Source Water Assessment Report for the

City of Grand Haven – North Ottawa Water Facilities
Ottawa County, Michigan

April 2004

Prepared for: Northwest Ottawa Water Supply; WSSN 4847

Prepared by: U.S. Geological Survey, Water Resources Division, Michigan District
Michigan Department of Environmental Quality, Water Division
Michigan Source Water Assessment Report 44

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Acknowledgement: Standard language used within this portion of the document describing the Designating was provided by U.S. Geological Survey, Water Resources Division, Michigan District Michigan Department of Natural Resources & Environment, Water and Division Michigan Source Water Assessment Report No. 1

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Executive Summary

The purpose of the Source Water Assessment is to analyze the sensitivity and determine susceptibility of a community's source of drinking water to potential sources of contamination. Sensitivity is determined from the natural setting of the source water (raw water to the water treatment plant), and indicates natural protection afforded the source water. Using procedures established in the Great Lakes Protocol, Michigan Source Water Assessment Program, the onshore, collector-system and offshore, infiltration-bed intake for the Northwest Ottawa Water Treatment Plant have a moderate degree of sensitivity to potential contaminants. When the effects of winds and lake currents, the influence of the Grand River, and the prefiltration offered by the intake construction are considered, the Northwest Ottawa intakes are categorized as moderately sensitive.

Susceptibility identifies factors within the community's source water area that may pose a risk to the water supply. The susceptibility determination provides information with respect to listed facilities and land areas within the source water area that should be given greater priority and oversight in implementing a source water protection program. The source water area for the Northwest Ottawa intake includes 1,401 potential contaminant sources, plus urban and agricultural runoff from the Grand River watershed into Lake Michigan. While these potential contaminant sources, in combination with the moderately sensitive intake, indicate that the source water has moderately high susceptibility, the contaminant sources are less likely to infiltrate into a buried collector system and thus, the Northwest Ottawa source water is moderately susceptible to contamination.

The Northwest Ottawa source water is categorized with moderate susceptibility, given intake construction, plus land uses and potential contaminant sources within the source water area. It is noted that historically, the Northwest Ottawa Water Treatment Plant has effectively treated this source water to meet drinking water standards. Local communities have instituted pollution prevention programs, but should be cognizant of additional potential threats to its source of drinking water that are identified in this report. This report explains the background and basis for these determinations.

Using this Assessment

Clean, safe drinking water is fundamental to the viability of any community. Protecting the drinking water **source** is a wise and relatively inexpensive investment in your community's future. The overall intent of this assessment is to provide background information for your community to use in developing a local source water protection program. The assessment benefits your community by providing the following:

- ***A basis for focusing limited resources within the community to protect the drinking water source(s).*** The assessment provides your community with information regarding activities within the **source water area** (**SWA**) that directly affect your water supply. It is within this SWA that a spill or improper use of **potential contaminants** may cause these contaminants to migrate toward the water **intake**. By examining where the source waters are most susceptible to contaminants, and where potential contaminants are located, the assessment clearly illustrates the potential risks that should be addressed.

- ***A basis for informed decision-making regarding land use within the community.*** The assessment provides your community with a significant amount of information regarding where your drinking water comes from (the source) and what the risks are to the quality of that source. Knowing where the resource is allows your community planning authorities to make informed decisions regarding proposed land uses within the SWA that are compatible with both your drinking water resource and the vision of growth embraced by your community.

- ***A basis for dealing with future regulations.*** The assessment has been designed to functionally meet proposed requirements for surface-water supplies. Information needed to address regulatory needs and requirements has been collected and made available to your community through this report.

This source water assessment also provides the basis for a locally developed, voluntary source water protection program. Communities interested in voluntarily developing source water protection programs should contact the Michigan Department of Environmental Quality (MDEQ) or visit the Department web page at http://www.deq.state.mi.us.

Introduction

In 1996, Congress amended the **Safe Drinking Water Act** and provided resources for state agencies to conduct source water assessments by identifying SWAs, analyzing the **sensitivity** of the source to natural conditions, conducting contaminant source inventories, and determining the **susceptibility** of the source to potential contamination. Delineations, sensitivity analyses, contaminant inventories, and susceptibility determinations comprise a "source water assessment." Assessments will be completed for every public water supply source in Michigan. To support this effort, the MDEQ Water Division established a partnership with the U.S. Geological Survey (USGS) to develop a method for conducting source water assessments for surface water supplies (Sweat and others, 2000; Sweat and others, *in p*ress)**.**

The requirements for public water supplies in Michigan to meet United States Environmental Protection Agency (USEPA) **maximum contaminant levels (MCLs)** provide some degree of assurance of safe drinking water; however, all systems are vulnerable to potential contamination. 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.

Background

The Northwest Ottawa water treatment plant (WTP) is located in Ottawa County, on the eastern shore of Lake Michigan, at Grand Haven, Michigan (fig. 1). The Northwest Ottawa WTP serves Grand Haven, Spring Lake, and Ferrysburg, plus Crockery, Grand Haven Charter, and Spring Lake townships. The Northwest Ottawa water supply was first constructed in 1912 for the city of Grand Haven, using water from the Grand River, and 33 wells located along the banks of the Grand River and Lake Michigan. In 1927, a water plant was constructed for filtration and chlorination purposes. In 1931-32, collector wells were installed in Lake Michigan, and the plant began using Lake Michigan water as its source. Following World War II, 3 horizontal, collector systems (well) were installed, and the riverbank and lakeshore wells were abandoned. In 1961 a submerged intake termed a "Crows Foot" was installed below the bottom of Lake Michigan. In 1984, construction began on a "direct filtration" plant, and it went on line in 1986 with a capacity of 12 million gallons per day (MGD). In 1990, a third type of intake structure referred to as an infiltration bed was constructed, along with the Lake Pumping Station. In 2001, construction was started on another infiltration bed intake, south of the 1990 intake. This bed was completed in 2002 and the Ranney Collector Wells and Crows Foot was abandoned. Consultants located the new intake based on greater bottom energies compared with the existing site. When completed, collector wells will be abandoned, and intake capacity will be 28 MGD of prefiltered Lake Michigan water. Three low service pumps deliver raw water to the WTP

INTAKE DESCRIPTIONS (from Dec. 1999 Sanitary Survey; MDEQ; Timm & Pardini)

Note: Intake #1 described as the Ranney Collector Wells and Intake #2 referred to as the Crows Foot were formally abandoned in 2002.

INTAKE	DIAMETER	MATERIAL	LENGTH	CAPACITY	BELOW LAKE	CRIB
#1	16-inch	Ductile Iron	240'	2.2 MGD	22.0'	NO
#2	18-inch	Steel	550'	2.0 MGD	14-15'	NO
#3	30-inch	Ductile Iron	1700'	14.0 MGD	12'-14'	NO
#4	30-inch	Ductile Iron	2300'	14.0MGD	10'-12'	NO

Intake #3 – Intermediate Intake Infiltration Bed (North bed)

The infiltration bed currently supplies the majority of raw water to the plant and is rated at 14.0 MGD. This buried collector was installed in 1990 and is approximately 240 feet by 260 feet in size located approximately 1200 feet from shore. The infiltration bed is approximately 14 feet below lake bottom with a water depth (submergence) of approximately 18-20 feet. Current capacity of the infiltration bed is 14.0 MGD or less. The capacity of the intake bed can vary depending on a number of factors. These include: lake sediments, wave action, influences from the Grand River, wind direction, currents, lake upwelling (turnover), water temperature (P. Stankowitz, July 2002) and lake plumes. East-West winds along the lake can also produce a Seiche effect where water can actually pile up or collect on one side of the lake.

The collector piping is 8-inch diameter PVC piping slotted on the bottom side with 3/16-inch slots 4-inches long on 1-inch centers. The 8-inch pipes are on 20 foot centers and are 130 feet long. These lateral pipes are connected to a main 30-inch header which leads to the pump station. The header pipe is 240 feet long and contains an extra 20 foot pipe length and a 30-inch plug on the downstream end. This pipe extension was to be for a future intake bed connected in series.

