PROJECT UPDATE: BRINE CONTAMINATION TO AQUATIC RESOURCES FROM OIL AND GAS DEVELOPMENT IN THE WILLISTON BASIN, U.S.A.

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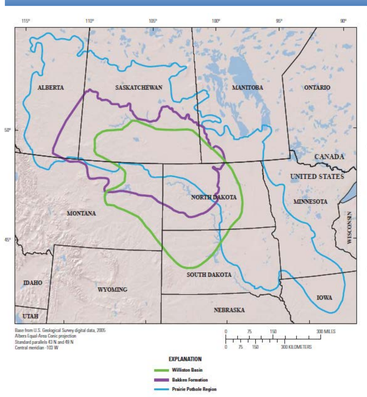
Overview

The Prairie Pothole Region (PPR), which overlies the northeastern portion of the Williston Basin in the U.S., is characterized by a high density of closed-basin, depressional wetlands that provide critical habitats for a majority of North America's migratory waterfowl and other wildlife. Wetlands and shallow groundwater in parts of the PPR have been affected by saline water (brine) produced with oil and gas using conventional drilling methods, and there are concerns over potential ecological effects associated with this historic production, as well as the recent unconventional development of the Bakken and Three Forks Formations.

Gleason, R.A., and Tangen, B.A., eds., 2014, Brine contamination to aquatic resources from oil and gas development in the Williston Basin, United States: U.S. Geological Survey Scientific Investigations Report 2014–5017, 127 p.

The U.S. Geological Survey's (USGS) multidisciplinary "Science Team About Energy and Prairie Pothole Environments," or STEPPE (http://steppe.cr.usgs.gov/), formed in response to information needs related to potential ecological effects of oil and gas production in the Williston Basin. The STEPPE has produce a soon-to-be released four-chapter report (http://pubs.er.usgs.gov/) that presents comprehensive background information related to oil and gas production and natural resources (Chapter A), results of a field study (Chapter B), results of a regional spatial characterization (Chapter C), and a description of a Decision Analysis workshop (Chapter D). This poster provides an overview of the USGS report, as well as ongoing research.

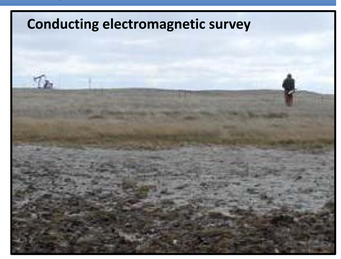
Chapter A: Oil and Gas Production, Aquatic Resources, and Brine Contamination in the Williston Basin, United States



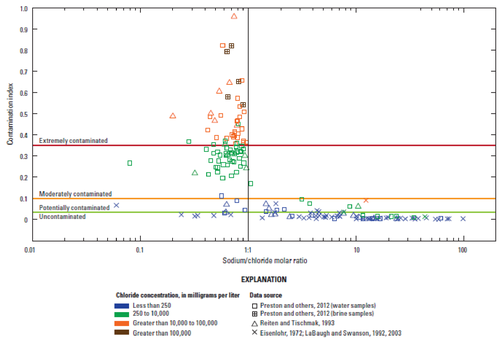
- The Williston Basin has been a top domestic oil-producing region since the 1960s and is in the midst of a modern oil boom.
- Research has identified contamination of surface waters and groundwater by produced waters (brine).
- The primary source of concern is the migration of brine from buried reserve pits; however, other potential sources have been identified.
- Overlying the northeastern half of the Williston Basin is the PPR, which includes critical wetland breeding and nesting habitats for a large proportion of North America's waterfowl.
- Water chemistry differs greatly between natural and produced waters, and there are concerns about possible ecological effects of oil and gas production to aquatic resources.
- There has been very little research pertaining to the direct effects of brines to biotic communities, especially in the Williston Basin.

Brine pit located in Sheridan County, Montana

Chapter B: Brine Contamination of Prairie Pothole Environments at Three Study Sites in the Williston Basin, United States

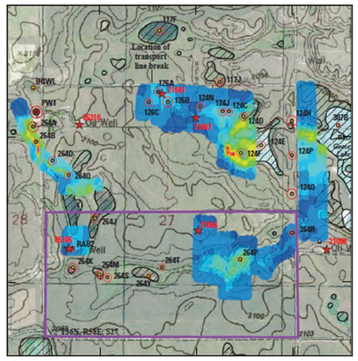

Conducting electromagnetic survey

- Surface-water and shallow groundwater samples were collected and electromagnetic geophysical surveys were performed at three study sites in the Prairie Pothole Region to assess saline contamination from produced waters (brine) from nearby oil and gas production.
- Water-quality results indicated that 34 of the 48 samples were moderately or extremely contaminated with brine, and another 7 were potentially contaminated.
- Salts likely came from buried reserve pits that were installed in the mid- to late-1960s, indicating that contamination can persist for at least four to five decades.



