

Water Quality and Beneficial Use

*Water quality, soils and beneficial use in the
Tongue
and Powder basins*

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Bozeman**

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I am a certified professional soil scientist, consultant, and owner of a Montana-registered LLC. I currently provide consulting and/or contracted services to clients in MT, WY, CO, FL, MT Departments of Revenue and Commerce, the USDA, and the USDI.

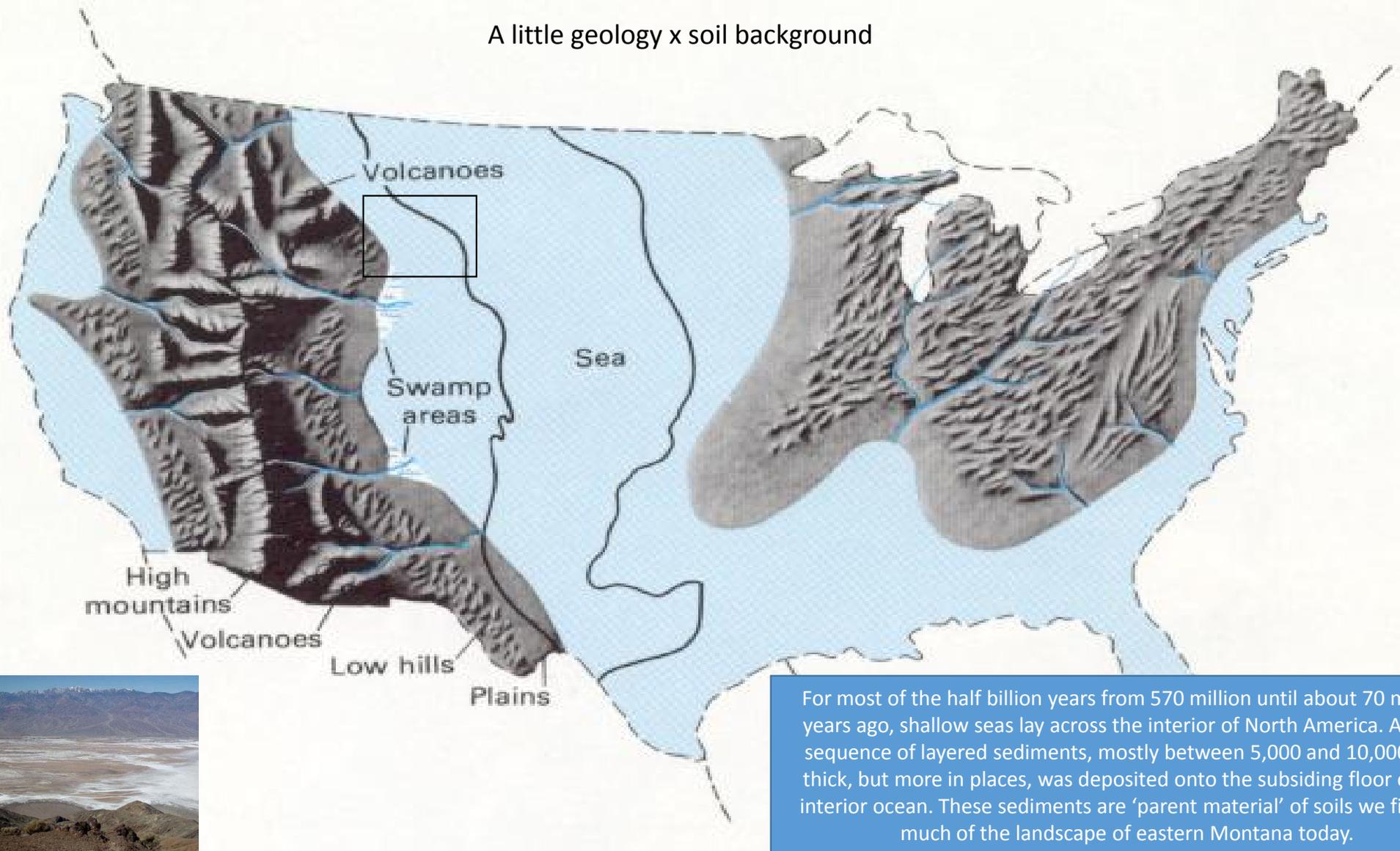
I live on an irrigated hay and cattle-producing ranch in Powder River County.

- My primary research interest and expertise addresses management and consequences of saline and sodic soil and water conditions and reclamation/restoration of salt-affected soils. I have been researching the soils and water quality of southeast Montana since 1980 and have lived in Powder River county since 2007.



