Department of Mineral Resources
Lynn D. Helms, Director

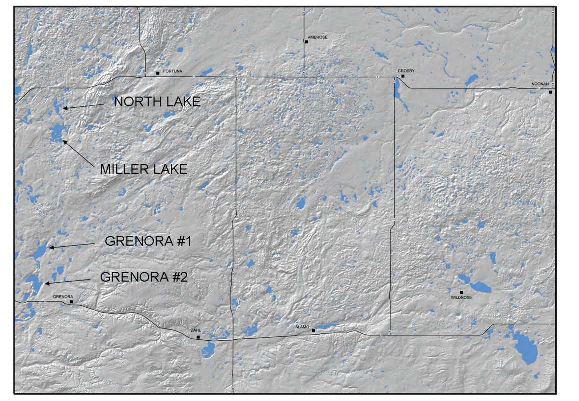
SHALLOW NATURAL GAS OCCURRENCES IN QUATERNARY DEPOSITS IN NORTH DAKOTA

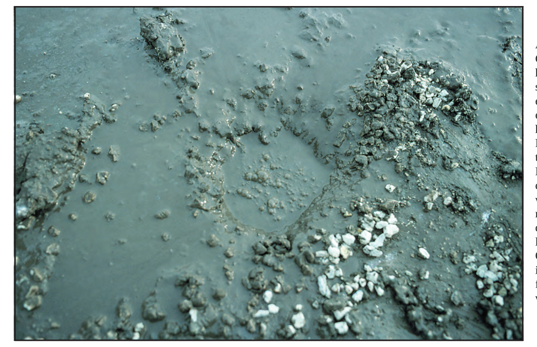
Fred J. Anderson[1], Edward C. Murphy[1], John P. Bluemle[2], and David W. Fischer[3]

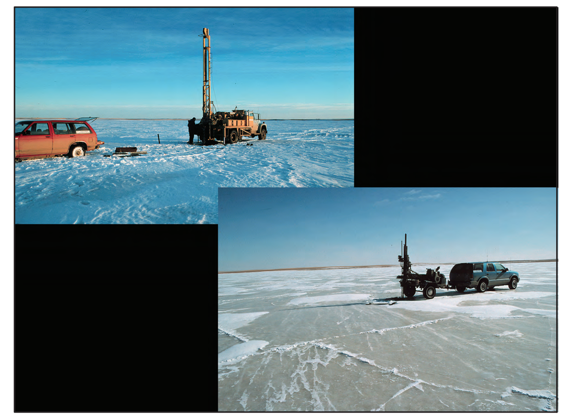
Fred J. Anderson
2006

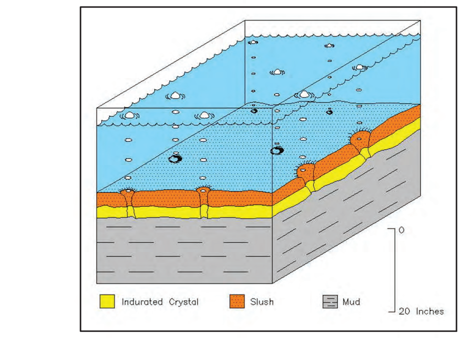
North Dakota Geological Survey
Edward C. Murphy, State Geologist
Geologic Investigations No. 25