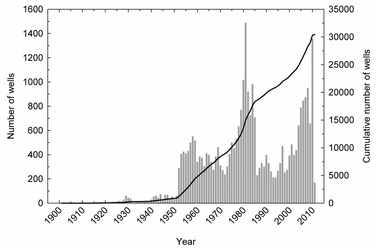
Sodium/chloride molar ratio compared to contamination index for 96 water-quality samples and 5 produced water samples.

- Geophysical surveys performed at the three study sites measured elevated apparent conductivity near most of the oilfield facilities. Analysis of groundwater samples confirmed that areas of elevated apparent conductivity were areas of brine-contaminated groundwater.
- The lateral migration of brine in groundwater appears to be controlled, in part, by the type of near-surface sediments, with observed migration distances of at least 600 and 800 m in glacial outwash deposits and at least 400 m in glacial till.
- Strontium isotope data from samples of produced waters, surface water, and groundwater confirmed that the source of high salinity contamination at the three study sites is brine produced with hydrocarbons.

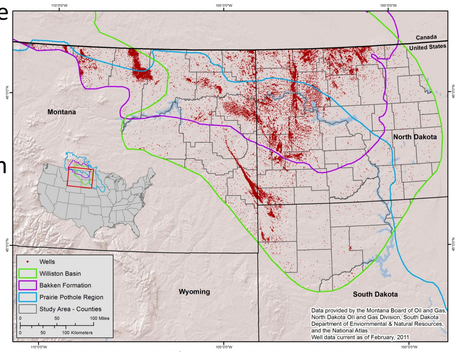

Geophysical survey and water quality results.

Chapter C: Spatial Characterization of Oil and Gas Development and Aquatic Resources in the Williston Basin, United States

- A spatial characterization of the Williston Basin and various county-level assessments of the distribution of aquatic resources and oil- and gas-related wells were performed using databases describing wells, wetlands and streams, and critical riparian habitats.



- The county-level assessments were conducted to identify areas with the greatest likelihood of containing brine-affected aquatic resources. These assessments were founded on the premise that counties with the greatest numbers and densities of wells and aquatic resources would have a greater probability of containing wetlands and streams affected by brine than counties with fewer of these features.
- Counties with more wetlands and streams adjacent to, or in close proximity to, wells also were identified.
- >30,000 oil/gas wells were drilled through 2011.
- Approximately 30,000 km^2 of wetlands and 190,000 km of streams occur within Williston Basin/Bakken Formation.
- Approximately 1/3 of all wetlands in the PPR Part of the Williston Basin are located within 1.6 km of oil and gas wells.



Spatial distribution of oil/gas-related wells within the Williston Basin/Bakken Formation of the U.S.

- There are ~290,000 wetlands covering almost 1,800 km^2 and >7,000 km of streams within 1.6 km of oil/gas wells.
- There are >1,200 oil/gas wells, >80,000 km^2 of wetlands, and nearly 3,000 km of streams on or adjacent to U.S. Fish and Wildlife Service lands in the Prairie Pothole Region part of the study area.

Chapter D: Charting a Course Forward—Identifying Research and Decisionmaking Priorities in the Williston Basin, United States

A formal decision analysis workshop was held in Bismarck, North Dakota, during April 2011. The overarching goal of this workshop was to frame the issues surrounding natural resource management and conservation decisionmaking with regard to oil and gas development within the Williston Basin. This decision analysis framework provides a clearer understanding of the decision context and provides guidance on how future applied scientific studies will provide the most value to decisionmakers. Additionally, this framework will clarify means to effectively communicate information about oil and gas development to those decisionmakers.

A sample of ongoing and related studies:

Data compilation and web mapping: Acquire, manage and serve seamless spatial datasets describing oil and gas development and environmental factors within the Williston Basin and Bakken Total Petroleum System (oil and gas wells, geologic formations, horizontal well lines, surficial geology, soils, water chemistry, transportation networks, etc).

Documenting land use change: Quantify the acreage of agricultural and native landscapes lost to the development of recent energy infrastructure (i.e. oil well pads, site access roads, and pipelines) since 2000.

Modeling avian abundance or occupancy: Develop a Bayesian hierarchical model, to assess relationships between bird abundance and patterns of oil development.

Differentiating salinity sources and project future water chemistry: Apply inverse geochemical models to differentiate salinity sources and project future water chemistry under a variety of reaction path scenarios using existing major, trace, and isotopic data previously collected from study sites in the PPR of Montana and North Dakota.

Salt toxicity to aquatic resources to update salt model: Expand the applicability of the EPA salt toxicity study with additional species and background waters that reflect the Williston Basin and PPR.

Visit the STEPPE web site for contact and general information, current projects, presentations, reports & data, images, publications, and related links: http://steppe.cr.usgs.gov/