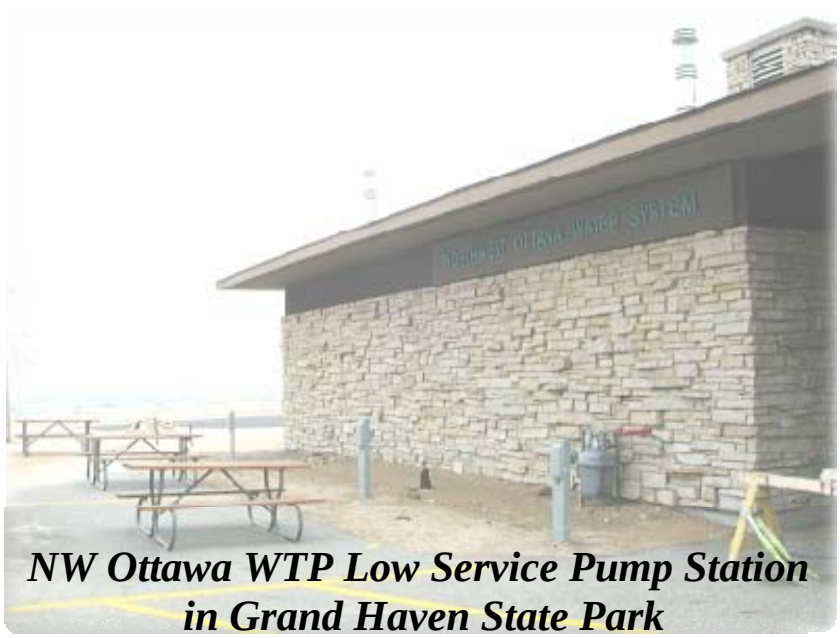
Filter media in the infiltration bed consists of gravel, course sands and lake bottom sands of the same effective size as found in the area prior to bed installation. The bed was initially developed and fines were removed. Normal operation of the bed is daily to meet both summertime and wintertime demands. The bed is operated by monitoring suction pressure. Normal suction pressures when the bed is operating at or near full capacity range from +4.0-+6.0 psi. As the bed becomes dirty or plugs off the suction pressure will drop. At around +1.0-+2.0 the bed is backwashed. If this doesn't improve capacity and lake conditions are calm, then the intake will usually have to be dragged with an I-beam. When suction pressures reach a negative range of –2.0 to -3.0 psi, air binding is encountered and cavitation bubbles can be noticed in the flocculation basins. In addition, bed capacity can drop 50 percent during silting conditions. The intermediate intake is washed once per week regardless of need, except during wintertime demands when the bed is not washed from November to April.

The backwash and cleaning procedure can become somewhat detailed depending on conditions. If the weather and lake conditions provide wind and wave action, the normal backwash procedure will remove accumulated fines and sediments from on top of the bed. However, if weather and lake conditions are calm, there is not usually enough wave action to remove accumulated material from the bed area and operators have to drag the infiltration bed with a 24-inch I-beam. Accumulation of material may be due to the following: harbor and river dredging and re-depositing dredge spoils south of the intakes, lake plumes, and river sediments.

Backwash Procedure: The whole backwash procedure takes about one hour to complete. The supply of backwash water comes from the 1.0 MG raw water backwash tank and the intake bed in service. The backwash tank provides approximately 800,000 gallons of water and the Ranney wells provide about an additional 100,000 gallons. Backwash rates for the intakes are approximately 15,000 to 20,000 GPM with an average being 18,000 GPM.

The plant is out of operation during the backwash procedure because there is only one raw water transmission line to the plant. This 30-inch transmission main connects the low service station to the raw water backwash tank and the plant. During the backwash procedure, the plant is off-line for approximately one hour, two hours if the backwash tank is immediately filled. However, the backwash tank is normally filled in off-peak times. Plant operators like to have the main plant clearwell full before starting backwash procedure.

There are no emergency intakes on the system. Emergency measures call for direct pumping from the collector system wells, and reliance on interconnections with Norton Shores, Fruitport Township, and (or) Grand Rapids. A new intake is currently being constructed, with an offshore distance of approximately 800 feet at a depth of approximately 12 feet. The new intake is an infiltration bed, buried approximately 11 feet below the lakebed. Total low service pumping capacity is rated at 15.5 (MGD), with an original plant design capacity of 12.0 MGD (Timm and Pardini, 1999). The City's WTP uses the addition of coagulant, flocculation, clarification, filtration, and chlorination. Chemicals added to the water include alum (coagulation), chlorine (disinfection), fluoride (dental health), and activated carbon (taste and odor problems). The WTP has a total onsite storage capacity of 1.65 million gallons (MG). There are seven reservoirs located on the distribution system with a capacity of 6.317 MG. The Northwest Ottawa WTP serves approximately 37,300 people (Timm and Pardini, 1999).



NW Ottawa WTP Low Service Pump Station in Grand Haven State Park

Water treatment plants are periodically inspected to identify construction, maintenance, operational or source defects that could make them vulnerable to contamination, particularly from contaminants that are microbial in nature, such as fecal coliforms. Water suppliers are provided a sanitary survey report that notes any deficiencies in the system, and the State may direct the system to make necessary corrections. The sanitary survey is an important part of a safe drinking water program. The most recent sanitary survey of the Northwest Ottawa WTP was completed in 1999 (Timm and Pardini).

2.5 Climate

The Northwest Ottawa water supply is located in the West-Central Lower Peninsula hydrologic province (Rheaume, 1991). The region experiences temperate summers with moderate winters. The Grand Rapids weather station reports long term average annual precipitation for the period 1961-2001 was 36.04 in, with about 31 percent of that as snowfall between November and March. Average annual precipitation from 1996-2000 was 30.5 in (NOAA, 2001). Annual average runoff for the Northwest Ottawa SWA, extrapolated from Miller and Twenter (1986, fig. 1) is 12 inches to 15 inches, with the higher runoff values closest to Lake Michigan.

2.6 Source Water Area Geology and Hydrology

The study area for evaluating the extent of the Grand Rapids WTP SWA includes a portion of the Grand River watershed, in addition to Lake Michigan (fig. 1). The SWA consists of end moraines of fine-textured till, end moraines of coarse-textured till, fine-textured glacial till, coarse-textured glacial till, lacustrine sand and gravel, post-glacial alluvium, and sand dunes. These landforms are underlain by Coldwater shale, Marshall sandstone, Bayport limestone, the Red Beds shales, and the mixed shales, limestone and sandstone of the Michigan Formation (Martin, 1955; Milstein, 1987). Soils in the Grand Rapids SWA are primarily from these soil associations: Grattan-Pipestone-

Granby, Perrinton-Ithaca-Coloma, Boyer-Fox-Wasepi, Plainfield-Spinks-Metea, and Ithaca-Ziegenfuss-Pewamo. They include sand, loamy sand, loam, and muck (BASINS, 1998).

Soil permeability is based on the calculated time of travel, in inches per hour (in/hr), for water to move vertically through a saturated soil zone. Soil thickness and permeability values are available in soil survey reports published by the National Cooperative Soil Survey and U.S. Department of Agriculture (1986). Permeability ranges from less than 0.06 in/hr, rated as very slow, to more than 20 in/hr, rated as very rapid.

Very slowly permeable soils significantly reduce the movement of water through the soil zone and, as a result, allow greater time for natural degradation of contaminants. However, such soils also provide for rapid overland transport of contaminants directly to receiving waters, which in turn may affect the water supply intake. In contrast, very rapidly permeable soils allow for rapid infiltration and passage through the soil zone from the surface. Such soils potentially allow rapid transport of contaminants with minimal contact-time available for contaminant breakdown. Erosion and transport of soils by surface waters can cause an increase in turbidity.

Mean, area-weighted, depth-integrated permeabilities for the Grand Rapids SWA range from 0.9 to as much as 12.7 in/hr. The mean permeability is 8.1 in/hr (Schneider and Erickson, undated, series of 5 maps; BASINS, 1998;). Soils are predominantly rapidly permeable over highly sensitive drift lithology throughout the SWA (fig. 2; BASINS, 1998), with some small areas of moderate and moderately rapid permeability in the south and central of the SWA. Soils with rapid permeability are close to the Grand River, and Lake Michigan (Lusch and others, 1992; BASINS, 1998).

