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OAKLAND COUNTY MICHIGAN

Center for Applied Environmental Research
University of Michigan-Flint

Arsenic, Nitrate, and Chloride in Groundwater, Oakland County, Michigan

INTRODUCTION

In 1996, the U.S. Geological Survey (USGS), in cooperation with the Michigan Department of Environmental Quality (MDEQ) and nine southeast Michigan counties, began a study of the factors controlling arsenic concentrations in drinking water. The early results of this study raised broader concerns in Oakland County about the quality of groundwater in general and drinking water in particular. In response to these concerns, Oakland County worked with the USGS and the Center for Applied Environmental Research at the University of Michigan - Flint (CAER) to study distributions of arsenic, nitrate and chloride in groundwater, with emphasis on sites where concentrations of these constituents exceeded the Maximum Contaminant Levels (MCL's) and Secondary Maximum Contaminant Levels (SMCL's) set by the U.S. Environmental Protection Agency. The maps produced for this report are based on historical data compiled from MDEQ records.

Figure 1. *A new well being drilled in Oakland County. Over 3,000 new drinking-water wells are drilled each year in Oakland County.*

ARSENIC

Arsenic is a naturally occurring element in the environment. Historically, arsenic compounds have been used in the manufacture of pesticides, metal products, pigments and dyes, and medicine. Concentrations of arsenic in water have been expressed in a variety of ways: milligrams per liter (mg/L), micrograms per liter (µg/L) or parts per billion (ppb). These units can be compared as follows: 1 mg/L = 1,000 µg/L = 1,000 ppb. The U.S. Environmental Protection Agency (1996a) MCL for arsenic in drinking water is 0.05 mg/L, 50 µg/L or 50 ppb.

What is the source of arsenic in groundwater?

Arsenic is the twentieth most common element in the Earth's crust, and is present in the soil and rocks of Oakland County. Arsenic in groundwater is usually a result of arsenic minerals dissolving naturally over time.

Where does arsenic occur in Oakland County?

Low concentrations of arsenic can be found in wells all across Oakland County, but only 24 wells out of 2,373 sampled (about 1 percent) exceeded the MCL. Most of these wells are in the northern and northwestern parts of the county, with all but five in Brandon, Groveland, Holly, or Independence Townships (fig. 2). The highest arsenic concentration detected in Oakland County is 221 µg/L (221 ppb).

Arsenic is present in all of the major aquifers of Oakland County, including the glacial drift, the Marshall Sandstone, and the Coldwater Shale, although it does not appear to occur in very shallow (<40 ft) wells completed in glacial drift. Testing conducted as part of this study found arsenic

