Spatial Examination of Backfill Aquifer Water Quality Using GIS

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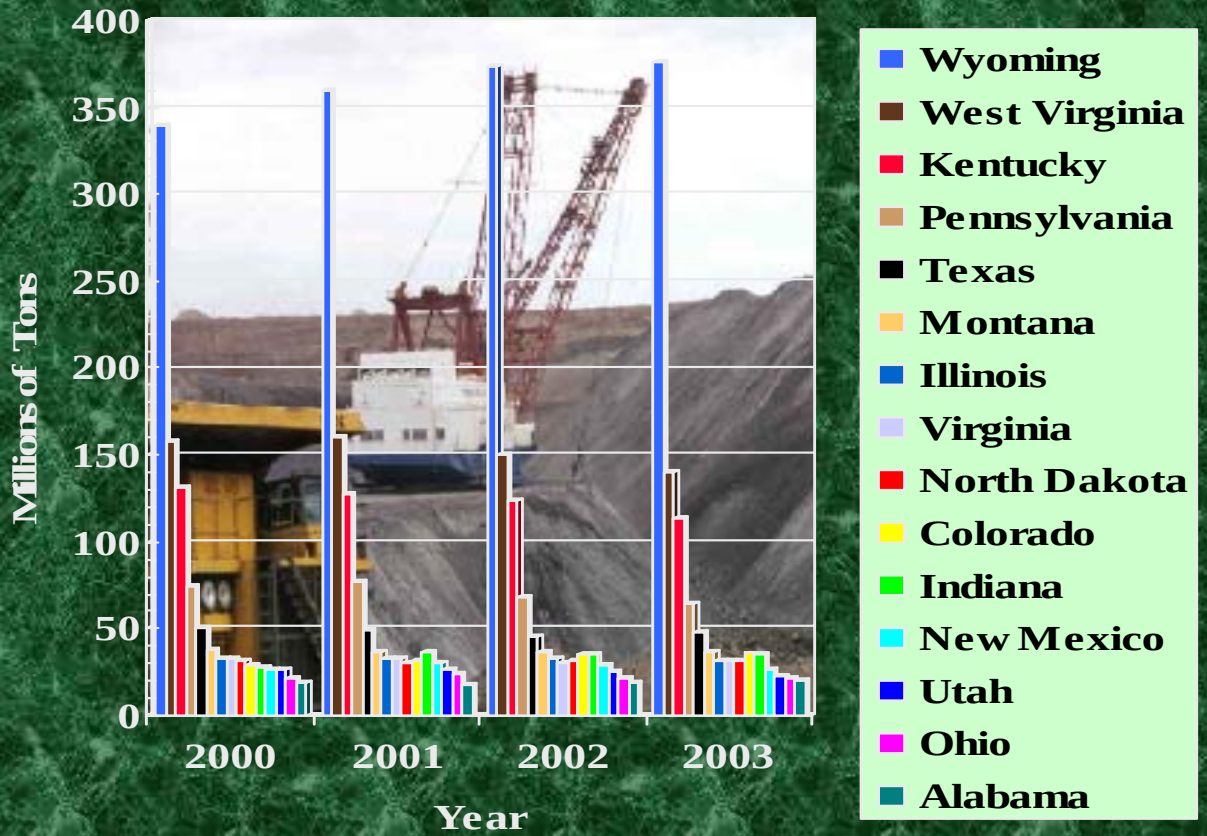
Introduction

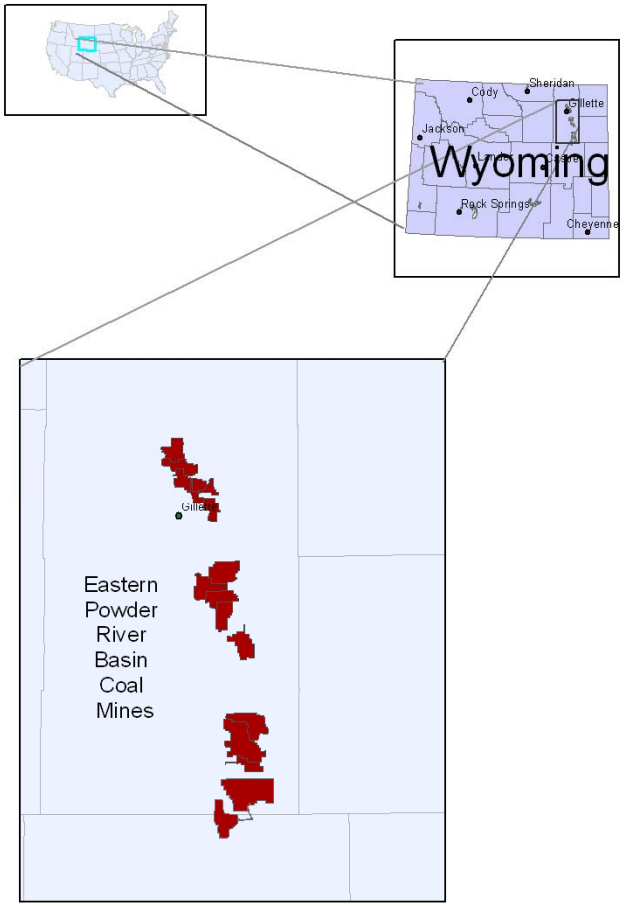
- Perspective of coal mining in Wyoming
- History of backfill water quality issues in Wyoming
- Wyoming's approach using GIS to assist us in assessing this issue

Wyoming Coal Mining

- Produce the most coal of any state in US



96% the coal is from the eastern Powder River Basin



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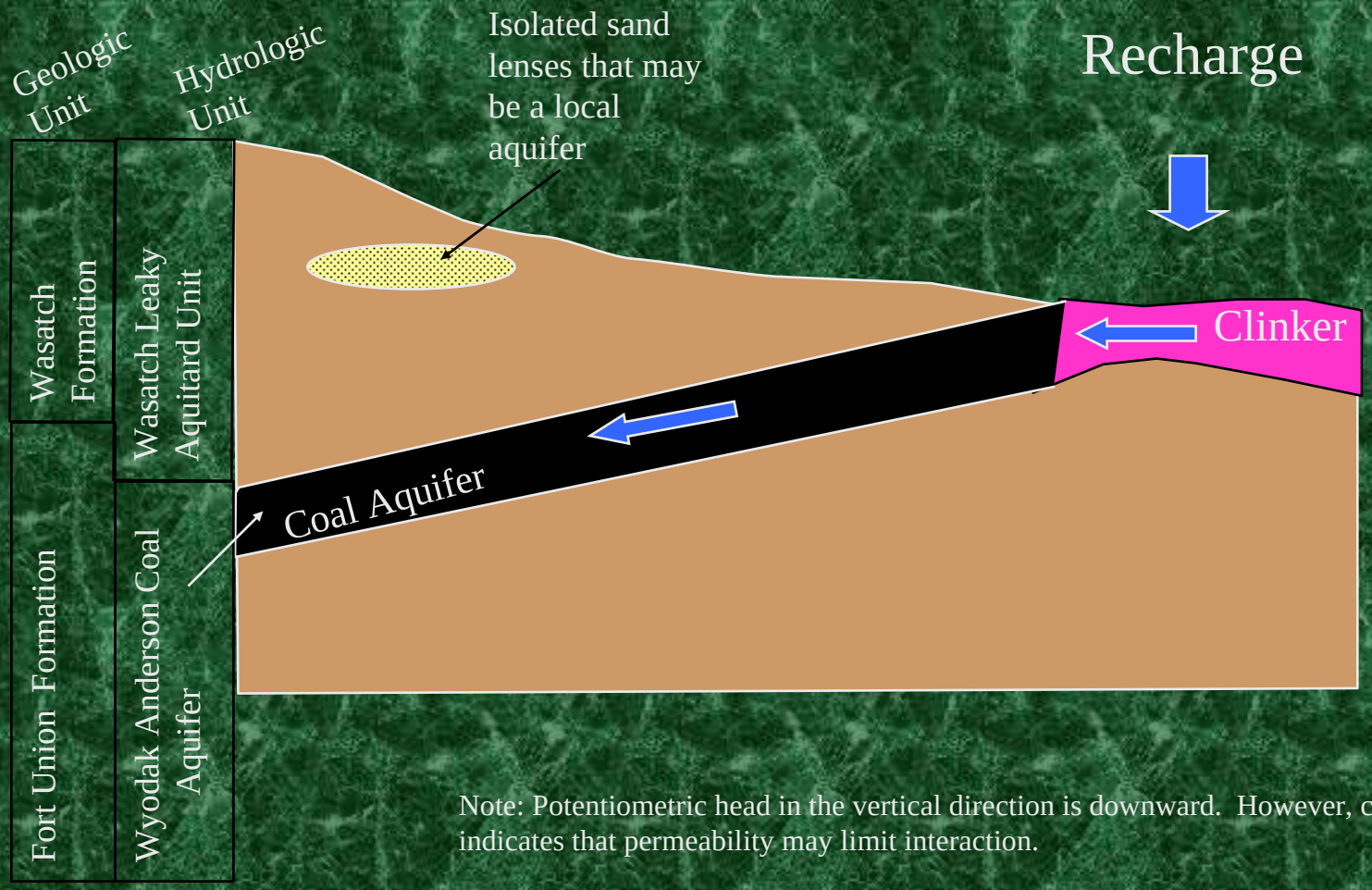
Backfill Aquifer Water Quality

Why is it important?

Coal is an aquifer in Wyoming, so backfill needs to replace that resource.

