MBMG
Montana Bureau of Mines and Geology

2017

Information Pamphlet 10

GROUNDWATER SAMPLING AROUND OIL AND GAS DEVELOPMENT

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Pumpjack outside Baker, Montana. Photo courtesy of Allison Brown, MBMG.

MONTANA DNRC

DEQ Montana Department of Environmental Quality

Saline Seep Reclamation

U.S. Fish & Wildlife Service

To address requests from citizens concerned with increased development and new development practices, a partnership was formed by the Montana Bureau of Mines and Geology (MBMG), the Montana Department of Natural Resources and Conservation (DNRC), the Montana Department of Environmental Quality (DEQ), the Montana Salinity Control Association (MSCA), and the U.S. Fish and Wildlife Service (USFWS) to characterize groundwater quality near current oil and gas development.

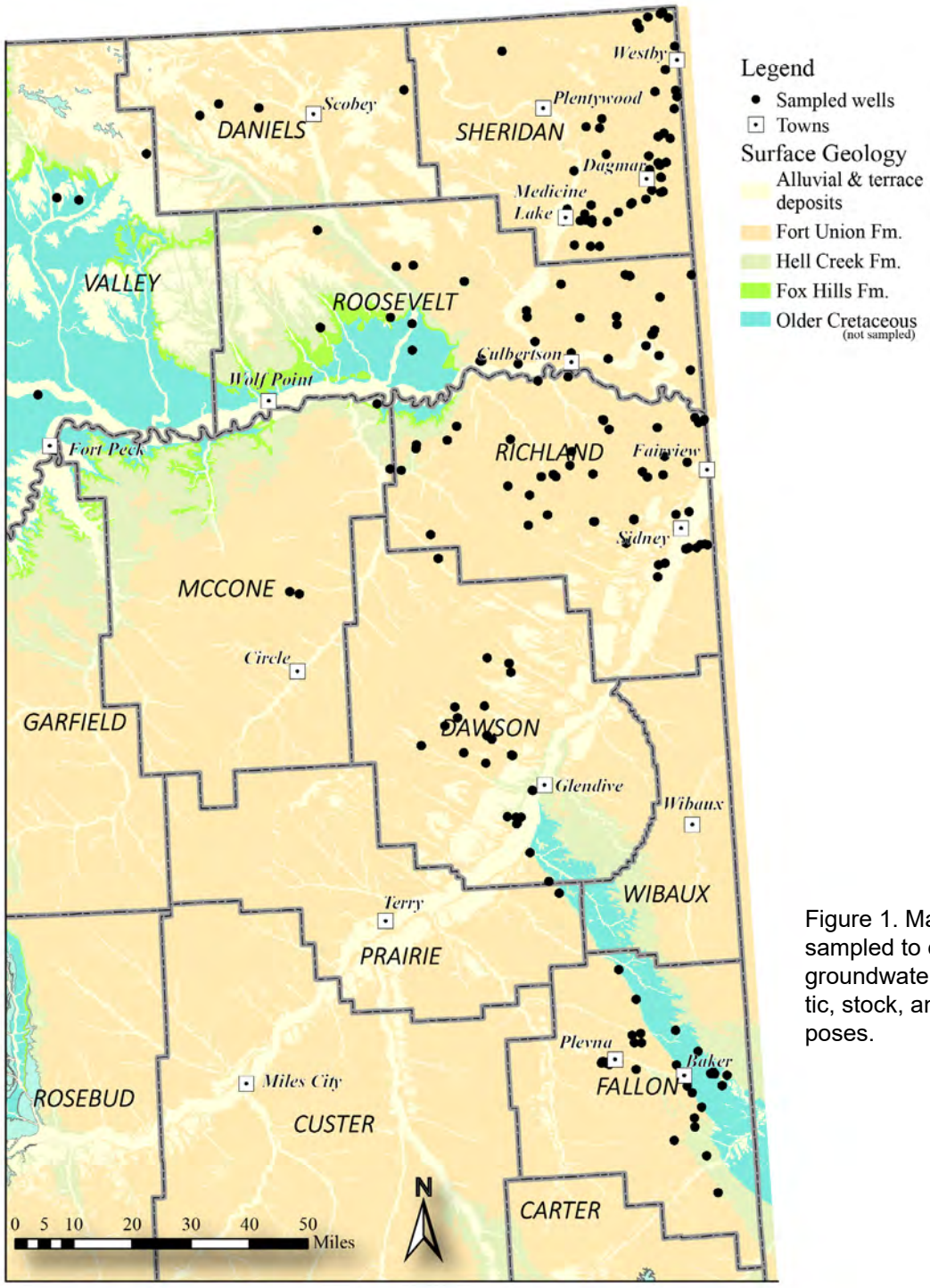

Figure 1. Major aquifers were sampled to characterize the groundwater used for domestic, stock, and irrigation purposes.