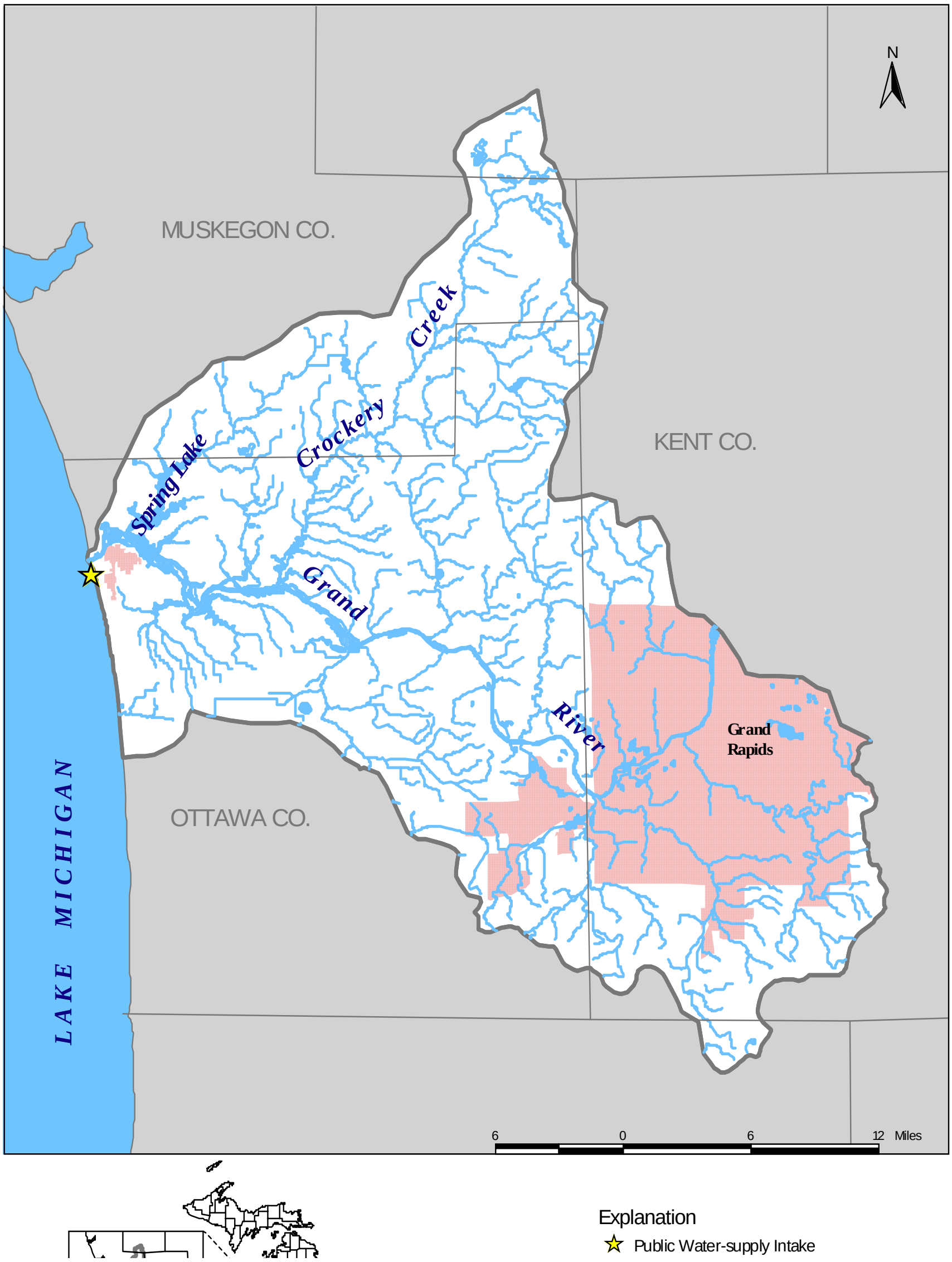


Figure 1
Source water area (SWA) for the Northwest Ottawa water supply,
Grand Haven, Michigan.

The NW Ottawa SWA contains an area of about 708 square miles (mi2) and is directly connected to Lake Michigan. The most significant tributary to Lake Michigan from the SWA is the Grand River. From 1901as many as 4 stream gages have been operated in SWA by the USGS (Blumer and others, 2002). Currently, one gage is operating within the SWA. Annual mean discharge at the Grand River at Grand Rapids gauging station was 2,580 cubic feet per second (cfs) between 1901 and 2001, and ranged from 1,264 to 6,314 cfs.

Under ambient conditions, currents in Lake Michigan are, typically, from the south-southwest. Water from the Grand River flows north from its mouth, away from the intakes. Sustained strong winds from the west, however, often affect lake currents, causing increases in near shore turbidity, and possibly increases in coliforms. Sustained winds from the northwest through northeast may cause the flow of the Grand River to pass over the intakes, causing changes in water quality and chemistry at the intake. Moreover, the Pigeon River empties into Lake Michigan about 11 miles up current from the Northwest Ottawa WFP intakes, and the Lower Grand River empties into Lake Michigan about 20 miles up current from the Northwest Ottawa WFP intakes. Water from these rivers flows north from their mouths, and due to their locations south of the Northwest Ottawa WFP intake, they may influence water quality and chemistry at the intake.

2.9 History of Raw Water Quality at the Source

Public water supplies are required to routinely monitor raw water quality for selected parameters to optimize treatment, and to monitor treated water quality for a list of contaminants that is determined by MDEQ and the Safe Drinking Water Act. A detection of any contaminant may indicate that a pathway exists for contaminants to reach the intake. It is important to realize that the results from a given sample only provide information regarding the water quality at the time the sample was collected. Water quality can change with time for a number of reasons. The fact that a water sample does not contain contaminants is no guarantee that contamination will not occur in the future. Conversely, the detection of a contaminant in the past does not indicate that it will occur in the future.

The Northwest Ottawa WTP records show that water use between 1993 and 1998 fluctuated between 4.65 and 6.07 MGD, with an average annual use of 1,900 million gallons (VanderStel, 2001). Water quality and meteorological conditions have been monitored since about 1912. An analysis of wind direction, water and air temperature, precipitation, discharge from the Grand River, and source water chemistry indicates that there may be an indirect correlation between wind direction and turbidity, and perhaps wind direction and total coliform bacteria. Regression analysis of these data indicated that when the wind is from the south through southwest (180-225°), it can cause in increase in turbidity. These changes are most likely associated with changes to circulation patterns in Lake Michigan, which can cause sediments near the intake to be suspended in the water column due to wave action, and, are possibly associated with increased flow of the Grand River over the intake. While not regulated, esthetic parameters such as taste and odors associated with algae blooms are also a source water concern for the Northwest Ottawa WTP.

Thermal inversions in Lake Michigan can also cause treatment problems for the plant. Thermal inversions are typically associated with heating of the surface of the lake in spring, and cooling

of the surface of the lake in the fall or early winter. Both events cause density differences in the lake that cause the water to turnover and mix, often stirring up bottom sediments and detritus. These materials enter the WTP through the intake and may cause treatment difficulties. In addition, rapidly fluctuating lake temperatures and very cold water can upset the treatment process at the plant but are less likely to occur with direct filtration.

The Northwest Ottawa WTP periodically tests both raw and treated water for the presence of total coliform bacteria. Fecal coliform bacteria are rarely detected in the raw water (2001 water quality results, accessed May 13, 2002).

1993 -1998 MOR Data from December 1999 Sanitary Survey
*Number greater than 200 may be TNTC (too numerous to count)
Hardness and alkalinity; ppm as CaCO3, Turbidity as NTU
Lab currently runs MF (Membrane Filter) & HPC

	Average	Range
TURBIDITY	0.08	0.02-1.11
pH	7.76	5.81-8.40
HARDNESS	160	130-216
ALKALINITY	126	96-170
MF	42.5	0-200*
HPC	29	0-427