Hailstone National Wildlife Refuge

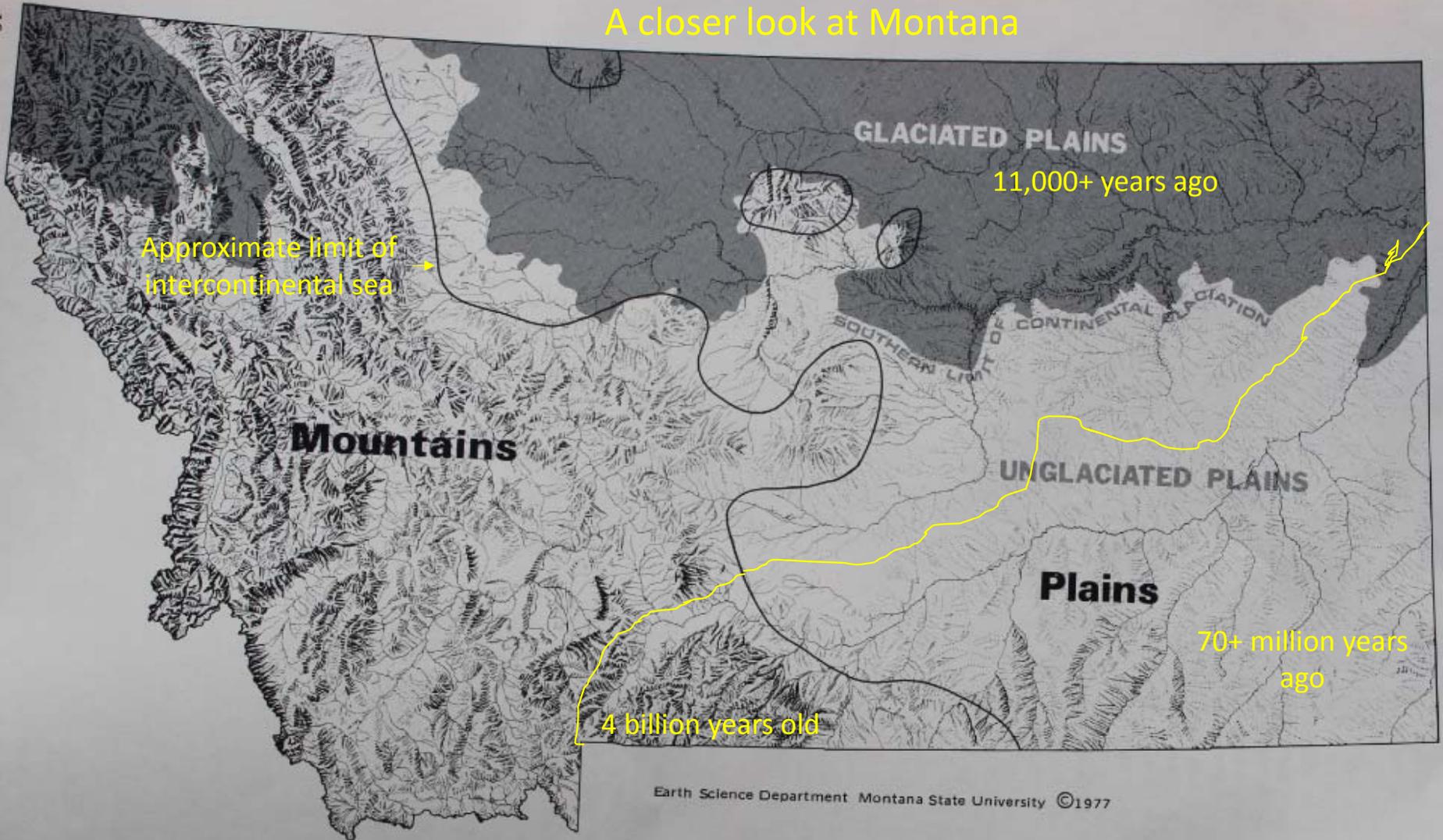
A little geology x soil background

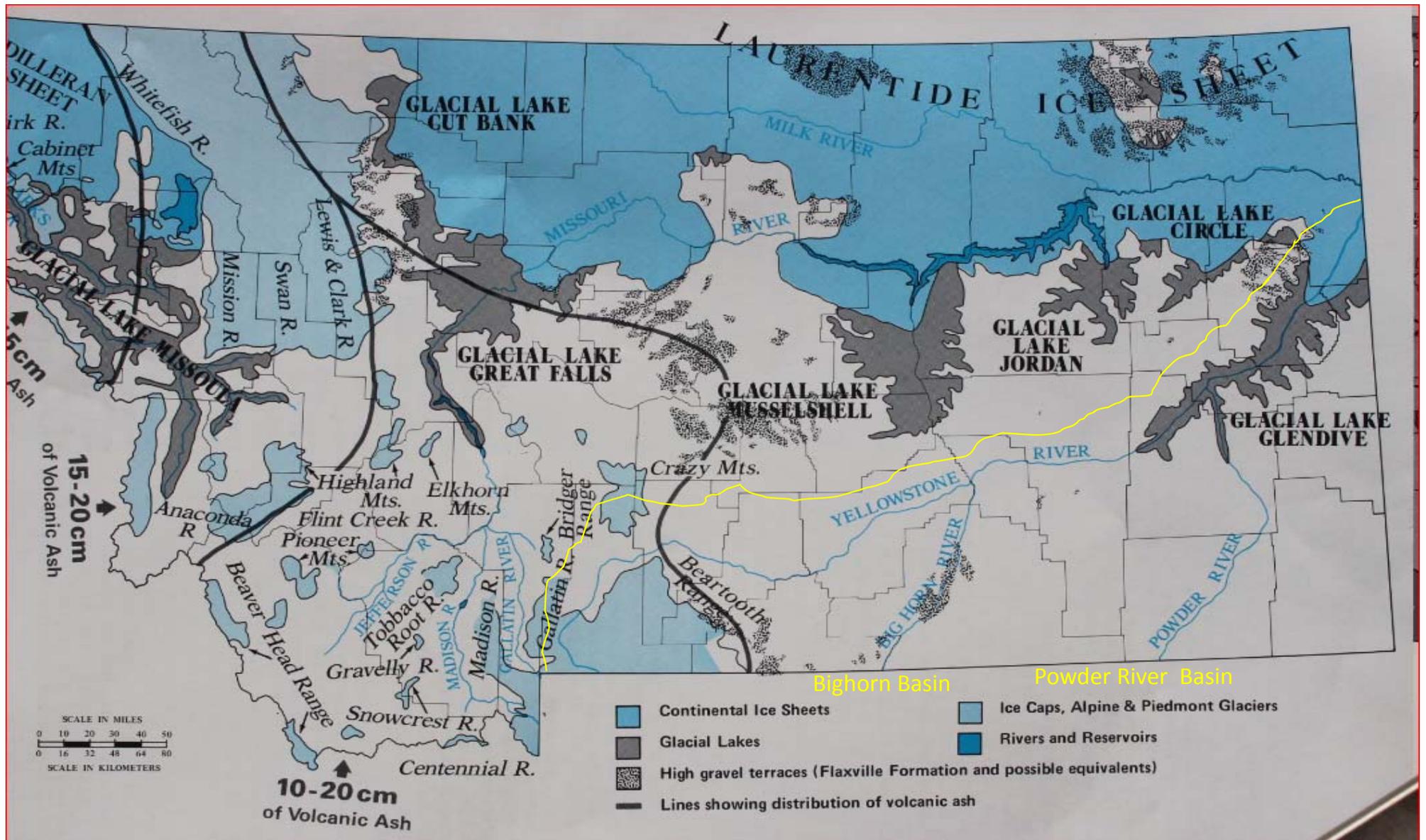


For most of the half billion years from 570 million until about 70 million years ago, shallow seas lay across the interior of North America. A thick sequence of layered sediments, mostly between 5,000 and 10,000 feet thick, but more in places, was deposited onto the subsiding floor of the interior ocean. These sediments are 'parent material' of soils we find on much of the landscape of eastern Montana today.

A closer look at Montana

10

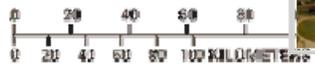








Digital elevation data from U.S. Geological Survey digital elevation data, 30 arc seconds, 1993
 Topographic map from U.S. Geological Survey digital data, 1:250,000, 1972