Natural Gas Generation within Playa Lakes in North Dakota

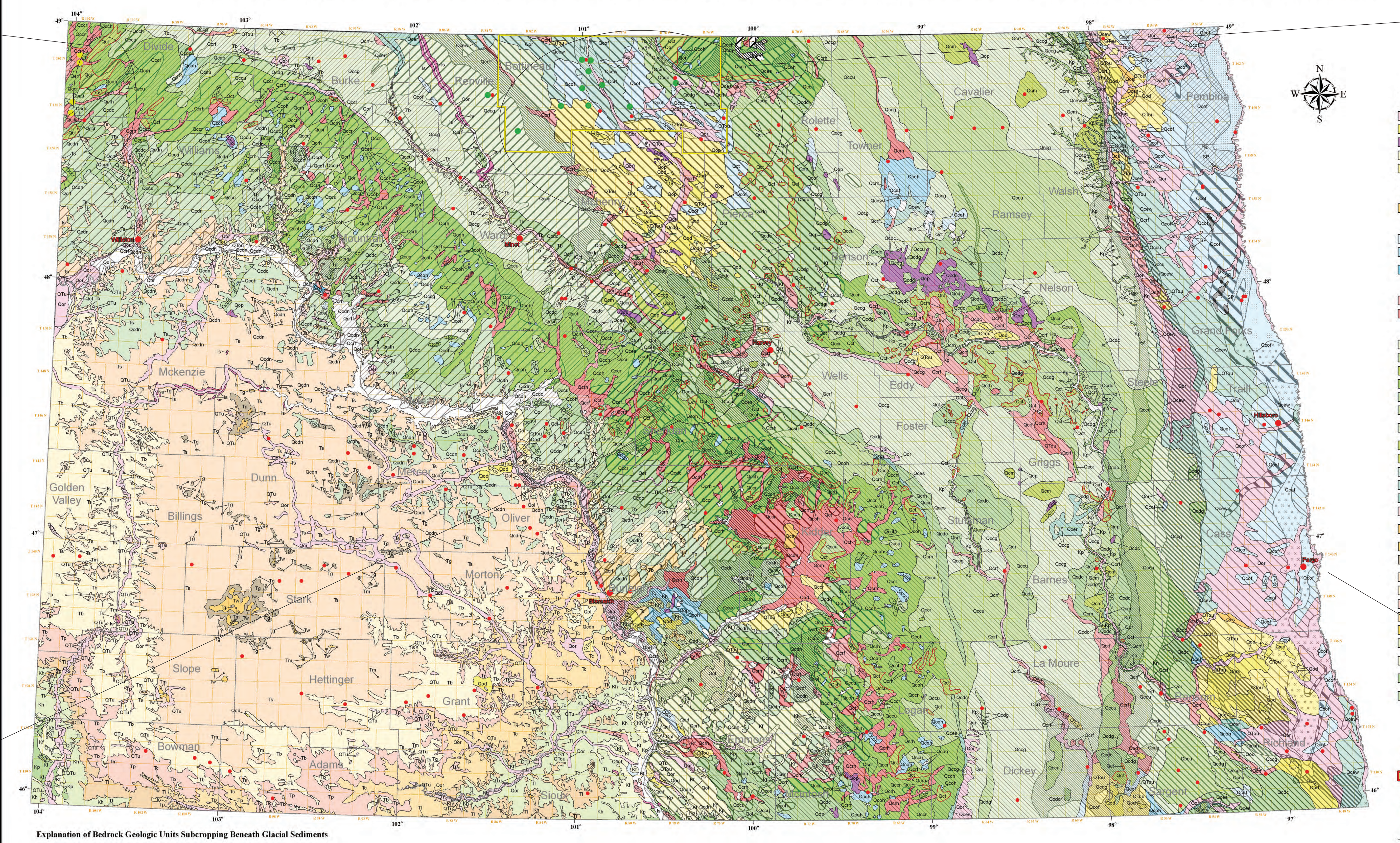






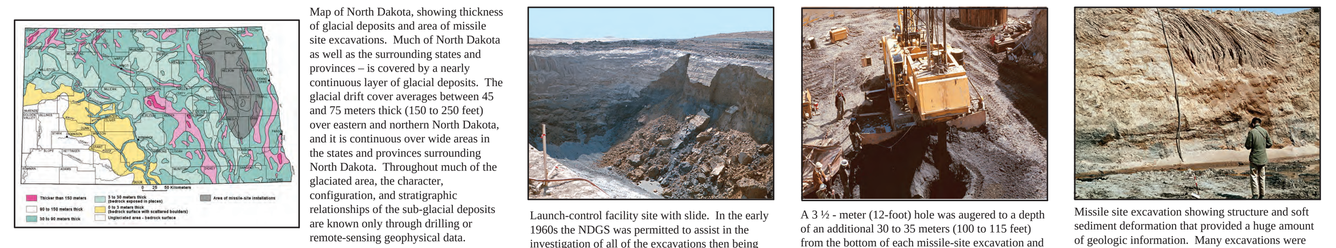


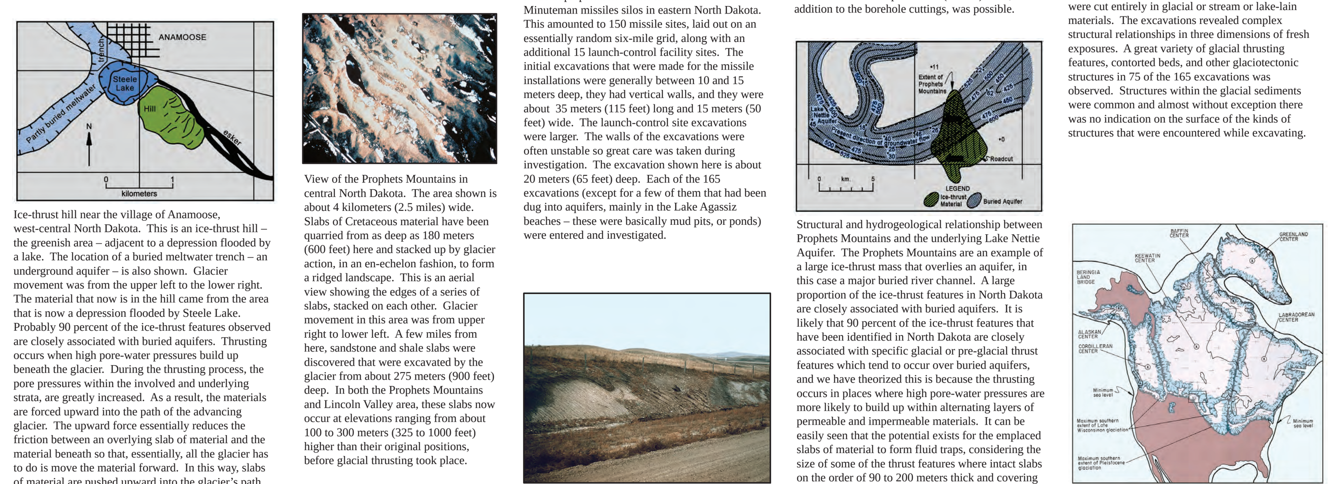
Relationship of Surface and Subsurface Geology and Occurrences of Shallow Natural Gas in North Dakota



GIS Map Compilation by Elroy L. Kadrmas