- Especially important given the land area disturbed – 110 sq. mi. by 2004
- Recharge must pass through the mined area to reach the remaining portion of the aquifer

Backfill Aquifer Water Quality



Note: Potentiometric head in the vertical direction is downward. However, chemistry indicates that permeability may limit interaction.

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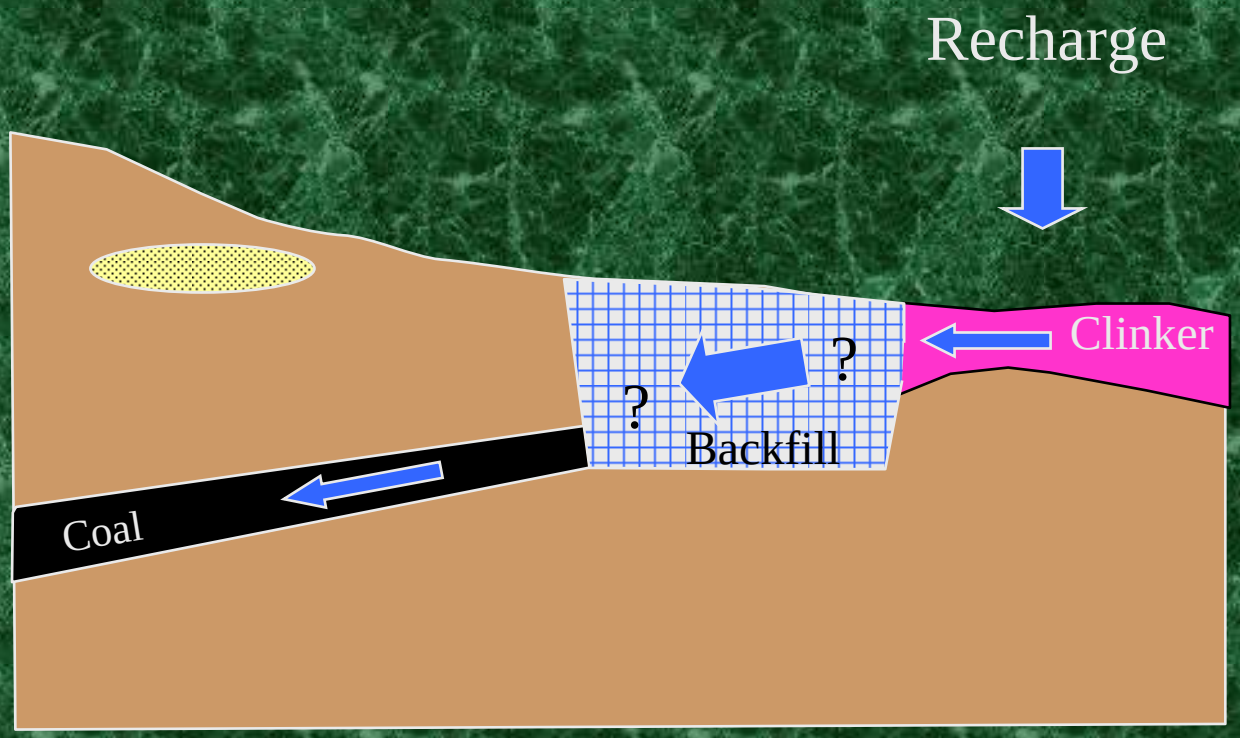
Backfill Aquifer Water Quality



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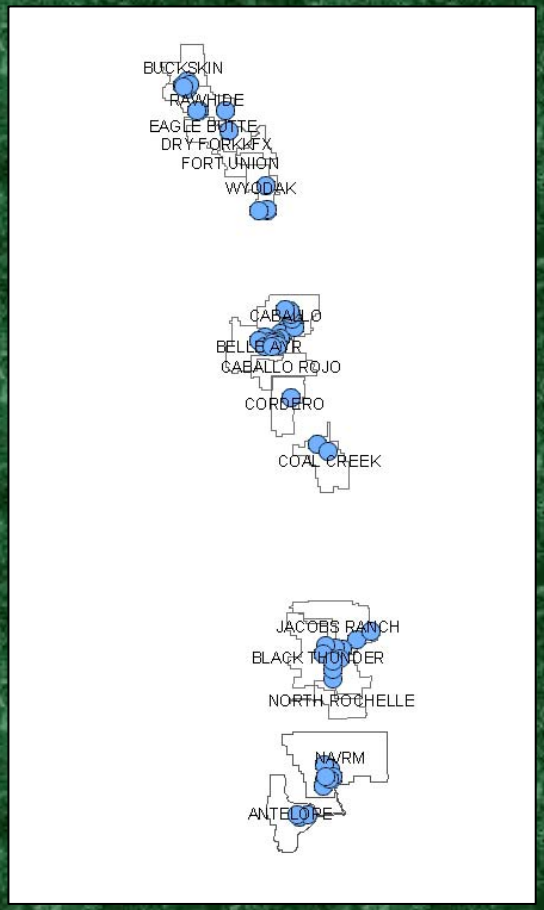
Backfill Aquifer Water Quality

- **Early predictions**
  - **Identified as a significant problem**
  - **It appeared concentrations of TDS might preclude use in some areas**
  - **1 to 3 pore volumes of flushing would be needed.**
  - **Was based on limited information and lab tests such as column leach and saturated paste.**

Backfill Aquifer Water Quality

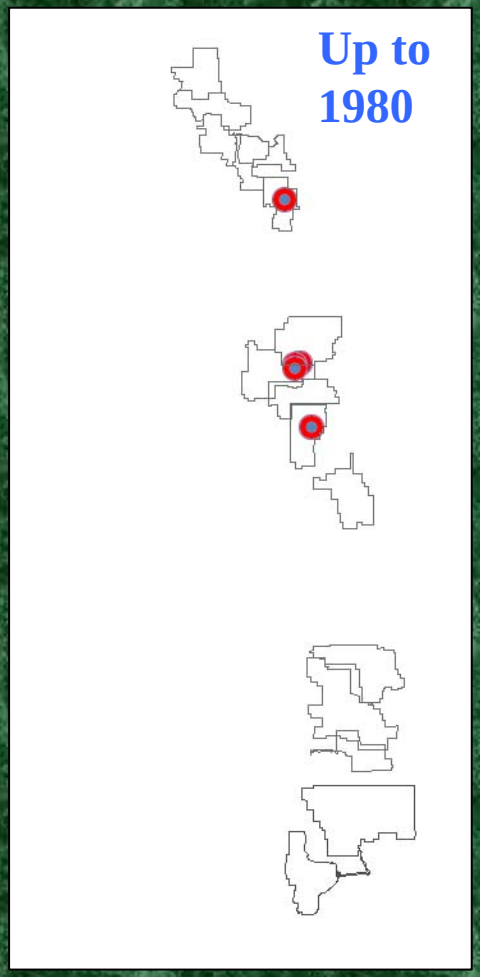


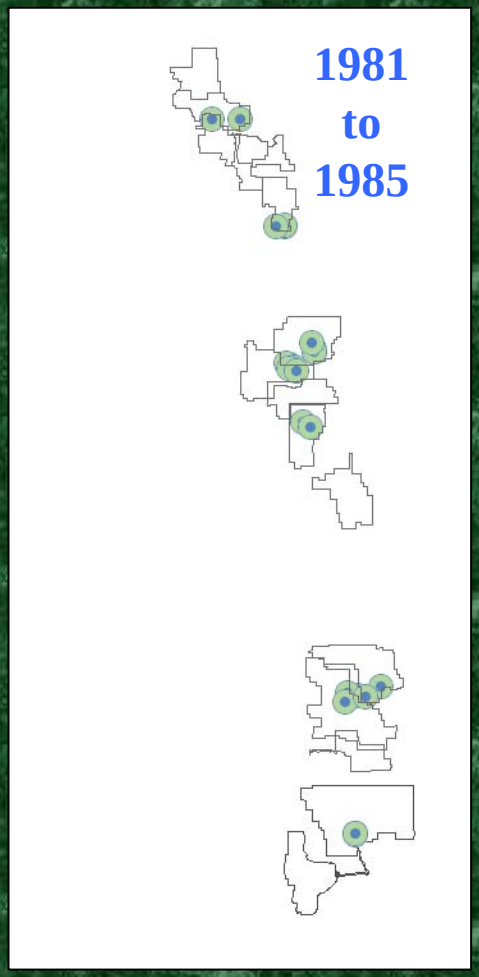
- **Now**
  - Real data are available
  - 95 monitor wells are completed in the backfill aquifer
  - 17 mines
  - Over 2,000 samples collected

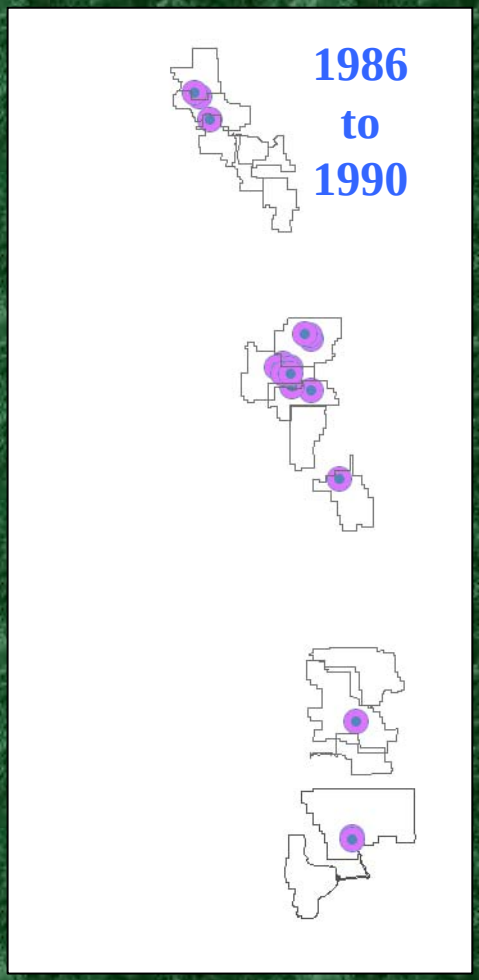
Examination of the Data

- Period of installation
- Distribution of wells in the three mining areas
- Depth of monitor wells
- Distribution of elevated TDS values