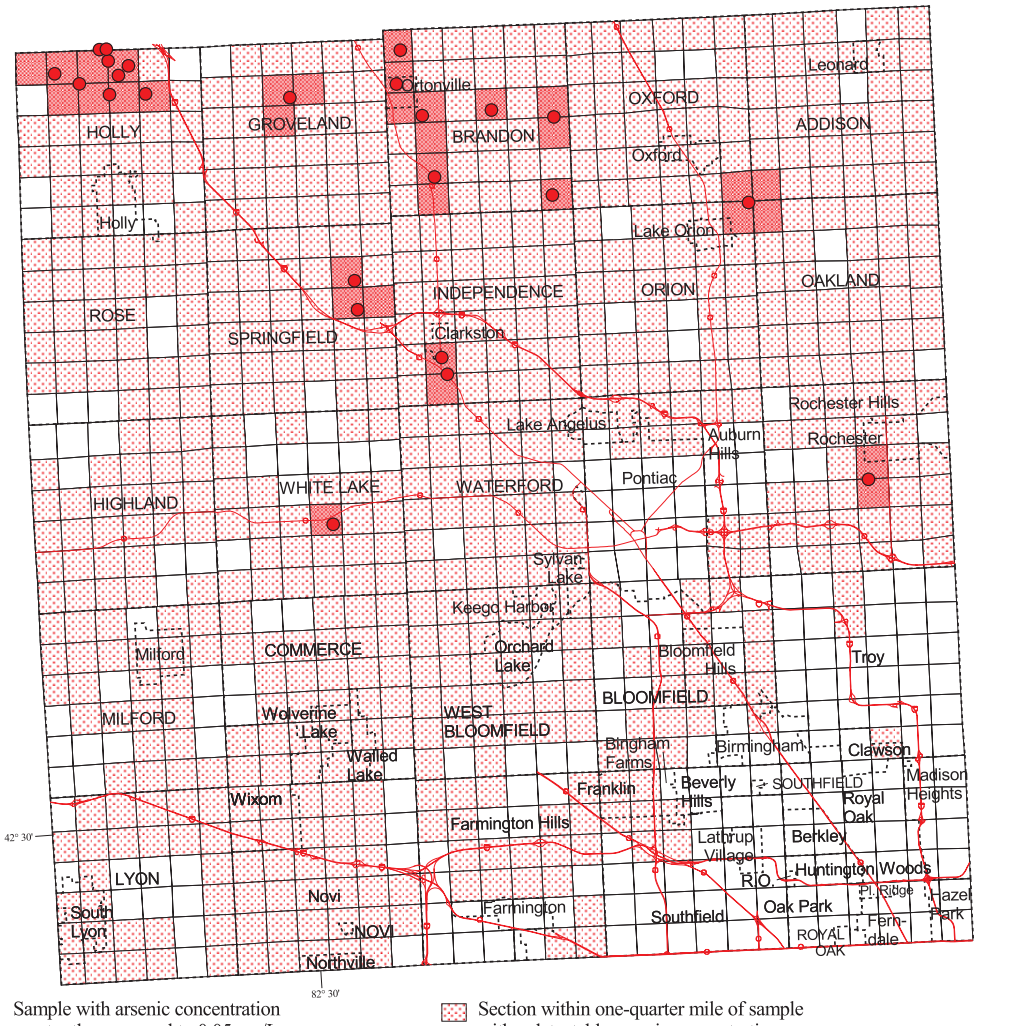
concentrations in groundwater comparable to historical Oakland County Health Division (OCHD) and MDEQ measurements.

Is arsenic in drinking water a concern?

The health effects of arsenic depend on the amount consumed (measured in µg). This amount is determined by the concentration of arsenic in the water (measured in µg/L) and the quantity of water consumed (measured in L). A person who drinks 2L (eight 8-ounce glasses) of water per day containing arsenic at a concentration of 50 µg/L, which is the MCL, would consume about 100 µg of arsenic per day. Individuals consuming up to 500 µg of arsenic per day are unlikely to experience any symptoms of illness, but may increase their long term risk of cancer (Kosnett, 1997).

Persons consuming more than 500 µg of arsenic per day for several years may exhibit certain chronic health problems, including a characteristic pattern of skin abnormalities, a tingling sensation in the extremities, or anemia (Kosnett, 1997). Persons regularly consuming more than 1,500 µg of arsenic per day may experience fatigue, gastrointestinal disturbances, and certain types of heart problems (Kosnett, 1997). To have this highest level of exposure, a person would have to regularly consume 2L (eight 8-ounce glasses) of water containing nearly 750 µg/L of arsenic. This is more than 3 times the highest concentration observed in Oakland County, and 15 times greater than the MCL.

Arsenic is classified as a carcinogen by the U.S. Environmental Protection Agency. Some epidemiological studies have suggested that consuming arsenic, even at levels less than 500 µg of arsenic per day, may increase the lifetime risk of lung, bladder, kidney, liver, and skin cancers (Kosnett, 1997). The MCL is currently under review by the U.S. Environmental Protection Agency to incorporate consideration of cancer risks in the standard.