 Albers Equal-Area conic projection
 Standard parallels 28°38' and 49°20', central meridian -107°28'





- Geologic material – marine sediments – both lithified and unconsolidated
- The red rock – oxidized, baked clay – like the terracotta flower pots
- Parent material is fine, often well-sorted – except in outwash areas
- Mostly ‘secondary’ minerals or finely ground ‘primary’ minerals
- Marine-derived, silty and clayey soils
- Typically highly erosive, slow infiltration, slowly drained, high water holding capacity, and often ‘salty’ – especially subsoil



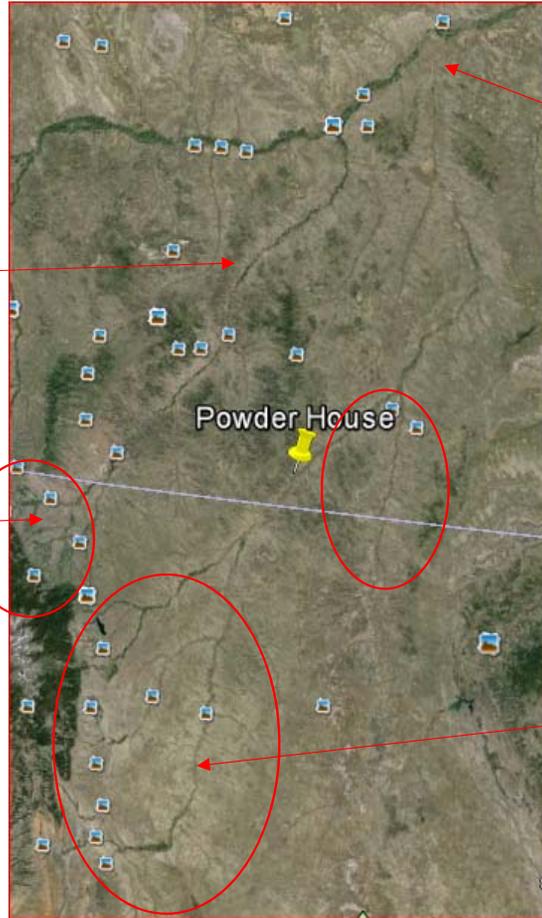
- Salt in the soil is from weathering and leaching of marine sediments
- Salt in the river water is from the soils – either overland runoff or leaching