SPECIAL POINTS OF INTEREST:

- All 237 groundwater samples (fig. 1) indicate no obvious contamination from upward movement from oil and gas formations or development at depth.
- Low but detectable concentrations of hydrocarbons in Sheridan County require further investigation to determine sources and natural variability.
- Isotopic analyses of 10 samples indicate the methane in sampled aquifers did not migrate from oil and gas sources.

EASTERN MONTANA AQUIFERS

Groundwater is the primary source of domestic and stock water for most of eastern Montana. Major aquifers in eastern Montana include:

- Near-surface, unconsolidated aquifers deposited by rivers and glacial processes,
- The Fort Union Formation, specifically the sandstone-rich Tongue River Member, and
- The Fox-Hills/Hell Creek Formation sandstones.

POTENTIAL SOURCES OF CONTAMINATION FROM OIL AND GAS ACTIVITIES

Alluvial and glacial till aquifers can be impacted by surface activities including unintentional releases during storage or transport of hydraulic fracturing solutions and produced brines.

Potential impacts to the Fort Union and Fox Hills/ Hell Creek aquifers (generally 100 to 400 feet but can exceed 1,000 feet below land surface) include contamination from oil-well or injection-well casing or cement failure.

Around 5,000 to 8,000 feet of rock, including thick sequences of Cretaceous shale, prevent direct groundwater movement between oil and gas targets and eastern Montana aquifers (figs. 2 and 3).

Figure 2. Oil development near irrigated ground in eastern Montana. Photo courtesy of Kevin Chandler, MBMG.

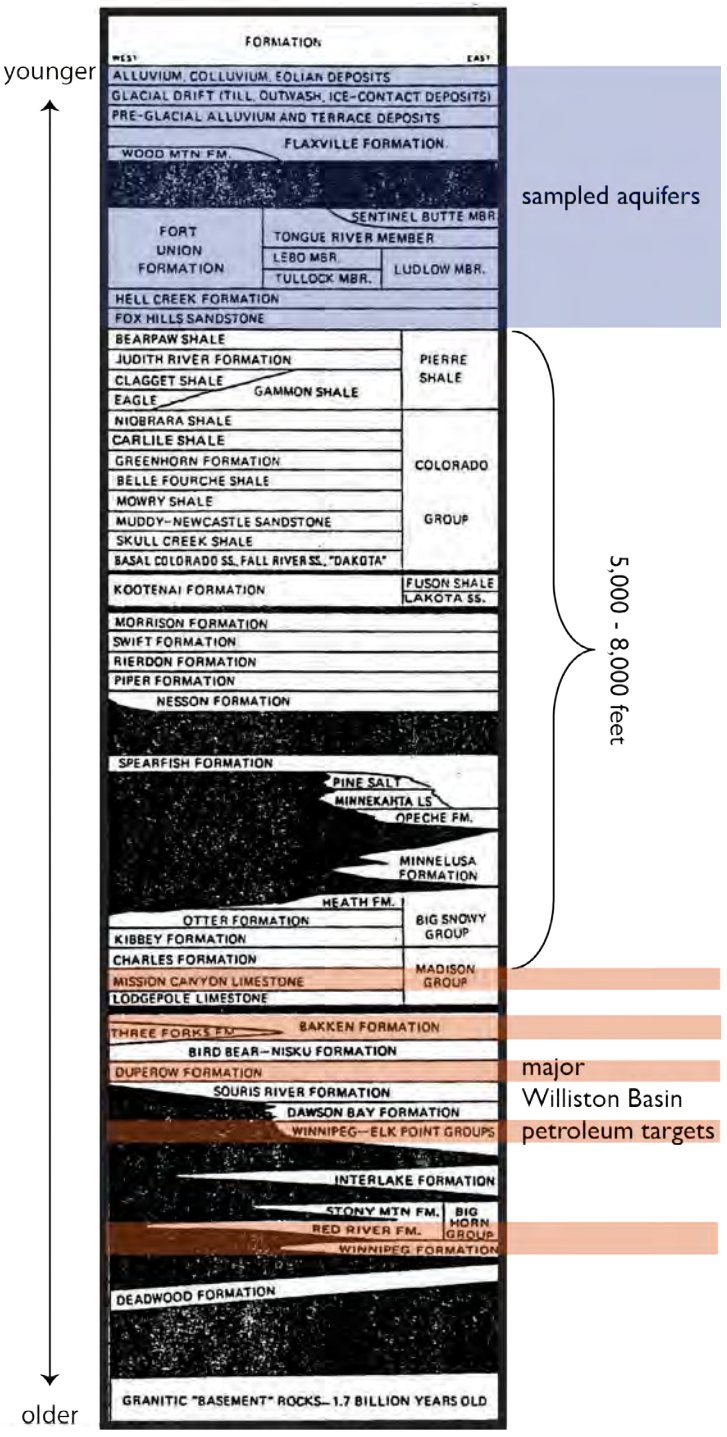

Figure 3. Stratigraphic column illustrating the relative position of aquifers compared to oil and gas targets (from Donovan, 1988).

