Monitoring Locations, Wind/Bighorn River Basin



## Explanation

### USGS Monitoring Locations

- Manually measured
- Mechanically measured

— Fault

--- Yellowstone National Park Boundary

--- Wind River Reservation Boundary

Water and Ice

Volcanic Rocks

### Major Aquifer Groups

Cenozoic

Mesozoic

Paleozoic

Precambrian

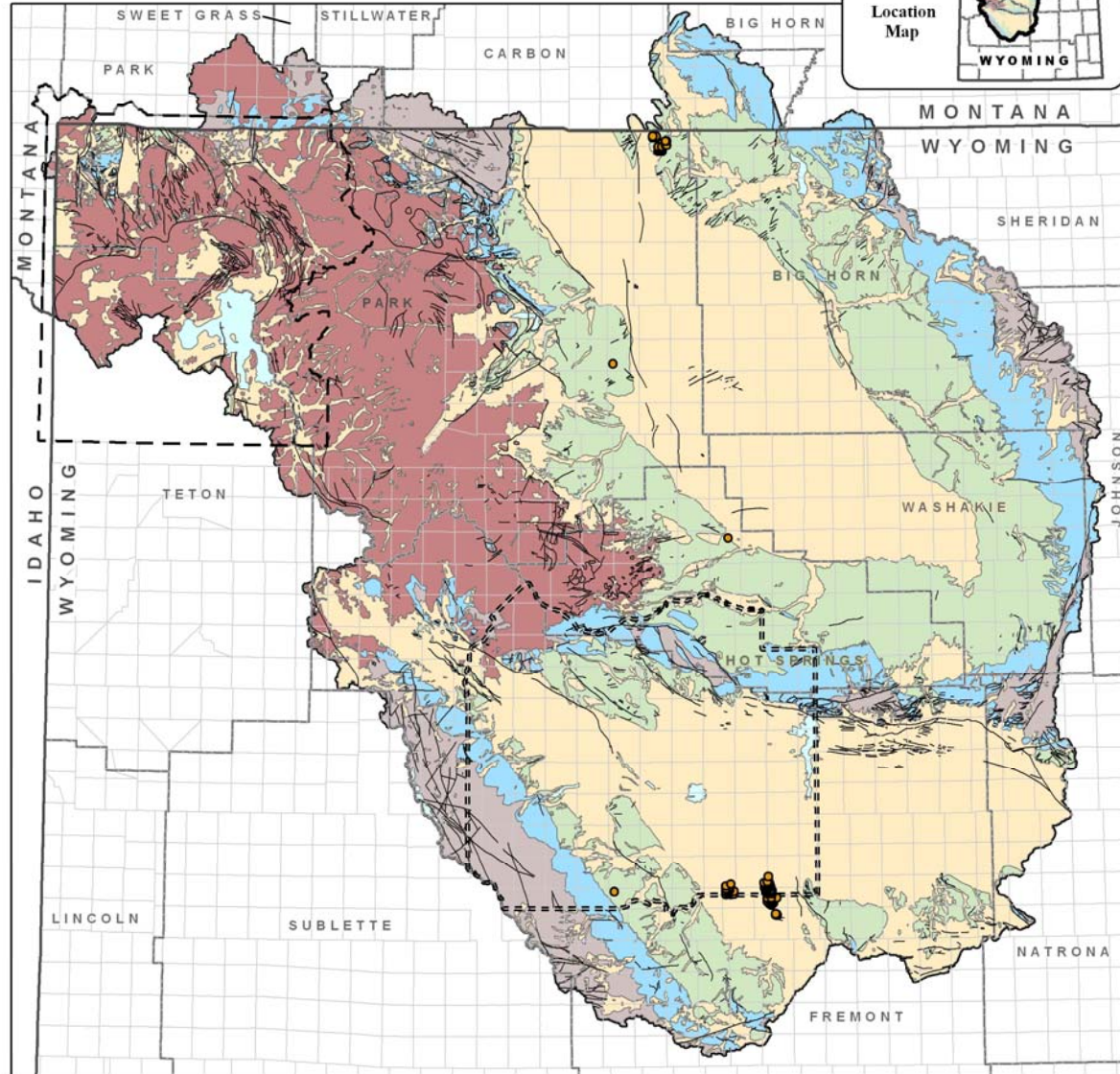
WSGS 2009

Projection: NAD 1983  
UTM Zone 12N

### Data Sources:

Stoeser, et al. (2005)  
U.S. Geological Survey (USGS)  
Water Data for the Nation  
(<http://waterdata.usgs.gov/nwis>)