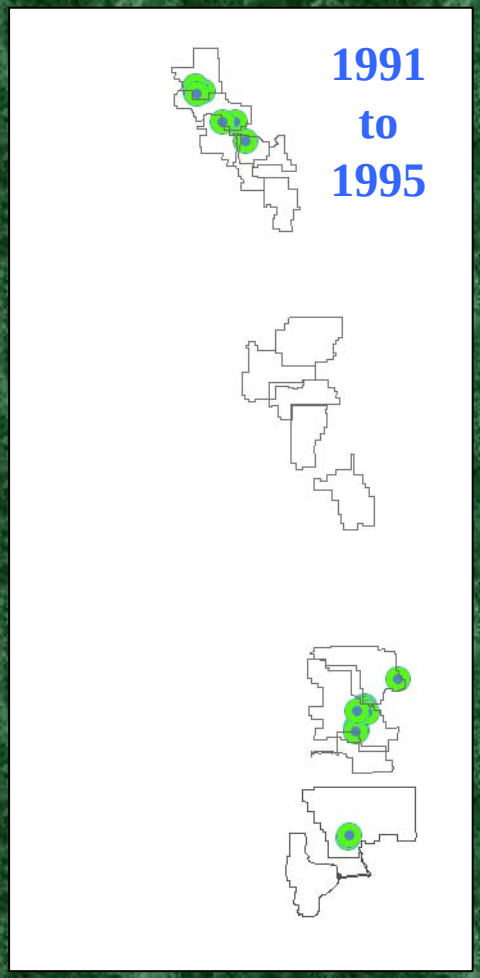
Period of Well Installation

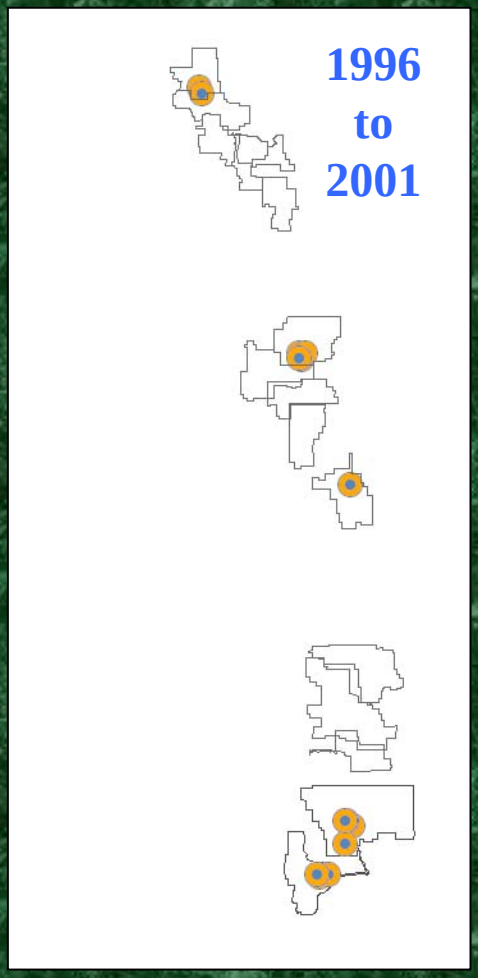


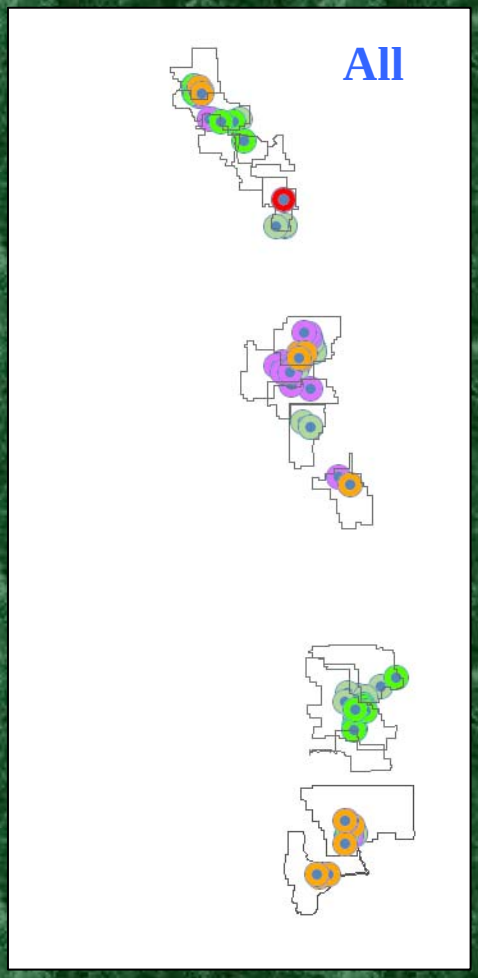




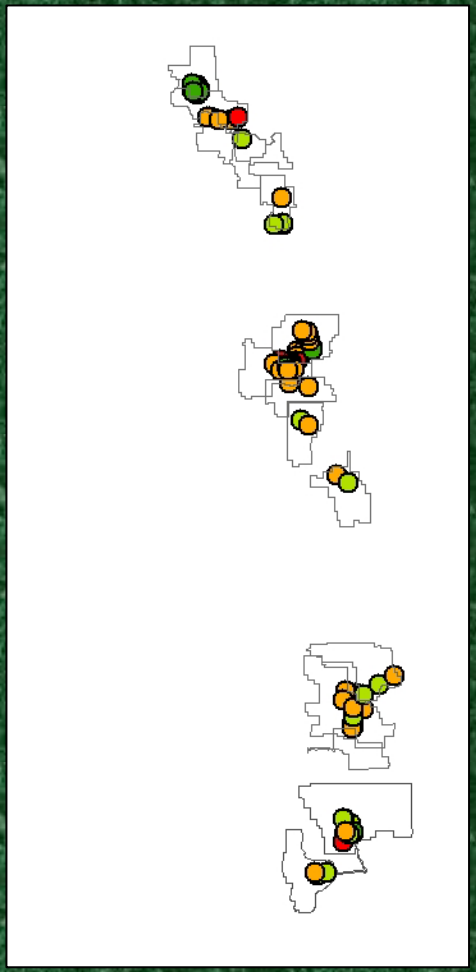
Period of Well Installation





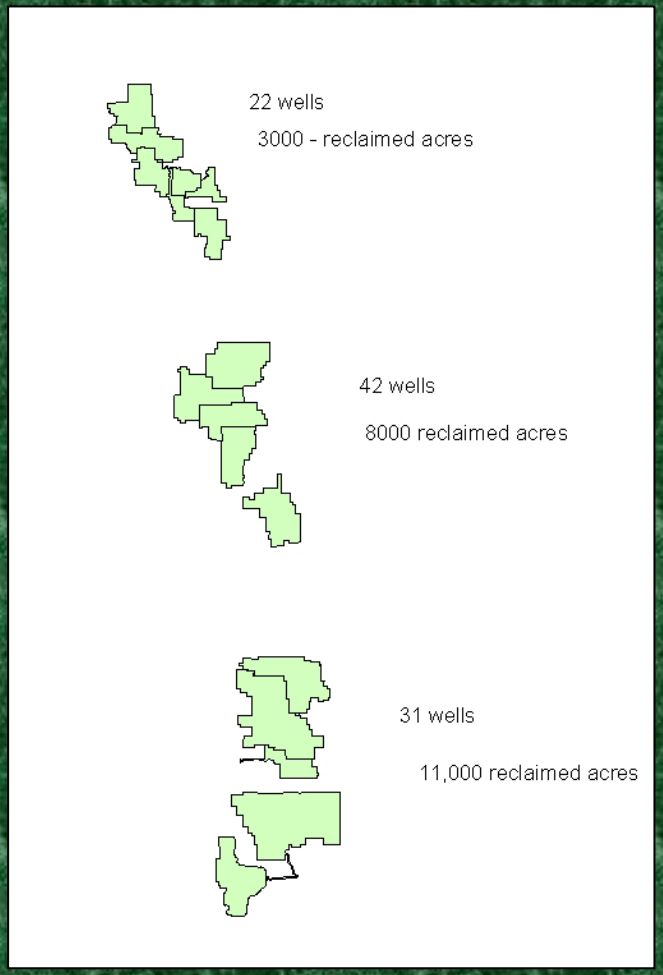


Depth of Backfill Monitor Wells



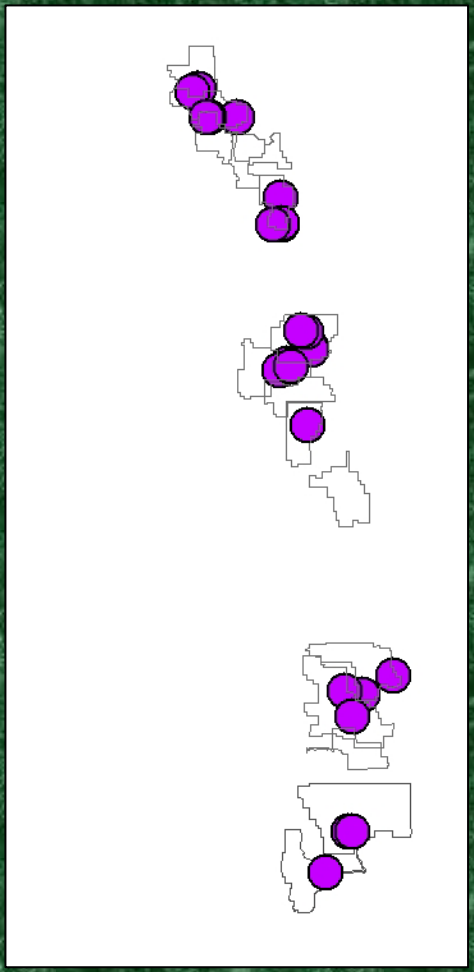
- Mean 108 feet
- Range 6 feet to 272 feet
- Factors affecting depth
  - Alluvial backfill areas
  - Pit backfill
  - Dip of coal to the west

Wells Per Mining Area



<u>Three Areas</u>

1. Northern – 22 wells
2. Middle – 42 wells
3. Southern – 31 wells



Backfill aquifer monitor wells with at least one TDS sample greater than 5,000 mg/l

Results

- Data are well distributed throughout the mining area and are suitable for additional analysis.

