Facing east from bluffs of Oak Creek's source water area at Lake Michigan shoreline
Photograph courtesy of E.J. Judziewicz

Source Water Assessment
For Oak Creek Water Utility

Oak Creek, Wisconsin
May 16, 2003

A report provided by the
Wisconsin Department of Natural Resources
Bureau of Drinking Water and Groundwater

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DEPT. OF NATURAL RESOURCES

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Summary

The 1996 amendments to the Safe Drinking Water Act require that States complete source water assessments for all public drinking water systems. The primary purpose of this assessment is to determine the relative susceptibility of Oak Creek's source water to contamination. For this assessment, susceptibility is defined as the likelihood that a contaminant of concern will enter a public water supply at a level that may result in adversely impacting human health. Source water is untreated water from streams, rivers, lakes, and groundwater aquifers. A susceptibility determination is based on a stepwise synthesis of information regarding the well or surface water intake vulnerability and the source water's sensitivity to a potential source of a contaminant of concern. Due to the vulnerable nature of surface water, most drinking water systems utilizing surface water are determined to have high levels of susceptibility to source water contamination.

Affordable, safe drinking water is essential to the health, development and stability of all communities. Conventionally, treatment has been the only step in maintaining safe drinking water for surface water systems. The quality of your community's drinking water is a function of the pretreatment water quality. Little concern has been paid to a preventive approach of protecting the source water. One of the best ways to ensure safe drinking water is to develop a local program designed to protect the source of drinking water against potential contamination. Not only does this add a margin of safety, but it also raises the awareness of consumers and/or the community of the risks of drinking water contamination. It is expected that source water assessment results will provide a basis for developing a source water protection program.

The City of Oak Creek, Wisconsin is located in the southeastern portion of the state. Oak Creek Water Utility receives most source water directly from Lake Michigan to provide treated drinking water to its more than 20,000 consumers. Oak Creek Water Utility also maintains 3 groundwater wells, which currently supply a small amount of drinking water. Oak Creek Water Utility also provides drinking water to an additional 26,000 consumers serviced by the Caddy Vista Sanitary District, the Crestview Sanitary District, the Town of Franklin and the North Park Sanitary District.

A source water area is the area that contributes source water to the public drinking water system. Lake Michigan drains approximately 45,600 square miles. Due to its size and diverse variety of land covers, it is not feasible to assess the impact of the entire Lake Michigan drainage basin on Oak Creek's source water. In an attempt to improve source water quality at a practical scale, the WDNR delineated local source water areas based on watersheds that may specifically impact source water entering the Oak Creek surface water intakes. Source water areas for groundwater systems were based upon local geology. It is important to note that a surface water source water area is only one potential factor in the quality and susceptibility of source water. Other factors may include unmanageable, lake-wide episodic events that have little to do with human activities.

Located in Southeastern Wisconsin, Oak Creek's delineated source water area is 19 square miles. The source water area is composed of the Windpoint Watershed and is drained by two perennial streams and multiple intermittent streams, which are prone to highly fluctuating stream flows. Soils in the source water area are relatively impermeable red clays and clayey loams. Land uses include a mix of agriculture and urban areas with little natural vegetative cover. Though not originally part of the delineated source water area, the Oak Creek Watershed, located to the north of the Windpoint Watershed, was determined to play a role in localized water quality of the source water.

Oak Creek Water Utility has reliably provided its customers with high quality drinking water. The method of water treatment practiced by Oak Creek Water Utility includes flocculation, sedimentation, filtration and chlorination. The capacity of this water treatment facility is 15 million gallons per day (mgd). There is a year round daily average demand of 7-mgd. Water drawn from the Oak Creek wells is chlorinated prior to distribution.

As with most surface water systems, Oak Creek's surface source water is impacted by the source water area and highly susceptible to contamination. This is due to land usage in the source water area, proximity of potential contaminant sources and the intakes' distance and relative direction from the discharge of a large stream. Potential negative impacts from the source water area include sewer overflows and runoff from urban and agricultural activities. More information on source water protection can be found at http://www.epa.gov/safewater/protect.html.

The Oak Creek Waterworks system has moderate susceptibility to contamination by volatile organic compounds (VOCs), synthetic organic compounds (SOCs), nitrate, and microbes. The system has low susceptibility to ethylene dibromide (EDB) and inorganic compounds (IOCs). See Appendix B for an explanation of the susceptibility determination process.

There is no wellhead protection plan or ordinance for the Oak Creek wells. Protection activities should focus on obtaining additional information on the potential sources of contamination in the area to evaluate and manage their risk. Other efforts should include implementing a wellhead protection plan, and identifying and managing improperly abandoned wells or other features that may provide direct pathways for contamination to enter the aquifer. More information on Wisconsin's wellhead protection program is available at http://www.dnr.state.wi.us/org/water/dwg/gw/wellhead.htm

A paper copy of the detailed assessment is available at the Oak Creek Public Library. An electronic version of the detailed assessment is accessible on the Wisconsin Department of Natural Resources website at http://www.dnr.state.wi.us/org/water/dwg/gw/SWP.HTM

Introduction

In 1996, the U.S. Congress amended the Safe Drinking Water Act to provide resources for states to conduct Source Water Assessments. Information about Wisconsin's Source Water Assessment Program can be found on the Wisconsin Department of Natural Resources (WDNR) website mentioned previously. In cooperation with other Great Lakes states, WDNR has developed a method--Wisconsin's Source Water Assessment Program, Appendix R (Assessment Protocol for Great Lake Sources)--for conducting Source Water Assessments for water supplies that use the Great Lakes as their water source. A source water assessment involves identifying a source water area, analyzing the sensitivity of the source to natural conditions, conducting potential contaminant source inventories and determining the susceptibility of the source to contamination.

The requirements for public water supplies in Wisconsin to meet U.S. Environmental Protection Agency maximum contaminant levels (MCLs) provide a base level of assurance of safe drinking water. However, all systems are vulnerable to some degree to potential contamination. With this in mind, susceptibility determinations were made qualitatively relative to other systems.

Purpose of this Assessment

The purpose of this source water assessment is to determine the susceptibility of Oak Creek's source of drinking water to contamination and to make recommendations on how to help protect this valuable resource

Safe, affordable drinking water in ample supply is essential to the health, development and stability of all communities. Conventionally, treatment has been the only step in maintaining safe drinking water for surface water systems and little concern has been paid to a preventive approach of protecting the source water. The quality and cost of treated drinking water is often a function of pretreatment source water quality.

Source water quality can be improved through the implementation of a source water protection program. A source water protection program is composed of four steps: assessment, planning, implementation and long term management. By assessing localized impacts on source water quality, this assessment completes the first step in a source water protection program. For more information on completing a source water protection program please visit http://www.epa.gov/safewater/protect/protect.html on the World Wide Web.

Source Water Contaminant Categories

Contaminants can enter source water through various means. Pathways of contamination can be split into two major categories, point source pollution and nonpoint source pollution. Point source pollution includes specific, identifiable dischargers of contaminants. Examples of these include industrial and municipal wastewater outfalls. Point source dischargers are more easily regulated and held accountable for contaminating source water. Nonpoint source pollution comes from no specific source and diffusely enters source water. Nonpoint source pollution includes contaminated runoff and atmospheric deposition. Examples of nonpoint source pollution are runoff from agricultural and urban land covers and atmospheric deposition from burning of fossil fuels.

Source water contaminant categories include microbial, inorganic, synthetic organic, volatile organic, disinfection by-product precursors and radioactive contaminants. This assessment describes these general contaminant categories associated with potential contaminant sources. For a more detailed description of contaminants associated with potential contaminant sources please visit http://www.epa.gov/OGWDW/swp/sources1.html on the World Wide Web. For information on health effects and methods of protection from particular chemical contaminants please visit http://www.epa.gov/safewater/hfacts.html on the World Wide Web.