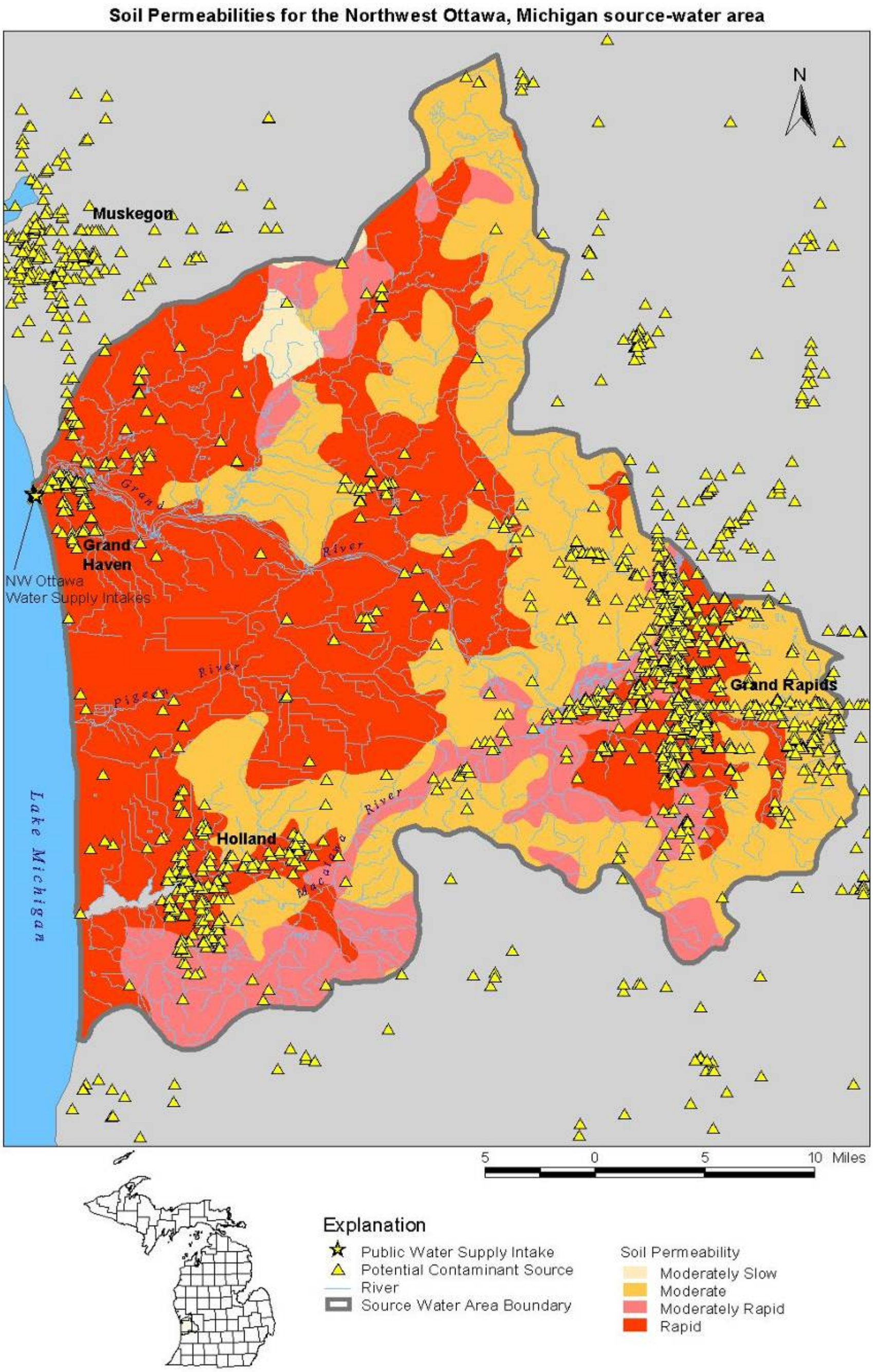


Figure 2. Permeability map for the Northwest Ottawa water supply, Grand Haven, Michigan, including potential influence from the Lower Grand which is outside the defined source water area for the NW Ottawa WTP.

2.10 Source Water Assessment Methodology

Technical guidelines for completing source water assessments are contained in the Michigan ***Source Water Assessment Program***, Assessment Protocol for Great Lakes Sources (Protocol) (MDEQ, 1999, Appendix L) available at http://www.michigan.gov/ deq/0,4561,7-135-3313_3675_3693---,00.html. In general, an assessment is a process for evaluating a drinking water supply and the potential for its treated water to exceed an MCL due to raw water contamination. A source water assessment considers the SWA, potential sources of contamination within the SWA, conditions of the water supply intake, and susceptibility to contaminants in order to identify potential risks to drinking water quality. Although the Protocol provides the minimum requirements and instructions on how to conduct an assessment, each water supply is unique with respect to how the process is carried out, due to local conditions and information. Sweat and others (2000, in press) have developed and documented the methodology used in the preparation of this assessment.

2.11 Delineating Source Water Areas

Delineation of the SWA is accomplished by using ***geographic information system*** (GIS) software to map the watershed(s) that have the potential to affect source water at the intake. Using information from the water supply, a ***critical assessment zone*** (CAZ) is defined for the intake (MDEQ, 1999, Appendix L). A buffer is then created along any shoreline intersected by the CAZ, and from the edge of the CAZ to the mouth of any river(s) that might influence the intake. Finally, the buffer is extended along the shoreline of any river(s) that might influence the intake, from the mouth of the river to its headwaters. The area defined by the CAZ, river and shoreline buffers is termed the ***susceptible area***. The susceptible area within the SWA defines locations where a water supply should focus its management strategies and resources to benefit the drinking water resources.

Using the Great Lakes Protocol and the Northwest Ottawa water supply information, the CAZ for the current Northwest Ottawa intakes is calculated as:

- The length of the intake in ft., 1,280 x the depth of the intake in ft., 14 = 17,920 (unitless). This results in rating the intake as moderately highly sensitive, with a CAZ of 3,000 ft (MDEQ, 1999, Appendix L; fig. 3). However, as the intake is buried beneath approximately 11 feet of lake bottom sands, which acts as a prefilter, the intakes are rated as moderately sensitive (Brad Brogren, oral commun., May 9, 2002).

- Because the buried collector offers some protection from shoreline influences, a shoreline susceptible area was not calculated for this assessment.

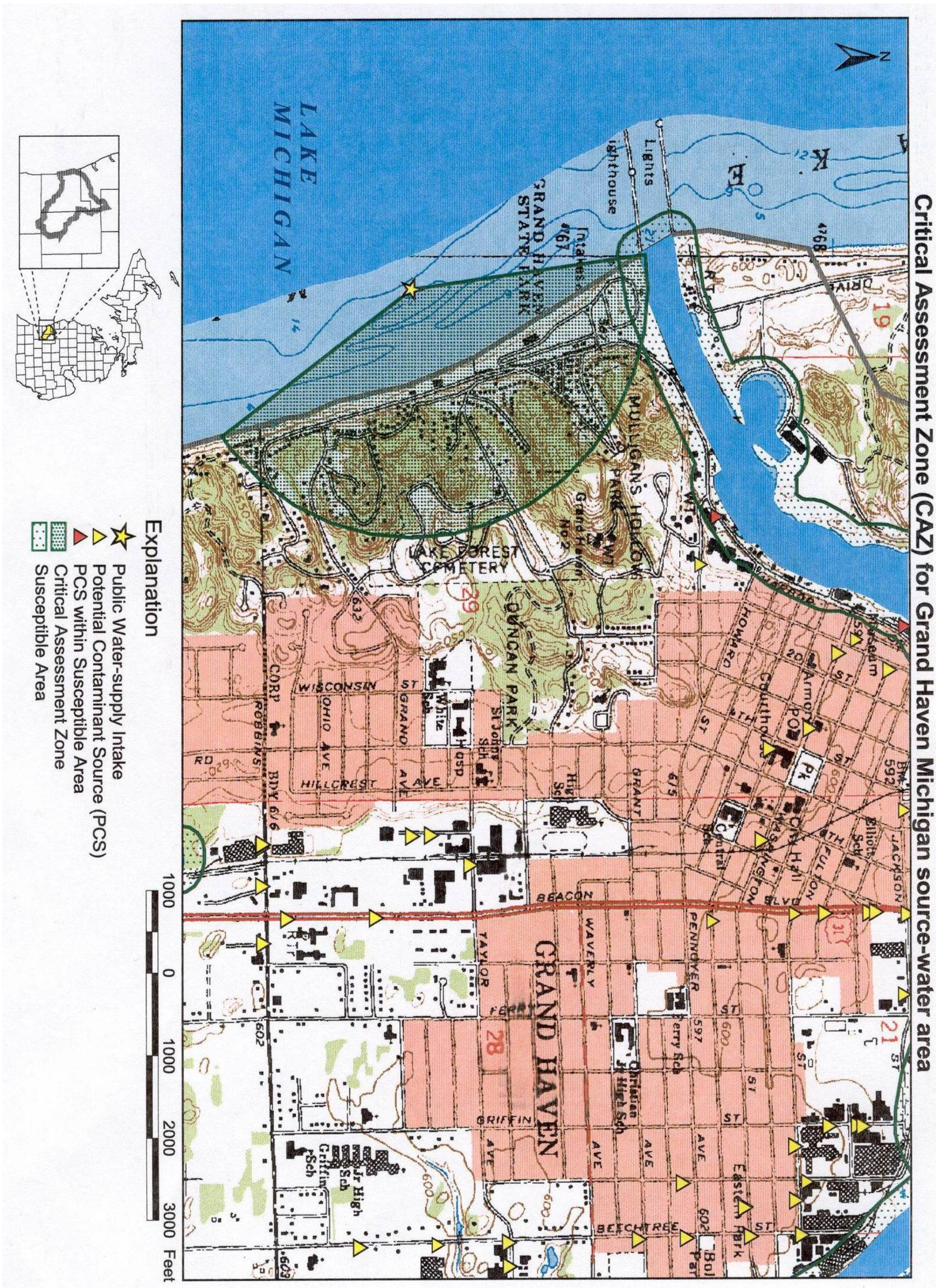


Figure 3.
Critical Assessment Zone for the Northwest Ottawa Water Supply, City of Grand Haven, Michigan.

2.12 Contaminant Source Inventory

Past, current, and potential future sources of contaminants were inventoried to identify several categories of potential sources of contaminants including microorganisms (bacteria, oocysts, and viruses), inorganic compounds (nitrates and metals), organic compounds (solvents, petroleum compounds, pesticides), and disinfection by-product precursors (trihalomethanes, haloacetic acids).

It is important to remember that sites and areas identified by this process are only potential contaminant sources (PCS) to the drinking water. Environmental contamination is not likely to occur when potential contaminants are used and managed properly. In addition, assumptions were made about particular types of land uses and risks associated with those land uses. Assumptions are discussed further in the results portion of this report.