Sample with arsenic concentration greater than or equal to 0.05 mg/L

Section within one-quarter mile of sample with arsenic concentration greater than or equal to 0.05 mg/L

Section within one-quarter mile of sample with a detectable arsenic concentration

Section where arsenic was not detected or no sample was available

SOURCES: Michigan Department of Environmental Quality 1983-1997 (excluding 1991-92)
Michigan Department of Natural Resources, Michigan Resource Information System (MIRIS), 1978

***Figure 2**. Oakland County arsenic distribution.*

Important Points About Arsenic

- ***Arsenic occurs naturally in groundwater as arsenic minerals dissolve over time.***
- ***Arsenic concentrations in 24 out of 2,373 wells (1%), exceeded the MCL of 0.05 mg/L (50 µg/L or 50 ppb).***
- ***Low concentrations of arsenic are present in all the major aquifers of Oakland County.***
- ***Immediate reactions to arsenic in drinking water are unlikely at the concentrations found in Oakland County.***
- ***The health effects of arsenic depend on the concentration of arsenic in drinking water and the amount of water consumed.***
- ***OCHD recommends that all private well owners test regularly for arsenic.***

NITRATE

Nitrate is formed when oxygen in air or dissolved in water combines with nitrogen. The U.S. Environmental Protection Agency (1996a) has set a MCL of 10 mg-N/L (milligrams of nitrogen per liter) for nitrate in drinking water. Nitrate can occur naturally in precipitation, at concentrations typically around 1 mg-N/L. Elevated concentrations, particularly those greater than 3 mg-N/L, are usually the result of human activity (U.S. Environmental Protection Agency, 1996b).

What is the source of nitrate in groundwater?

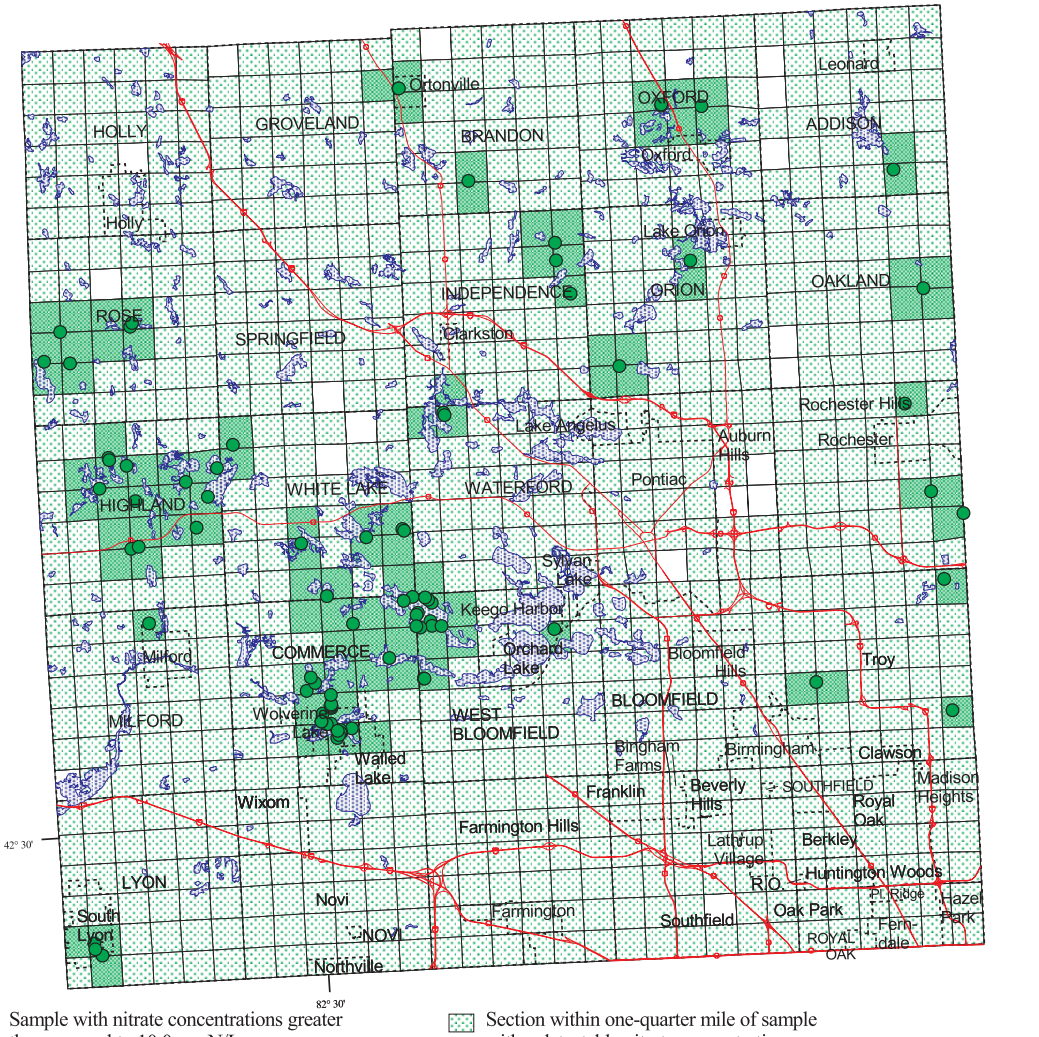
In Oakland County, the likely sources of elevated nitrate in drinking water are septic tank leachate and fertilizers, both of which are rich in nitrogen. Nitrate dissolves readily in water and moves freely with water through soil and rock where it is commonly consumed by microorganisms. Nitrate at concentrations greater than 3 mg-N/L indicates a fairly direct connection between one of the sources listed above and the drinking-water supply.