- *Microbial contaminants*, such as viruses and bacteria, which may come from sewage treatment plants, septic systems, agricultural livestock operations, and wildlife. Microbial contaminants can lead to widespread acute illnesses in customers of a contaminated drinking water system. Examples of microbial contaminants include *Giardia*, *Cryptosporidium* and *E. coli*.
- *Inorganic contaminants*, such as salts and metals, which can occur naturally or result from among other sources, urban storm water runoff, industrial or domestic wastewater discharges, oil and gas production, mining, or farming. Among other detrimental health affects, inorganic contaminants can negatively impact various organs and the circulatory system in the human body. Some examples of inorganic contaminants include nutrients such as nitrogen and phosphorous and heavy metals such as cadmium, lead and mercury.
- *Synthetic organic contaminants*, such as industrial products, pesticides and herbicides, which may come from a variety of sources such as agriculture, storm water runoff, industrial activities, landfills, wastewater treatment facilities and residential areas. As well as being carcinogenic, synthetic organic contaminants can negatively impact the nervous system, liver and kidneys and affect development. Some examples of synthetic organic contaminants include atrazine, polychlorinated bi-phenyls (PCBs) and lindane.
- *Volatile organic contaminants*, such as petroleum products, solvents, cleaners and degreasers, which may come from industrial activities, petroleum production, gas stations, urban storm water runoff, wastewater treatment facilities and septic systems. As well as being carcinogenic, volatile organic contaminants can negatively impact the nervous system, liver and kidneys and affect development. Some examples of volatile organic contaminants include benzene, vinyl chloride and styrene.
- *Precursors of disinfection by-products* lead to the formation of carcinogenic by-products during source water treatment. Some examples of precursors of disinfection by-products include dissolved organic carbon and bromide. Likely sources of dissolved organic carbon are from agricultural and urban storm water runoff.
- *Radioactive contaminants*, can be naturally occurring or be the result of oil and gas production and mining activities. Radioactive contaminants are carcinogenic. Some examples of radioactive contaminants include radium and uranium.

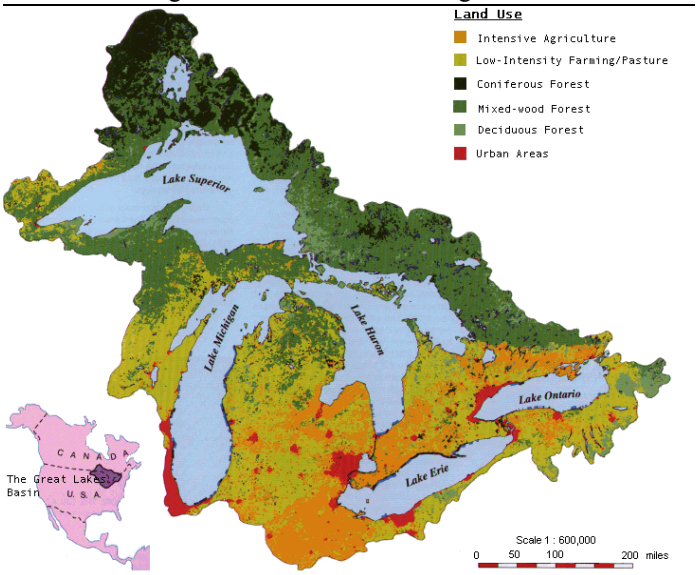
Source Water Assessment for the Oak Creek Surface Water System

Hydrologic Setting

Description of the Source Water Area

As shown in Figure 1, the Great Lakes drains over 200,000 square miles of varying land uses. The size and variety of land uses found in this drainage basin make a basin-wide assessment impractical and ineffective at identifying impacts on Oak Creek's source water. In response to this, the WDNR identified smaller local source water areas that contribute source water to Lake Michigan in close proximity to the drinking water intakes. Source water areas are composed of one or more established watersheds that discharge near the surface water intakes. Source water areas for this assessment were delineated based on WDNR surface watersheds, not groundwater basins. Generally, groundwater basin boundaries are similar to their surface water counterparts but may vary due to geology.

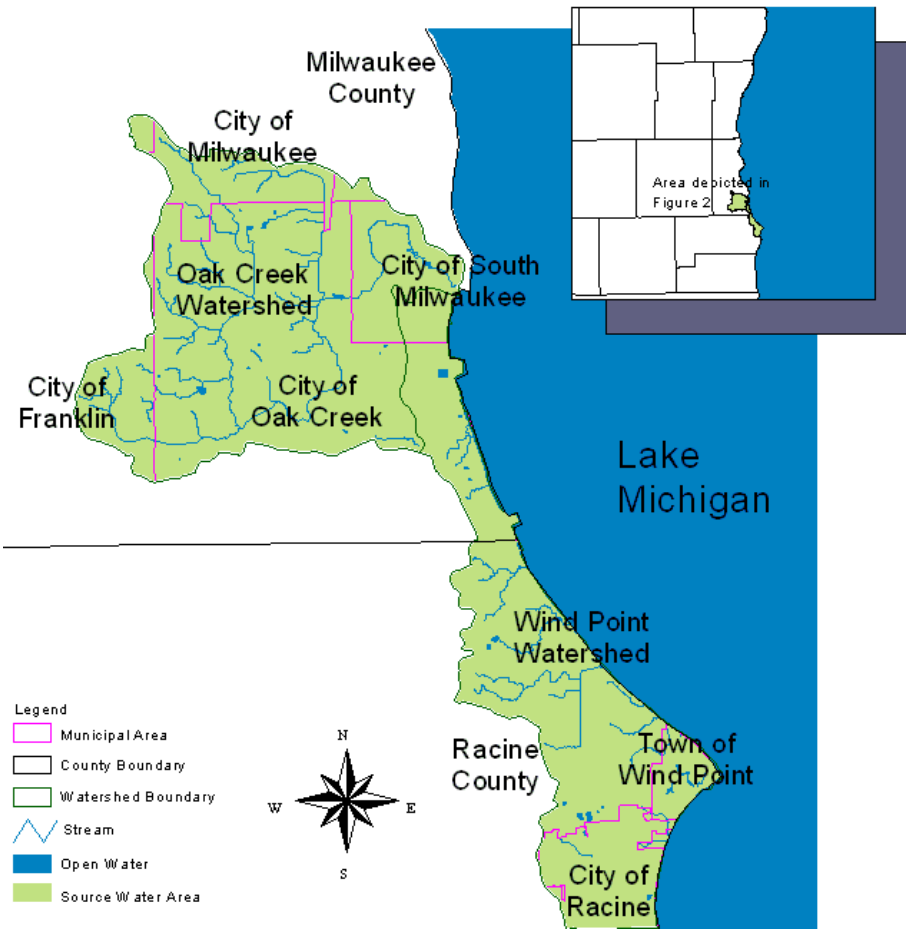
Figure 1: Great Lakes Drainage Basin



As shown in Figure 2, Oak Creek's source water area is located along Lake Michigan in southeastern Wisconsin. It includes portions of Southeastern Milwaukee and Northeastern Racine Counties. The cities and towns of Racine, North Bay, Wind Point, Crestview, Carrolville, Oak Creek and South Milwaukee are located at least partially within the source water area. Oak Creek's source water area is only 19 square miles and is drained by the Wind Point Watershed.

Though not delineated as part of the Oak Creek source water area, the land drained by the Oak Creek may have a significant localized impact on source water at the intakes. This is due to the land use, size and proximity of the Oak Creek Watershed. Located wholly in Milwaukee County, the Oak Creek drains

Figure 2: Oak Creek Source Water Area



approximately 26 square miles of land to the north and northwest of the Windpoint Watershed. As shown in Figure 2, the Oak Creek Watershed encompasses portions of the cities of Green Field, Franklin, Oak Creek, South Milwaukee and Milwaukee.

Hydrology

As shown in Figure 2, two perennial streams and multiple intermittent streams, which discharge independently into Lake Michigan, drain the Windpoint Watershed. These streams are prone to highly variable and erratic stream flows. The relatively impermeable soils and land coverage inhibits water from precipitation from entering into the soil. This water quickly travels overland and enters streams unfiltered. This results in excessively high stream flows during and following periods of spring thawing or heavy precipitation and unnaturally low flows during drier periods of the year. The unfiltered runoff also affects water quality by transporting and depositing contaminants into surface water. Little is known concerning water quality in the streams, which drain the source water area. These streams discharge into Lake Michigan over two miles south of the Oak Creek drinking water intakes. Their highest flows occur during spring and autumn months, but monitoring has not been carried out to measure water flows.

As shown in Figure 2 the Oak Creek originates in the town of Franklin. It flows east receiving flow from the North Branch, which drains largely urban areas. Prior to reaching the City of South Milwaukee, the Oak Creek receives flow from the Mitchell Field Drainage Ditch, which drains a mix of urban and grassland areas. After flowing through the city of Oak Creek and South Milwaukee, the Oak Creek discharges into Lake Michigan less than a mile north of the Oak Creek drinking water intakes. As with streams in the Windpoint Watershed, the Oak Creek is prone to highly variable and erratic stream flows due to runoff. From 1964 to 1999, the Oak Creek's stream flow at the city of Oak Creek was 23 cubic feet per second.