The process for completing the inventory included several steps, which are summarized as follows:

1. Reviewed readily available land use maps and historical/current aerial photographs.

2. Plotted relevant information from applicable state and federal regulatory databases including the following lists:
   - MDEQ leaking underground storage tank (LUST) sites;
   - MDEQ registered underground storage tank (UST) sites;
   - MDEQ Environmental Cleanup Site Information System (ECSI) sites;
   - MDEQ Source Information System (for water discharge permit sites including National Pollutant Discharge Elimination System (NPDES) permits, Water Pollution Control Facility (WPCF) permits, storm water discharge permits, and on-site sewage (septic) system permits);
   - MDEQ Underground Injection Control (UIC) database;
   - MDEQ Active Solid Waste Disposal Permits list;
   - Michigan Department of Transportation (MDOT) - Hazardous Materials database;
   - State Fire Marshall registry of above-ground fuel storage tank sites;
   - State Fire Marshall Hazardous Material Handlers and Hazardous Material Incidents (HAZMAT) sites; U.S. EPA BASINS software, version 2.01.
   - U.S. EPA Envirofacts database;
   - U.S. EPA Resource Conservation Recovery Act (RCRA) generators or notifiers list;
   - U.S. EPA RCRA Treatment, Storage, and Disposal Facility (TSDF) Permits list;
   - U.S. EPA National Priorities List (NPL);
   - U.S. EPA Comprehensive Environmental Response, Compensation and Liability Information System (CERCLA) List;
   - U.S. EPA RCRA Corrective Action Activity List (CORRACTS);
   - U.S. Department of Transportation (DOT) Hazardous Materials Information Reporting System (HMIRS);
   - U.S. EPA Toxic Chemical Release Inventory System (TRIS); and
   - U.S. EPA Oil Pollution Act of 1990 Spill Response Atlas.

3. Met with public water supply and community officials on May 16, 2002 to identify potential sources not listed elsewhere in databases or on maps and completed a preliminary inventory form to be used in completing the SWA base map. Subsequent contacts by email and telephone on numerous occasions to request additional data, clarify data, and discuss results.

4. Land use and/or ownership (for example, residential/municipal; commercial/industrial; agricultural/forest; and other land uses) was mapped and evaluated in relation to PCS, soil characteristics, and proximity to the intakes.

5. Conducted an informal field inventory to locate additional PCS.

6. Completed final inventory form of PCS and plotted locations of PCS on the base map.

The purpose of the inventory is three fold: first, to provide information on the location of PCS, especially those within the susceptible area; second, to provide an effective means of educating the public about PCS; and third, to provide a reliable basis for developing a management plan to reduce potential contaminant risks to the Northwest Ottawa water supply.

The inventory process attempts to identify potential point-source contaminants within the SWA. It does not include an attempt to identify specific potential contamination problems at specific sites, such as facilities that do not safely store potentially hazardous materials. However, assumptions were made about particular types of land use. For example, it is assumed that rural residences associated with farming operations have specific potential contamination sources such as fuel storage, chemical storage and mixing areas, and machinery repair shops. It should also be noted that although the inventory depicts existing agricultural uses (crops grown), these are likely to undergo continual change due to normal crop rotation practices. What is irrigated farmland now may be non-irrigated farmland next year, or vice versa.

The results of the inventory were analyzed in terms of current, past, and future land uses and their relationship to the susceptible area and the supply intake. In general, land uses and PCS that are closest to the supply intake pose the greatest threat to a safe drinking water supply. Inventory results are summarized in tables 1 and 2 (Appendix) and are shown on figure 4.

Many PCS are readily identifiable because they have a single discharge point, and often a permit is required for these discharges. Dredging in the Grand River is also be a point source concern for the Northwest Ottawa SWA. Dredging activities could potentially release contaminated sediments into the water column and could have an adverse affect on water quality. Dredging has also, in the past, caused an overburden of sediments to clog the intakes.

Other PCS have diffused, poorly defined discharge locations. These are known as non-point discharges because they occur over large areas and may not be quantifiable by readily accepted methods. These non-point source discharges are difficult to identify and control, and consequently to quantify, yet they are a major source of water pollution (Carpenter and others, 1998). Non-point sources also include atmospheric deposition over water and

lots, and roadways. Runoff from these areas can contain many types of pollutants including sediments, metals, organic and inorganic chemicals, viral and bacterial pathogens, pharmaceuticals, and animal wastes.

Table 1. Potential contaminant sources in the Northwest Ottawa source water area

Type of potential contaminant source	Number of potential contaminant sources	Number of potential contaminant sources with permitted discharges to Lake Michigan
Hazardous or Solid Waste Site	1114	59
Industrial Facilities Discharge Site	67	12
National Priority List Sites	9	2
Permit Compliance System	50	6
Toxic Release Inventory	161	6

Transportation also represents a non-point source of contamination. Trucking, railroads, and shipping all transport potential contaminants through the SWA. An accident causing a spill could lead to potential contaminants entering a storm sewer, or in the case of shipping, directly discharge to Lake Michigan, possibly near the water intake. Non-point sources of concern to the Northwest Ottawa water supply are primarily from agriculture and livestock in the Northwest Ottawa SWA, and from industrial, commercial, and residential sources in Grand Haven and surrounding communities, and from the transport of fuel, coal, salt, and cement on Lake Michigan.

The Michigan Department of Agriculture has identified at least 5 concentrated animal feedlots (greater than 1000 animal units) in the Muskegon and Grand River watersheds. In addition, at least one animal feedlot operation has a documented discharge to the watershed.

The U.S. Environmental Protection Agency (USEPA) has identified 8 impaired water bodies in the Grand Rapids SWA on its Clean Water Act 303(d) list. The parameters of concern listed for the river and its tributaries are: fish consumption advisories for polychlorinated biphenyl's (PCBs), poor fish and macro-invertebrate communities, nutrient enrichment, pathogens, dissolved oxygen violations, fish kills, untreated sewage discharge, combined sewer overflows, and mercury exceedances (MDEQ, 2001).

In addition, the Grand River is listed as a major contributor of trans-Nonachlor (USEPA, 2001). The Grand River is a significant contributor of mercury to Lake Michigan, and the Grand River was identified as a minor contributor of PCBs. Results for atrazine have not yet been released.

In general, PCS within the susceptible area pose greater risks than those outside the susceptible area. The presence of PCS within the SWA indicates potential sources of chemicals that could, if improperly managed or released, affect the water quality at the intake. A small quantity of these chemicals, in some cases a gallon or less, can significantly affect the supply. Also of concern is the location and distribution of these sources with respect to highly permeable soils. Overlaying the PCS locations and the soil permeability map for the WTP SWA indicates that more than 1007 of the located PCS are located on or very near to areas with moderately rapid to rapidly permeable soils (fig. 2).

The SWA consists of primarily agricultural land (fig. 4). The results of the PCS inventory performed for the Grand Rapids water supply are shown on figure 4 and are summarized as a function of PCS locations within the SWA relative to land use. Inventory results indicate that there are 74 PCS within the SWA holding 85 permits (tables 1, 2).

2.13 Sensitivity Analysis

Sensitivity is the natural ability of a SWA to provide protection against the contamination of the water supply intake, and includes physical attributes of lakes, rivers, and soils. The sensitivity analysis requires consideration of several different variables related to the natural environment, for example:

- Water quality history of the source.
- Distribution of moderately to highly-permeable soils.
- Amount of available water from precipitation or runoff.
- Potential for runoff to affect the intake.
- Nature of the intake, including: depth, distance from shore, age, and materials used.
- Surface water flow patterns in vicinity of intake.

To perform this analysis, USGS, MDEQ, and the operator of the Northwest Ottawa WTP collected, researched, and analyzed information from the WTP, monthly operator reports, sanitary surveys, soil maps, published reports, and historical plant operation and raw water quality data. The Michigan SWAP has three categories of sensitivity for surface water sources ranging from moderately sensitive to very highly sensitive. Analysis of this information, using

guidelines provided in Brogren (1999) and Sweat and others (2000, 2002), indicates that the Northwest Ottawa intake is moderately sensitive (fig. 5). This means that the natural environment offers some limited protection against contamination of the water supply intake.

2.14 Susceptibility Determination

Susceptibility is the relative potential for contamination to reach the public water supply intake used for drinking water purposes. Whereas the sensitivity of a water supply is the natural ability of the area to protect the intake against contamination, the susceptibility determination also takes into account other factors that will affect whether a contaminant reaches the intake. Whether or not a particular drinking water source becomes contaminated depends on three factors:

1. The distribution of PCS;
2. The source water area; and
3. The natural protection, or sensitivity, of the source.

In conducting a susceptibility determination, the part of the SWA that yields water to the water supply-system intake is identified by establishment of the susceptible area within the source water area. PCS within the susceptible area are then located. Based on the distribution of PCS within the susceptible area, the type of PCS, and the nature of the chemicals they use or store, PCS are analyzed for the risk they may represent to the water supply intake. Along with the presence and distribution of PCS, the sensitivity analysis is then used to determine the susceptibility of the water supply (fig. 5). This leads to a determination of whether the drinking water source is moderately susceptible, highly susceptible, or very highly susceptible to contamination (Sweat and others, *in press*). It is important to understand that a system can have low sensitivity relative to some conditions (for example, intake construction and location), and high susceptibility because of other conditions (for example, the type of PCS). In Michigan, surface water sources of drinking water range from moderately low to very-high susceptibility.