Where does nitrate occur in Oakland County?

Nitrate concentrations in excess of the 10 mg-N/L MCL have been found in groundwater in most townships in Oakland County (fig. 3). The exceedances often occur in high-density lakeshore communities using on-lot wells and septic systems. As an example, wells within 1 mile of Union Lake, Wolverine Lake, or Commerce Lake account for more than one third of all nitrate concentrations greater than 10 mg-N/L.

Is nitrate in drinking water a concern?

A nitrate standard is required by the U.S. Environmental Protection Agency because nitrite, which is produced when nitrate is broken down in the body, can impair the ability of the blood to carry oxygen. Elevated nitrate is not typically a concern for healthy people, but fetuses, infants (under 6



Sample with nitrate concentrations greater than or equal to 10.0 mg-N/L

Section within one-quarter mile of sample with nitrate concentration greater than or equal to 10.0 mg-N/L

Section within one-quarter mile of sample with a detectable nitrate concentration

Section where nitrate was not detected or no sample was available

N

0 5 MILES

0 5 KILOMETERS

SOURCES: Michigan Department of Environmental Quality 1983-1997 (excluding 1991-92)
Michigan Department of Natural Resources, Michigan Resource Information System (MIRIS), 1978

Figure 3. Oakland County nitrate distribution.

Important Points About Nitrate

- ***Nitrate concentrations that exceed the 10 mg-N/L MCL have been found in most Oakland County townships.***
- ***In Oakland County, the likely sources of elevated nitrate concentrations in groundwater are septic tank leachate and fertilizers.***
- ***Nitrate concentrations in 96 of 7,814 wells (approx. 1%) exceeded the MCL of 10 mg-N/L.***
- ***Nitrate concentrations of 10 mg-N/L or greater are often found in high density lakeshore communities.***
- ***Elevated concentrations are not typically a problem for healthy people, but they pose a risk to fetuses, infants and the elderly.***
- ***OCHD recommends that all private well owners test regularly for nitrate.***

months), and the elderly are populations at risk. "Blue-baby syndrome" (infantile methemoglobinemia) resulting from high nitrate consumption can be lethal to infants (U.S. Environmental Protection Agency, 1996b).