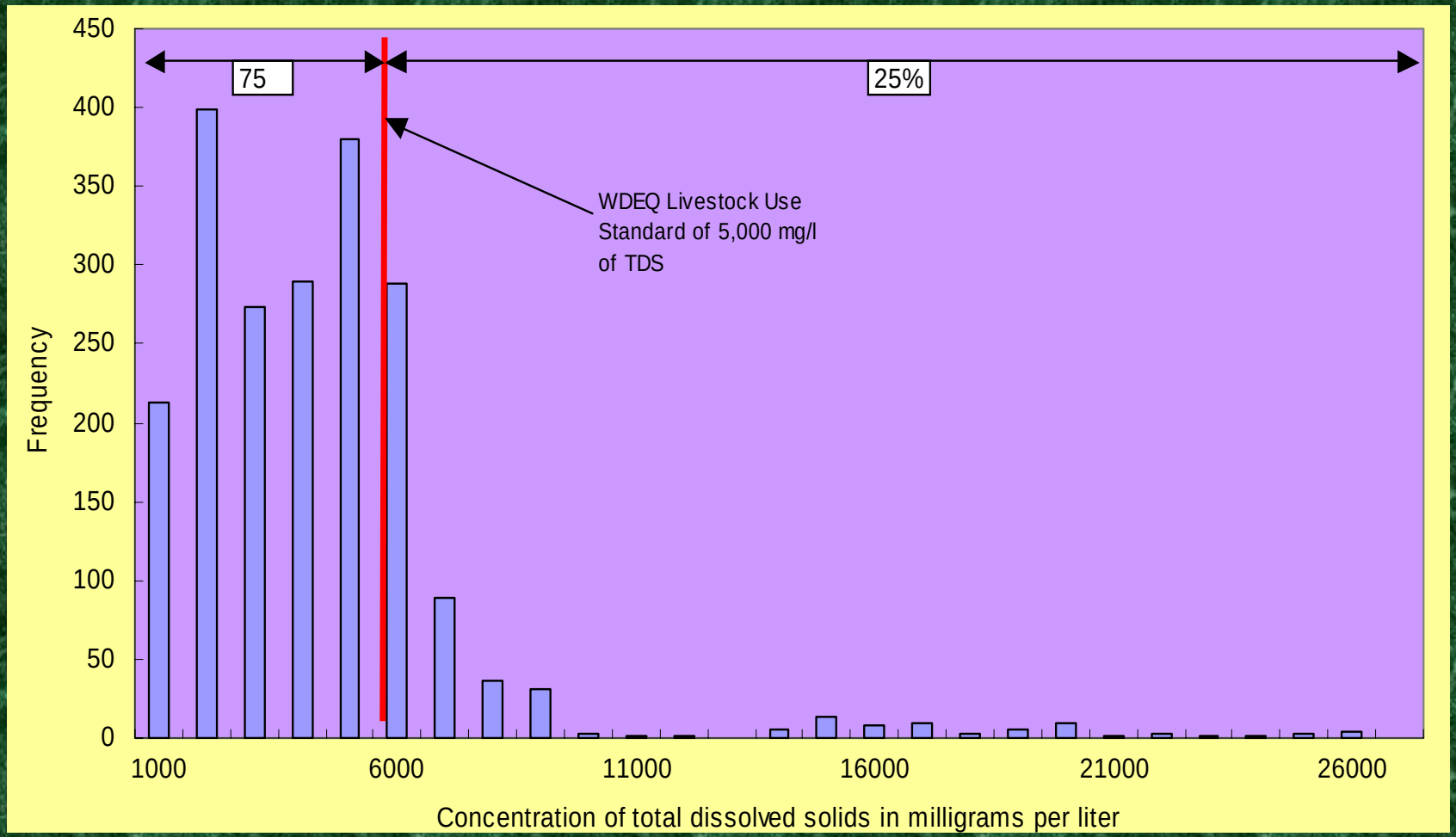
Analysis of Water Quality

- Statistical Summary
  - Centrality Measures – mean, median
  - Standard Deviation
  - Range
  - Count
  - Confidence Level @90%

Analysis of Water Quality

	All Mines							
Constituent	Na	K	Ca	Mg	Cl	HCO3	SO4	TDS
	in mg/l							
Statistical summary data								
Mean	413	26	343	282	52	842	2,082	3,920
Median	**353**	**25**	**393**	**197**	**24**	**868**	**1,847**	**3,514**
Standard Deviation	290	17	211	399	70	342	2,169	3,264
Minimum	39	1	1	0	1	7	0	1
Maximum	3,000	380	957	3,060	706	2,991	17,170	25,812
Count	2,082	2,083	2,078	2,080	2,081	2,081	2,083	2,074
Confidence Level (90.0%)	10	1	8	14	3	12	78	118

Histogram of TDS



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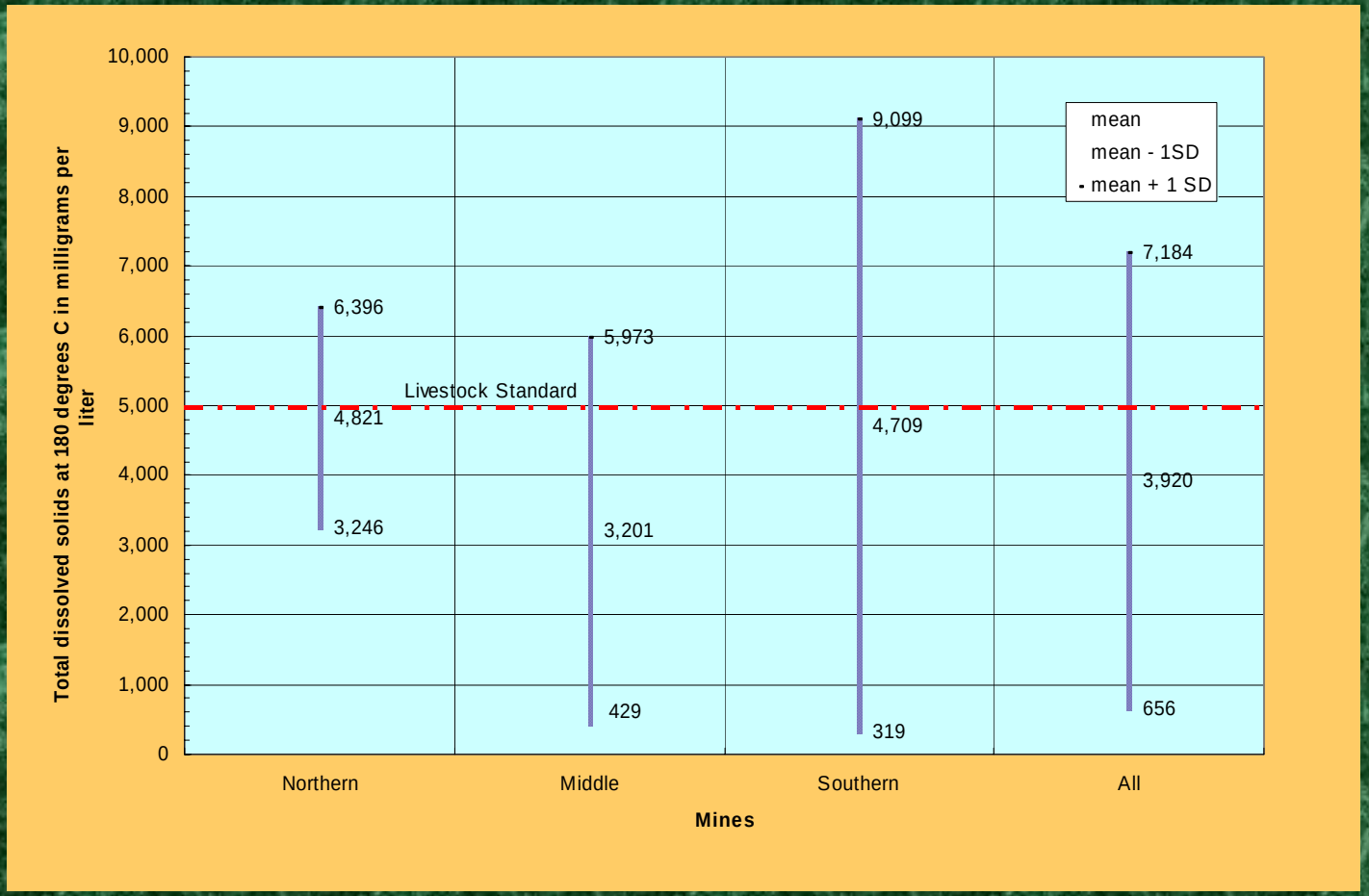
TDS Concentration