When a public water supply is determined to have a moderately high, high, or very high susceptibility because of a particular condition or set of conditions, there is a significant risk of contamination of the drinking water source because of that condition or set of conditions. Although the susceptibility determination does not predict when or if contamination will actually occur, it does recognize conditions that are highly favorable for contamination of the supply. In the event of a contaminant release to soils or surface water within the susceptible area, it is very likely that contamination at the intake would occur without completion of remedial actions.

If a public water supply's drinking water source is determined to be highly susceptible, it is recommended that the system identify the condition(s) that lead to the high susceptibility. Immediate steps should be taken to protect the source, and action should be considered to remedy the condition (for example, repairing or replacing faulty intake construction, working directly with facility operators to implement sound management practices, etc.).

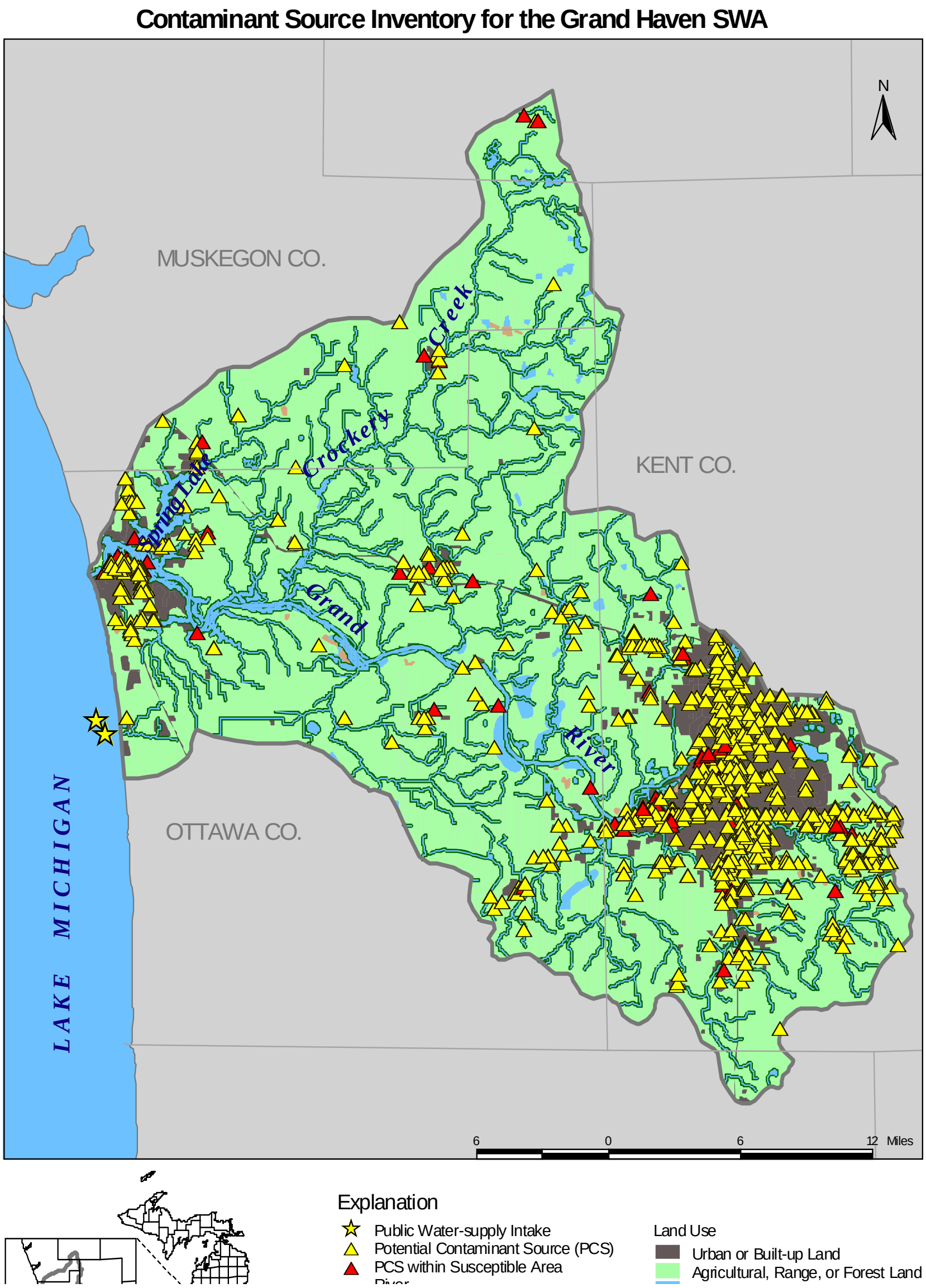


Figure 4.
Contaminant Source Inventory for the Northwest Ottawa Water Supply, Grand Haven, MI

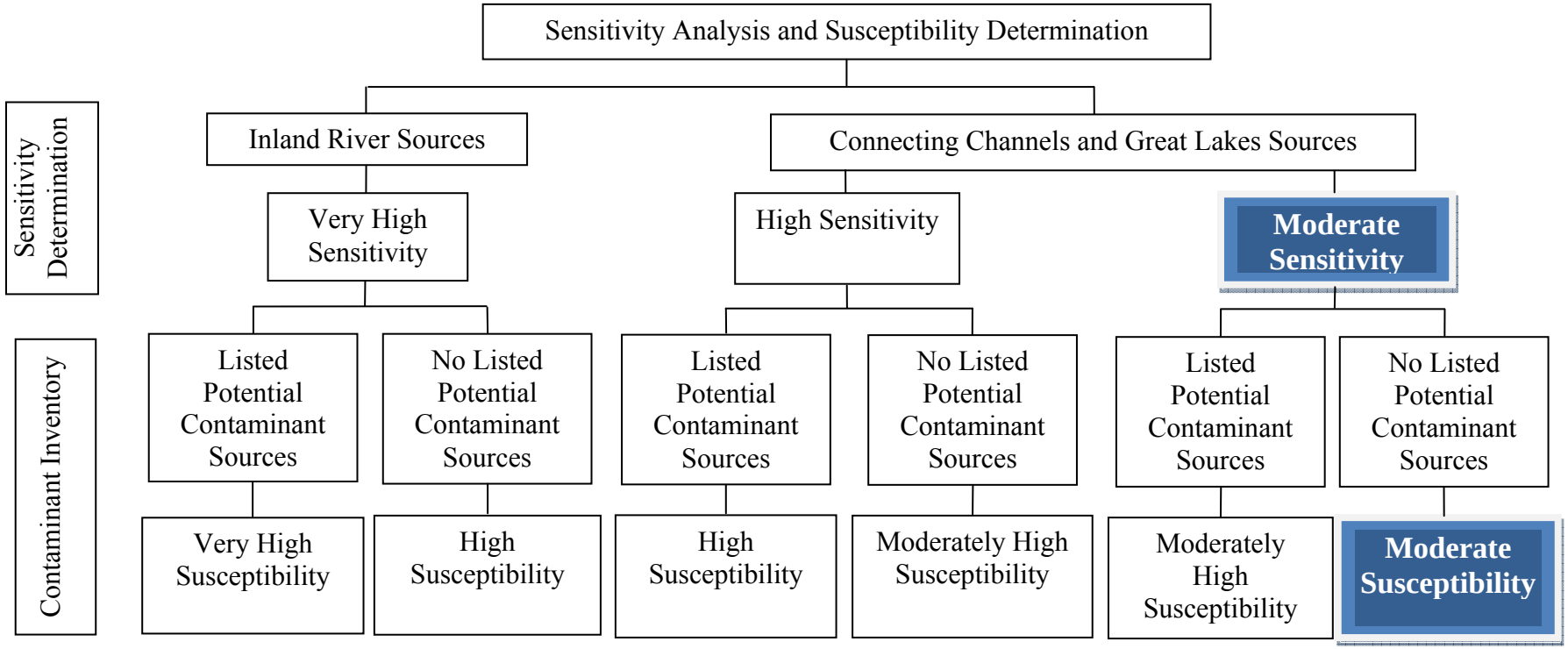
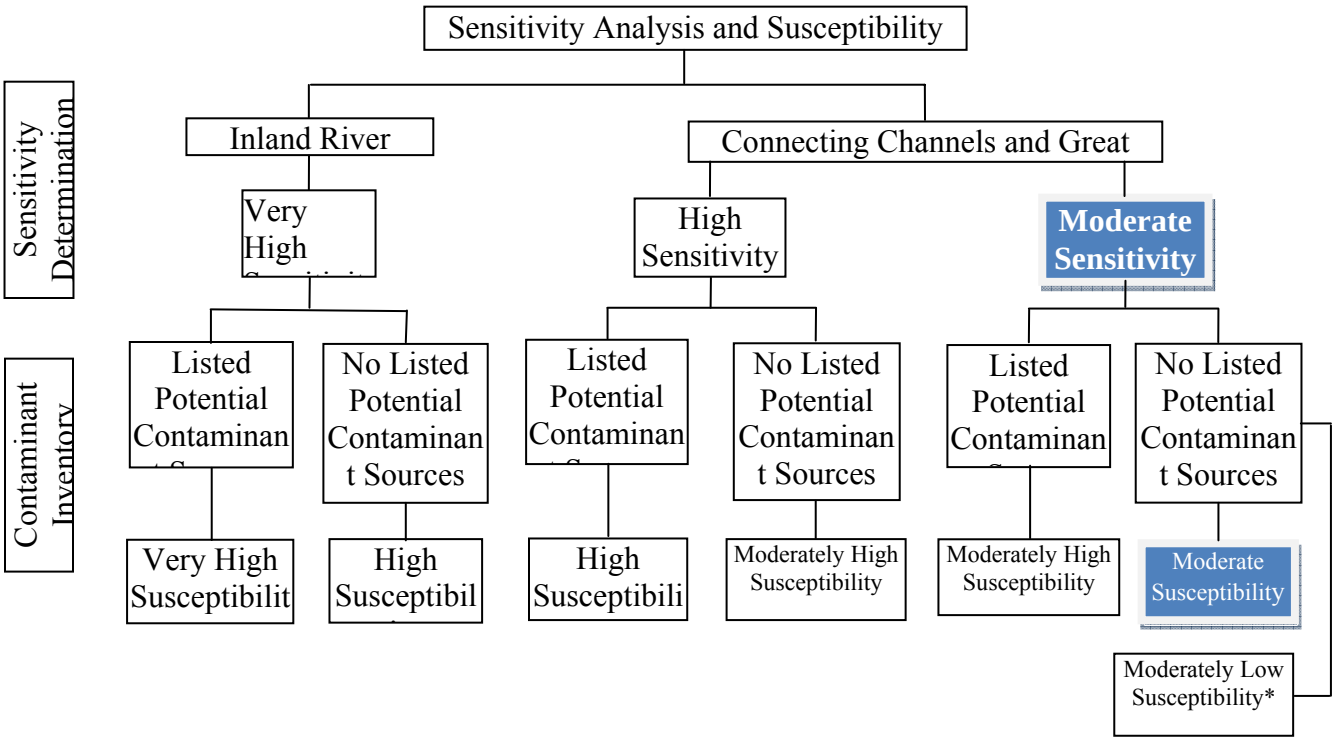