CHLORIDE

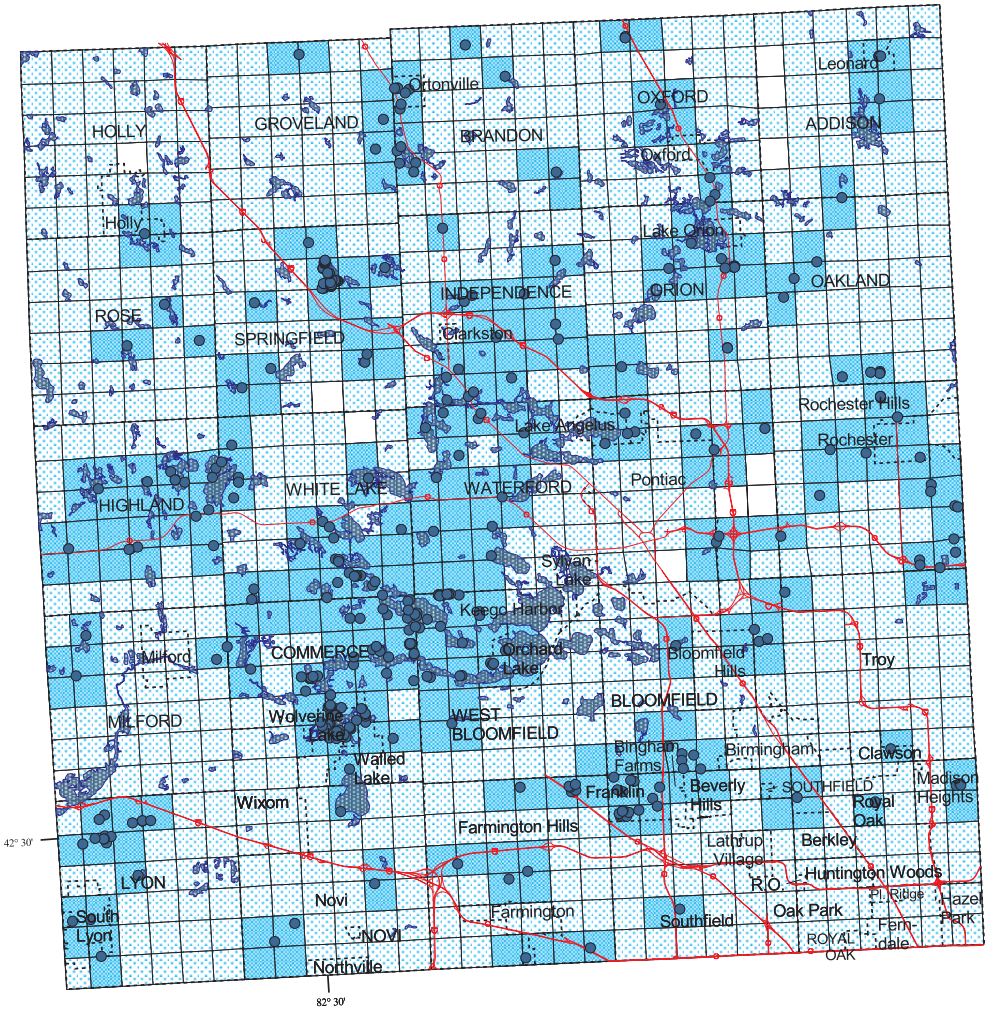
Chloride is an element found in most common salts, such as road salt, table salt, and water-softener salt. The U.S. Environmental Protection Agency (1996a) has set an SMCL of 250 mg/L for chloride. This limit was established because water with chloride concentrations greater than 250 mg/L tastes salty to most people. Chloride is naturally present in groundwater, particularly in deep bedrock aquifers. Background concentrations of chloride in drinking-water wells are highly variable, ranging from less than 10 mg/L in some glacial aquifers to more than 500 mg/L in deeper bedrock wells.

What is the source of chloride in drinking water?

Chloride occurs naturally in some sedimentary bedrock layers, particularly shales. This chloride is a remnant of the seawater present at the time the rocks were formed. Chloride is very soluble in water and moves freely with water through soil and rock. Chloride is not readily consumed by microorganisms, so it is more persistent than nitrate. Road salt, applied for deicing or dust control, may infiltrate the soil and contaminate groundwater. Chloride also may originate from septic tank leachate, as a result of water softening or other activities in the household.

Where does chloride occur in Oakland County?