Tongue River



About the Tongue and Powder River watersheds and sources of water



Powder River



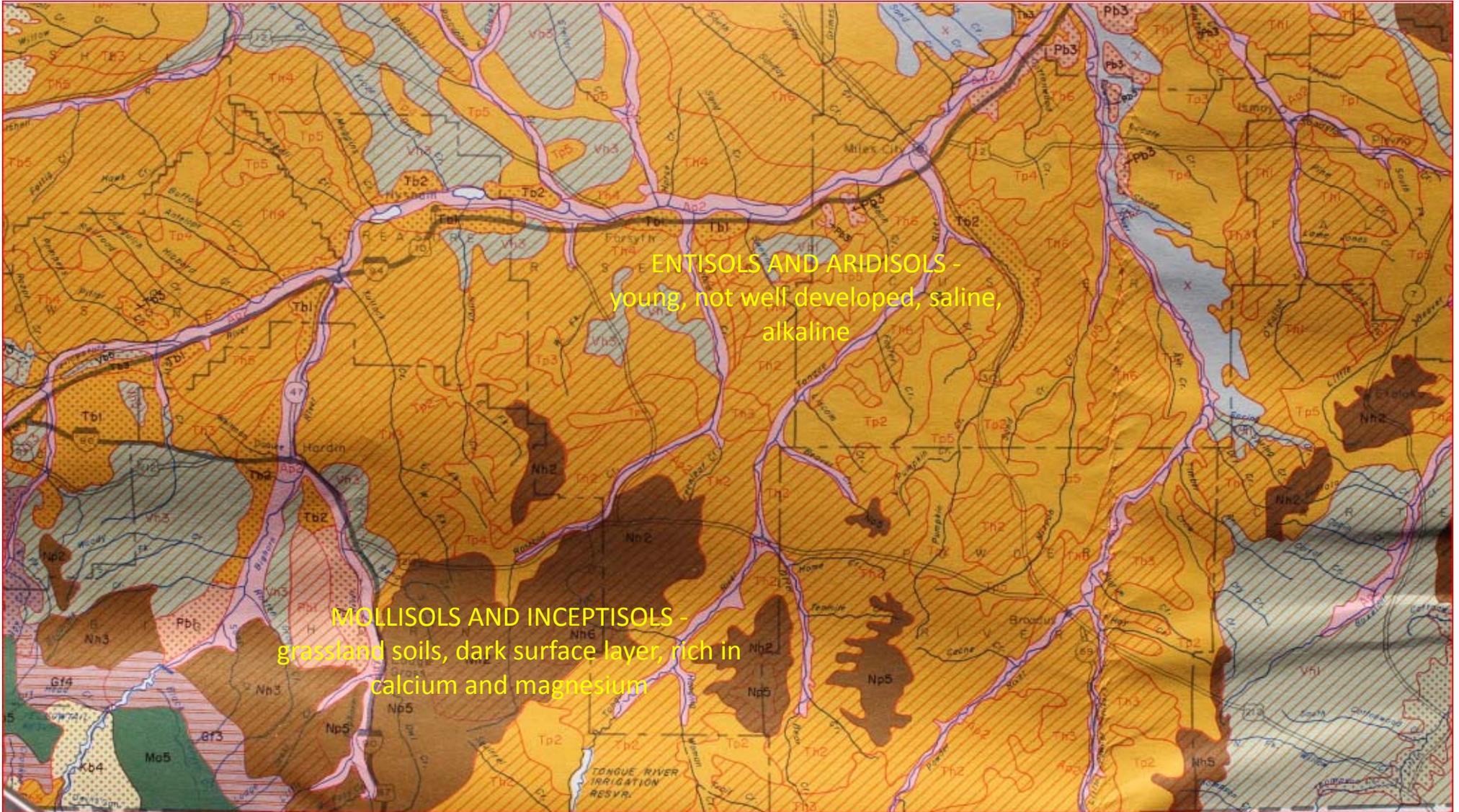
Perennial – Mountain primarily

Perennial/ephemeral – Prairie primarily



Many peoples' mind-image of southeast Montana







Sub-irrigated flood plains



Deep, uniform,
unconsolidated valley
bottom sediments



Outwash and stream terrace



Minimally weathered benches, terraces, and open
rangeland

ARIDISOL

Arid, shallow, little development



ARIDISOL

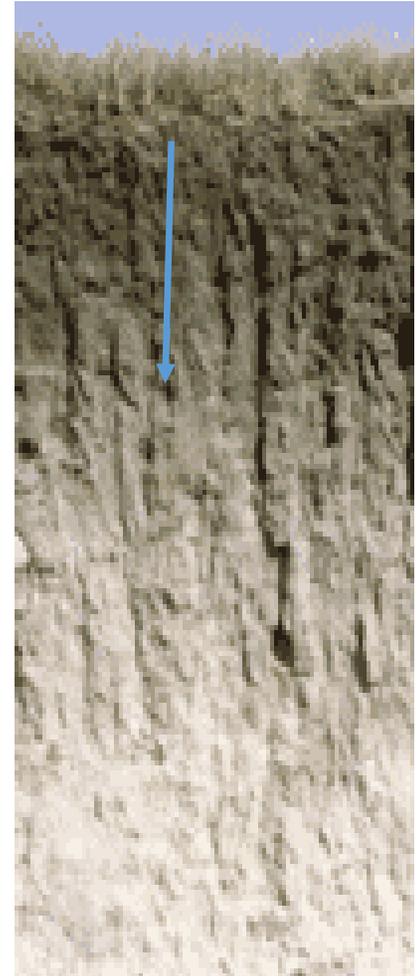
Arid, shallow, little development



INCEPTISOL
Young, shallow



MOLLISOL
Grassland, dark surface



Some GENERALIZATIONS (mostly) about the Tongue and Powder Rivers

- Typical water quality issues: salinity (salts), sodicity (sodium salts), sediment (Pryor Creek, Powder - 2-3 million tons per year, perennial; Other rivers – primarily during high flows and irrigation season), temperature
- Typical water quantity issues: primarily a matter of supply from reservoir storage, low flows, reduced or restricted allocations for irrigation during latter part of irrigation season. Powder, Pryor, Shields – highly dynamic flow fluctuations, insufficient flow to support irrigation during July-August, lack of flow and pumping regulation
- Issues of attention: influence of CBM discharges, dewatering, oil and gas development impacts, fisheries (Shields, Tongue – somewhat mitigated; Powder, during irrigation dewatering), tribal water rights (Tongue), Yellowstone River Compact disputes
- Bighorn, Clarks Fork much like the Tongue – sourced mainly from snowpack, then picking up sediment down stream, substantially less salinity

Here's a 'Trivial Pursuit' question for you? Do any of you recognize the location of a **proposed** water storage and flood control reservoir in the Powder River Basin? It does relate to water quality!