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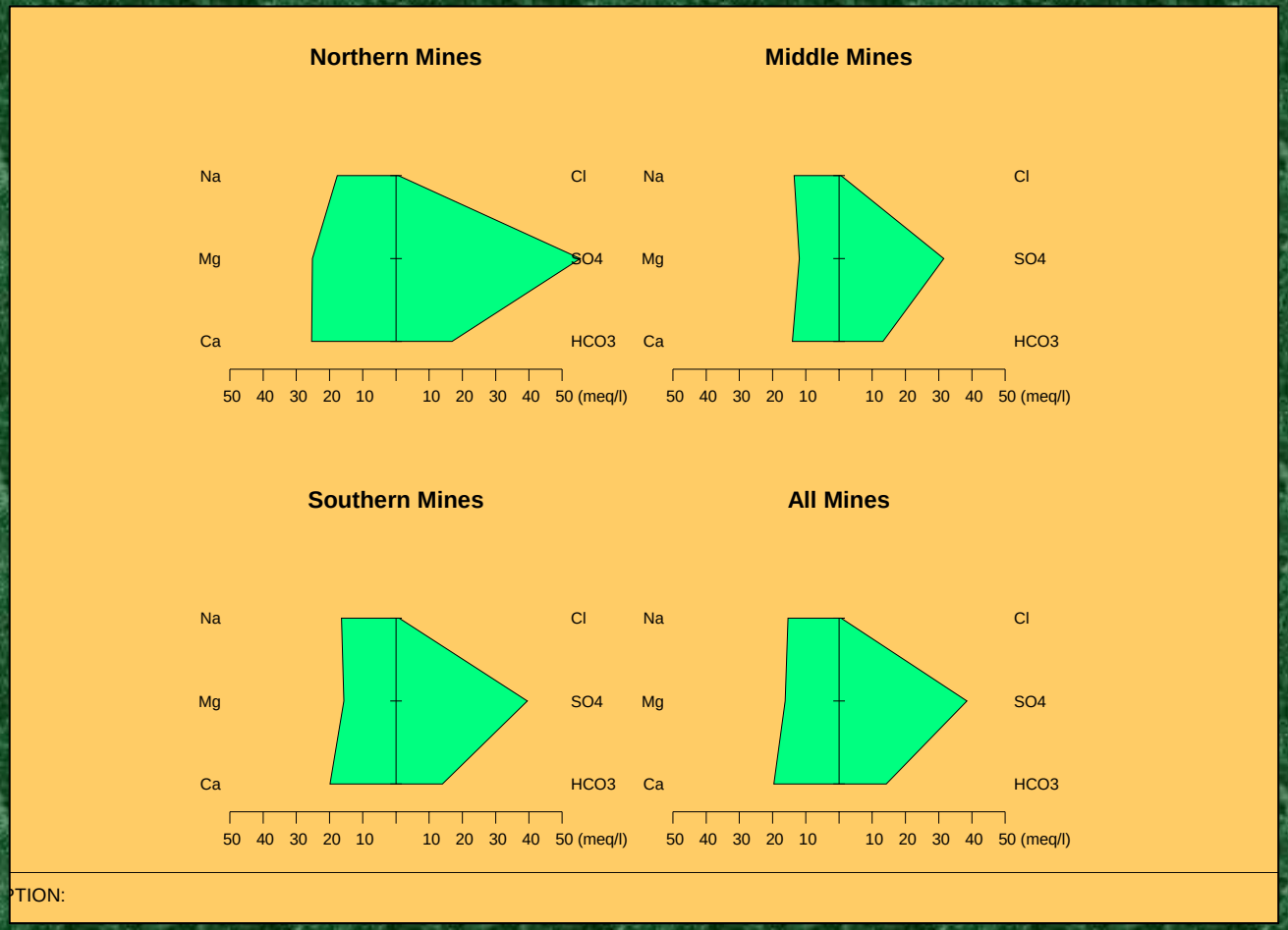
Major Ions



PTION:

Physical Features

- Clinker
- Stream Channels

Both have been identified as serving recharge functions in the Powder River Basin

Clinker

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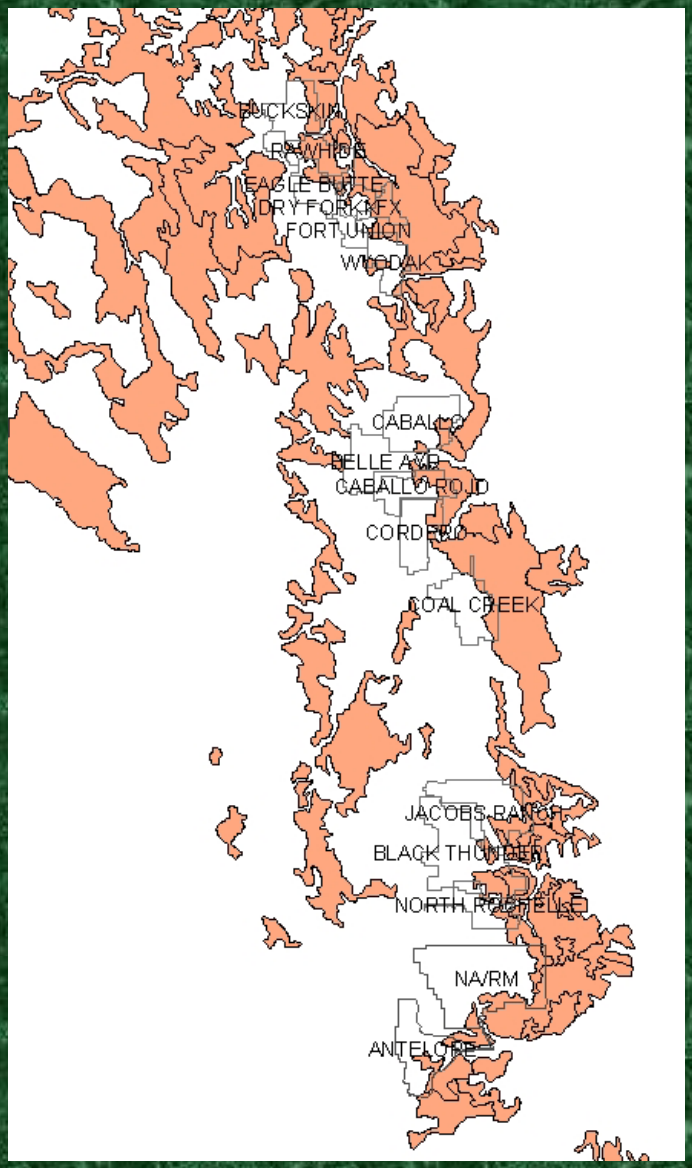

Clinker area in the Powder River Basin

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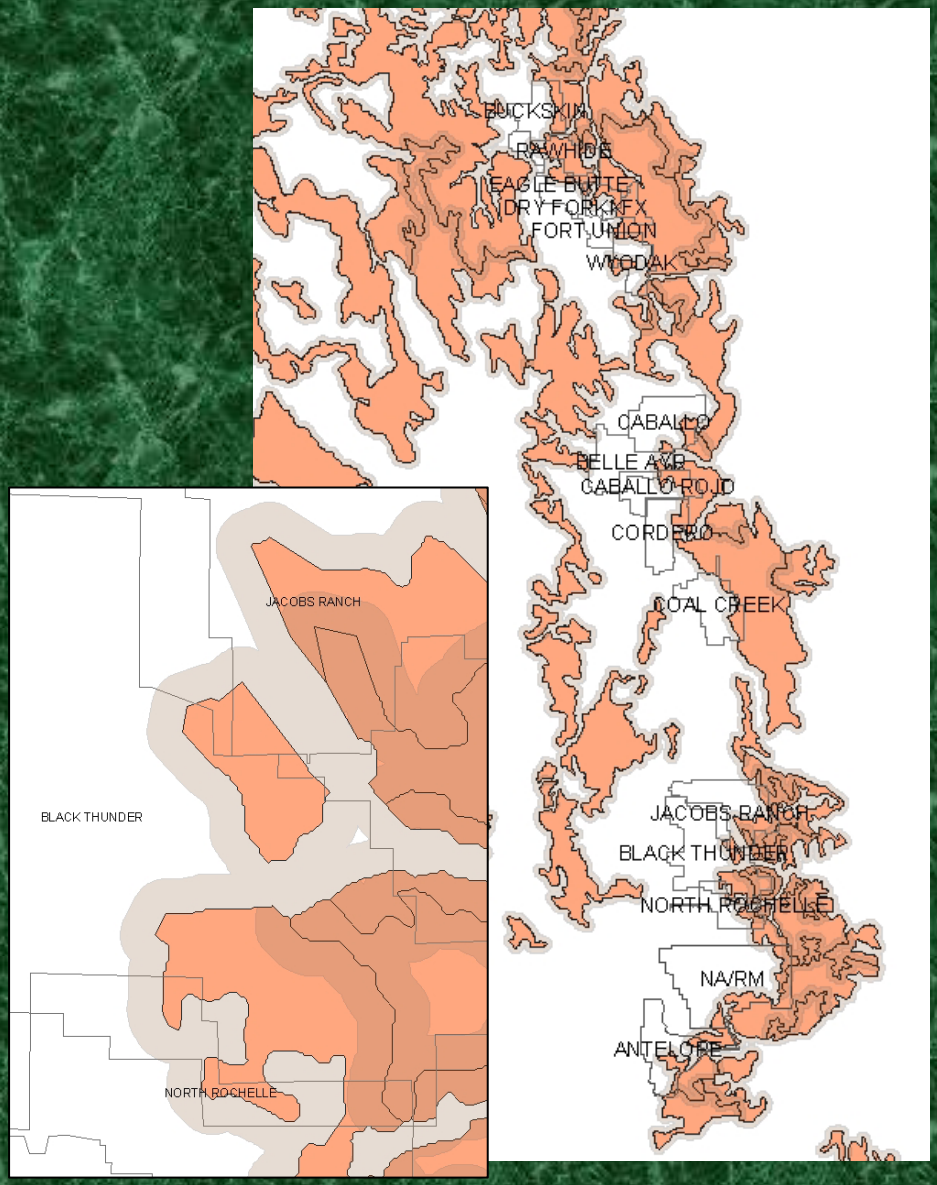