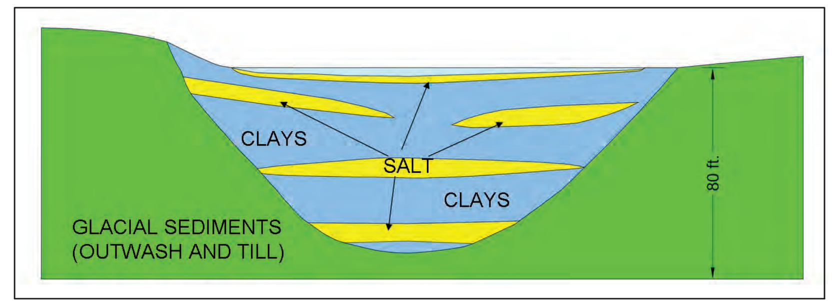
Possible Occurrence of Shallow Gas Resulting from Glacial Processes in the Northern Great Plains



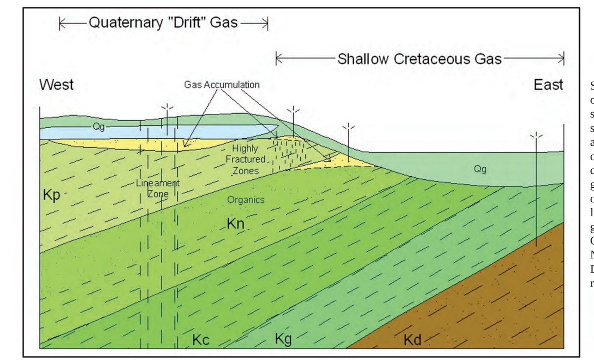


Conceptual Geologic Models of Shallow Natural Gas Occurrence

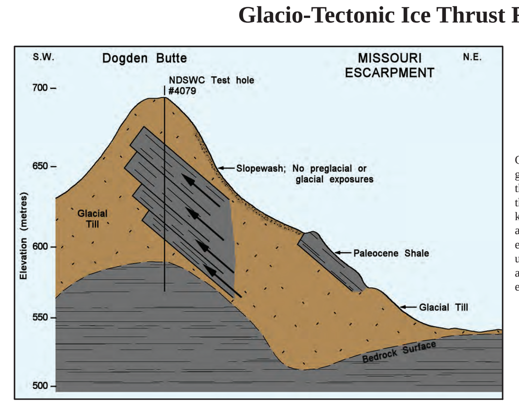
Playa Lake Setting in Northwestern North Dakota