The remnants of the housing plan – Moorhead ~ 3 miles north of the MT-WY border. Project abandoned - sedimentation



Some examples – Contrasting Water quality statistics

	Median flow	Median EC	Median SAR	
Powder River @ Moorhead	109 cfs/81 yrs	2050 dS/cm/7 yrs	3.0/5 yrs	
Tongue River @ Stateline	246 cfs/52 yrs	740 dS/cm/9 yrs	0.96/9 yrs	



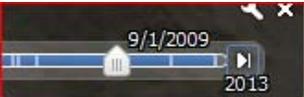


Image USDA Farm Service Agency

Salinity and Sodicity we are all familiar with – and contribute to the salinity and sodicity of soil and water of the Powder River Basin.

- What salts: **sodium**, **calcium**, **magnesium**, **potassium sulfates**, **chlorides**, **bicarbonates**, **carbonates**



Magnesium sulfate
Epsom salts



Sodium bicarbonate
Baking soda



Sodium sulfate
Glauber's salt



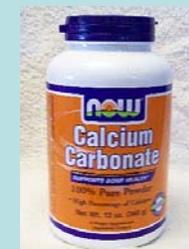
Sodium chloride
Table salt



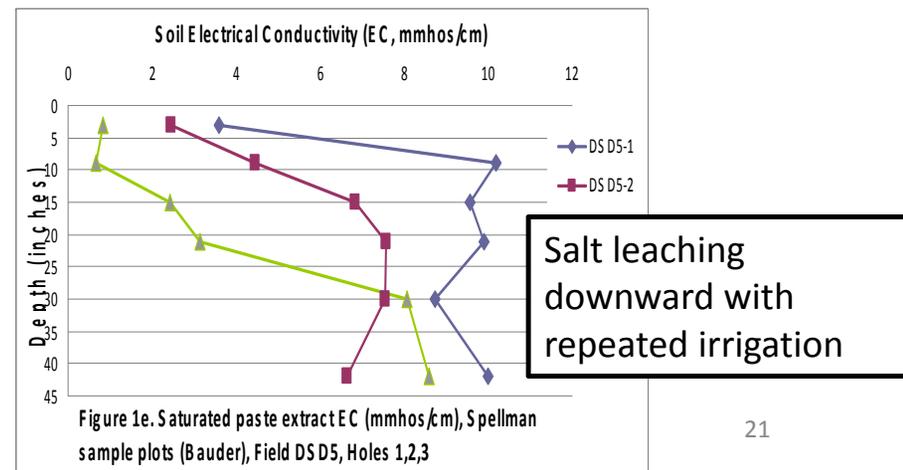
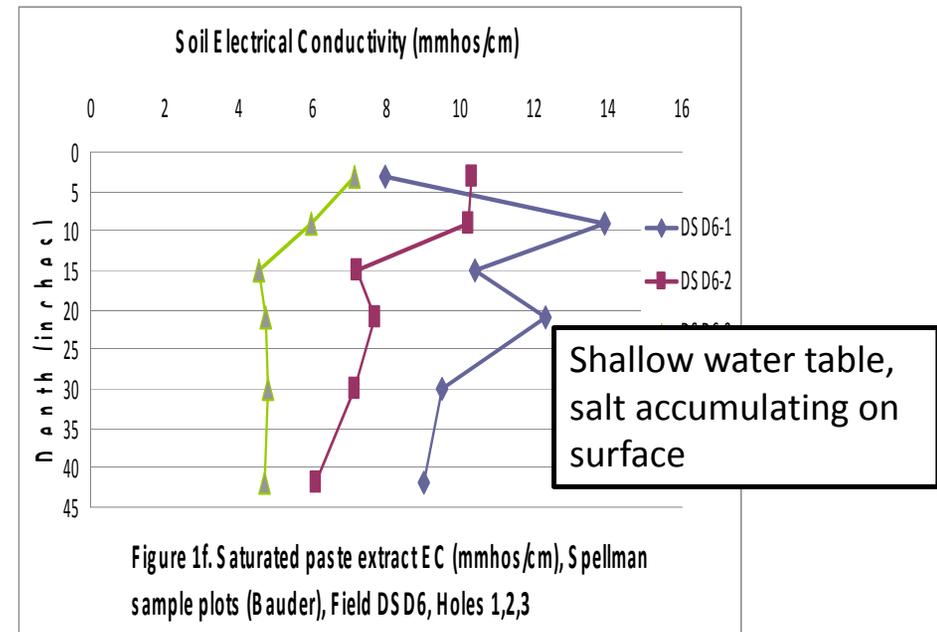
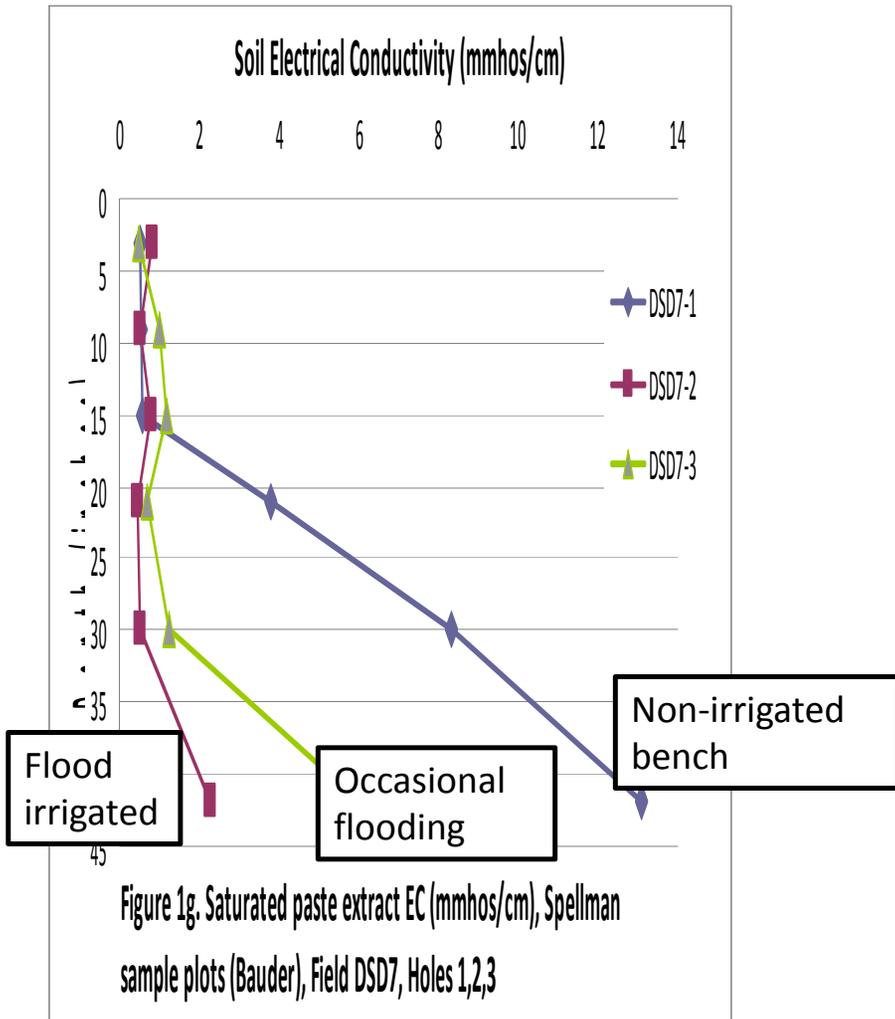
Calcium sulfate
Gypsum

