STATE OF MICHIGAN
SOURCE WATER ASSESSMENT PROGRAM REPORT

Alpena Water Treatment Plant, Alpena, Michigan

for submittal to the

U.S. Environmental Protection Agency

by

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Water Bureau
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MICHIGAN SOURCE WATER ASSESSMENT PROGRAM
Executive Summary

The reauthorization of the federal Safe Drinking Water Act (SDWA) of 1996, P.L. 104-182, Section 1453 required federal guidance and defines state requirements for a Source Water Assessment Program (SWAP). The SDWA requires the state to:

- Identify the areas that supply public tap water.
- Inventory contaminants and assess source water susceptibility to contamination.
- Inform the public of the results.

Michigan has almost 12,000 public water supplies with an estimated 18,000 sources requiring assessments. Of these, approximately 10,650 are noncommunity public water supplies with groundwater as the source. There are approximately 1,250 community systems, including 650 systems using groundwater sources and supplies that purchase water. There are only 60 surface water intakes, but these 60 sources provide drinking water to over 75 percent of the persons served by public water systems or about 50 percent of the state's population. These figures presented Michigan with some unique challenges in developing a SWAP.

In 1998, the Michigan Department of Environmental Quality (MDEQ) convened a SWAP Advisory Committee composed of stakeholders from federal, state regulatory, local health departments (LHDs), universities, nonprofit organizations, and representative trade associations to assist with developing the Michigan SWAP. The final SWAP document was submitted to the U.S. Environmental Protection (USEPA) in February 1999 and approved in October 1999.

The MDEQ established a unique partnership with numerous federal, state, and local agencies in working to complete the SWAP. For the noncommunity public supply water assessments (NCPWS), Michigan State University (MSU) Institute of Water Research, Groundwater Education in Michigan (GEM) Centers, and LHD staff coordinated roles in completing assessments. Staff from the Michigan Department of Agriculture completed assessments of the migrant labor camps defined as NCPWS. The MDEQ staff was primarily responsible for completing community groundwater sources. Michigan surface water sources were assessed using protocol developed with the USEPA Region 5 states and refined with methodologies developed and completed by the U.S. Geological Survey (USGS), MDEQ Groundwater Section staff, and the Michigan Public Health Institute. The National Oceanic and Atmospheric Administration, Detroit Water and Sewerage Department, and Environment Canada also played significant roles in assisting with the connection channels flow model used to delineate intakes in Southeast Michigan.

Of the approximately 10,650 noncommunity public water supplies, significant financial and staff resources were invested addressing these systems. The present Noncommunity Public Water Supply (NCPWS) Program includes a sanitary survey of each system every five years. These surveys are done through contracts with LHDs. It was decided to tie the source water assessments of these sanitary surveys to make the system more efficient and to make the assessments a tool for future use. The work on the noncommunity assessments was completed using existing programs and expertise and directed toward providing tools that assist with improving protection efforts.

The noncommunity Source Water Assessment Score (SWAS) is based upon evaluation of the following:

1. The geologic sensitivity of the NCPWS well.
2. The construction, maintenance, and use of the NCPWS well.
3. Chemistry data from the NCPWS well water.
4. Isolation of the NCPWS well from sources of contamination.

Michigan State University provided support in all aspects of the noncommunity assessment process, proving oversight for contractual efforts with the GEM centers. These centers provided assistance to the LHDs, as needed, for using the Global Positioning System (GPS) units and assisting in other areas of the program.

Michigan has a voluntary Wellhead Protection Program (WHPP). There are 120 Community Public Water Supplies (CPWSs) that have approved WHPPs and an additional 80 that have an approved delineation. The remaining 953 systems (of which 397 are Mobile Home Parks) were assessed using a protocol similar to the noncommunity system.

A WHPP provides information necessary for source water assessment. The geologic sensitivity was determined from data derived from wellhead protection area (WHPA) delineation reports. Potential sources of contamination were derived from the WHPP report. For communities with approved delineations, but no program approval, the potential sources of contamination were identified in the WHPA, and the assessments were completed and analyzed as a separate group.

The community groundwater systems without WHPPs were completed using state staff or a third party contractor. The assessments on the remaining small systems are similar to those conducted for the noncommunity systems.

Public surface water supply intakes were assessed using procedures defined in the Great Lakes Protocol and with assistance from water treatment plant personnel.

The Michigan SWAP defined susceptibility to contamination for sources of public drinking water and recommended protection activities. The protection of Michigan's sources of drinking water can be accomplished through a variety of local, state, and federal programs. Information derived from the source water assessments will enhance these protection programs. Public and private well construction and isolation requirements in the Michigan SDWA and Public Health Code, along with the technical expertise of local and state department personnel, have been the foundation of the state's water supply program. Properly constructed and isolated wells are considered the first line of defense in Michigan for source water protection of groundwater sources. Routine field surveillance and sanitary surveys by DEQ and LHD staff have also been a strong focal point in source water protection. The integration of results of the source water assessments into the ongoing sanitary surveys enhances the protection of the supplies. Geographic Information System (GIS) tools and data will improve productivity and effectiveness of the LHDs.