Chloride concentrations in excess of 250 mg/L are widely distributed in Oakland County (fig. 4). They are commonly associated with high-density lakeshore communities using on-lot wells and septic systems. The chloride found in shallow wells around lakes and in densely populated areas probably comes from salts used in



Sample with chloride concentrations greater than 250.0 mg/L

Section within one-quarter mile of sample with chloride concentration greater than or equal to 250.0 mg/L

Section within one-quarter mile of sample with a detectable chloride concentration

Section where chloride was not detected or no sample was available

SOURCES: Michigan Department of Environmental Quality 1983-1997 (excluding 1991-92)
Michigan Department of Natural Resources, Michigan Resource Information System (MIRIS), 1978

Figure 4. *Oakland County chloride distribution.*

Important Points About Chloride

- ***Chloride occurs naturally in groundwater and is also in most common salts.***
- ***Chloride concentrations in 383 of 7,809 wells (approx. 5%) exceeded the SMCL of 250 mg/L.***
- ***High concentrations are often associated with high-density, lakeshore communities.***
- ***Elevated chloride concentrations may be associated with road salt applications or storage and septic tank leachate.***
- ***Chloride is not generally considered to be a health concern.***
- ***The SMCL of 250 mg/L is based on aesthetic considerations (taste) rather than health considerations.***

What does all this mean?

- ***The maps refer to all areas not serviced by public water. Public water supply wells are routinely monitored to ensure compliance with U.S. Environmental Protection Agency standards.***

- ***Arsenic, nitrate, and chloride were the only constituents addressed in this study. Other potential water contaminants have been observed in Oakland County and may occur in your area. Please contact the OCHD for details specific to your area.***

- ***All the maps support the OCHD recommendation that homeowners regularly test drinking water that comes from wells.***

- ***Each of the chemical constituents evaluated is widely distributed and homeowners should carefully review the county maps to see if their homes are in areas where concentrations above the U.S. Environmental Protection Agency standard have been reported. Township maps, which are included on separate fact sheets, provide more specific details on particular locations.***

- ***Some individuals may be more sensitive than others to contaminants in drinking water. If symptoms persist, OCHD recommends you consult a physician for assistance.***

the household and then discharged through septic systems. Elevated chloride levels also may be associated with road salt application or storage. Several cases have been documented in Oakland County of road salt storage facilities leaching chloride into groundwater.

Is chloride in drinking water a concern?

Chloride is not generally considered to be a health concern. However, some evidence indicates that high chloride intake may pose a hazard to persons with heart or kidney disease (Hutchinson, 1970).

SUMMARY

The distributions of arsenic, nitrate and chloride concentrations in groundwater in Oakland County, Michigan were investigated on the basis of historical water-quality data obtained from MDEQ databases. Results indicate that about 1 percent of the sampled wells had arsenic or nitrate concentrations greater than the U.S. Environmental Protection Agency's MCL. About 5 percent of wells sampled for chloride exceeded the U.S. Environmental Protection Agency's Secondary MCL. Maps provided in this report show the known distribution of arsenic, nitrate, and chloride in groundwater within Oakland County, Michigan.

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Pontius, F., Brown, K., and Chen, C., 1994. Of arsenic in drinking water. Journal of the AWWA, vol. 86, no. 10, p. 52-63.

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U.S. Environmental Protection Agency, 1996b, Environmental indicators of water quality in the United States. Washington, D.C., U.S. Environmental Protection Agency, Office of Water, EPA 841-R-96-002.

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HOW WERE THE MAPS PREPARED?

The MDEQ maintains a database of results from water-quality tests conducted for homeowners and businesses. In this study, maps were prepared from records of tests in Oakland County where arsenic, nitrate and chloride measurements were made. The data spanned the years from 1988 through 1997 (excluding 1991-92).

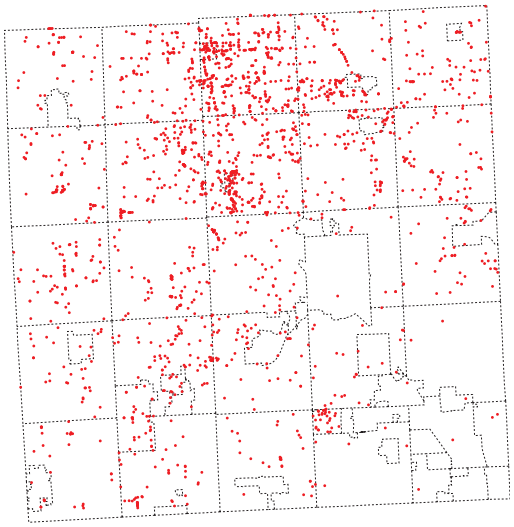
Addresses for each of the records were matched to an Oakland County road file through an address-matching procedure in a Geographic Information System. The address-matching percentage for each constituent indicates how many records were finally mapped (fig. 5). All sites with arsenic concentrations greater than the MCL were mapped. For nitrate and chloride, the success rates were 94 percent and 81 percent, respectively. Data coverage for all the chemical constituents was extensive, although the distribution of test results for arsenic was least concentrated in the southeastern part of the county, where public water supply is most available. The number of nitrate and chloride test results is much greater, and their locations more evenly distributed throughout the county (fig. 5).