Soils and topography

Soil types in the Windpoint and Oak Creek Watersheds are relatively impermeable flat clayey loams. Large fragile bluffs are typical along the Lake Michigan shoreline near the drinking water intakes. These bluffs have little natural protection and are prone to rapid erosion.

Land cover

Land cover can play a major role in source water quality. Spatial data in Figure 3 was generated based on locational data from 1995.

As shown in Figure 3, urbanized land covers dominate in the southern portions and northern tip of the Wind Point Watershed. Pockets of agricultural lands occur along the western side of the watershed and a large area of unused grassland is located to the west and southwest of the intakes along the Lake Michigan shoreline. Urbanized areas are the dominant land cover in the Oak Creek Watershed.

Residential areas occur throughout the Oak Creek Watershed but are most concentrated in the northern, eastern, central and southwestern. Agricultural cropland and pasture make up the majority of the remaining land cover, particularly in the west. Industrial activities are concentrated in the central portion of the watershed, along transportation corridors and in the city of South Milwaukee. Multiple major transportation corridors, such as railways and highways cross the source water area, as well as arterial and local roads. A large airfield is partly located in the northern portions of the source water area. Small pockets and corridors of natural vegetation, such as wetlands and wood lands dot the source water area but make up a relatively small percentage of the total land coverage. Recreational areas including parks and golf courses also compose a relatively small portion of the Oak Creek Watershed.

- *Residential related land cover*

  Residential areas depicted in Figure 3 include single- and two-family homes, low and high rises and mobile homes, at varying levels of density. Due to high concentrations of impermeable surfaces, such as driveways, sidewalks and roofs, residential land cover has increased potential to create large quantities of runoff during and following precipitation events. Runoff from residential areas transports contaminants associated with this land cover into source water. Contaminants associated with residential land cover include synthetic organic, volatile organic, inorganic, precursors of disinfection

by-products and microbial contaminants. These contaminants can also enter source water from residential areas through spills and atmospheric deposition.

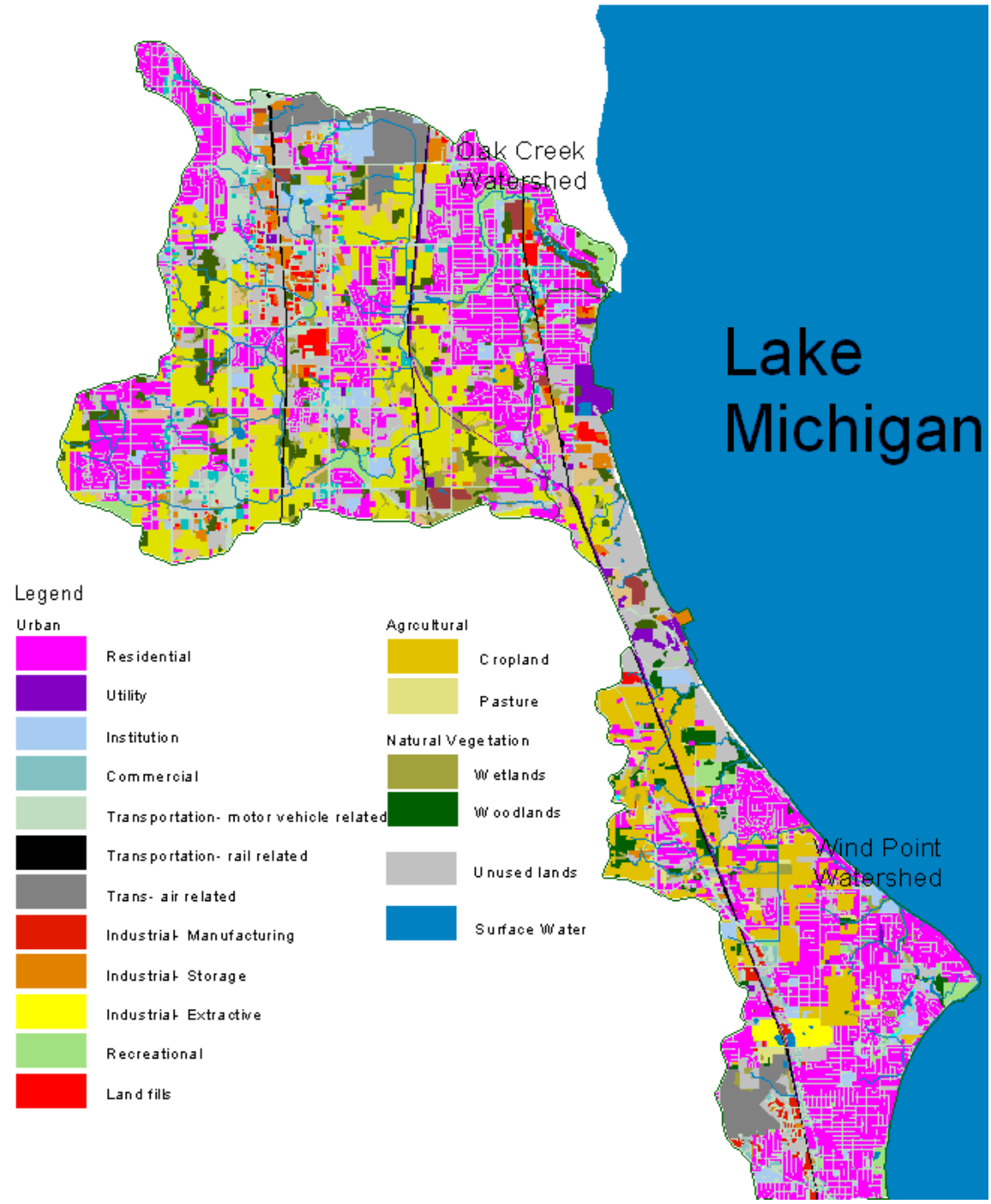
Residential areas are believed to be negatively impacting source water in various streams throughout the Oak Creek Watershed. Particular areas of concern are drained by the headwaters of the Oak Creek and the Mitchell Field Drainage Ditch and the land buffering the lower 4 miles of the Oak Creek. It is unknown if residential related land cover is impacting streams in the Oak Creek Watershed.

- *Industrial related land cover*

  For this assessment industrial land cover includes activities related to manufacturing, wholesale and storage and extractive processes. Similarly to residential land cover, industrial areas have high concentrations of impermeable surfaces, which prevent large amounts of precipitation from infiltrating the ground. This runoff transports contaminants associated with industrial activities into source water. These include volatile organic, synthetic organic and inorganic contaminants. Industrial activities can also lead to contamination of source water through point source discharges, spills and atmospheric deposition.

  Streams in the Oak Creek Watershed being negatively impacted by industrial runoff include the Oak Creek and the North Branch. There are no streams in the Oak Creek Watershed that have been identified as being negatively impacted by industrial point source discharges. Impacts from industrial activity have not been documented on streams in the Oak Creek Watershed.

Figure 3: Land Cover



- *Transportation related land cover*

  For this assessment transportation related land cover includes all forms of motor vehicle corridors and parking lots along with rail-related and air-related forms of transportation. Most all transportation related land cover is impermeable to precipitation. Contaminants associated with runoff from transportation related land cover includes volatile organic, synthetic organic and inorganic contaminants. Contaminants from transportation related land cover could also enter source water through atmospheric deposition and spills.

- *Agricultural land cover*

  For this assessment agricultural land cover includes cropland, pasture, orchards and nurseries. Agricultural practices generally cause the land to be more susceptible to erosion and runoff. Due to common practices and activities, agricultural land cover can be a major source of inorganic, treatment by-product precursors, microbial and synthetic organic contaminants.

- *Natural vegetation*

  For this assessment, natural vegetation includes wetlands, woodlands and some unused lands. Generally, natural vegetation has positive impacts on source water. These impacts include increased infiltration of precipitation into the ground, decreased quantity of storm water runoff, removal of contaminants from source water, reduced potential for erosion and less drastic fluctuations of streamflow.