The results of the assessments and use of GIS tools developed and disseminated under the SWAP should be used to prioritize protection efforts. CPWSs that have been determined to be “High” or “Very High” susceptibility should be reviewed and plans developed to address protection efforts at these sites.

Community groundwater supplies that are not pursuing wellhead protection should be encouraged to do so. Public surface water supplies should develop protection programs similar to wellhead protection on a watershed basis. Tools for providing source water protection of surface water supplies are available through the federal Clean Water Act.

CHAPTER 1 – INTRODUCTION

Michigan has almost 12,000 public water supplies with over 18,000 sources requiring source water assessments. Of these, approximately 10,650 are noncommunity public water supplies with groundwater as the source. There are approximately 1,250 community systems, including 650 systems using groundwater sources and supplies that purchase water. There are only 60 surface water intakes, but these 60 sources provide drinking water to over 75 percent of the persons served by public water systems, or about 50 percent of the state's population. These figures presented Michigan with some unique challenges in developing a SWAP.

The efforts toward developing the SWAP in Michigan were divided into three sections with a total of seven assessment categories:

- Noncommunity Groundwater Supplies

- Community Groundwater Supplies
  - Wellhead Protection Program
  - Wellhead Protection Area Delineations
  - Remaining Groundwater Assessments

- Community and Noncommunity Surface Water Supplies
  - Great Lakes Sources
  - Great Lakes Connecting Channels
  - Inland Lakes and Rivers

The present NCPWS Program includes a sanitary survey of each system every 5 years. These surveys are done through contracts with LHDs. The surveys were expanded by these contractual efforts through a contract amendment to include an assessment using an assessment survey form, scoring different criteria that affect the vulnerability of the source, and tabulating an assessment score for the site. These assessments evaluated major potential sources of contamination within 800 feet of the water source. Eight hundred feet is the separation requirement between a source of contamination and a NCPWS source as defined in the Michigan Safe Drinking Water Act. An on-site visit was required to locate the well in a statewide groundwater data base through the use of GPS units along with submittal of a water well and pump record (well drilling record) where available. The well construction, pumping capacity, chemical monitoring records, and the geological setting were assessed. All noncommunity systems, both transient and nontransient, were assessed in the same manner.

MSU provided oversight for contractual efforts with the GEM centers. These centers provided assistance to the LHDs, as needed, for using the GPS units and assisting in other areas of the program.

The master contract with MSU included provisions to map the elevations of “first water.” This information will assist in determining direction flow for “first water” throughout the state. When contaminants enter the ground, they generally follow the direction of this “first water” flow. Knowledge of this flow direction will assist in evaluating the threat of contaminants to public drinking water supplies.

Evaluation of work done by the LHDs was assessed as the work was submitted to the state. The GPS locations were verified through an assessment system along with the well drilling record entries. Payment was made for work completed.

The community groundwater systems without WHPPs were completed using state staff or a third party contractor. The assessments on the remaining small systems are similar to those conducted for the noncommunity systems.

A small number of public water supplies derive their water from karst hydrologic systems (KHSs). Groundwater flow in KHSs is typically controlled by a continuum of vertical and horizontal conduits formed in and enhanced by dissolution of limestone, dolomite, gypsum, and other soluble rocks and minerals. Groundwater flow rates in KHSs are typically an order (or orders) of magnitude faster than groundwater flow in porous media (typically hundreds of feet per day in a KHS). Karst hydrologic systems that are near or at the earth's surface provide a pathway for surface drainage and contaminants to directly enter drinking water supplies. Areas in the state where karst or fractured bedrock were within 25 feet of the surface were mapped. The source water assessments in these areas were completed using criteria developed jointly by the MDEQ and the USGS, Michigan District.

The SWAP included susceptibility determinations that take into account source sensitivity related to area geology or hydrology and contaminant sources within the assessment area. These factors are used to determine the potential to draw water contaminated by inventoried sources at concentrations that would pose concern. For groundwater sources, the sensitivity could be determined by reviewing depth to "first water," recharge from precipitation and surface waters, thickness of confining layers, plus well construction, maintenance, and pumpage. The sensitivity analyses are then evaluated with the source chemical and/or isotope data and isolation from contaminant sources to determine susceptibility.

The assessments were enhanced with the use of data previously collected from vulnerability assessments and from data collected during sanitary surveys. This information will also be beneficial for future sanitary surveys.

Michigan has a voluntary WHPP. There are 120 CPWSs that have approved WHPPs and an additional 80 that have an approved delineation. The remaining 953 systems (of which 397 are Mobile Home Parks) were assessed using a protocol similar to the noncommunity system.

A WHPP provides information necessary for source water assessment. The geologic sensitivity was determined from data derived from WHPA delineation reports. Potential sources of contamination were derived from the WHPP report. For communities with approved delineations, but have not had their programs approved, the potential sources of contamination were identified in the WHPA, and the assessments were completed and analyzed as a separated group.