# Permitted Coal Bed Natural Gas (CBNG) Wells in Wyoming, Wind/Bighorn River Basin

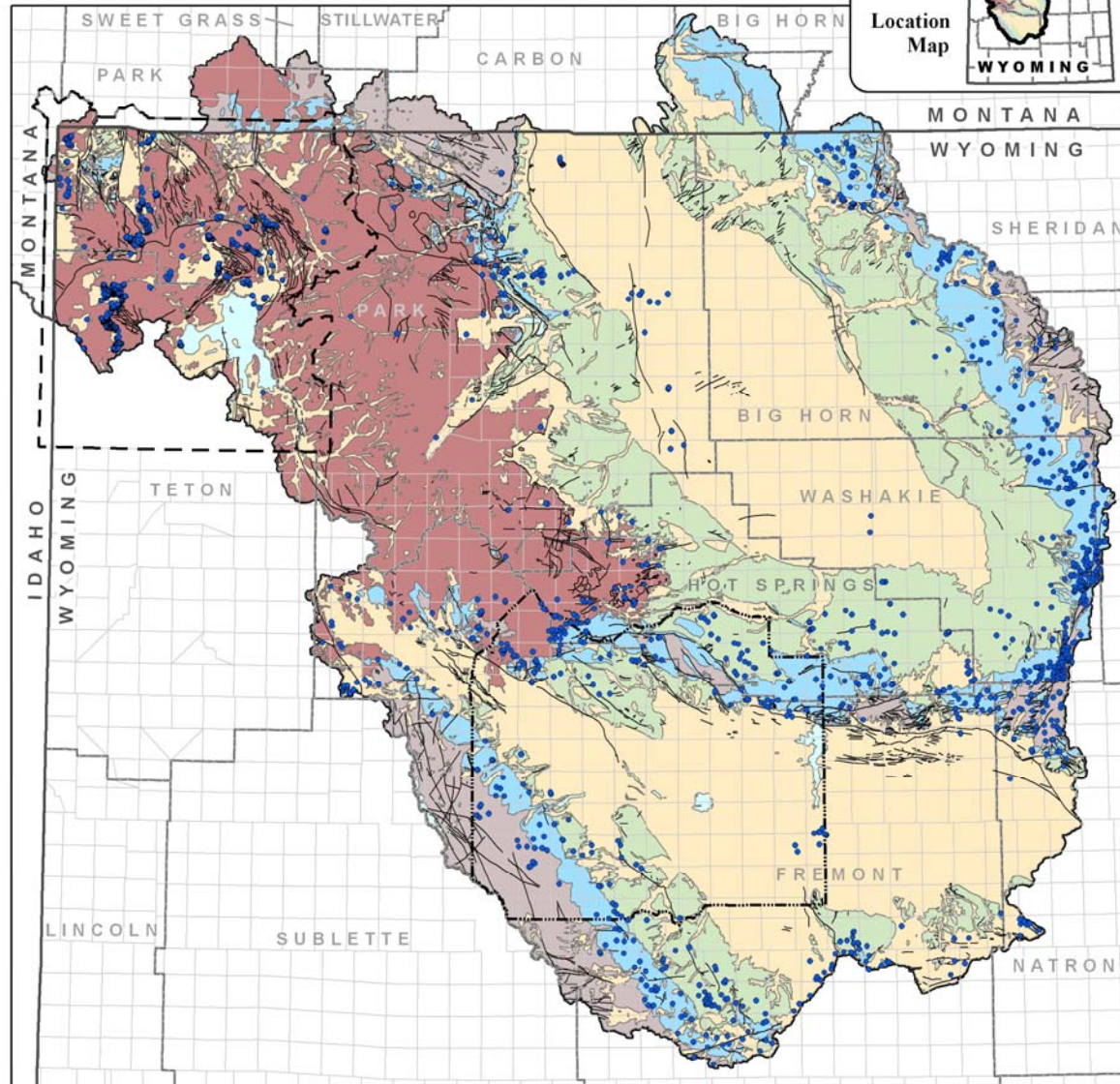


### Explanation

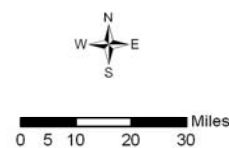
 	WOGCC Permitted CBNG Well	Yellowstone National Park Boundary	<b>Major Aquifer Groups</b>	WSGS 2008 Projection: NAD 1983 UTM Zone 12N
	Fault	Wind River Reservation Boundary	Cenozoic	<b>Data Sources:</b> Stoeser, et al (2005) Wyoming Oil and Gas Conservation Commission (WOGCC), Casper, Wyoming
		Water and Ice	Mesozoic	
		Volcanic Rocks	Paleozoic	
			Precambrian	



# U.S. Geological Survey Mapped Springs in Wyoming, Wind/Bighorn River Basin



## Explanation



- Spring