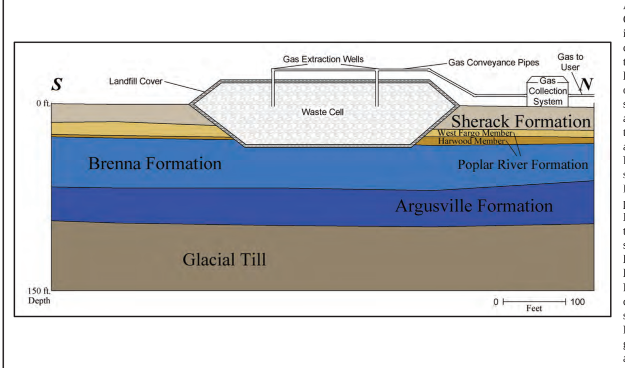
Glacial Drift and Shallow Cretaceous Geologic Setting



Glacio-Tectonic Ice Thrust Features



Anthropogenic Gas: Fargo Landfill in North Dakota



ABSTRACT

Shallow natural gas occurs within several near surface geologic environments in North Dakota. Occurrence has been observed or inferred to originate within glacial sediments accumulating as the result of glaciotectonic processes and anthropogenic means. Historically, gas has been produced from fields in Renville and Bottineau Counties. Geologic conditions and potential sourcing consist of a subcrop of Cretaceous marine sediments scoured and mantled by glacial sediments with contained organics as a potential source. Glaciotectonic ice-thrust masses, several square kilometers in areal extent, and structures within Cretaceous units, may impose structural control on shallow subsurface fluid flow. The advance and retreat of glacial ice across the northern Great Plains and subsequent sediment unloading may influence development of horizontal partings and vertical fracturing within glacial sediments and underlying sedimentary strata providing conduits for shallow gas flow. Gas-rich deposits of sodium sulfate up to 80 feet thick beneath 15 playa lakes in northwestern North Dakota consist primarily of black, organic-rich clays and crystalline layers of sodium sulfate of Holocene age. Borehole gas emanations and gas pockets beneath salt layers were observed along with gas escaping from vents on the bottom of Miller Lake in Divide County. Anthropogenic methane generation within landfills occurs in Minot, Harvey, Williston, Grand Forks, and Hillsboro representing a local gas resource with more than 400 cfm of gas extracted from a recently installed gas collection system in Fargo. Over 300 MCF of gas has been used locally, since system construction, as an alternative industrial fuel source.

REFERENCES

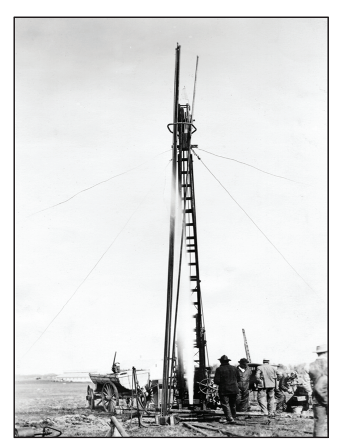
Anderson, F.J., and Murphy, E.C., 2005, Two Unconventional Sources of Methane in North Dakota, Geological Society of America, Abstracts with Programs, North Central Section, Volume 37, Number 5, p. 28.

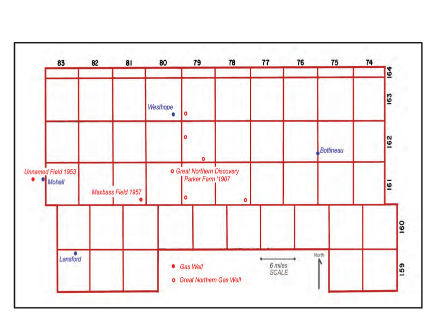
Barry, J.G., 1908, The Bottineau Gas Field, North Dakota Geological Survey, 5th Biennial Report, pp. 247-251.

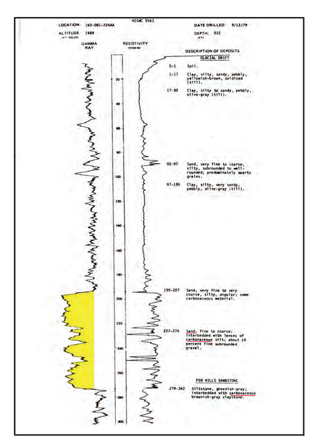
Natural Gas Production from Outwash in North Central North Dakota

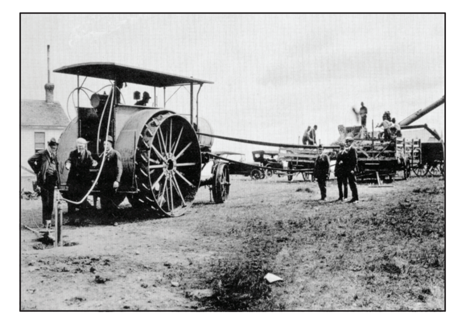
The reported production history (Figure 7) for the field averaged about 60 million cubic feet (MCF), including a minimum of 45 MCF produced and a maximum of 78 MCF per month.