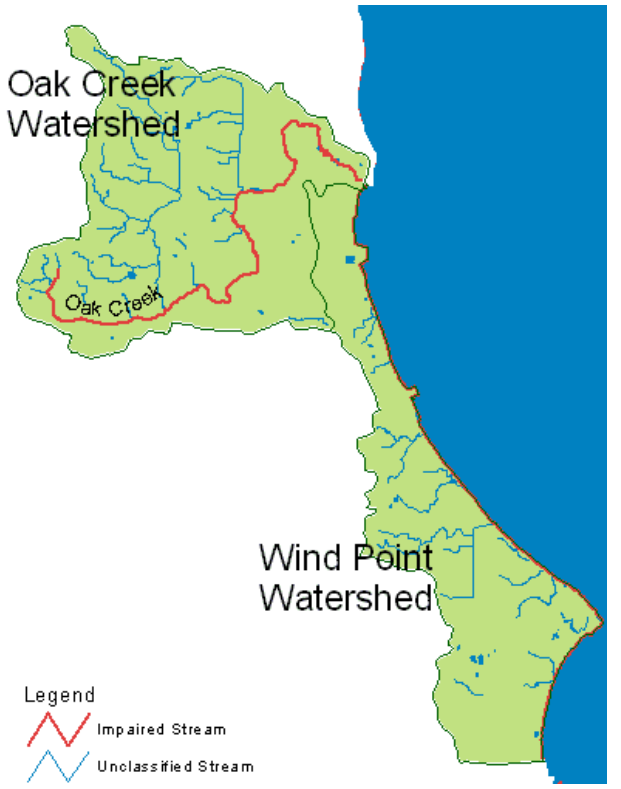
- *Recreational land cover*

  For this assessment, recreational land cover includes public as well as private, land and water related recreational areas. Examples of these include parks, fields, golf courses and beaches. Recreational land cover can affect source water similarly to natural vegetation. However it is also associated with microbial, synthetic organic and inorganic contaminants.

Water quality

Water quality monitoring has been carried out to a limited extent on the three larger streams in the Oak Creek Watershed. Little is known concerning the water quality of the streams that drain the Windpoint Watershed. As shown in Figure 4, the entire lengths of the Oak Creek and the North Branch are considered to be impaired from urban runoff. Impaired waters are defined by the WDNR as waters, which are not meeting water quality standards for specific substances or their designated uses. Urban areas that drain into these streams include Franklin, Oak Creek, South Milwaukee and Milwaukee. There are no exceptional or outstanding water resources in the source water area.

Figure 4: Source Water Quality

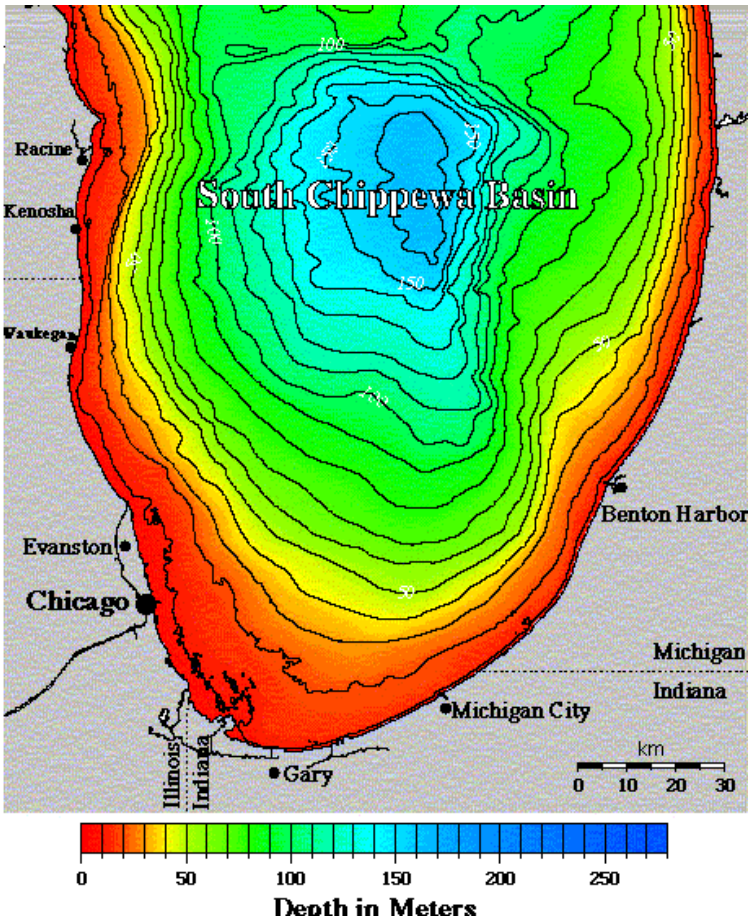


Description of Lake Michigan

Bathymetry

As shown in Figure 5, a shallow area extends parallel to shore, before dropping off into the relatively shallow South Chippewa Basin eight miles east of the primary intake. This relatively shallow area may have a negative impact on source water quality by preventing dilution of contaminants, allowing for more easily suspended lake bottom sediments and creating more variable currents near the intakes.

Figure 5: Bathymetry of southern Lake Michigan



Wind

Wind plays a major role in Lake Michigan currents and water quality in near-shore areas. The prevailing westerly winds gives way to variable easterly and southerly winds during the spring and summer months. Variable winds alter current direction and speed along with causing fluctuations in water quality. Windstorms from any direction can stir up lake bottom sediments, which result in poor source water quality. These events occur most commonly during the winter and spring months.

Currents

Direction and speed of currents in Lake Michigan are highly variable and largely dependent upon wind direction. As shown in Figure 6, unaffected circulation patterns near the Oak Creek intakes travel south as part of a larger southern Lake Michigan counterclockwise rotation. The large shoreline bluffs located near the intakes may lessen the impact of wind on current at the intakes. Easterly and southeasterly winds can quickly reverse the circulation pattern or cause lake water to stagnate along the shoreline near the intakes.

Figure 6: Lake Michigan Currents

Water quality

Water quality in Lake Michigan improves with distance from shore. Nearshore water quality is generally lower and more prone to fluctuations. Nearshore water quality fluctuations frequently occur in spring when precipitation and snow melt transport contaminants from land into Lake Michigan. Fluctuations also occur during windstorms, which can churn up lake bottom sediments. Atmospheric deposition of contaminants occurs near concentrated urban areas.

With distance from shore most contaminants evaporate, settle into the lake bottom sediments or dilute to undetectable levels allowing water quality to reach near drinking water purity. Farther from shore, Lake Michigan contains very low concentrations of drinking water contaminants. Organic chemicals and heavy metals are below Wisconsin safe drinking water standards. The majority of these contaminants enter the lake via nonpoint source pollution and atmospheric deposition. Coliform and microbial contaminants are higher nearshore,

but have been detected farther from shore. Similar to nearshore areas, easterly windstorms can resuspend sediments far from shore, which can cause water quality fluctuations.

It is important to note that water quality of source water at the intakes is based almost entirely on monitoring that occurs at the drinking water intakes. Few contaminants have been comprehensively monitored in source water at the intakes. Water quality near the drinking water intakes is generally of high quality but is prone to fluctuations. Fluctuations include higher turbidity, which coincides with springtime thaws, periods of heavy precipitation and easterly windstorms. Coliform detects in source water occur throughout the year, but pathogens have not been detected at the intakes. Organic contaminants associated with industrial activities have been detected in the source water entering the intakes. While never having reached maximum contaminant levels enforced by the state, carcinogenic water treatment by-products are from May to August.

Susceptibility Assessment

For the purposes of Wisconsin's source water assessments, susceptibility is defined as the likelihood that a contaminant of concern will enter a public water supply at a level that may result in an adverse human health impact. This definition applies to groundwater and surface water-based public water supplies. A susceptibility determination is based on a stepwise synthesis of information regarding the well or surface water intakes vulnerability and the source water's sensitivity to a potential source of a contaminant of concern.

Methodology

For a detailed explanation of the protocol for Great Lake source water assessments please Appendix R of Wisconsin's Source Water Assessment Program Plan Appendices.

An initial survey was performed on the Oak Creek source water area to assess local impacts to the source water. The initial survey included interviewing Oak Creek Water Utility employees, conducting a sensitivity analysis, delineation of a critical assessment zone and reviewing existing data. The initial survey revealed that source water is impacted by local factors.

A more in-depth study of the source water area was carried out to determine what events and which areas within the source water area affect the source water's susceptibility to particular types of contaminants. This more in-depth study reviewed the distribution of potential contaminant sources in the source water area, historical data, localized water quality of tributaries and background water quality levels and characteristics of Lake Michigan.

Sensitivity Analysis

Sensitivity is defined as the likelihood that source water will be impacted by contaminants due to the intrinsic physical attributes of the source water area. Sensitivity is determined from the natural setting of the source water and indicates the natural protection afforded the source water. Factors in sensitivity include hydrologic characteristics of the source water area, proximity, direction and quantity of discharge relative to the intake and degree of dilution afforded by distance from shore and depth of intake. Based on the Great Lakes Protocol for conducting a sensitivity analysis, calculated sensitivity is the product of the intake's distance from shore and the depth of water at the intake. It is important to keep in mind that this does not take into account numerous site-specific variables. Calculations are not included in this document for security reasons. Relative levels of calculated sensitivity include moderate, high and very high.