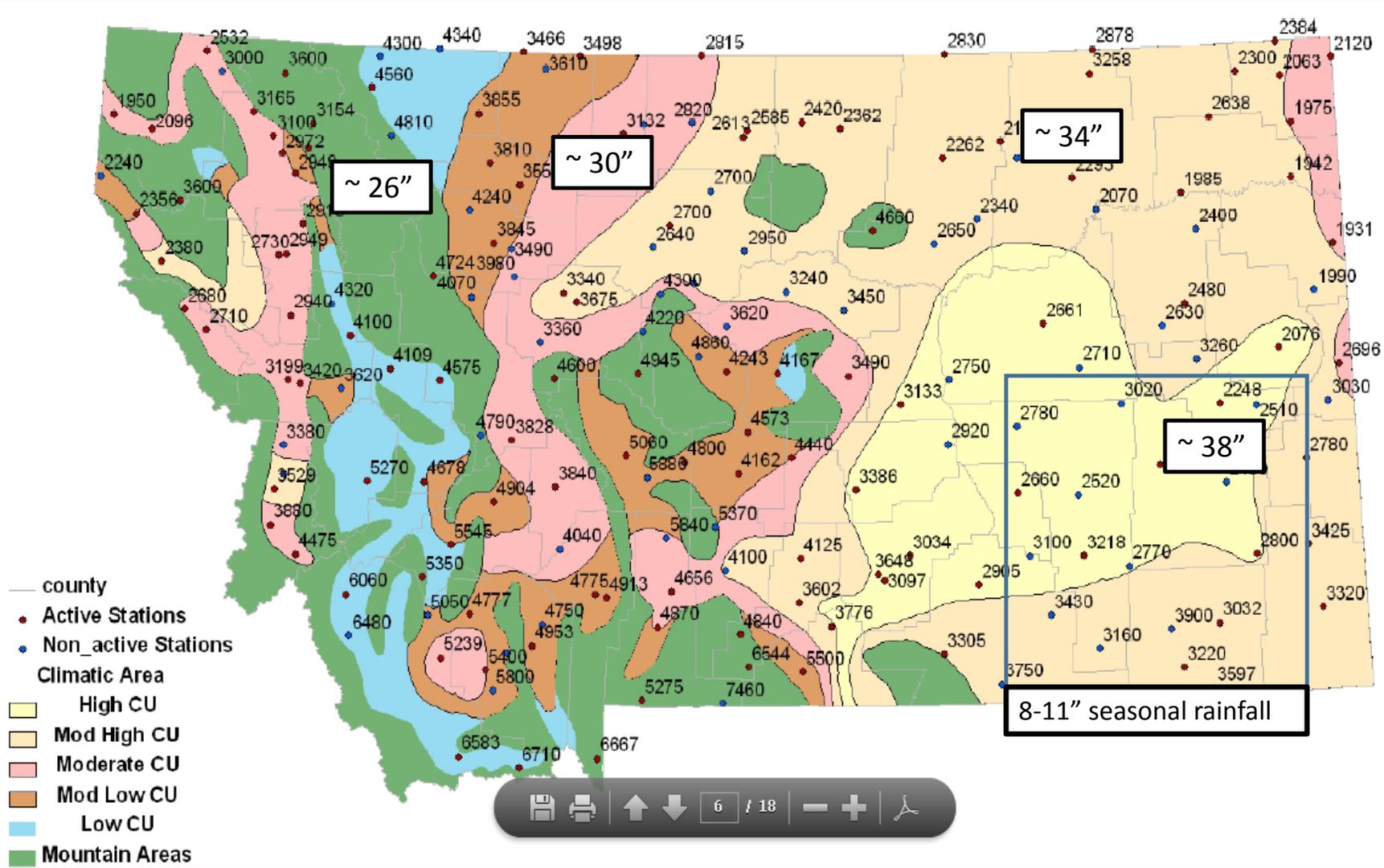


Potassium chloride



Calcium carbonate
Limestone





Irrigation accounts for ~71% of the alfalfa production, on less than 50% of the hay-producing land in Montana. For Custer, Powder River, Prairie, Rosebud, and Treasure counties - 2012



Cattle	305,000	10.6%	~\$150 million (calf sales)
Sheep	23,100	9.9%	~\$2.4 million (lamb sales)
Alfalfa/Hay	282,000 tons	~\$31 Million	

	Average water right: acre ft/acre	NASS 1997-2006 DNRC study: tons/acre	Water needed to produce the average yield: inches/acre	Yield attributable to irrigation: tons/acre
Richland	4.54	4.64	27-28	3.1
Yellowstone	3.05	4.30	24-25	2.8
Dawson	2.79	4.07	24	2.5
Treasure	2.16	4.89	29	3.4
Prairie	2.05	4.13	24	2.6
Custer	1.91	4.17	25	2.6
Rosebud	1.89	3.70	21	2.2
Fallon	1.80	2.37	14	0.8
Carter	1.68	2.45	14	0.9
Powder River	1.47	2.63	15	1.1
Current beneficial use attributable to irrigation				