Table 1. Michigan Public Water Supplies

Noncommunity Groundwater Supplies		
Transient =	8,930	
Nontransient =	1,720	
Subtotal =	10,650	with approximately 13,000 wells to assess
Community Supplies		
Groundwater =	1,123	with an estimated 5,000 wells to assess
		Purchased Groundwater Systems = 42
Surface Water Intakes		
Inland Rivers	8	
Great Lakes	52	
Subtotal =	60	Purchased Surface Water Systems = 233
Total Active Community Systems =	1,460	
Total Number of Public Water Supplies =	12,108	

Approximate Number of Sources to be Assessed = 18,000

CHAPTER 2 – NONCOMMUNITY ASSESSMENTS

Program Implementation

The SWAS was developed cooperatively among the Environmental Health, Groundwater, and Field Operations Sections within the Water Division, MDEQ. Staff from these sections may utilize the SWAS to assign monitoring requirements and identify NCPWSs that should receive follow-up activities.

The assessments of noncommunity groundwater supplies were conducted by LHD staff and were coordinated with the sanitary survey requirements that mandate a sanitary survey every 5 years. This required the state to begin the program as soon as possible to allow completion within the 5-year sanitary survey cycle. All public water supply assessments include an assessment area derived from standard and major contamination source isolation areas. Standard and major contaminant isolation areas as defined by the Michigan SDWA are 75 feet and 800 feet for noncommunity groundwater supplies.

Contaminants of concern and contaminant sources were evaluated in each assessment area. The program identified known and potential sites of environmental contamination that are included on a contaminant inventory list. Known sites of environmental contamination include leaking underground storage tanks, Superfund sites, Part 201 sites of Act 451, sites of environmental contamination, and oil and gas contamination sites. Other sites that represent a potential for contamination include registered underground storage tanks, certified aboveground storage tanks, hazardous waste generators, abandoned wells, plus surface and groundwater discharges. Land use associated with agricultural operations, commercial facilities, manufacturing and industrial facilities, institutional facilities, and utility companies may also have been considered potential sources of contamination, particularly as they relate to nonpoint source discharges. Contaminants from these sources that threaten public health were considered as contaminants of concern.

These contaminants and potential sources in combination with the source hydrogeology or hydrology sensitivity analysis yield a susceptibility determination. The critical factors considered in determining susceptibility are the relationships between the integrity and construction of the well or surface water intake, source sensitivity, and potential contaminant sources. This determination also took into account any maximum contaminant level (MCL) violations related to source water quality or contaminants of concern detected in the source water.

Source water assessments were completed for approximately 10,650 NCPWSs throughout the state**.** The objectives of the groundwater assessments were:

- Accurately establish, through the use of GPS and GIS, the location of NCPWS wells.
- Provide for the entry of water well and pump installation records into an electronic data management system.
- Identify the location and proximity of sources of contamination located within 800 feet of NCPWS wells.
- Establish a Source Water Assessment Score (SWAS) that reflects the "inherent vulnerability" of the NCPWS well and source water. This includes assessment of the integrity of the well and geologic setting.

Obtaining accurate location information and well drilling record information for NCPWS wells was an essential first step in the state SWAP. The location and well drilling record information was entered into the statewide groundwater data base (Wellogic). To obtain this data, the technical expertise and networking developed by the Kellogg Foundation, GEM Grant Program, was used. Training of LHD staff and the compilation of data was done by state staff and the GEM regional centers located around the state. The effort was coordinated by the MSU Institute of Water Research.

Location information was collected for each NCPWS well using GPS. LHDs, at their option, contracted for site visits to conduct assessments to obtain GPS locations on all NCPWS wells. State staff conducted assessments if the LHDs did not contract for the program. The majority of the LHDs did the program under contract with the state. The GPS locations were "corrected" to provide accurate well locations before the information was entered in Wellogic. Corrected locations were obtained through postprocessing collected location information to provide accurate locations.

Some LHDs received additional funds for corrected and accurate well locations. The supplemental funds were used to purchase new GPS units or upgrade existing GPS capabilities, if the LHD provided corrected and accurate GPS locations for entry into Wellogic. The state purchased 12 Trimble Geo Explorer II GPS units with a differential accuracy of 2 to 5 meters. These units were rotated among LHDs that did not purchase GPS units.

Information from well drilling records is critical to the SWAP. As part of SWAP, available well drilling records for NCPWS wells were compiled. Wellogic contains location verified well information compiled from well drilling records that had the NCPWS information added. WELLKEY was the software program that allows well drilling record information to be stored in a data base format and provided for the automated entry, storage, and retrieval of well information. The LHDs, at their option, were contracted to enter the well record information for NCPWS wells in WELLKEY. During the grant period, WELLKEY was replaced with Wellogic, which allows internet data entry.

GIS is an essential tool for analysis and display of SWAP data. ESRI products including ArcView were used. The GPS location and well drilling record information obtained by the LHDs was compiled and incorporated into the statewide GIS for use in the analysis of information and the presentation to the public. Through GIS the results are being used in protection efforts for public water supplies and can also be used to focus groundwater protection efforts for private water supply wells. Under the MSU contract, a special version of the Michigan MapImage Viewer was developed. A description of the GIS software is included as Appendix F (Community Ground Water Supply Source Water Assessment Worksheet).