- Fault
- ⎓ Yellowstone National Park Boundary
- ⎓ Wind River Reservation Boundary
- Water and Ice
- Volcanic Rocks

- Major Aquifer Groups**
- Cenozoic
  - Mesozoic
  - Paleozoic
  - Precambrian

WSGS 2009  
Projection: NAD 1983  
UTM Zone 12N

**Data Sources:**  
Stafford and Gracias (2008)  
Stoeser, et al. (2005)



# *Aquifer Recharge & Discharge*

## ➤ **Recharge to Aquifers**

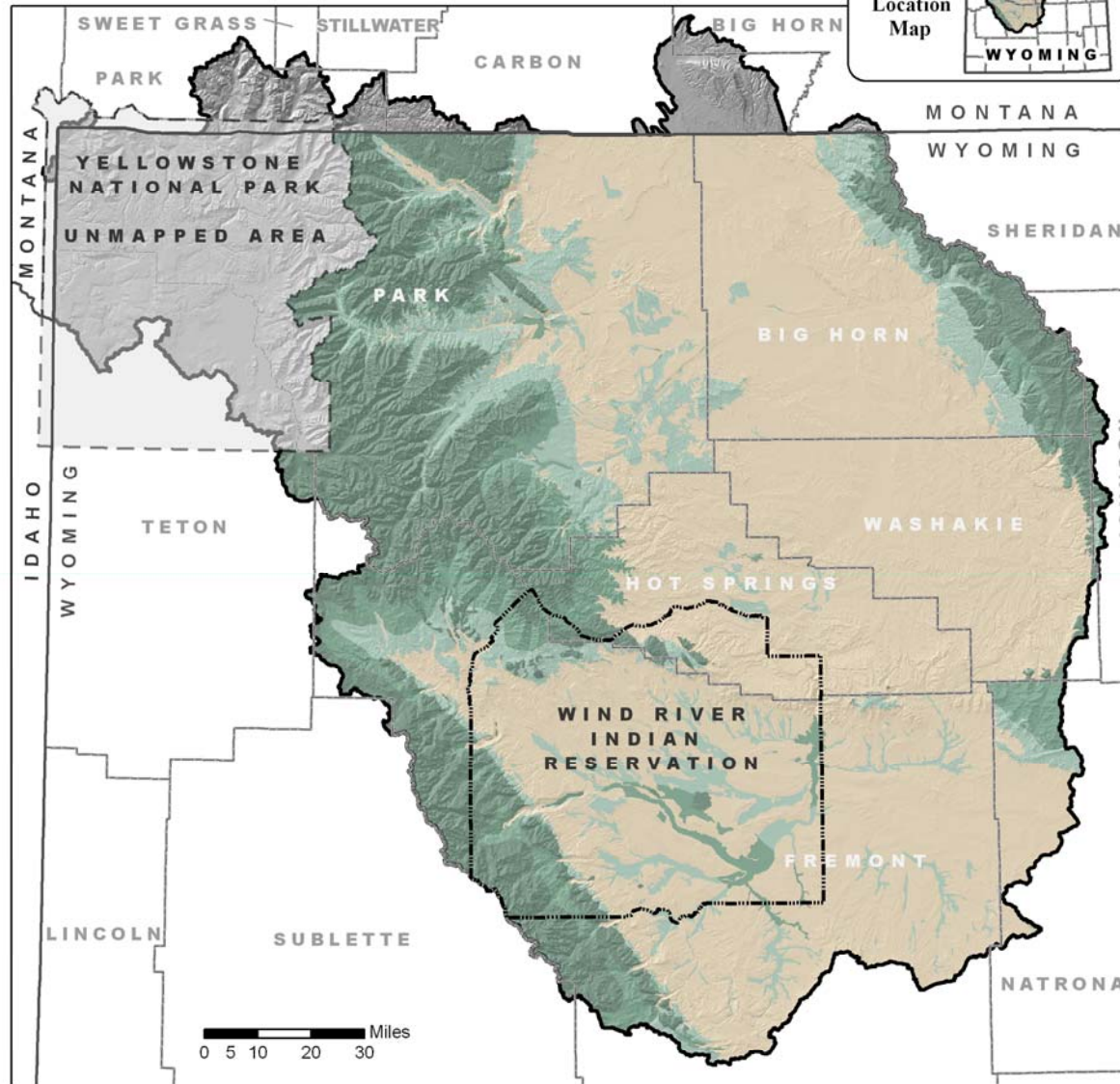
- Infiltration from precipitation & snowmelt
- Seepage from streams, ponds, lakes, reservoirs, & rivers
- Infiltration of irrigation water

