BAKKEN SHALE:

As oil production sets in, pollution starts to migrate -- scientists

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Hundreds of thousands of wetlands and thousands of miles of streams in North and South Dakota and Montana are within a mile of oil and gas wells, according to research by the U.S. Geological Survey, which is mapping the subsurface to identify groundwater contamination from brine.

The project began in 2007 when the USGS assembled scientists to study the transformation of the northern Great Plains fueled by the boom in oil production in the Bakken. Fossil fuel extraction was leaving behind an imprint on the land as distinct as the ones left by the receding ice sheets of the ice age.

About 10,000 years ago, the glaciers that had covered these parts for thousands of years drew back, revealing clayey soils. Ice melted and the running water brought sediments from distant rivers to the Great Plains. These riverine deposits were coarse-grained, unlike the heavy clays that the glaciers themselves left behind.

The sedimentation formed potholes that gave rise to the region's name: the Prairie Pothole Region. The area contains thousands of wetlands that are vital for ducks. Up to 60 percent of certain species in North America use the Prairie Pothole Region as a breeding ground.

"This is where a lot of the Fish and Wildlife Service land is," said Todd Preston, a hydrogeologist at USGS. "These are waterfowl protection areas, and [FWS staffers] are tasked with making these lands promote duck productivity."

The region has been mostly deserted in the past, except for patchy oil development. The East Poplar oil field started up in 1952 on the Fort Peck Indian Reservation in Montana, just a few miles north of the city of Poplar, population 810.

When oil is produced, brine or produced water rich in salts and toxic metals also comes out of the ground. The oil companies injected the wastes back underground to a depth of between 800 and 1,000 feet, where it was assumed the material would stay put. It did not.

In 2004, Bruce Smith, a geophysicist at USGS, flew a helicopter over a 100-square-mile area on the reservation. Dangling from his ride was a magnetic beam that could detect the presence of salty water below ground.

"It is kind of like a CAT scan of the Earth of very small areas as we fly over," Smith said.

Smith found two potential plumes covering 12 square miles that seemed to be migrating closer to Poplar's water supply.

The scientists drilled 40 boreholes, tested the water on the reservation and found it was significantly contaminated. In 2010, they tested three public wells Poplar draws its water from and found that all were contaminated with brine. The pollution was due to a well casing failure of an injection well, Smith said.

Meanwhile, farther north in North Dakota, the Bakken boom was continuing apace and the USGS directed its efforts there. Smith and his colleagues found at least 292,745 wetlands and 4,440 miles of streams were within a mile of an oil or gas well. Spills of oil and produced water were common in the state, which reported 1,129 incidents in 2012 (***EnergyWire***, July 8). A snowy winter in 2011 caused several waste pits containing brine to overflow in the spring.

These spills are noted in official databases, but the extent of brine contamination in the subsurface is unknown. Once a spill happens, there is some remediation of the soils, but the movement of brine below ground is not tracked.

'Strong correlation' on contaminated sites

The FWS is tasked with protecting some lands in the Prairie Pothole Region that coincide with the drilling, and it found itself with a huge job.

"A big concern is whether or not these brines will affect the ecological functioning of the wetlands," said Preston, the hydrogeologist at USGS.

The USGS offered to identify the vulnerable areas that the FWS should monitor. Preston honed his method in east

Sheridan County in northeastern Montana, which has experienced legacy oil and gas development. He worked at three study sites, each covering 1 square mile and containing five to 10 oil wells.

Preston gathered information about the age of the wells to identify the predominant well drilling practices and wastewater disposal methods. He looked at the type of soil left behind by the Wisconsin glaciation, since brine can move rapidly through coarse sediments but stays contained in clayey sediment. The risks posed by a spill would be greater when there is coarse sand and gravel. He also looked at the distance from wetlands and streams and the density of oil wells in the area.

Using these criteria, Preston could predict the likelihood of contamination. He checked his predictions by doing groundwater tests and usually found contamination.

"The results came out pretty good," he said. "We had a strong correlation with contaminated groundwater with a high vulnerability assessment score."

The work will be published in *Science of the Total Environment*.

Preston then worked at the Lostwood National Wildlife Refuge in northwestern North Dakota, which is at the epicenter of the Bakken boom. Using a similar assessment, he provided the FWS last week with a list of sites at greatest risk. The FWS will be monitoring groundwater at those sites to look for brine contamination. That work is funded until 2016.

Smith said he would like to do another aerial campaign to detect brine in the subsurface at Lostwood, followed by groundwater monitoring and analysis to confirm the contamination is brine. These tools could be used anywhere to study brine contamination, he said.

"So if an entity was interested in knowing in more detail about [contamination in] specific areas, we have demonstrated the tools that could be used to do that," he said.