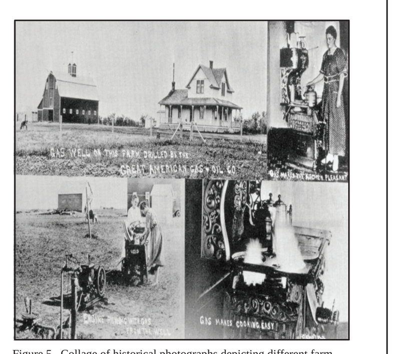
stratigraphy. As evidenced in the Parker Farm reference log (Figure 3) a well developed section of potentially carbonaceous sands is described at the base of the well which is trapped by

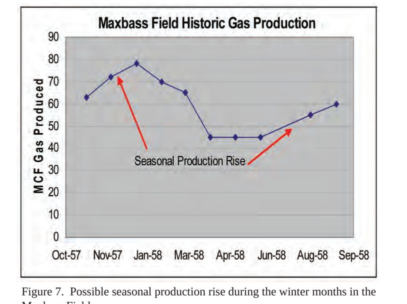


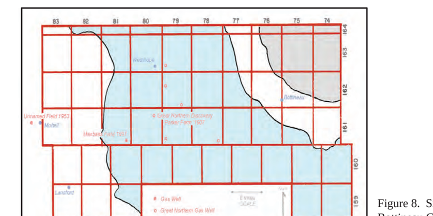


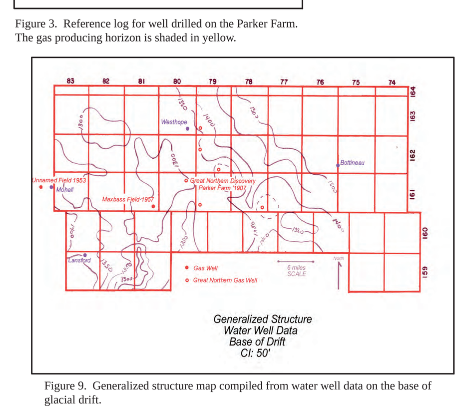


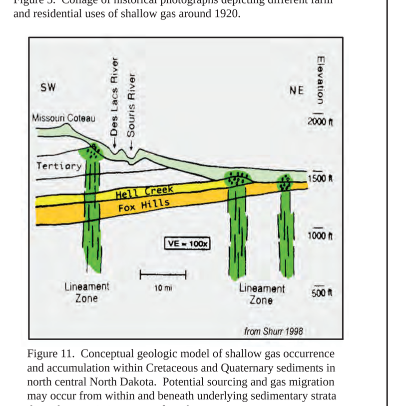






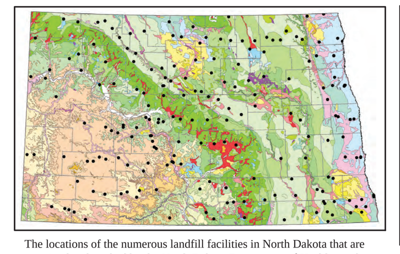


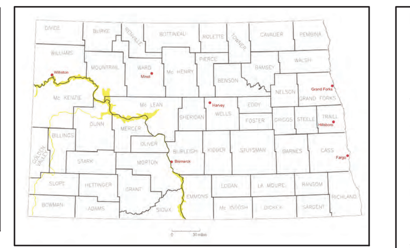




Important Questions for Exploration Consideration

Anthropogenic Methane Generation Potential at North Dakota Landfill Facilities





Estimation of Landfill Methane Generation Flow Rate[1]

$$Q_{CH4} = L_oR\,(e^{-kc} - e^{-kt})$$

where,

Q_{CH4} = maximum expected methane generation flow rate (cubic meters per year)

L_o = methane generation potential (cubic meters per Megagram solid waste)

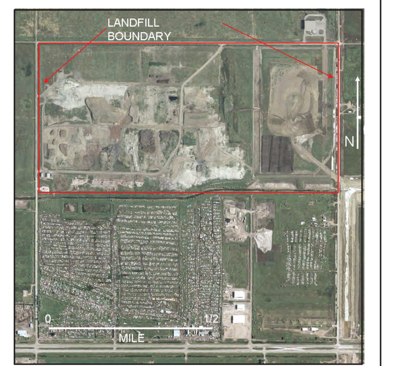
R = average annual acceptance rate (Megagrams per year)

k = methane generation rate constant (yr^{-1})

t = age of the landfill (yr)