In addition to the GPS/GIS phases of the source water assessment, the vulnerability of NCPWS wells was evaluated by determining a SWAS. The SWAS equates to a susceptibility determination. The SWAS has been created as a numeric system that assigns points for situations that represent a "perceived risk" based upon the evaluation of four criteria. The evaluation criteria provide a "qualitative assessment" of groundwater movement and the potential for movement of contaminants into the subsurface.

The SWAS is based upon evaluation of the following:

- The geologic sensitivity of the NCPWS well.
- The construction, maintenance, and use of the NCPWS well.
- Chemistry and/or isotope data from the NCPWS well water.
- Isolation of the NCPWS well from sources of contamination.

The criteria are evaluated in a manner such that a higher SWAS is equated to a greater potential of risk for the NCPWS source water.

Establishing a SWAS provides a rationale for identifying NCPWSs that should receive a priority in the NCPWS program. The SWAS system has been developed cooperatively with the Noncommunity Unit, Groundwater Section, Water Division, MDEQ. The Noncommunity Unit can utilize the SWAS to assign monitoring requirements and identify NCPWSs that should receive priority in the performance of sanitary surveys.

A more detailed description of how the methodology was developed and how it is calculated for NCPWS is included as Appendix B. The source water assessment worksheet used in the assessments is included as Appendix C.

The scores developed in the assessment process were used to determine system susceptibility using a digital version of the flow diagram in Figure 7.

Source water assessments in Karst Systems were completed using criteria developed jointly by the MDEQ and the USGS, Michigan District. These systems were assigned a "Very High" susceptibility based on the high geologic sensitivity of a karst hydrologic system that does not have significant overlaying drift material.

The SWAS system is based upon the accumulation of points for situations that represent a perceived risk to the NCPWS source water. The SWAS is derived from a sum of a geologic sensitivity score ($SWAS_G$); a well construction score ($SWAS_W$); a score for chemistry and isotope data ($SWAS_C$); and isolation and control from sources of contamination score ($SWAS_S$).

Geologic Sensitivity - $SWAS_G$ - The $SWAS_G$ is factored into the SWAS based on the total thickness of Continuous Confining Material (CCM) such as clay, clay-rich till, or shale penetrated in construction of the NCPWS well; or the total thickness of Continuous Partially Confining Material (CPCM) such as a mixture of sand and clay or sandstone and shale. The total thickness of CCM and CPCM should be determined from the well drilling record for the NCPWS well. Where a well drilling record is not available, well drilling records from adjacent wells or test hole borings may be used. Geologic maps (i.e., lithologic cross-sections) may also be used if they provide adequate coverage of the area in which the NCPWS well is located. If no lithology information is available, the well is considered highly sensitive for the assessment scoring.

Well Construction - $SWAS_W$ - The design, physical condition, and operation of a NCPWS well may allow the entrance of contaminants into the well despite a high level of intrinsic geologic protection. To account for this possibility, the SWAS is assigned points through the $SWAS_W$ based upon four criteria related to the construction and use of the NCPWS wells. The $SWAS_W$ is assessed points based upon well grouting, the age of the well, the casing depth, and the pumping rate of the well.

Water Chemistry and Isotope Data - $SWAS_C$ - Water chemistry data provides a refinement to the SWAS through the $SWAS_C$ that may increase or decrease the SWAS. As examples, the presence of nitrates, nitrites, volatile organic compounds, or synthetic organic compounds, even at low levels, regulated inorganic chemicals, and regulated radionuclides are indicators of source water vulnerability and increase the SWAS. Tritium is a naturally occurring radioactive isotope of hydrogen that was greatly increased in the atmosphere as a result of nuclear weapons testing in the 1950s. One tritium unit (TU) equals one tritium atom per 10^{18} hydrogen atoms and an equivalent gross beta radiation of 3.2 picocuries/liter. The absence of tritium in the source water indicates the source water is older than early 1950s and not vulnerable, thereby decreasing the SWAS. $SWAS_C$ cannot be less than 0 when tritium is less than 1 tritium unit. Review of chemical monitoring records should go back 5 years or more if appropriate.

Isolation from Sources of Contamination - $SWAS_S$ - *Isolation from Standard and Major Sources* - The isolation of a NCPWS well from sources of contamination is an important criterion in the source water assessment. The maintenance and control of isolation distances can significantly reduce the perceived risk associated with the use of a well. The $SWAS_S$ is assessed points for failure to maintain and/or control adequate isolation between "potential" sources of contamination and "known" sources of contamination. Known sources of contamination include those sources where the groundwater has been impacted, such as a leaking underground storage tank or other sites of environmental contamination.

An analysis of about 8,600 source water assessment scores has been completed. Each component of the source water assessment was evaluated. If necessary data was not available, the assumption was made for the "worst-case," resulting in higher assigned susceptibility of the supply. Information and knowledge form LHD staff or the supply owner could be used to make adjustment to the scores. For example, a well without an available well drilling record was rated as "high sensitivity" unless the LHD staff had information supporting lower sensitivity.

