Water Management Issues Associated with Bakken Oil Shale Development in Western North Dakota



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Schematic Diagram of a Horizontally Drilled Well



Water Demand for Oil Production

- Estimated 2.1 billion barrels of recoverable oil in the Bakken Formation using horizontal drilling and hydro-fracking techniques
- 2,500 new oil wells per year for the next 15-25 years
- Average water demand estimated at 2 million gallons (7.6 million liters) per well, mostly for hydro-fracking
- Estimated annual oil field water demand = 22,400 acre-feet (27.6 billion liters)

How Do We Meet This Demand?

- Surface Water Availability
- Ground Water Availability
 - Bedrock Aquifer
 - Fox Hills Aquifer
 - Glacial Aquifer
 - Killdeer Aquifer
- Status of Water Depot Permit Applications
- U.S. Army Corps of Engineers Lake Sakakawea Permitting Issues

Surface Water Availability



East Fork Shell Creek near Parshall, ND



Ground Water Availability Bedrock Aquifers FOX HILLS AQUIFER

Areal Extent of Fox Hills Aquifer



Fox Hills Aquifer

 Fox Hills Aquifer occurs from land surface to depths of ≈ 2,000 feet (600 m) in west central part of state

• Well yields of up to 200 gpm (756 Lpm)

- Variable water chemistry
 - Relatively high salinity
 - Sodium-bicarbonate type



Potentiometric surface of the Fox Hills-Hell Creek aquifer in feet above sea level on 1/1/09

Fox Hills Aquifer Cont.

Major source for stock use in western North
Dakota



Fox Hills Aquifer Cont.

- Monitoring since 1980s indicates pressure head declines of 1 to 2 feet/year (0.3 – 0.6 m/y)
- Negative impact on flowing wells in Little Missouri, Missouri, and Knife River valleys





Management of Fox Hills Aquifer

- Current trend in rate of pressure head decline is a major concern
- Fox Hills Aquifer is an important water source for ranchers/farmers
- Every effort should be made to develop large scale ground water supplies from other sources

Ground Water Availability in Glacial Aquifers KILLDEER AQUIFER

Dunn County

Glacial Drift Aquifers





Geohydrologic Section A-A' Showing the Killdeer Aquifer

 $\frac{1}{4}$ to $\frac{1}{2}$ mile wide (0.4 to 0.8 km wide)



Schematic Diagram Showing Movement of Bedrock Water Into A Glacial Meltwater Channel Aquifer





Allocation of Groundwater in Glaciofluvial Aquifers

Incremental development approach

- **Develop computer models**
- Uncertainty with regard to long-term sustainability (quality and quantity)
- **Recharge discharge relationships**
- Allocate conservative amounts of groundwater
- Monitor water levels and water chemistry
- **Update models**
- Make decisions on additional allocations
- Cannot fully allocate in a timely manner to meet current demand

"Sustainability is about being nimble, not being right, and being nimble is about taking small steps and keeping one' s eyes open. Politics help us decide the direction to step; science helps the eyes to focus."

Daniel Sarewitz - How Science Makes Environmental Controversies Worse. (Environmental Science and Policy, 2004, 385-403).



STATUS OF WATER DEPOTS - PERMITS AND APPLICATIONS (As of 8/30/12)

- Water permits issued 85 (73 groundwater, 12 surface water)
 - Annual quantity of groundwater permitted 11,519 acre-feet (3.7 billion gallons:14 billion liters)
 - Annual quantity of surface water permitted 31,679 acre-feet (10.3 billion gallons:39 billion liters)

(includes one permit approved for 24,900 acre-feet (29.6 billion liters) from the Missouri River in Lake Sakakawea) The most reliable water supply in terms of both quantity and quality required for oil field development in western North Dakota is Lake Sakakawea and the Missouri River



Missouri River/Lake Sakakawea Strategically Located



Missouri River Flow Statistics

- Average daily flow of Missouri River past Bismarck, ND is 40,658 acre-feet per day (50 billion liters per day)
- Estimated annual oil field demand = 22,400 acrefeet per year or about 61.4 acre-feet per day (75.7 million liters per day)
- Daily oil field demand is about 0.15% of the average daily flow past Bismarck, ND

U.S. Army Corps of Engineers – Permitting Issues from the Missouri River in Lake Sakakawea

- In May 2010, USACOE placed moratorium on issuance of permits to access water from the Missouri River in Lake Sakakawea.
- Moratorium is still in effect.
- USACOE does not recognize states rights to natural flows in Missouri River.
- USACOE plans to charge "surplus storage" fees to access natural flows of Missouri River in Lake Sakakawea.
- This act by the USACOE has placed undue burden on ground-water supplies and prevents the efficient distribution of water for oil field industrial use in western North Dakota.

Temporary Conversion of Irrigation Permits to Industrial Permits

- Converting existing irrigation permits to industrial permits
 - Due to the demand and lack of timely permitting, the State Engineer developed a policy to temporarily divert irrigation use to industrial use.
 - Conditions: 1) Must forgo irrigation for calendar year during which water used for industrial use, 2) If use is from ground water source, can only divert "average" amount of water used for irrigation, 3) Must install in-line totalizing water meter to record and report annual water use.
 - Allocated 4,894 acre-feet (1.6 billion gallons:6.0 billion liters) under this program in 2012.
 - If USACOE removes moratorium on permits from the Missouri River in Lake Sakakawea, this conversion program will be discontinued.

SWC Temporary Water Permits from Surface Water Ponds and Sloughs

- Winters of 2009-2010 and 2010-2011 abnormally wet with with increased snowfall and associated snowmelt
- Surface drainage commonly non-integrated thereby creating numerous small-scale surface water bodies throughout the landscape
- For the most part, water quality in these surface water bodies acceptable for oil field applications
- Farmers/ranchers would like to see water removed and put to beneficial use to return land to agricultural production
- Allocated 13,943.9 acre-feet (4.5 billion gallons:17.2 billion liters) under this program in 2012
- Winter of 2011-2012 very little snow pack and associated snowmelt this water source may be limited in the future

SUMMARY

- We are not depleting aquifers in western North Dakota to provide water for oil field applications
- More groundwater is available for oil field use but it cannot be permitted in a timely manner because of hydrologic system uncertainty
- The water demand for oil field industrial use is being met but more efficient distribution could be achieved if the USACOE would allow access to the Missouri River from Lake Sakakawea

Hydraulic Fracture Stimulation