GROUNDWATER HYDROCARBON-TESTING RESULTS

Low levels of hydrocarbons can occur naturally in some Montana aquifers, especially those, like the Fort Union Formation, that contain coal. The natural variability of these constituents in Montana aquifers is not well understood. With this in mind, organic analytes were chosen that, in combination, may identify groundwater contamination from hydraulic fracturing and oil and gas production. Samples were analyzed for one or more of the following organic constituents:

- Gasoline range organics (GRO);
- Total purgeable hydrocarbons (TPH)—includes gasoline range, benzene, toluene, xylene, naphthalene, and light aliphatics and aromatics;
- Diesel range organics (DRO);
- Total extractable hydrocarbons (TEH)—includes diesel range and heavy aliphatics and aromatics;
- Methane, ethane, and ethene;
- Radiochemical; and
- Isotopes of methane (10 samples).

Of the 237 samples, 51 had low but detectable hydrocarbons; 15 detections were in groundwater from the Fort Union Formation and 2 from the Fox Hills Formation.

Most detections were in alluvial and glacial till aquifers (34 of 51) because of a focus on unconsolidated aquifers near Medicine Lake Wildlife Refuge, Sheridan County (figs. 4 and 5). Some samples were collected from known contaminated sites.

Concentrations are generally low. Of the 34 alluvial aquifer samples with detectable TEH, 8 exceeded the Montana DEQ action level of greater than 1 mg/L; 3 of these were from sites with known contamination. Outside of known contaminated sites, the source of these organic constituents has not been determined. Further investigation is required to determine sources and define the hydrocarbon concentrations that exceed natural variability.

Figure 4. Medicine Lake Wildlife Refuge, Sheridan County. Photo courtesy of Kevin Chandler, MBMG.