The $SWAS_G$ in Figure 1 shows the distribution of the geologic sensitivity. Wells without an accurate well drilling record were rated as "high sensitivity" unless the LHD staff had information supporting lower sensitivity. Figure 2 shows the distribution of scores of wells with records.

FIGURE 1

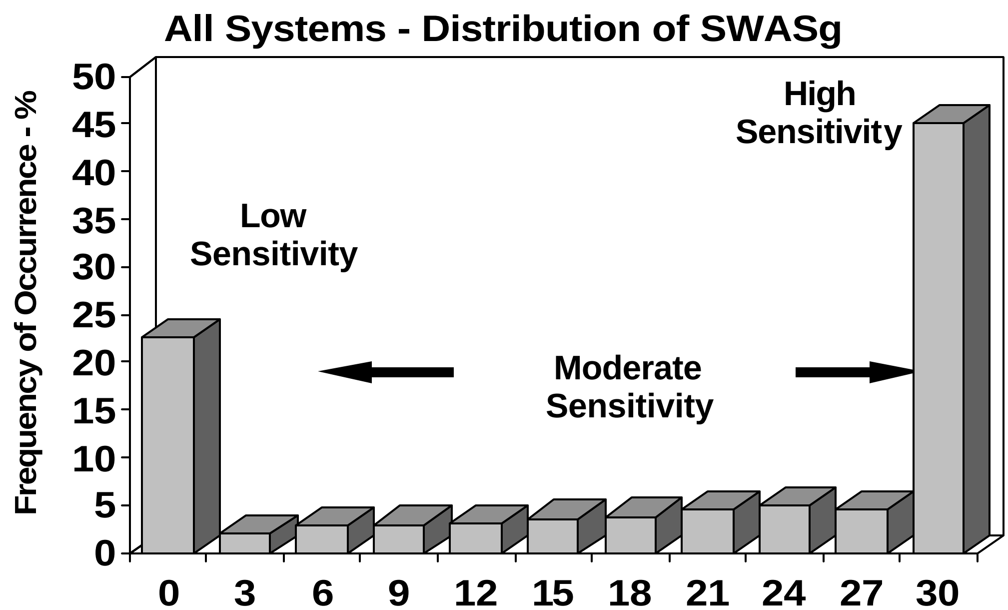
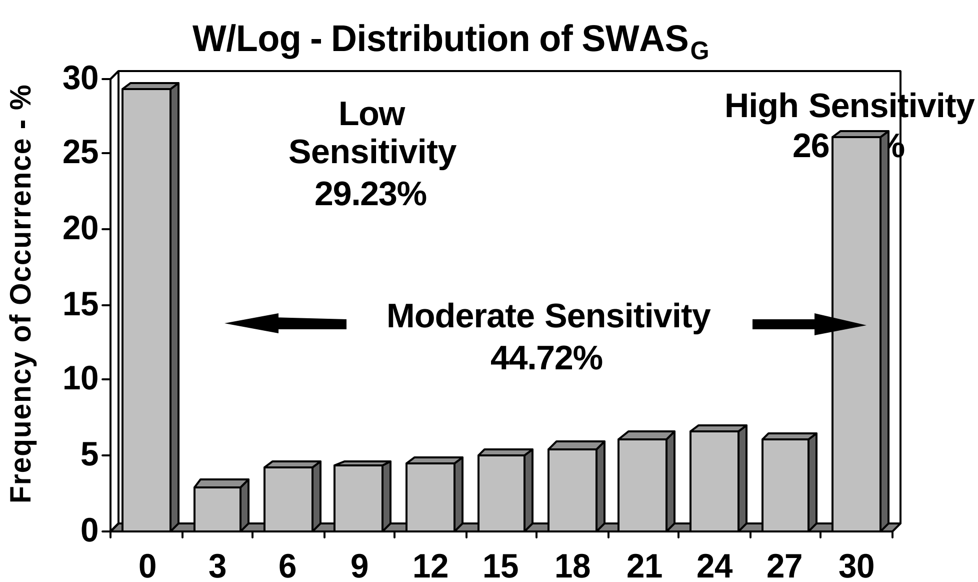
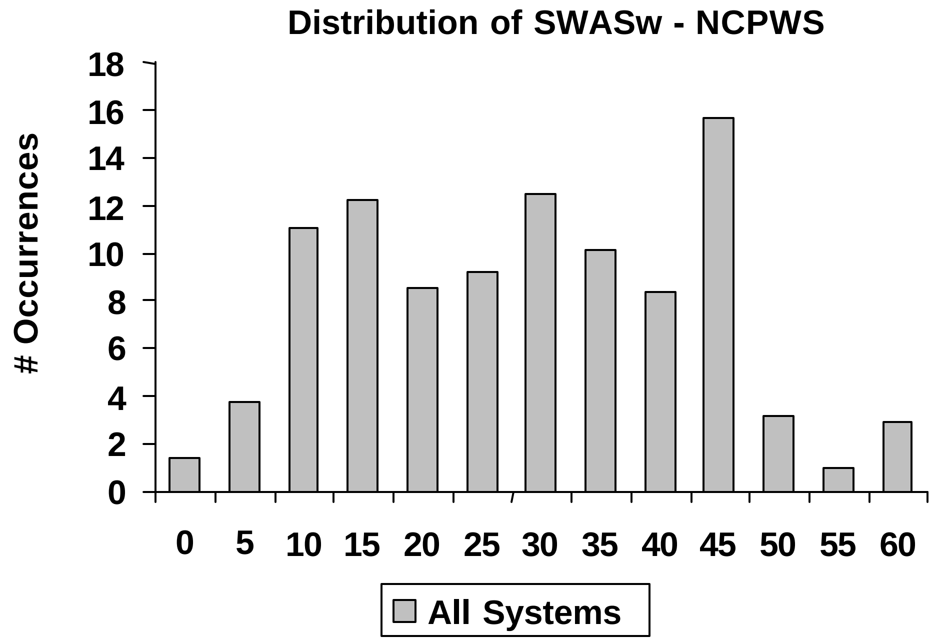