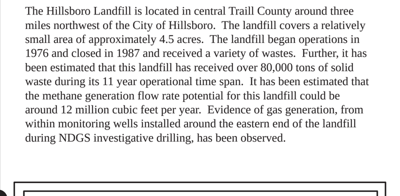
[1] EPA, AP-42

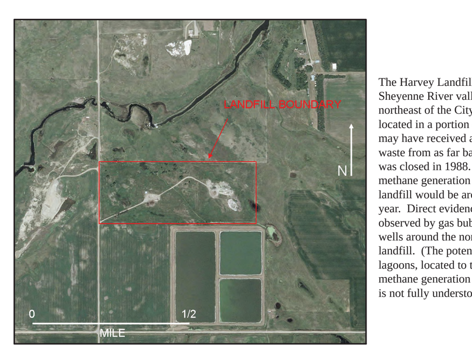
Estimation of Methane Generation Potential. Site specific information for each of the selected landfill locations was collected and applied to an equation for the estimation of methane generation flow rate at each landfill facility. This equation was used at each of the selected locations, using best available site specific information on waste amounts, with a few assumptions, in order to estimate the maximum expected methane generation flow rate for each landfill.



The Hillsboro Landfill ... 1976 and closed in 19... been estimated that ... around 12 million cub... within monitoring we... during NDGS investig...

View to the North/Northeast of the Williston Landfill. The Williston landfill is located approximately one mile west of the City of Williston situated within a north-south trending ... overlooking Sand Creek. The ... approximately 18 acres and has ... 190,000 tons of solid waste, ... and was in operation ... Waste placement occurred ... of the drainage ravine. ... along the central portion of ... It has been estimated that the ... flow rate potential for this ... around 12 million cubic feet per ... infiltration across the waste ... also been observed which could ... conditions for methane ... waste cell.





... 18 in the lined area and 2 in the unlined areas that were installed in 2001. From June 2002 through August 2003 the City of Fargo has sent approximately 146M cubic feet of landfill gas to local industry for use as an alternative fuel source. It has been estimated that the methane generation flow rate potential for this landfill would be around 255 million cubic feet per year.

... City of Grand Forks. The landfill began operations in 1965 and has received many different types of solid waste (MSW, inert, yard waste, etc.) throughout its history, and is currently active. It has been estimated that the methane generation flow rate potential for this landfill would be around 273 million cubic feet per year.

... is located on the edge of the ... around a mile and a half ... of Harvey. The landfill was ... an abandoned gravel pit and ... much as 170,000 tons of ... as the 1930's. The landfill ... It has been estimated that the ... flow rate potential for this ... around 6 million cubic feet per ... for methane generation was ... sampling from within monitoring ... north-northwest portion of the ... effect of the wastewater ... south of the landfill, on ... within the shallow groundwater ...

Estimated Maximum Potential Methane Generation for Selected ND Landfills

Landfill Location	Waste Amount[1] (Mg)	Average Annual Acceptance Rate R (Mg/yr)	Landfill Age t (yr)	Time Since Closure c (yr)	Methane Generation Factor[2] ($e^{-kc}-e^{-kt}$)	Max. Expected Methane Generation Q_{CH4} (Mft^3/yr)
City of Fargo (Active)	2,696,775	107,871	25	0	0.39	255
City of Grand Forks (Active)	3,636,364	82,727	40	0	0.55	273
Old Minot Landfill	249,113	24,911	44	34	0.09	14
Hillsboro	73,361	6,669	45	18	0.29	12
Williston (Sand Creek)	172,900	9,606	35	18	0.20	12
Harvey	155,711	3,114	50	17	0.34	6

[1] Methane generation potential L_o (m^3/Mg sw) = 170
[2] Methane generation rate constant k (yr^{-1}) = 0.02

A summary table of the values used for the variables in the methane generation flow rate estimation equation. Each of the landfills looked at in this work are presented here in descending order of methane generation flow rate. It is interesting to note the difference between the rates in methane generation between the active and closed facilities – the active facilities capable of considerably higher amounts of landfill methane over time.

Conclusions

- Anthropogenic me... several landfill loc... extracted at one lo...
- A potential for add... and anthropogenic ... throughout North ...