The calculated sensitivity rating of the primary drinking water intake is moderate. The Oak Creek emergency intake has a high-calculated sensitivity. Neither of these calculated sensitivities takes into account the proximity of nearby municipal wastewater treatment plant outfalls and the mouth of the Oak Creek, which may increase their sensitivities.

Critical Assessment Zone

In keeping with the Great Lakes protocol, a critical assessment zone was delineated based upon the intakes calculated sensitivity. Any land, particularly shoreline, which is within the delineated critical assessment zone, must be part of an in-depth assessment. The zone is a circle centered on the intake. The size of the circle depends on the calculated sensitivity rating. Neither of these critical assessment zones encompass any land.

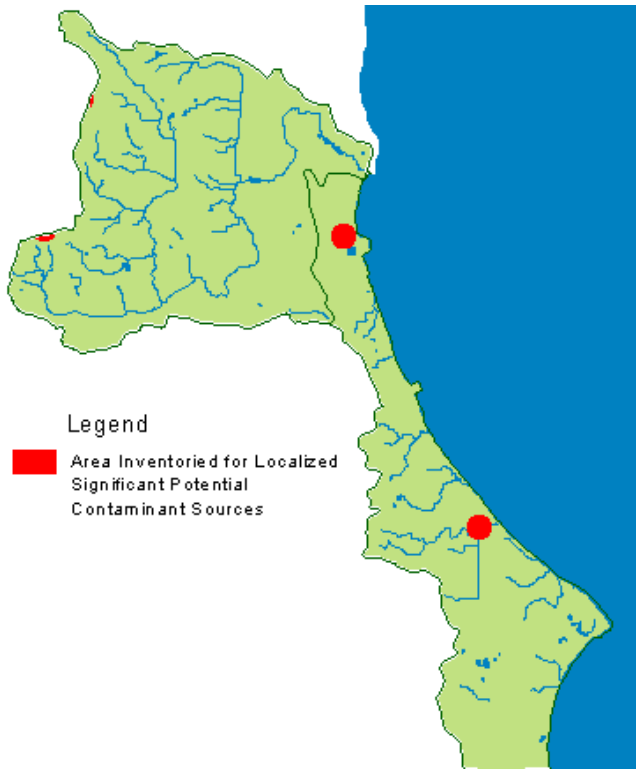
Potential Contaminant Source Inventory

A major component of the susceptibility determination is based on the distribution of potential contaminant sources in the source water area. A high density of potential contaminant sources in the source water area would indicate a higher probability of contaminating source water. Source water from a source water area with a low density of potential contaminant sources would be less likely to become contaminated.

It is important to understand that a potential contaminant source is not necessarily a source of contaminants. It has the potential to become a source of contaminants but if managed properly won't impact the source water.

Data used in the potential contaminant source inventory includes area-wide and localized information sources. Source water area-wide potential contaminant source data is shown in Figure 8. Locational information for localized potential contaminant sources shown on Figure 9 were inventoried only within areas encompassed by the source water areas for ground water systems. Figure 7 depicts the limited amount and distribution of land in the source water area inventoried for localized significant potential contaminant sources. Information concerning the distribution of localized significant potential contaminant sources is not available for land outside of the red areas in Figure 7.

Figure 7: Areas inventoried for localized potential contaminant sources



Landfills

In the past landfills were unregulated and were common sources of contaminants. Some of these are now classified as Bureau of Remediation and Repair Tracking System sites, which are discussed below. Licensed landfills are now strictly regulated and monitored. Closed and active landfills are frequently sources for inorganic, synthetic organic and volatile organic contaminants in source water.

As shown in Figure 8, there are sixteen known landfills in the Wind Point and Oak Creek Watersheds. According to the WDNR 2001 State of the Root-Pike River Basin, landfills are sources of environmental degradation for the Oak Creek and Mitchell Field Drainage Ditch.

Wastewater Treatment Facilities

Wastewater treatment facilities (WWTFs) include municipal and industrial operations. Municipal facilities can be sources of inorganic, microbial, synthetic organic and volatile organic contaminants as well as hormones, pharmaceuticals and other organic contaminants that have been linked to developmental and reproductive defects in animals. Following treatment, effluent is frequently discharged through an outfall directly into surface water. Typical treated and disinfected sewage contains low concentrations of contaminants. During or following a storm event, the municipal WWTF may be inundated with more raw sewage than it can process. In the event of this a bypass or sanitary sewer overflow occurs. This allows untreated sewage to enter directly into surface water. A typical bypass will contain a high concentration of contaminants associated with urban runoff and WWTFs. Contaminants associated with industrial WWTFs are dependent upon the specific industry but may include microbial, volatile organic, inorganic and synthetic organic contaminants.

See Figure 9 for the locations on WWTFs in the Oak Creek and Wind Point Watersheds. There are two WWTF outfalls located near the Oak Creek drinking water intakes. These outfalls service the cities of Milwaukee and South Milwaukee. Under normal conditions, these WWTFs discharge relatively clean effluent into Lake Michigan. However, following a period of high precipitation they have a history of experiencing sanitary sewer overflows.

WDNR's Bureau of Remediation and Redevelopment Tracking System

The WDNR Remediation and Redevelopment Program keeps track of sites where chemical contamination of soil, surface water and/or groundwater has occurred. There are several types of sites that are tracked by BRRTS, including leaking underground storage tank sites, Environmental Repair Program sites, spill sites and Superfund sites. For information on specific contamination sites in Wisconsin please visit BRRTS at, http://www.dnr.state.wi.us/org/aw/rr/brrts/index.htm on the World Wide Web.

- Leaking Underground Storage Tank sites

  A Leaking Underground Storage Tank (LUST) site is defined as a leaking underground storage tank that has contaminated soil and/or groundwater with petroleum.

  As shown in Figure 9, LUST sites are concentrated in urban areas throughout the source water area. As of 3/18/02, there is 78 LUST sites within the municipality of Oak Creek.

- Environmental Repair Program sites

  Environmental Repair Program (ERP) sites are sites other than LUSTs that have contaminated soil and/or groundwater. Often, these are old historic contaminant releases to the environment.

  As shown in Figure 9, ERP sites are concentrated in urban areas throughout the source water area. As of 3/18/02 there were 39 ERP sites located within the municipality of Oak Creek.

- Spills

  Spills are defined as a discharge of hazardous substances that may adversely impact, or threaten to adversely impact public health, welfare or the environment. It is important to note that the number of unreported spills is unknown, but is probably well beyond those spills that are reported.