FIGURE 2



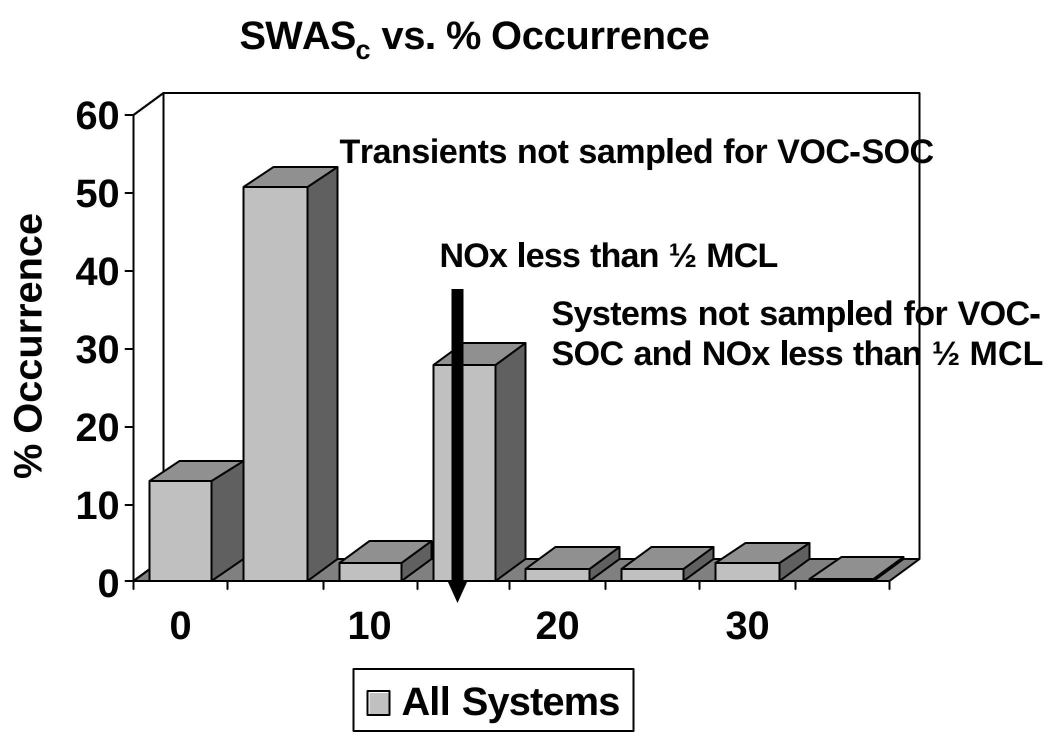
The SWAS$_W$ in Figure 3 shows the distribution of scores for well construction, including evaluation of well grouting, age of wells, casing depth, and pumping rates. This distribution is also impacted by lack of data. Much of this information is determined from the well drilling record. Note that the peak of scores is at 45. This score would result from no well drilling record and no supplemental data available.