Figure 5. Surface Source Sensitivity Analyses and Susceptibility Determinations

When a public water supply is determined to have a moderate, high, or very high susceptibility because of a particular condition or set of conditions, there is a significant risk of contamination of the drinking water source because of that condition or set of conditions. The susceptibility determination cannot predict when or if contamination will actually occur, it does recognize conditions that are highly favorable for supply contamination. In the event of a contaminant release to soils or surface water within the CAZ or susceptible area, it is very likely that contamination at the intake would occur without completion of remedial actions.

If a public water supply's drinking water source is determined to be highly susceptible, it is recommended that the system identify the condition(s) that lead to the high susceptibility. Immediate steps should be taken to protect the source, and action should be considered to remedy the condition (for example, repairing or replacing faulty intake construction, working directly with facility operators to implement sound management practices, etc.). All water supplies, regardless of their susceptibility, should consider identified factors that could lead to higher susceptibility in the future, and should prepare a strategy to protect the water supply source. Raising public awareness through signs and other education programs, encouraging proper intake construction and the use of best management practices in existing facilities are good ways of ensuring that a surface water source maintains its moderate susceptibility rating.



*Moderately Low Susceptibility determination is only applicable to deep, open water Great Lake intakes, free from littoral zone interferences, with excellent raw water quality histories, and where current flows and lake volume provide for an exceptionally high dilution factor in the event of a spill or contamination event.

Figure 5. Surface-water source sensitivity analyses and susceptibility determinations.

All water supplies, regardless of their susceptibility, should consider identified factors that could lead to higher susceptibility in the future, and should prepare a strategy to protect the water supply source. Raising public awareness through signs and other education programs, encouraging proper intake construction and the use of best management practices in existing facilities are good ways of ensuring that a surface water source maintains its moderate susceptibility rating.

Although the Northwest Ottawa intake has a CAZ of 3,000 ft, it is a buried infiltration bed, which offers protection from shoreline influences. Normally, an intake with a CAZ of 3,000 feet would be categorized as highly susceptible. Given that the buried infiltration bed offers protection from shoreline and surface water influences, the susceptibility is lowered to moderately susceptible.

2.15 Summary and Recommendations

The actual susceptibility of the drinking water source of a water supply depends on a number of contributing factors, some of which are only slightly related. Sensitivity is determined from the natural setting of the source and identifies the natural protection afforded to the source water. Susceptibility is determined by identifying those factors within the community's SWA that may pose a risk to the source water. The susceptibility determination provides information with respect to facilities within the SWA or land areas within the SWA that should be given greater priority and oversight in the implementation of a drinking water protection program.

Sensitivity Analysis: Based on criteria adopted in the Great Lakes Protocol of the Michigan Source Water Assessment Program, and modified by discussion with Brad Brogren (oral commun., May 9, 2002), the buried, offshore intakes and collector system intakes for the Northwest Ottawa Water Treatment Plant have a moderate degree of sensitivity to potential contaminants. When considering off shore winds and influences from the Grand River the Northwest Ottawa intake is categorized as moderately sensitive.

Susceptibility Determination: The SWA for the Northwest Ottawa intake includes 1,401 listed potential contaminant sources, plus agricultural, urban, and industrial runoff from the Northwest Ottawa SWA. However, the buried intakes effectively prefilter the source water, and PCS in the susceptible area are not as likely to affect the WTP. The moderately sensitive intake for the Northwest Ottawa WTP yields source water with a moderate susceptibility determination (fig. 5).

Effective Treatment: While it has been determined the Northwest Ottawa source water has moderate susceptibility to potential contamination, it is also noted the Northwest Ottawa Water Treatment Plant has, historically, effectively treated this source water to meet drinking water standards with minimal complaints from the public. This assessment provides the community with a basis to institute a source water protection program as another tool to assure the continued safety of its water supply.

The results of this assessment and the recommendations based on these results are summarized as follows:

- ***Intake*** - The Northwest Ottawa Water Supply was originally constructed in 1912. The current infiltration system draws water from approximately 1,280 ft offshore, at a depth of 14 ft, beneath approximately 11 ft of overlying sand, making it a moderately sensitive intake. There are no emergency intakes, although there is one buried riser that is not accessible.

- ***Soils*** – Using a mean, area-weighted, depth-integrated permeability estimation, the soil and subsoil material in the SWA range from 0.9 in/hr to as much as 12.7 in/hr. The mean permeability is 8.1 in/hr (Schneider and Erickson, undated, series of 5 maps; BASINS, 1998). There are 1007 PCS are located on moderately rapid to rapidly permeable soils within the SWA. These factors combine to make the SWA, and thus the intake, moderately sensitive. The community should take steps to evaluate current and future land use in areas of highly permeable soils, particularly those occurring within the susceptible area. Those PCS that have been identified either on or in close proximity to these soils should be informed of the sensitive nature of the area and encouraged to adopt best management practices designed to minimize the risk of a ground release. Residential areas that have been developed on these soils should be targeted for educational programs identifying steps that residents can take to protect the water supply.

- ***Historical Contaminant Detections*** - There have been no detections of synthetic or volatile organic contaminants in the systems raw water. Inorganic contaminants are typically at lake background levels. Nitrate concentrations are routinely below the detection limit. Positive coliform bacteria detections have occurred often associated with snowmelt, spring runoff, and discharge from the Grand River above median flow. The periodic presence of coliform bacteria before chlorination at the intake is indicative of a relationship between runoff and soil conditions, causing the occasional presence of bacteria at detectable levels in the source water. These factors indicate that the SWA, and thus the intake, is moderately susceptible.

- ***Sanitary Survey*** - The most recent sanitary survey (Timm and Pardini, 1999) revealed only minor defects. Those requiring repair either have been corrected or are scheduled for repair. It is important that the water supply continue to follow good management practices.

- ***Potential Contaminant Sources*** - A review of the PCS inventory and the moderately rapid and rapidly permeable soil distribution indicates that the Northwest Ottawa SWA has 1007 PCS located on moderately rapid and rapidly permeable soils. There are also 74 PCS holding 85 permits within the susceptible area. It is recommended that the community focus initially on PCS that are located on rapidly permeable soils and nearest any water bodies (the susceptible area), as they pose the greatest potential threat to the water supply. These facilities should be made aware of free technical assistance that is available through MDEQ's pollution prevention programs. Through chemical inventory, waste reduction, and by increasing awareness of best management practices, the risk these facilities pose to source waters can be reduced. The PCS inventory indicates that the source has moderate susceptibility.