Average growing season rainfall is ~ 10 inches. Growing season rainfall is about 80-90% effective, which means the average rainfall which would contribute to alfalfa production would be about 8-9 inches for this area.

Alfalfa production is directly related to water use. DNRC uses a figure of 0.17 tons/inch of water used by the plant. That being the case, 8-9 inches of rainfall would product about 1.5 tons of alfalfa per acre.

Effective ET for this area is 34-38".
Potential alfalfa yield is ~ 5.8-6.5 tons/acre.

Additional water that could be put to beneficial use: 9-26 acre inches/irrigated acre. ~ ¾ - 2 acre feet/irrigated acre





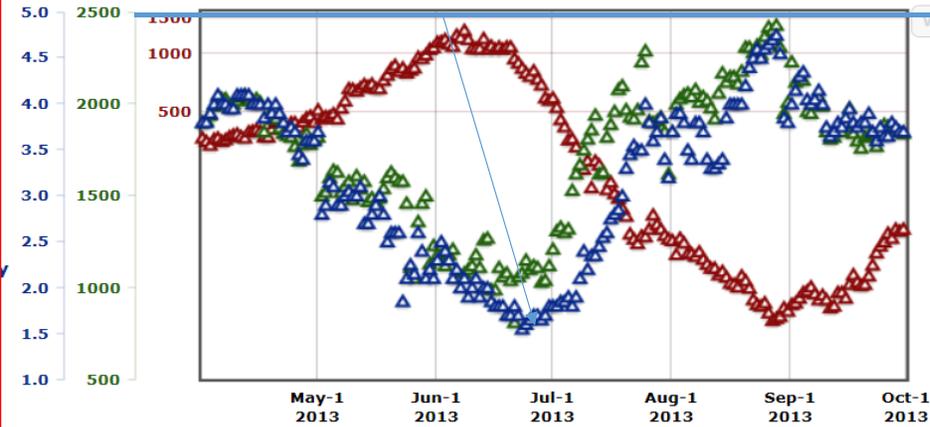
Other beneficial uses



USGS 06324500 Powder River at Moorhead MT

Zoom period plot

Wednesday Feb 13 2013 22:59



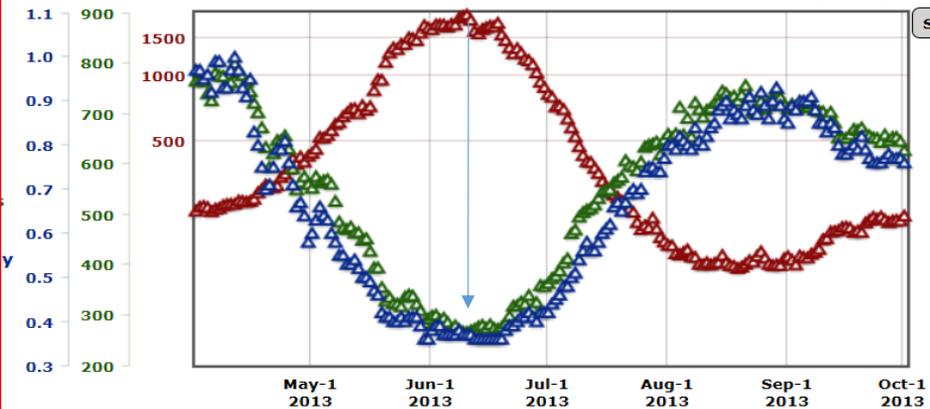
Explanation

- Discharge
- Measured discharge
- 109 Median daily statistic (81 years)
- Specific conductance
- 2050 Median daily statistic (7 years)
- Sodium adsorption ratio
- 3.8 Median daily statistic (5 years)