FIGURE 3



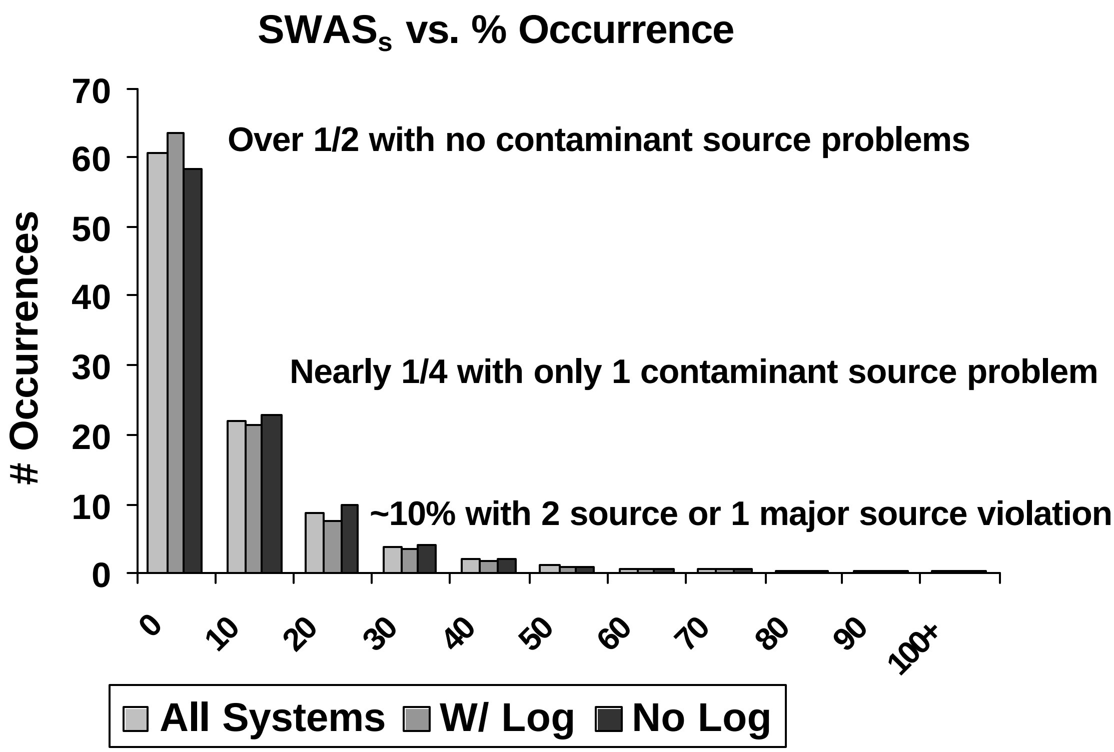
The SWAS$_C$ in Figure 4 shows the distribution of the scores from detection of VOC, SOC, Nitrates, and Nitrites.

FIGURE 4



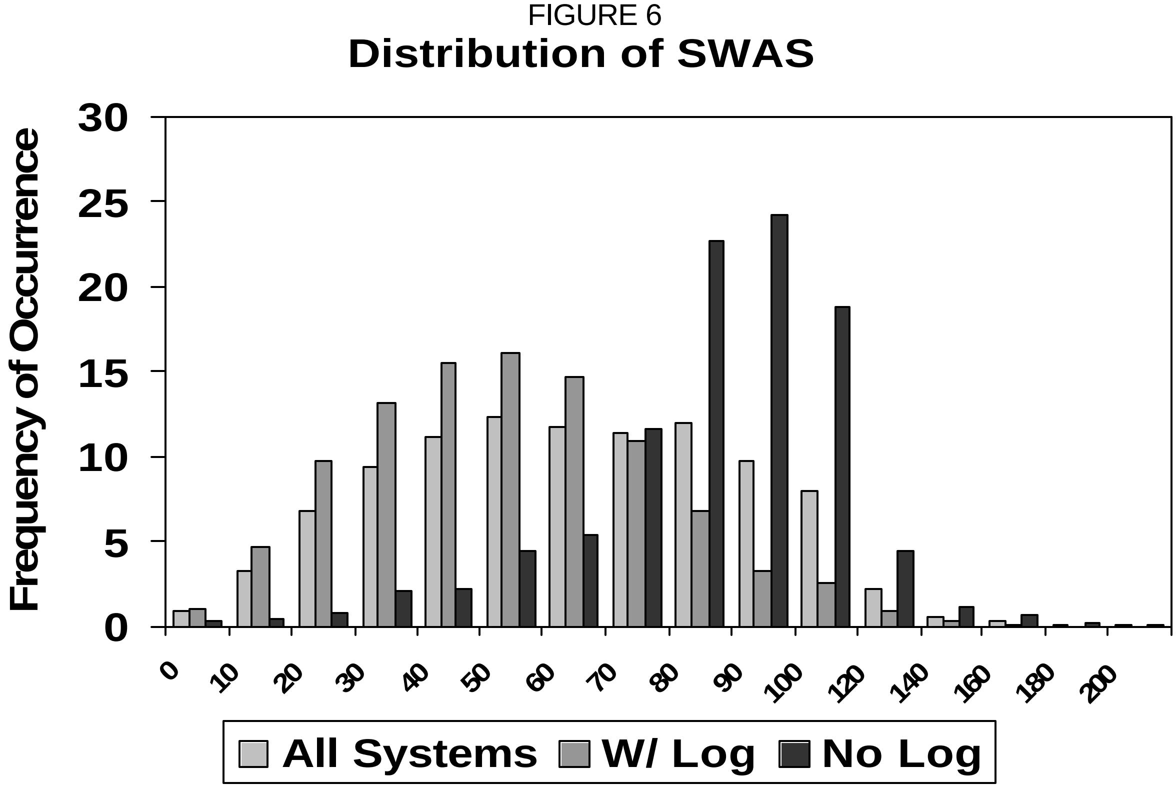
The SWAS$_S$ in Figure 5 shows the distribution of scores from well separation from potential or known sources of contamination.

FIGURE 5



The distribution of SWA scores is shown in Figure 6. Note the concentration of higher scores of wells with no records. The distribution of source water assessment scores of all wells is shown in Figure 6.