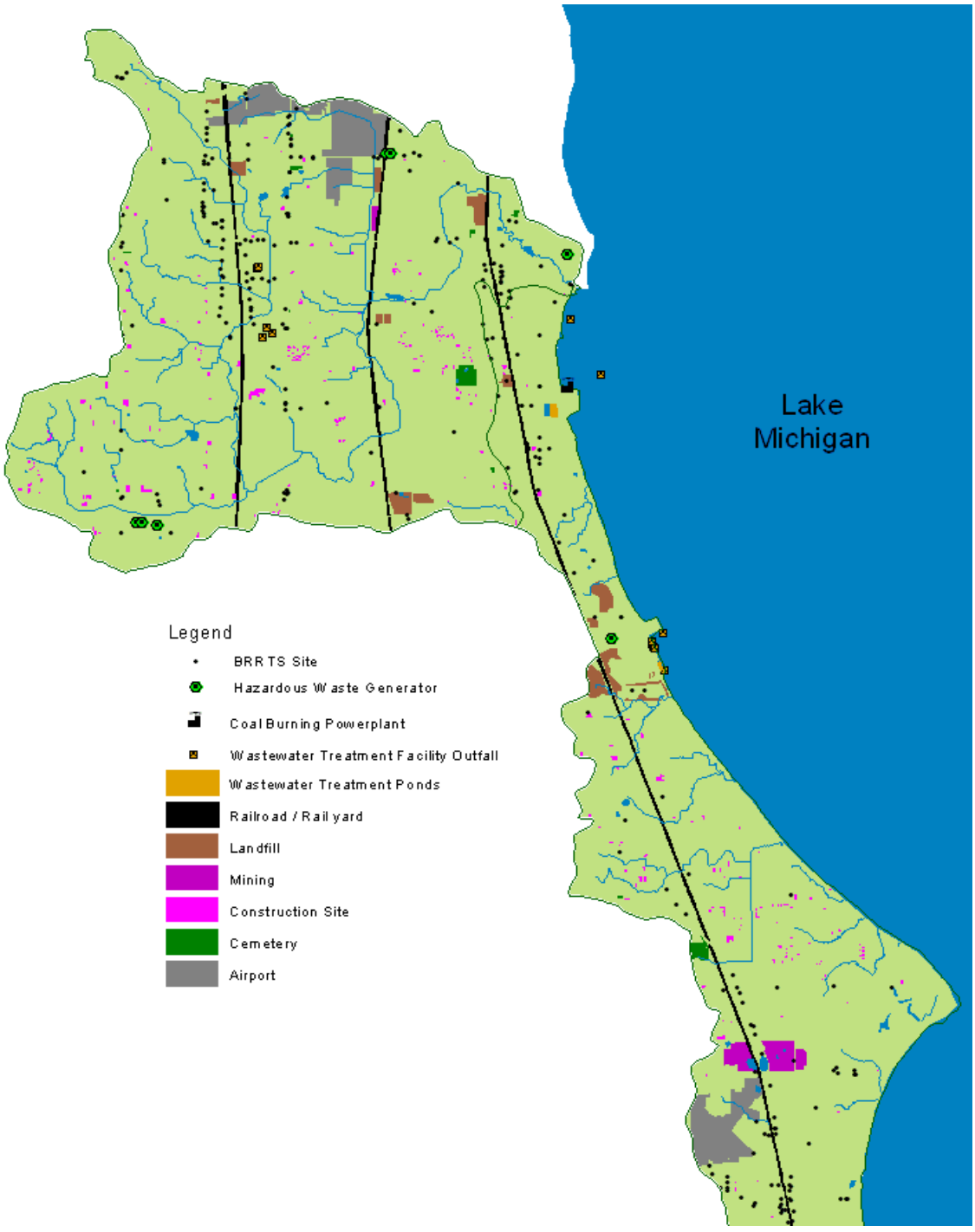
  Most spills are concentrated in urban areas throughout the source water area. From January of 1978 to August of 2000 there were 238 spills reported within the municipality of Oak Creek. 53 of these spills entered directly into surface water and 18 entered conduits to surface water, such as storm sewers.

Hazardous Waste Generators

Hazardous waste generators are defined as facilities, which handle materials classified as hazardous waste. Hazardous waste is defined as any substance that is toxic to humans. Contaminants associated with hazardous waste generators are site specific. Hazardous waste generators include a wide array of facilities ranging from hospitals and schools to manufacturing and industrial operations.

As shown in Figure 8, there are 6 large quantity hazardous waste generators located in the Oak Creek

Figure 8: Area-wide Potential Contaminant Source Inventory



Watershed and none in the Windpoint Watershed. This does not account for the more numerous small quantity hazardous waste generators, which are concentrated in the cities of Racine and South Milwaukee.

Wildlife

Natural levels of wildlife generally do not have a negative impact on water quality. However, concentrated animal populations can have a major impact on water quality. They are known to contaminate water with microbial contaminants. These concentrations are frequently related to human activities, such as landfills, protected waterways and recreational areas where feeding occurs.

As shown on Figure 8, the Oak Creek flows through a small pond approximately half a mile from Lake Michigan. There is a large population of ducks and geese, which reside at this pond year round.

Construction Sites

Due to uncovered material, handling of toxic chemicals and exposed ground construction sites can heavily impact the source water. They are potential sources of inorganic, volatile organic and synthetic organic contaminants. Locational information for construction sites in Figures 8 is based on 1995 data.

Cemeteries

Cemeteries are potential sources of microbial, inorganic and synthetic organic contaminants. Contaminants from cemeteries can enter source water via leachate into groundwater or runoff into surface water. There are multiple cemeteries located throughout the source water area. As shown in Figure 8, there are eleven cemeteries located in the Oak Creek and Wind Point Watersheds.

Airports

Airports are potential sources of inorganic and volatile organic contaminants. As shown in Figure 10, there is a portion of one airport located in the Oak Creek Watershed and one in the southern portions of the Wind Point Watershed.

Railroads and Switchyards

Railroads and switchyards can be sources of contaminants via spills, which are transported as cargo on trains or by contaminants used in the day to day operation of trains. Contaminants associated with cargo vary depending on individual trains and regions, but in 2000 there was an estimated 4.4 million tons of hazardous material transported by rail statewide. Contaminants associated with the day to day operation and maintenance of railroads and switchyards include synthetic organic, volatile organic and inorganic contaminants. The City of Milwaukee, located to the north of the source water area is a hub for railroads in Wisconsin. As shown in Figure 8, there are three railways that cross the Oak Creek Watershed, one of which continues through the Wind Point Watershed.

Coal Burning Power Plant

Coal burning power plants can be major sources of inorganic contaminants, including mercury and other heavy metals. After combustion, exhaust is released into atmosphere through smokestacks. Approximately 50% of mercury and other trace heavy metals will fall to earth within fifty miles of the smokestack. These contaminants can enter into surface water and threaten drinking water. As shown in Figure 8, a large coal burning power plant is located over a mile south of the intakes.

Localized Agricultural and Bulk Storage Potential Contaminant Sources

Localized agricultural and bulk storage potential contaminant source locations for this assessment are shown in Figure 9. Agricultural activities include active farming operations, animal feedlots, agricultural irrigation and lined and unlined manure storage facilities. These activities are potential sources of synthetic organic, inorganic and microbial contaminants. Bulk storage activities include feed mills, agricultural co-ops, 500 gallon and larger petroleum and chemical storage sites and road salt storage sites. Contaminants associated with storage facilities are largely site-specific, but generally they are potential sources of inorganic, synthetic organic and volatile organic contaminants.

Localized Commercial Potential Contaminant Sources

Localized commercial potential contaminant source locations for this assessment are shown in Figure 9. Commercial activities include airports, auto body shops, boat yards, car washes and Laundromats in unsewered areas, cemeteries, dry cleaners, gas service stations, machine/metal working shops, motor vehicle repair shops, paint shops, photo processing facilities, jewelry and metal plating facilities, printing facilities, rail yards, rail road tracks, scrap/junk yards and seed production plants. These activities are frequently associated with inorganic and volatile organic contaminants.

Figure 9: Localized potential contaminant source inventory

Localized General and Industrial Potential Contaminant Sources

Localized general and industrial potential contaminant source locations for this assessment are shown in Figure 9. General activities include above-ground and below-ground storage tanks, municipal and non-municipal sewer lines, sewage holding tanks, septic tanks, sumps, drainfields, mounds and dry wells. These activities are potential sources for synthetic organic, volatile organic, inorganic and microbial contaminants. Industrial activities include asphalt plants, industrial chemical production facilities, electronic product manufacturers, electroplating / metal finishing facilities, furniture or wood manufacturing / refinishing / stripping facilities, foundries / smelting plants, mining operations / mine waste sites, paper mills, petroleum and chemical

pipelines, plastics manufacturer / molding facilities, wood preserving facilities. These activities are potential sources of volatile organic, synthetic organic and inorganic contaminants.

Localized Waste Management and Miscellaneous Potential Contaminant Sources

Localized waste management and miscellaneous potential contaminant sources and contaminant conduits are shown in Figure 9. Waste management activities include municipal incinerators, injection wells, sludge spreading sites, solid waste transfer stations and wastewater lagoons. These activities are potential sources of inorganic, synthetic organic, microbial and volatile organic contaminants. Miscellaneous sources include fire training facilities, golf courses, gasification plants, laboratories and military installations. These sources are associated with microbial, synthetic organic and volatile organic contaminants.

Description of Surface Water Treatment Facilities

The city of Oak Creek provides its more than 15,000 consumers a year-round daily average of 7 million gallons per day. During the summer months demand can reach 14 to 15 million gallons per day and during the winter months demand can drop to 4 million gallons per day.

Potassium permanganate is applied at the surface water intakes to control zebra mussel growth. Upon entering the treatment plant source water undergoes flocculation, sedimentation and filtration to physically remove contaminants. Chlorine is then added to disinfect source water prior to distribution.

Surface Water Susceptibility Determination

As with most surface water systems, Oak Creek's source water quality is significantly impacted by local factors and highly susceptible to contamination. Source water entering Oak Creek's intakes is significantly impacted by both manageable local factors in the source water area and larger less controllable features of southern Lake Michigan. Local factors in the source water area include non-point source pollution from urban and agricultural areas. Larger, less manageable southern Lake Michigan features, which affect source water, include wind-induced suspension of lake bottom sediments, variable currents and annual sediment transport. Source water quality drops during springtime thaw, periods of heavy precipitation and sustained winds.