USGS 06306300 Tongue River at State Line nr Decker MT

Zoom period plot

Sunday Feb 17 2013 01:26



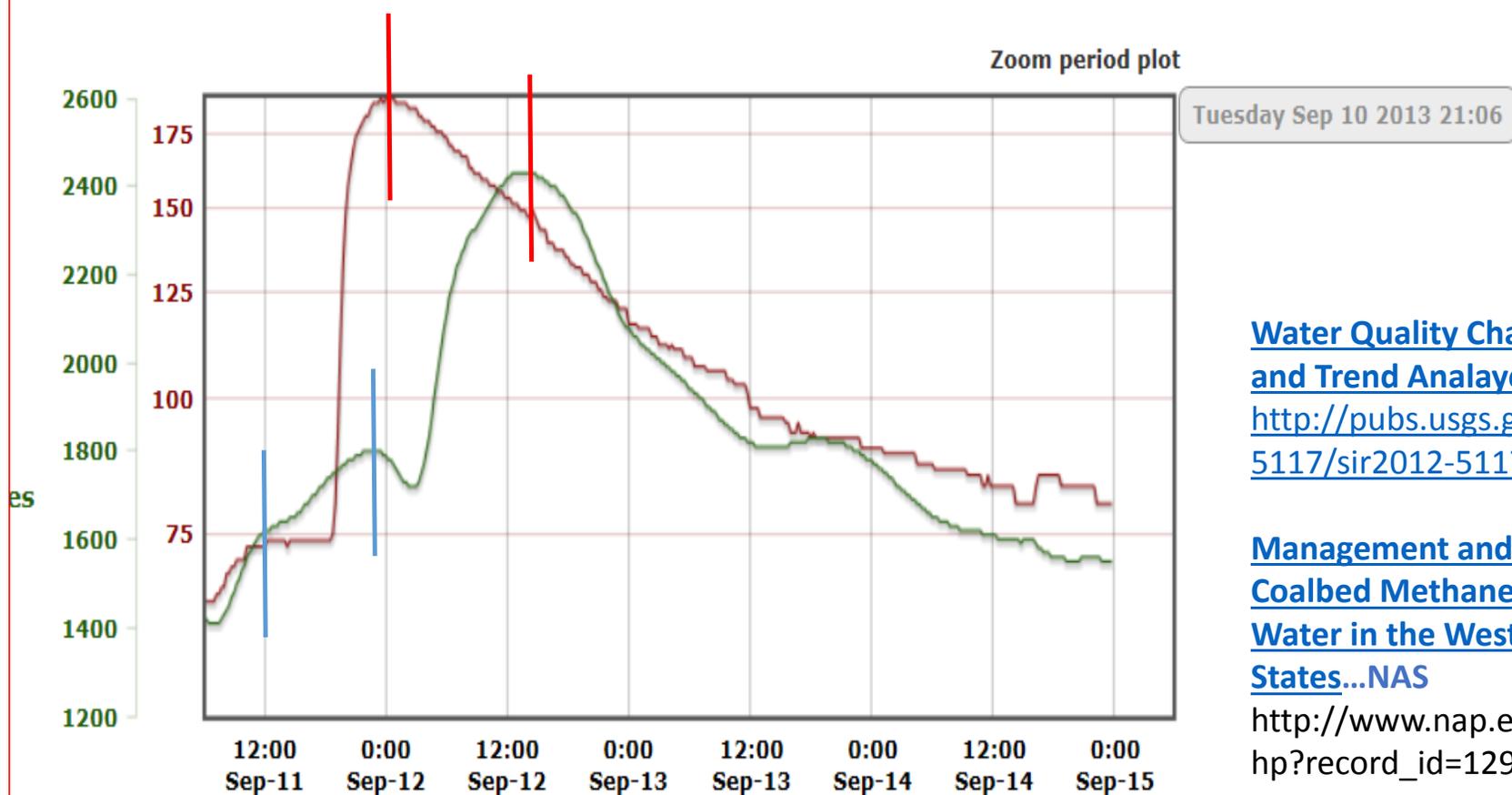
Explanation

- Discharge
- Measured discharge
- 246 Median daily statistic (52 years)
- Specific conductance
- 740 Median daily statistic (9 years)
- Sodium adsorption ratio
- 0.96 Median daily statistic (9 years)

River water standards, quantity and quality – comparisons, contrasts and similarities of the Tongue and Powder Rivers

Median daily statistic	Powder River at Moorhead	Tongue River at stateline
Flow – cfs (purple)	109	246
EC – $\mu\text{S}/\text{cm}$ (green)	2050	740
SAR (blue)	3.8	0.96

USGS 06324500 Powder River at Moorhead MT



[Water Quality Characteristics and Trend Analyses...USGS](http://pubs.usgs.gov/sir/2012/5117/sir2012-5117.pdf)
<http://pubs.usgs.gov/sir/2012/5117/sir2012-5117.pdf>

[Management and Effects of Coalbed Methane Produced Water in the Western United States...NAS](http://www.nap.edu/catalog.php?record_id=12915)

http://www.nap.edu/catalog.php?record_id=12915



Questions/Comments