Clinker area with 2,000 feet buffer zone

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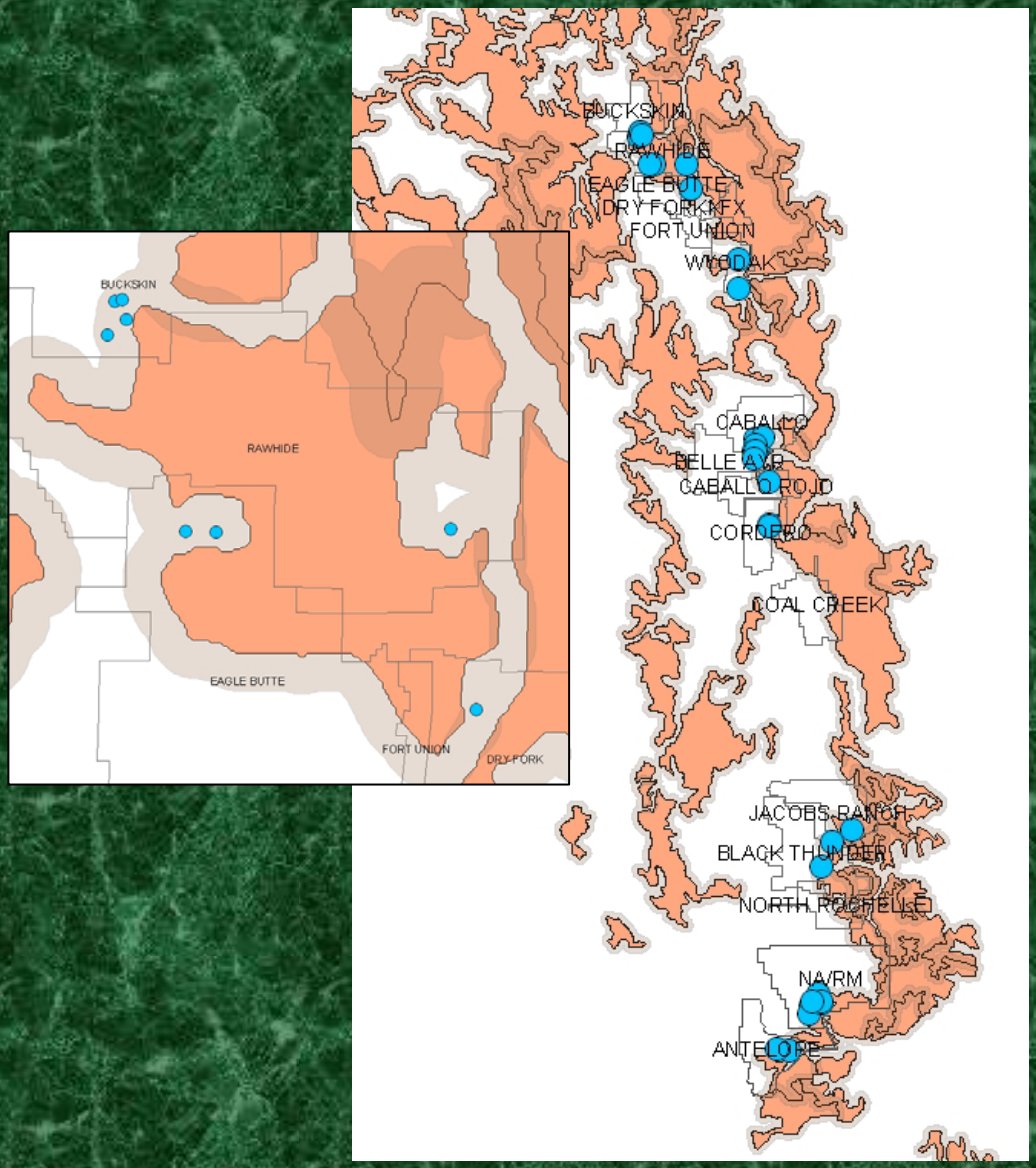

Backfill wells within buffer zone

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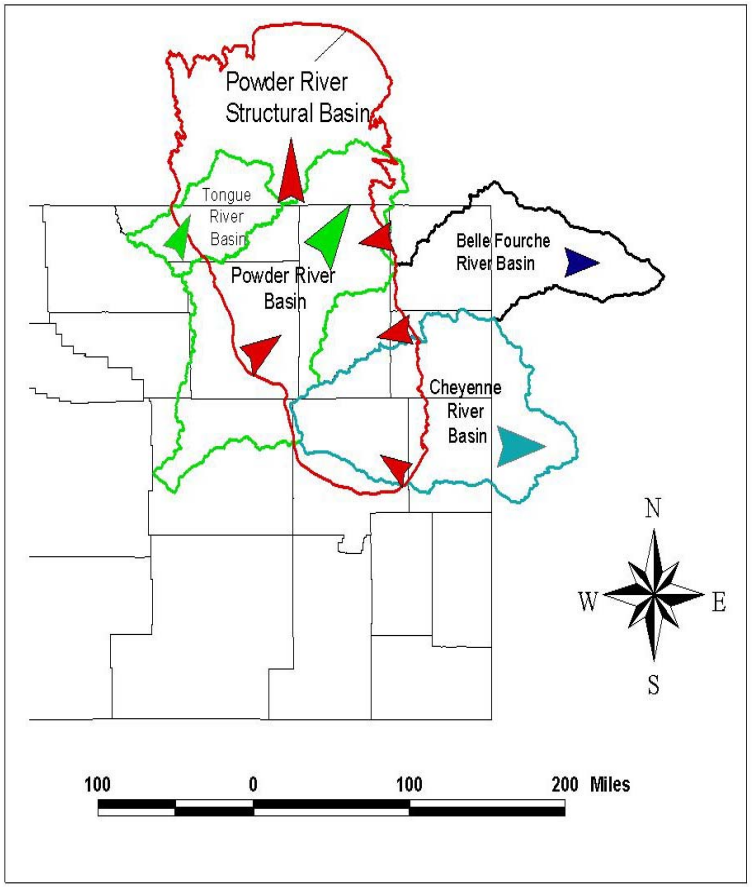
Mean TDS of samples from backfill wells within 2,000 feet of clinker deposits

- 36 wells (38% of the wells)
- 820 samples were collected from those wells
- Mean TDS concentration 4,597 mg/l
- Higher TDS by 677 mg/l than mean of all wells.



Streams in the Powder River Basin

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Stream Channels within the permit areas

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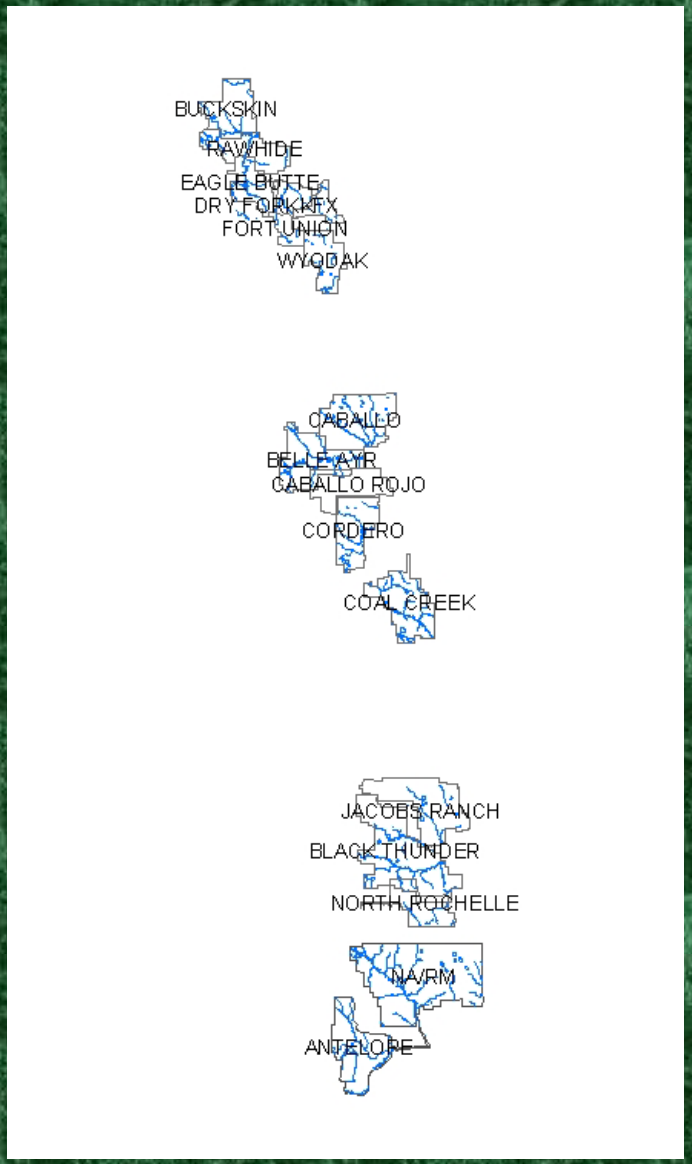