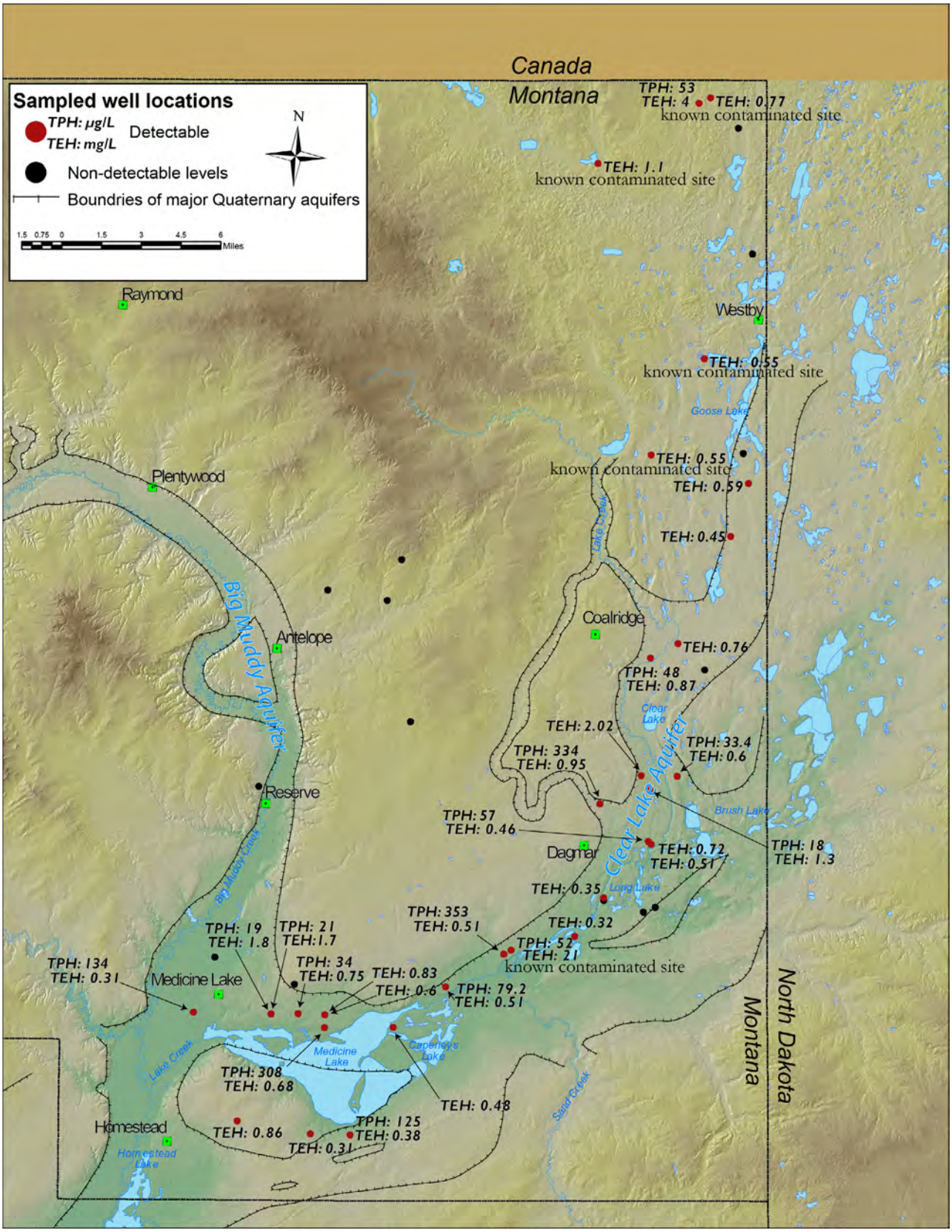

Figure 5. TPH and TEH results in the Medicine Lake area, Sheridan County. The major Quaternary aquifers are outlined. Values generally fall below DEQ's required action level.

METHANE ISOTOPE RESULTS

Methane occurs naturally in many of Montana's aquifers. The source of naturally occurring methane in aquifers less than 300 feet below land surface is through microbial (biogenic) processes that impart a unique carbon and hydrogen isotope signature. Deep sources of methane created by thermocatalytic processes, such as the methane produced in the Bakken Formation, have isotope ratios that are generally greater than -50 ‰ δ13C and -200 ‰ δD. The presence of thermocatalytic methane in shallow aquifers could be an indication of methane contamination from deep sources.

The 10 groundwater samples with the highest methane concentrations were analyzed for isotopes of methane. Results indicate this methane is generated locally (biogenic) and did not migrate from oil and gas sources (thermocatalytic) (fig. 6).

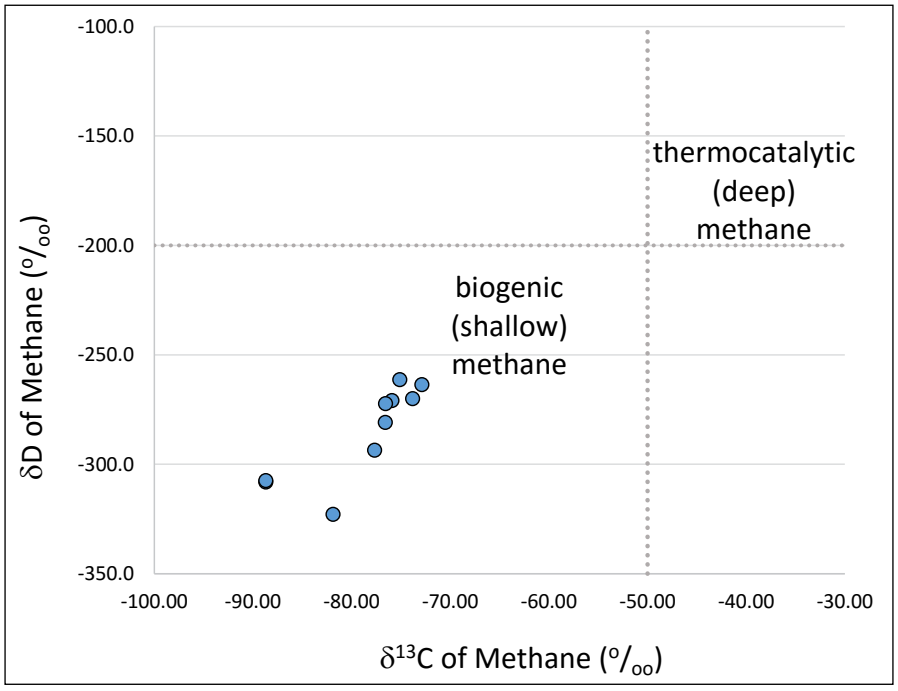

Figure 6. Methane isotope results.

ADDITIONAL INFORMATION

All groundwater testing results are available on the GWIC database under the project group "Energy Development Baseline Sampling": http://mbmggwic.mtech.edu/; a full discussion of all results will be available from the MBMG in 2017.

REFERENCES

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ACKNOWLEDGMENTS

This was a collaborative project between the MBMG and Montana DNRC, MSCA, Montana DEQ, and U.S. Fish and Wildlife Service. The MBMG thanks the numerous landowners who allowed access to their wells and the Conservation Districts in Sheridan, Roosevelt, Richland, Dawson, Wibaux, and Fallon Counties.