Recommendations for Surface Water Source Water Protection

Source water protection should begin with the formation of a team composed of local, regional and state members to more completely assess impacts to source water and implement best management practices to prevent source water contamination. Source water protection by this team should first focus on the following,

- Properly managing urban runoff in Milwaukee and South Milwaukee to prevent overflows from the Milwaukee Metropolitan Sewerage District (MMSD) and South Milwaukee wastewater treatment facilities
- Reducing the quantity of urban runoff entering the Oak Creek
- Managing runoff from construction sites in the source water area

As mentioned previously a comprehensive source water protection plan is beyond the scope of this assessment. The source water protection team may consider using resources provided by the USEPA at http://www.epa.gov/safewater/protect/sources.html on the World Wide Web for overall source water protection planning. This website offers general source water information, financial assistance contacts, source water protection case studies, contaminant source inventories and contingency planning among other subjects. For specific information concerning best management practices and dealing with potential contaminant sources please visit http://www.epa.gov/ogwdw/protect/swpbull.html on the World Wide Web.

Source Water Assessment for the Oak Creek Groundwater System

Groundwater source water assessments consist of several components:

1) an identification of the source water area, the land area that contributes water to the drinking water system;

2) an inventory of significant potential sources of contamination within that area; and

3) a susceptibility determination for each system. For groundwater systems this determination is based on geology, well construction, monitoring results, and potential contaminant sources located within the source water area (see Appendix A for a diagram of how susceptibility is determined for Wisconsin's Source Water Assessments).

The Wisconsin Department of Natural Resources (DNR) used an automated system to produce assessments for the approximately 11,500 groundwater public water systems in the state.

This document is for informative purposes only. Source water assessments do not affect monitoring requirements. It is recommended you retain this assessment to help guide your future source water protection work.

About Your Groundwater System:

The system consists of 3 well(s).

Well #3 (Wisconsin Unique Well #BG459)
- Well site geology (from land surface to bottom of well): Drift, niagara, richmond(maquoketa), galena platteville, st peters, franconian, galesville(dresbach), eau claire, and mt. simon.
- Sensitive area: No
- Well depth: 1800 feet Casing depth: 584 feet Length of open interval: 1216 feet
- Casing ends in: galena platteville formation
- Formations that well draws water from: galena platteville, st peters, franconian, galesville(dresbach), eau claire, and mt. simon
- Age of well: 44 years Well construction code compliance: Yes

Well #4 (Wisconsin Unique Well #BG460)
- Well site geology (from land surface to bottom of well): Drift, silurian, maquoketa, galene platteville, st. peter, eau claire, and mt. simon.
- Sensitive area: No
- Well depth: 1846 feet Casing depth: 1117 feet Length of open interval: 729 feet
- Casing ends in: mt. simon formation
- Formations that well draws water from: mt. simon
- Age of well: 35 years Well construction code compliance: Yes

Well #5 (Wisconsin Unique Well #BG458)
- Well site geology (from land surface to bottom of well): Drift, niagara, richmond, galene-platteville, st. peter, franconian, galesville, eau claire, and mt. simon.
- Sensitive area: No
- Well depth: 1800 feet Casing depth: 584 feet Length of open interval: 1216 feet
- Casing ends in: galene-platteville formation
- Formations that well draws water from: galene-platteville, st. peter, franconian, galesville, eau claire, and mt. Simon
- Age of well: 45 years Well construction code compliance: Yes

Groundwater Source Water Assessment Area(s):

The source water assessment area was determined using a regional groundwater flow model. A mathematical model was constructed using known and estimated parameters for aquifer thickness, extent, hydraulic conductivity, recharge, and porosity; well construction and pumping rate; and regional hydrologic conditions. A 5-year time-of travel was used. This means that the source water assessment area approximates the area that would contribute water to the well in 5 years. For wells where the model yielded

a source water area that extends less than 600 feet in any direction, a minimum 600-foot radius is added to the modeled area.

Well and source water area locations are considered to be sensitive information and so are not included in this assessment. They will be provided to the water system upon request.

Groundwater Water Quality:

Owners and operators of public drinking water systems test their well water regularly in accordance with Safe Drinking Water Act requirements. For the purpose of this source water assessment a detection of a contaminant is generally regarded as an indication that the well is susceptible to that type of contaminant. For contaminants that may be naturally occurring a trigger level has been set to indicate susceptibility.

If water is treated then testing is done on treated water. If water is not treated then test results reflect source water quality. The Oak Creek Waterworks system does treat its water, so the test results do not reflect source water quality.

Modern analytical techniques in laboratories are capable of detecting extremely small quantities of contaminants in water. Detecting a substance does not necessarily indicate a health risk. Any monitoring detections of contaminants are noted in the following section.

Well Susceptibility to Contamination:

The Oak Creek Waterworks system has moderate susceptibility to contamination by volatile organic compounds (VOCs), synthetic organic compounds (SOCs), nitrate, and microbes. The system has low susceptibility to ethylene dibromide (EDB) and inorganic compounds (IOCs). See Appendix A for an explanation of the susceptibility determination process. Details for individual wells follow.

Well #3 (Wisconsin Unique Well Number BG459):

- is moderately susceptible to contamination by microbes for the following reasons:
  - Well is not located in an area identified as karst, gravel, fractured bedrock or other sensitive area, nor is well located in an area identified as sand & gravel.
  - Potential coliform source(s) were found in the source water area.
- is moderately susceptible to contamination by nitrate for the following reasons:
  - Potential nitrate source(s) were found in the source water area but no nitrate monitoring detections.
- is moderately susceptible to contamination by volatile organic compounds (VOCs) for the following reasons:
  - Potential VOC source(s) were found in the source water area but no VOC monitoring detections.
- has low susceptibility to ethylene dibromide (EDB), synthetic organic compounds (SOCs), and inorganic compounds (IOCs).

Well #4 (Wisconsin Unique Well Number BG460):

- is moderately susceptible to contamination by microbes for the following reasons:
  - Well is not located in an area identified as karst, gravel, fractured bedrock or other sensitive area, nor is well located in an area identified as sand & gravel.
  - Potential coliform source(s) were found in the source water area.
- is moderately susceptible to contamination by nitrate for the following reasons:
  - Potential nitrate source(s) were found in the source water area but no nitrate monitoring detections.
- is moderately susceptible to contamination by volatile organic compounds (VOCs) for the following reasons:
  - Potential VOC source(s) were found in the source water area but no VOC monitoring detections.
- is moderately susceptible to contamination by SOCs/pesticides for the following reasons:
  - Potential SOC source(s) were found in the source water area but no SOC monitoring detections.
- has low susceptibility to ethylene dibromide (EDB) and inorganic compounds (IOCs).

Well #5 (Wisconsin Unique Well Number BG458):

- is moderately susceptible to contamination by microbes for the following reasons:
  - Well is not located in an area identified as karst, gravel, fractured bedrock or other sensitive area, nor is well located in an area identified as sand & gravel.
  - Potential coliform source(s) were found in the source water area.
- is moderately susceptible to contamination by nitrate for the following reasons:
  - Potential nitrate source(s) were found in the source water area but no nitrate monitoring detections.
- is moderately susceptible to contamination by volatile organic compounds (VOCs) for the following reasons:
  - Potential VOC source(s) were found in the source water area but no VOC monitoring detections.
- has low susceptibility to ethylene dibromide (EDB), synthetic organic compounds (SOCs), and inorganic compounds (IOCs).

General Comments:

Well #5 (Wisconsin Unique Well Number BG458)
This well serves as the aquifer monitoring well for the Oak Creek ASR pilot study.

Well #3 (Wisconsin Unique Well Number BG459)
This well is the injection well for the Oak Creek ASR pilot study.

Source Water Protection:

There is no wellhead protection plan or ordinance for well(s) well 3 (BG459), well 4 (BG460), and well 5 (BG458). Protection activities should focus on obtaining additional information on the potential sources of contamination in the area to evaluate and manage their risk. Other efforts should include implementing a wellhead protection plan, and identifying and managing improperly abandoned wells or other features that may provide direct pathways for contamination to enter the aquifer.