- ***Source Water Assessment*** - The Northwest Ottawa source water assessment of moderate susceptibility is based on these site-specific parameters:
  1. Definition of a Critical Assessment Zone around the collector system, crowsfoot, and buried intakes for a source with moderate sensitivity;
  2. Definition of a SWA for the Grand River and the shoreline near the intake;
  3. Wind and current patterns in Lake Michigan near the Northwest Ottawa WTP intakes and their effects on source water quality; and
  4. Listed and nonlisted potential contaminant sources.

- ***Source Water Protection*** – The city of Grand Haven has initiated source water protection activities with an Industrial Pretreatment Program incorporating management plans, chemical containment, and spill response, spill response training, and a street cleaning program.

The Northwest Ottawa WTP and/or its member communities should assemble a team to assist in the development and implementation of a source water protection program that uses this assessment to further protect the Northwest Ottawa source water area.

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GLOSSARY

Critical Assessment Zone (CAZ) – the area from the intake structure to the shoreline and inland, including a triangular water surface and a land area encompassed by an arc from the endpoint of the shoreline distance on either side of the on shore intake pipe location

Geographic Information System (GIS) – a system to capture, store, update, manipulate, analyze, and display all forms of geographically referenced information

Impaired water bodies – As defined by USEPA and Clean Water Act 303(d) list

Intake – the point at which source (raw) water is drawn into a pipe to be delivered to a water treatment plant

Lignins – an amorphous, cellulose-like, organic substance that acts as a binder for the cellulose fibers in wood and adds strength and stiffness to cell walls

Maximum Contaminant Level (MCL) – the maximum permissible level of a contaminant in water that is delivered to any user of a public water system

Potential Contaminant Sources (PCS) – listed and non-listed agricultural sites, businesses, and industries that have the potential to cause contaminants to be introduced into source water

Sensitivity – a measure of the physical attributes of the source area and how readily they protect the intake from contaminants

Source – the water body from which a water supplier gets its water

Source Water Area (SWA) – the land and water area upstream of an intake that has the potential to directly influence the quality of the water at the intake

Source Water Assessment Program (SWAP) – in Michigan, the process defined by the state Department of Environmental Quality to complete assessments of all the state's public water supplies

Susceptibility – the Susceptibility identifies factors that may pose a risk within the community's source water area

Susceptible Area – the area defined by the critical assessment zone and a buffer on either side of any drainages that contribute water to an intake

Synthetic Organic Contaminants (SOC) – Manmade organic chemical compounds such as pesticides, etc.

Tannins – naturally occurring phenolic compounds that precipitate proteins, alkaloids, and glucosides from solution that has a yellowish appearance

Volatile Organic Contaminants (VOC) – Unnatural, volatile organic chemical compounds such as gasoline components, solvents, degreasers, etc.

Appendix

Table 2. Potential-contaminant source-inventory results, Grand Rapids source-water area, Michigan.

Site Name	Identification Number	Reason for Permit	Reason for Listing as Potential Contaminant Source
ADAMS R L PLASTICS INC	MID088874037	On-Site Storage	Hazardous and Soild Waste Site
ADVANCED DISPOSAL SERVICES INC [a]	MID982070088		
ADVANCED ENVIRONMENTAL TEC [a]	MID982070088		
ALPHA TRAN ENGINEERING CO INC	MID044563161		
AMOCO OIL CO 7381	MID985608058		
ANDERSON AND ASSOCIATES INC	MID053666780		
BASF CORP COATINGS AND INK DIV [b]	MID001868595		
BLODGETT MEMORIAL MEDICAL CTR	MID079292512		
BO JAC INC	MI0000083642		
CAPITAL LEASING CO	MID017076118		
CHEMCENTRAL/GRAND RAPIDS [c]	MID017108192		
CHICAGO DRIVE COLLISION SVC	MID106757776		
CLARK STORE 1467	MI0001338987		
CLARKLIFT OF WESTERN MICHIGAN	MID117461517		
DODGEN AIRCRAFT REF INC	MID985566850		
ELECTRO CHEMICAL FINISHING CO [d]	MID980990113		
EMRO MARKETING 6304	MID985577071		
ENVIRONMENTAL CONTROL SERVICE INC [a]	MID981536030		
FAST DELIVERY INC	MI0001339498		
FMC CORP ACG	MID000718502		
FREIGHTLINER OF GRAND RAPIDS	MID085900751		
GR MFG CO	MID092951953		
GRAND RAPIDS WASTEWATER TREATMENT PLT [f]	MID980273668		
GRAND VALLEY STATE UNIV	MID059692996		
H AND L INC	MID985627298		
HANSON MANUFACTURING INC	MI0001185206		
HAVILAND PRODUCTS CO	MID006028492		
IDEAL SEATING CORP	MID006017412		
INDUSTRIAL WASTE TECHNOLOGY	MID981536030		
JACKSONS INDUSTRIAL MFG INC	MID072598840		
JOHNS TOWING SVC	MID985635325		
KAISER AUTO REPAIR	MID017088725		
KOCH MATERIALS CO [g]	MID981099252		
LASH D W PRODUCTS INC	MID083696724		

Site Name	Identification Number	Reason for Permit	Reason for Listing as Potential Contaminant Source
MAPLE ISLAND ESTATES INC	MI0000992883	On-Site Storage	Hazardous and Soild Waste Site
MICHIGAN COLPROVIA CO	MID006018766		
MOL BELTING	MID985636505		
NATIONAL NAIL	MID985636513		
PLASTIC PLATE II	MID980998538		
PLUMMERS SEPTIC TANK SERVICE INC	MID017097601		
PRIME PRODUCTS INC	MID079296679		
PRO TECHNOLOGY INC	MI0001185438		
RAPID FINISHING INC	MID985567767		
RAVINA CITY OF	MID985642743		
REITSMA AUTO SALES	MID985622208		
SHELL OIL CO GRAND HAVEN [h]	MID000609099		
SUNOCO SERVICE STATION	MID000684936		
THOMPSON MCCULLY	MID981803356		
TON TEX CORP	MID006016737		
UNIQUE INDUSTRIAL PACKAGING	MID982218653		
UNIVERSAL ELECTRO COATERS	MI0001339480		
VALLEY CITY DISPOSAL INC	MID981956063		
VAN ECK COLLISION	MID985577709		
VANS INDUSTRIAL EQUIPMENT CO	MID985603489		
VERHAGE MOTORS SALES CO	MID985616846		
WELLER AUTO PARTS INC TRUCK PARTS	MID980609218		
WOLVERINE BRASS WORKS	MID006025332		
WOLVERINE PIPE LINE CO GRAND HAVEN STA	MID000717033		
WORK SAFE SUPPLY CO INC	MI0001185222		
CHALLENGE STAMPING&PORCELAIN	MI0002780	Process, Treatment, and Waste Waters	Industrial Facilities Discharge Site
CONSTRUCTION AGGREGATES CORP	MI0004570		
CORDUROY RUBBER CO	MI0002798		
DEBRUYN PRODUCE CO	MI0002810		
GARDNER-DENVER CO-GRAND HAVEN	MI0003671		
GEORGIA-PACIFIC-KENTWOOD	MI0002861		
GRAND HAVEN BL&P [e]	MI0001546		
GRAND HAVEN BL&P ISLAND STA [e]	MI0000728		
GRAND HAVEN-SPRING LAKE WWTP	MI0021245		
GRAND RAPIDS WTP	MI0005282		
KENOWA HILLS PUBLIC SCHOOLS	MI0029041		
NORTH SHORE MOBILE HOME CT.	MI0025810		
CHEM-CENTRAL [c]	MID980477079	Superfund Site	National Priority List
SANICO NORTH GRAND GARBAGE CO	MID980678783		

Site Name	Identification Number	Reason for Permit	Reason for Listing as Potential Contaminant Source
ALLENDALE TWP WWTP	MI0023019	Waste Water, Dust, and Process Water	Permit Compliance System
GRAND HAVEN BL&P [e]	MI0001546		
GRAND RAPIDS WWTP [f]	MI0026069		
RIVER HAVEN MHP WWTP	MI0042871		
SHELL OIL CO-GRAND HAVEN [h]	MI0046914		
YAMAHA MUSICAL PRODUCTS [i]	MI0053091		
ALOFS MFG.	MID985595180	Release or Manufacture Toxic Compounds	Toxic Release Inventory
BASF CORP. COATINGS DIV. [b]	MID001868595		
COUNTRY FRESH	MID005869078		
ELECTRO CHEMICAL FINISHING CO. [d]	MID980990113		
KOCH MATERIALS CO. [g]	MID981099252		
YAMAHA MUSICAL PRODS. [i]	MID985569946		

Note: Superscript indicates multiple permits.