## ➤ **Discharge from Aquifers**

- Evapotranspiration
- Discharge from springs
- Discharge to streams & rivers
- Subsurface leakage from an aquifer to adjacent aquifers
- Pumpage from water & coal bed natural gas (CBNG) wells

## ➤ **Estimates of Recharge & Discharge Rates**

# Estimated Aquifer Recharge in Wyoming, Wind/Bighorn River Basin



**Estimated Average  
Annual Aquifer Recharge  
(inches / year)**



WSGS 2009

Projection: NAD 1983  
UTM Zone 12N

**Data Sources:**

Hamerlinck and Ameson, Eds. (1998)

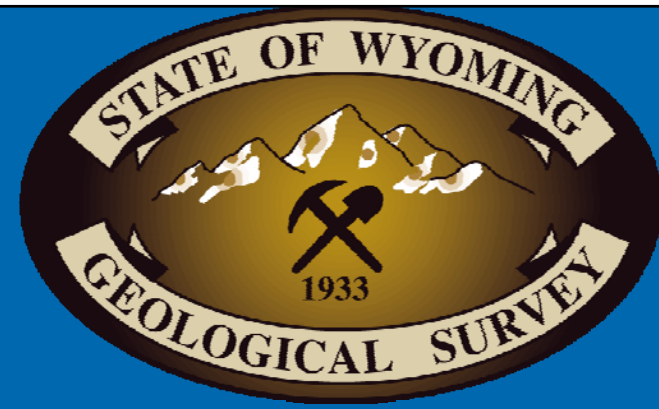
USGS National Elevation Dataset

# *Aquifer Storage*

- Very little is known about water storage quantities in WBH aquifers.
- Estimates of groundwater storage and availability are being prepared based on a set of assumptions from aquifer properties.
- Estimates of storage quantities will incorporate volume calculations based on areal extent and thickness of the aquifers in the WBH.

# *Summary*

- The WSGS-USGS-WRDS team is progressing with the groundwater study for the updated Wind/Big Horn Basin study.
- Aquifers in the WBH are being inventoried and characterized from the available data.



*Thank you,  
Questions?*

*Scott Quillinan  
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scottyq@uwyo.edu*