Stream Channels in permit areas

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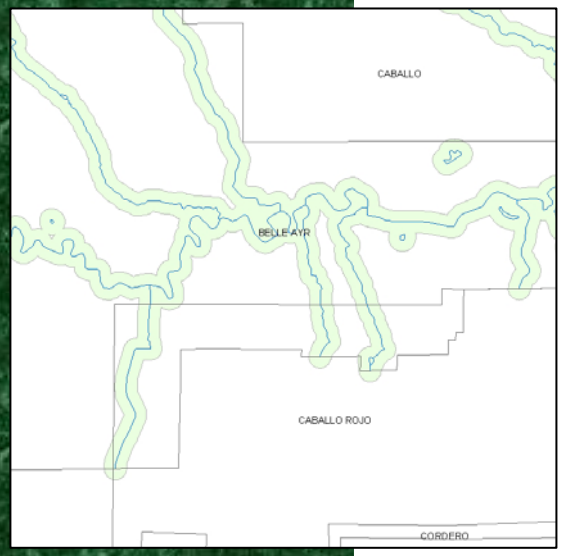
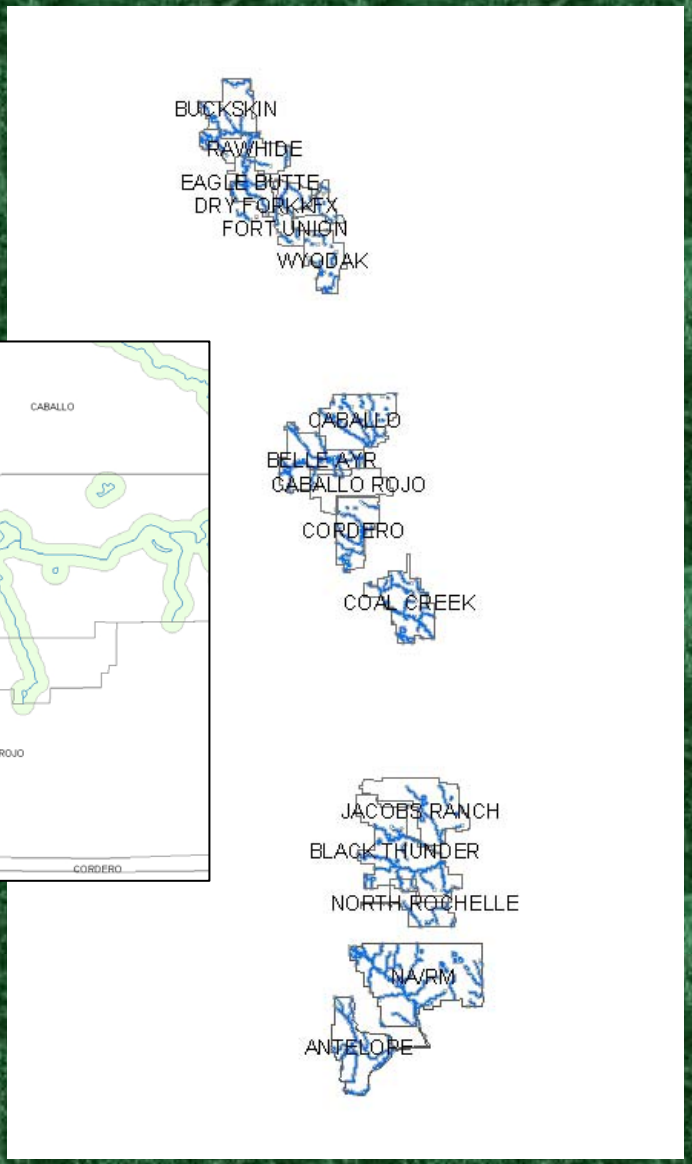
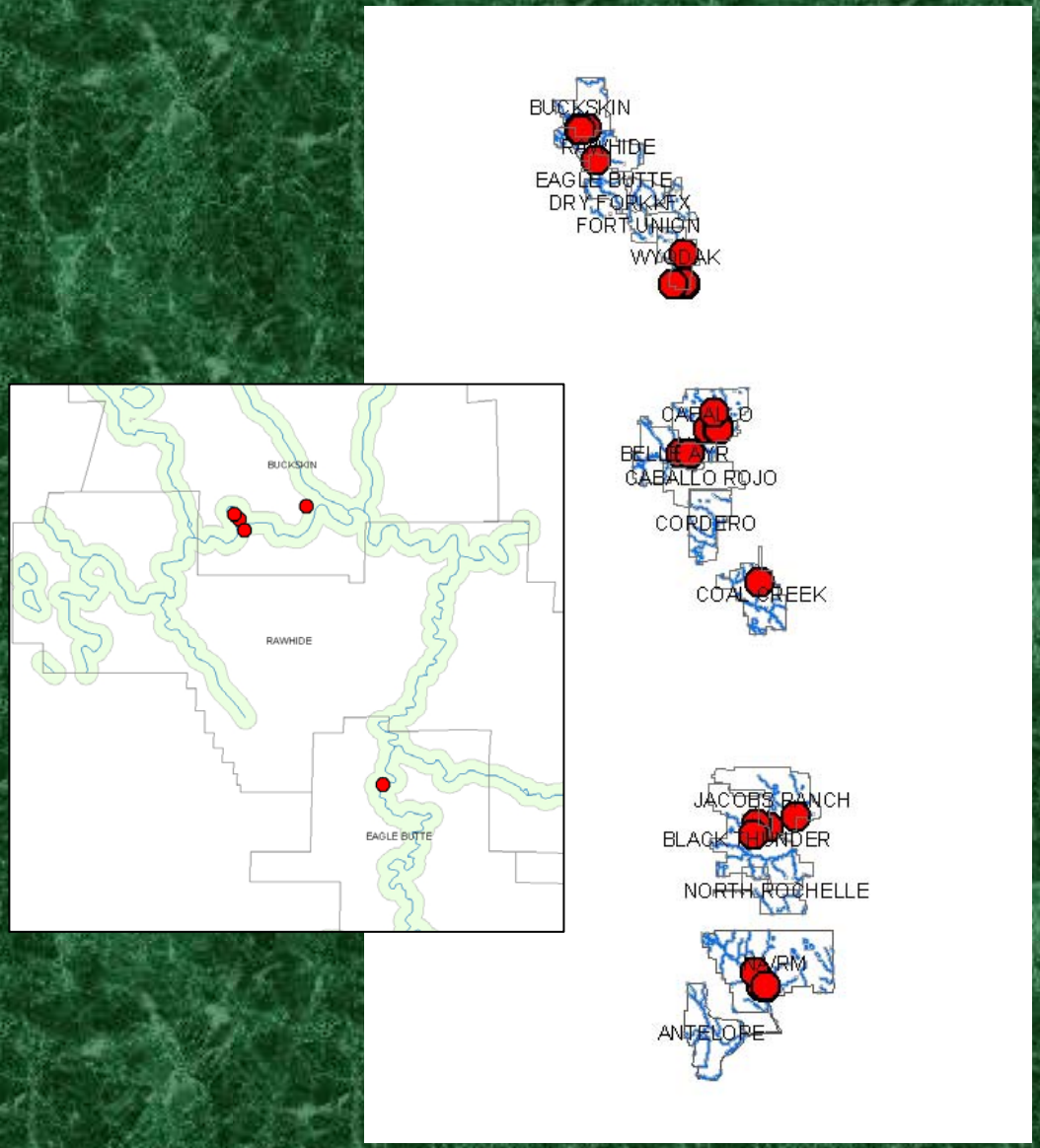