To prepare the final maps, locations of wells with a measurement for each of the chemical constituents were plotted on an Oakland county base map. When wells had more than one measurement, the highest measured concentration was used. Wells for which measured concentrations of constituents were higher than the (S)MCL were given point symbols to highlight their distribution in the county. Sections within ¼-mile of the well were highlighted by dark shading ensuring that the maps included both the section in which the well was located and adjoining sections. Sections within ¼-mile of wells with detectable concentrations below the (S)MCL were shaded in a lighter color.

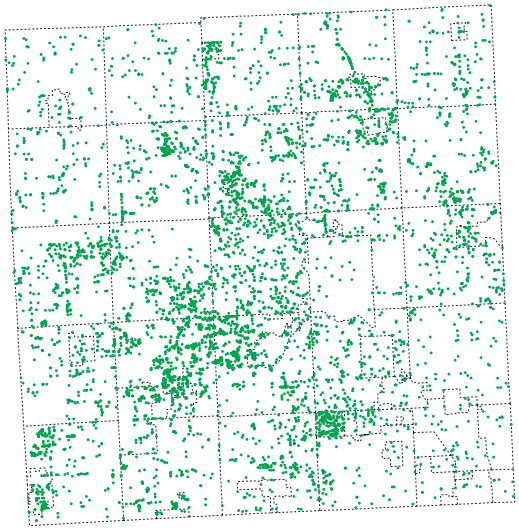
HOW WERE THE SAMPLE DATA COLLECTED AND EVALUATED?

The USGS collected water samples across Oakland County at selected sites with previous analyses for arsenic, nitrate or chloride. Each new sample was collected using clean sampling techniques to minimize the risk of contamination. Duplicate samples were sent to both the MDEQ lab and the USGS National Water Quality Lab (NWQL) in Denver, Colorado. Results from the USGS NWQL were compared against the results from MDEQ and against results from the previous samples. The results from the MDEQ lab agreed very closely with the results from the USGS NWQL. This sample testing confirmed the validity of using the MDEQ database in maps prepared for the study.

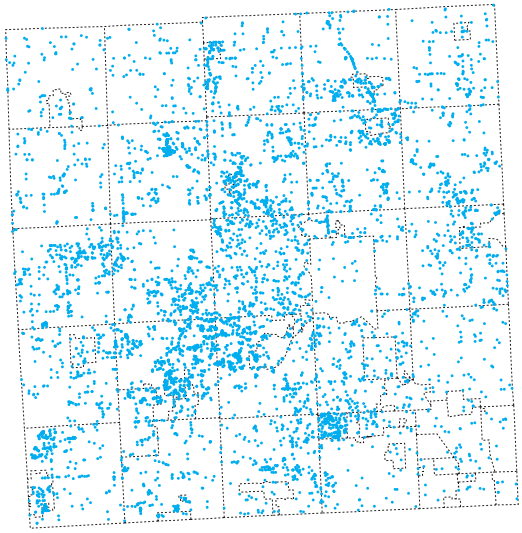
Figure 5. *Locations of well records used to prepare the county maps*



Total arsenic samples: 3,509 Total unique locations: 2,373
Unique locations mapped: 1,988 (84%)



Total nitrate samples: 12,942 Total unique locations: 7,814
Unique locations mapped: 6,198 (79%)



Total chloride samples: 12,960 Total unique locations: 7,809
Unique locations mapped: 6,228 (80%)