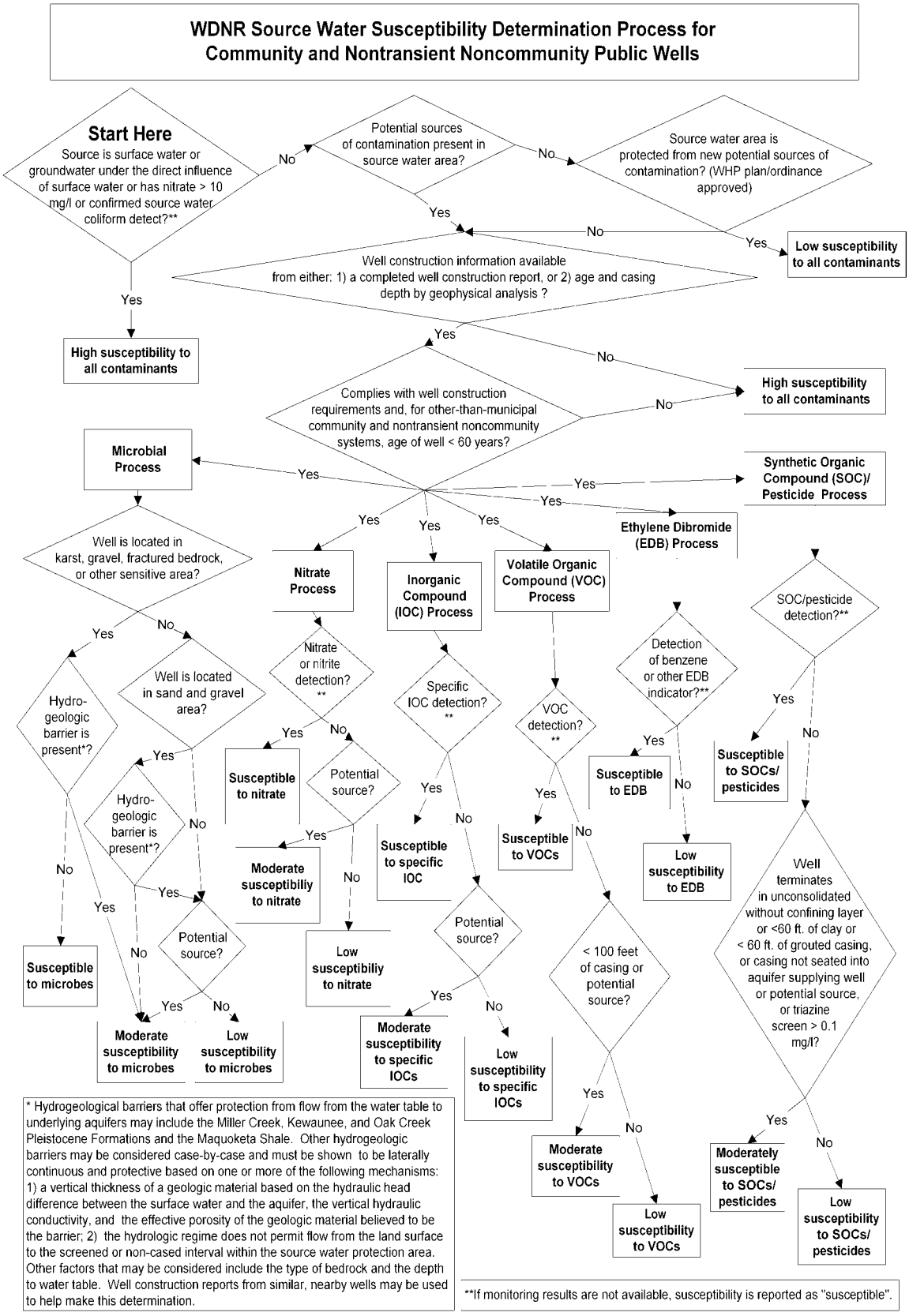
More information on source water protection is available at

http://www.epa.gov/safewater/protect.html

More information on Wisconsin's wellhead protection program is available at

http://www.dnr.state.wi.us/org/water/dwg/gw/wellhead.htm

Appendix A


WDNR Source Water Susceptibility Determination Process for Community and Nontransient Noncommunity Public Wells
Start Here
Source is surface water or groundwater under the direct influence of surface water or has nitrate > 10 mg/l or confirmed source water coliform detect?**
Potential sources of contamination present in source water area?
Source water area is protected from new potential sources of contamination? (WHP plan/ordinance approved)
Low susceptibility to all contaminants
Well construction information available from either: 1) a completed well construction report, or 2) age and casing depth by geophysical analysis ?
High susceptibility to all contaminants
Complies with well construction requirements and, for other-than-municipal community and nontransient noncommunity systems, age of well < 60 years?
High susceptibility to all contaminants
Microbial Process
Synthetic Organic Compound (SOC)/ Pesticide Process
Ethylene Dibromide (EDB) Process
Well is located in karst, gravel, fractured bedrock, or other sensitive area?
Nitrate Process
Inorganic Compound (IOC) Process
Volatile Organic Compound (VOC) Process
SOC/pesticide detection?**
Hydro-geologic barrier is present*?
Well is located in sand and gravel area?
Nitrate or nitrite detection? **
Specific IOC detection? **
VOC detection? **
Detection of benzene or other EDB indicator?**
Susceptible to nitrate
Potential source?
Susceptible to specific IOC
Susceptible to VOCs
Susceptible to EDB
Susceptible to SOCs/ pesticides
Hydro-geologic barrier is present*?
Moderate susceptibiliy to nitrate
Low susceptibiliy to nitrate
Potential source?
Low susceptibility to EDB
Susceptible to microbes
Potential source?
Moderate susceptibility to specific IOCs
Low susceptibility to specific IOCs
< 100 feet of casing or potential source?
Well terminates in unconsolidated without confining layer or <60 ft. of clay or < 60 ft. of grouted casing, or casing not seated into aquifer supplying well or potential source, or triazine screen > 0.1 mg/l?
Moderate susceptibility to microbes
Low susceptibility to microbes
Moderate susceptibility to VOCs
Low susceptibility to VOCs
Moderately susceptible to SOCs/ pesticides
Low susceptibility to SOCs/ pesticides
* Hydrogeological barriers that offer protection from flow from the water table to underlying aquifers may include the Miller Creek, Kewaunee, and Oak Creek Pleistocene Formations and the Maquoketa Shale. Other hydrogeologic barriers may be considered case-by-case and must be shown to be laterally continuous and protective based on one or more of the following mechanisms: 1) a vertical thickness of a geologic material based on the hydraulic head difference between the surface water and the aquifer, the vertical hydraulic conductivity, and the effective porosity of the geologic material believed to be the barrier; 2) the hydrologic regime does not permit flow from the land surface to the screened or non-cased interval within the source water protection area. Other factors that may be considered include the type of bedrock and the depth to water table. Well construction reports from similar, nearby wells may be used to help make this determination.
**If monitoring results are not available, susceptibility is reported as "susceptible".

Selected References

- Beletsky, D.; Saylor, J. H.; Schwab, D. J., 1999, Mean Circulation in the Great Lakes, Journal of Great Lakes Research.
- Hole, F.D., 1980, Soil Guide for Wisconsin Land Lookers, University of Wisconsin-Extension.
- Knuth, D.; Jankowski, S., 1980, Municipal Water Supply Lake Michigan Water Quality Inventory.
- Lee, K. K., 1994, Pre-Design Study of Improvements to Raw Water Intake and Low Lift Pumping Station for the City of Oak Creek, Wisconsin, University of Wisconsin- Milwaukee.
- National Oceanic and Atmospheric Agency, Bathymetry of Lake Michigan, available on the World Wide Web at http://www.ngdc.noaa.gov/mgg/greatlakes/lakemich_cdrom/start.htm visited on 2/12/02
- Oak Creek Public Utility employees, 2002, Personal interviews.
- Skinner, E.L.; Borman, R.G., University of Wisconsin-Extension. Geological and Natural History Survey. 1973. Water Resources of Wisconsin-Lake Michigan Basin. US Geological Survey.
- U S Geological Survey, Surface Water Data for the Nation, available on the World Wide Web at http://waterdata.usgs.gov/nwis/sw
- Wisconsin Department of Natural Resources (WDNR), Racine Public Utility water quality monitoring data, available on the World Wide Web at http://www.dnr.state.wi.us/org/water/dwg/DWS.htm visited on 3/9/02
- WDNR, List of 303.(d) Waterbodies http://www.dnr.state.wi.us/org/water/wm/wqs/303d/waterbody.html visited on 3/9/02
- WDNR, 2001, Sewer Overflows in Wisconsin- A Report to the Natural Resources Board.
- WDNR, 1999, Wisconsin's Source Water Assessment Program Plan.
- WDNR, 1999, Wisconsin's Source Water Assessment Program Plan Appendices.