Buffered 500 feet either side of the stream channels



Wells within 500 feet of stream channels

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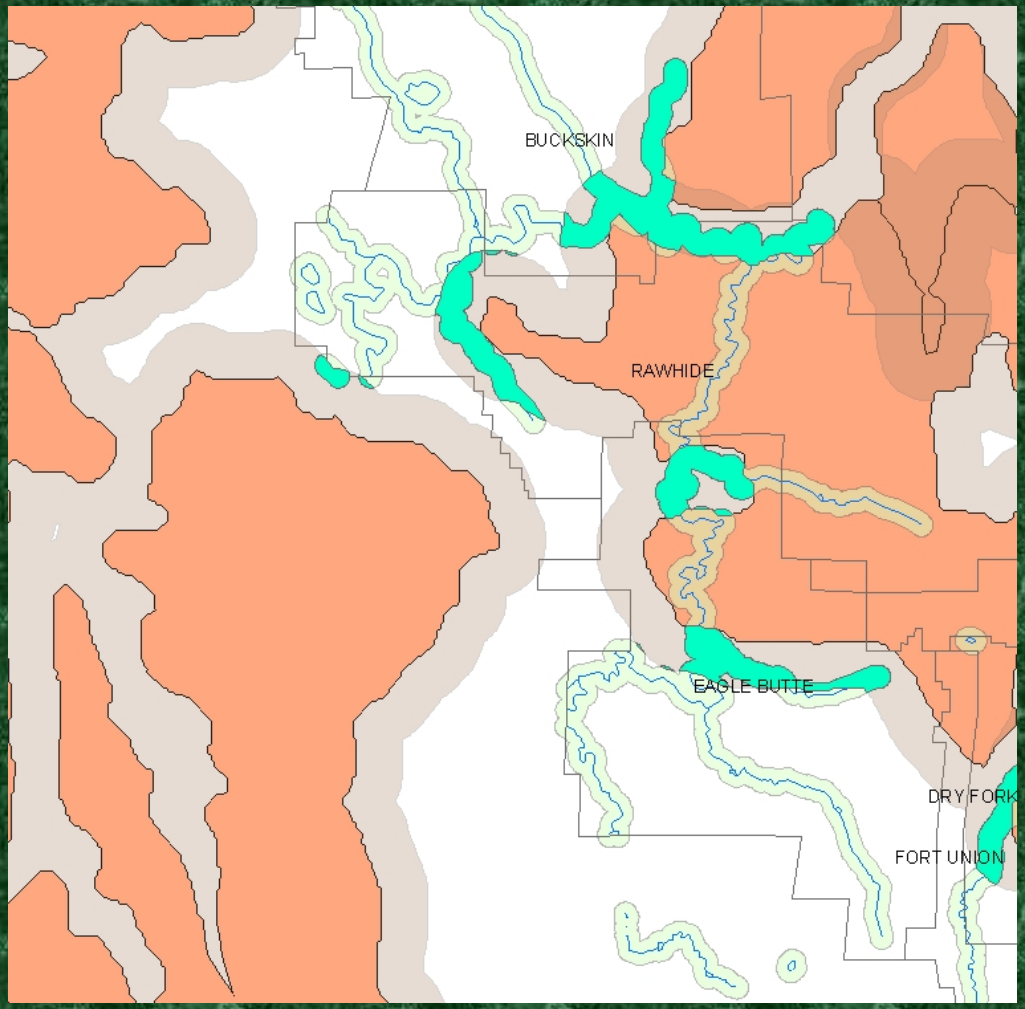
Mean TDS of samples from backfill wells within 500 feet of stream channels

- 40 wells (42% of the wells)
- 1,006 samples were collected from those wells
- Mean TDS concentration 4,738 mg/l
- Higher TDS by 818 mg/l than mean of all wells.

Examination of areas where both the clinker deposits and the stream channels might be influencing the backfill water quality



Intersection of clinker buffer and stream channels buffer areas

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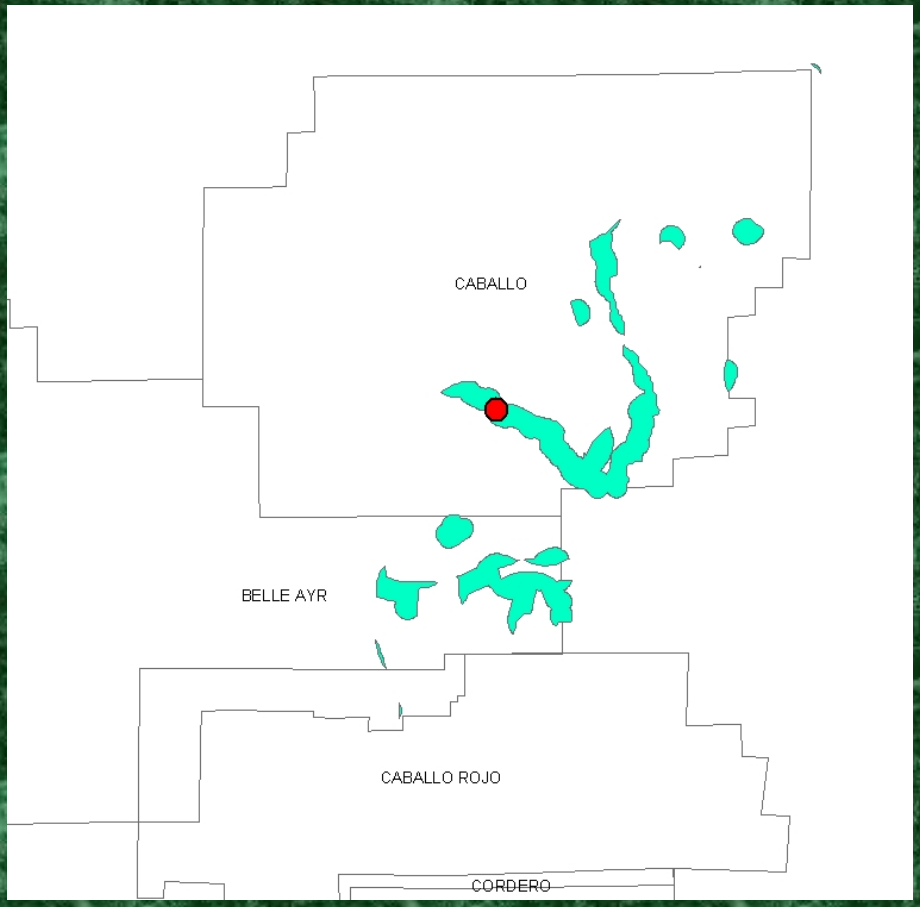
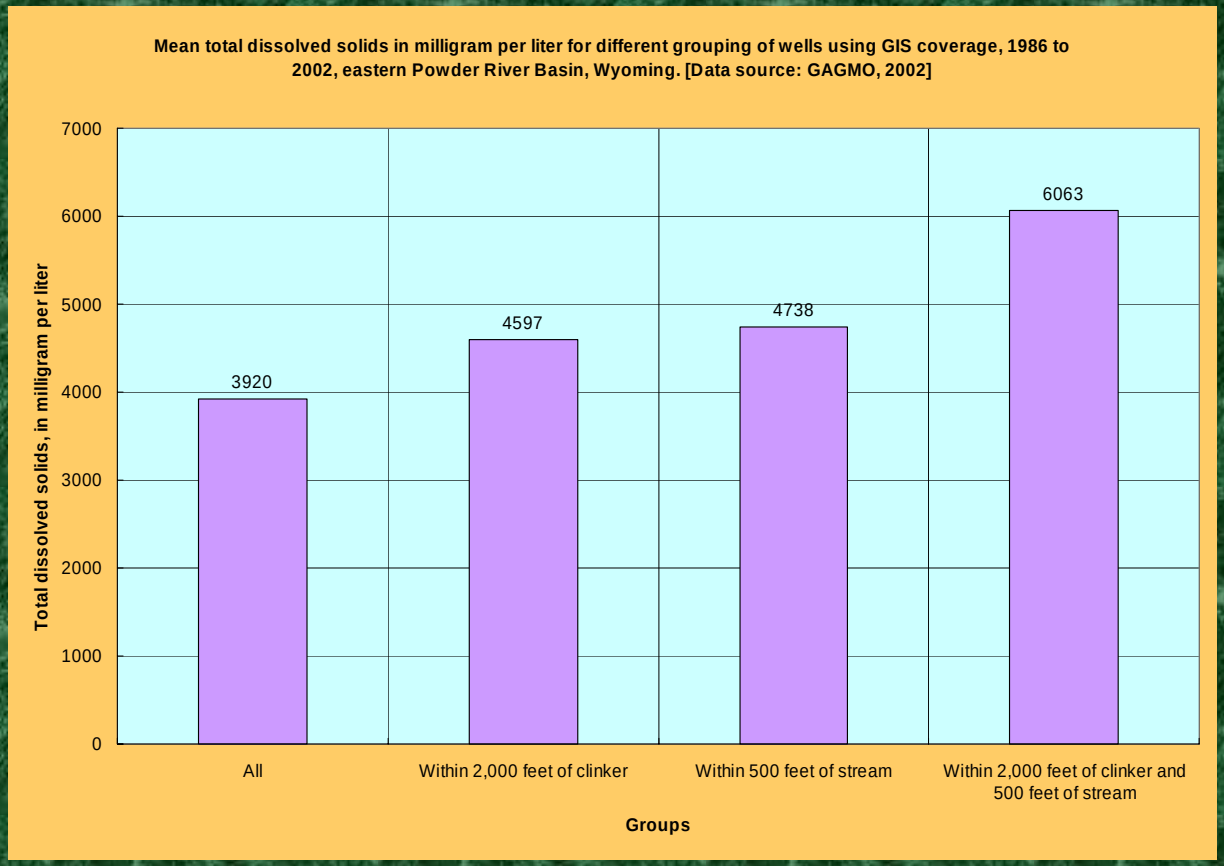


Wells in proximity to both features

Mean TDS of samples from backfill wells within 2000 feet of clinker deposits and 500 feet of stream channels

- 11 wells (12% of the wells)
- 384 samples were collected from those wells
- Mean TDS concentration is 6,063 mg/l
- Higher TDS by 2,143 mg/l than mean of all wells.

Comparison



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Conclusions

- 2,000+ water samples
- 95 wells at 17 mines
- Distributed through the mining areas
- Generally meet the Wyoming Livestock groundwater standards

Conclusions

- Mean TDS is 3,920 mg/l
- Mean and median of TDS and sulfate concentrations are below Wyoming Livestock Standards
- sulfate water type, with calcium, sodium and magnesium about equal
- Water type is generally comparable between areas

Conclusions

- 75 % below Wyoming Livestock TDS standard, 25% exceed
- Proximity to clinker recharge area increases TDS by 17 %
- Proximity to stream channels increases TDS by 20 %
- Proximity to both stream channels and clinker increases TDS by 55 %

The End

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