FIGURE 6



The "weighting" of each component of the scores were:

- Well Construction provides 44.8 percent of the score
- Chemical History represents 13.5 percent of the score
- Geology contributes 29.5 percent of the score
- Contamination Sources is 12.2 percent of the score

The susceptibility was determined using a susceptibly flow diagram (Figure 7). Karst Hydrologic Systems were assigned "Very High" susceptibility. Figure 7 shows the significance of not having a well drilling record on the distribution of susceptibility, with a significantly higher percentage of no record systems classified as "Moderately High" or "High." The distribution of scores for all systems is shown in Figure 8. The final analysis shows an excellent distribution of scores, providing clear distinctions of systems needing priority.

FIGURE 7

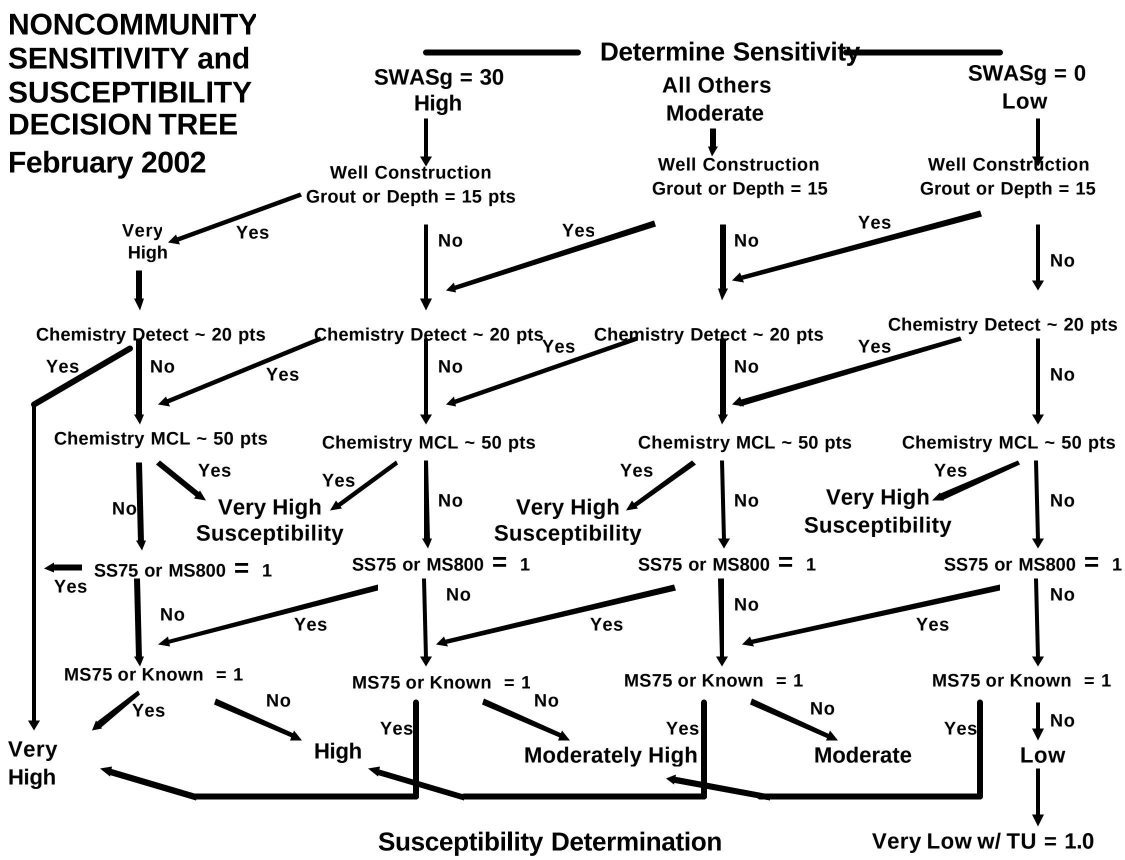
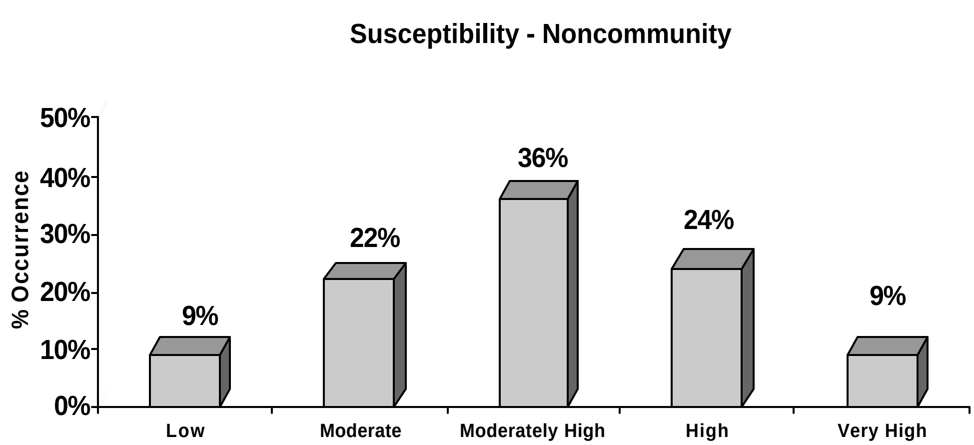


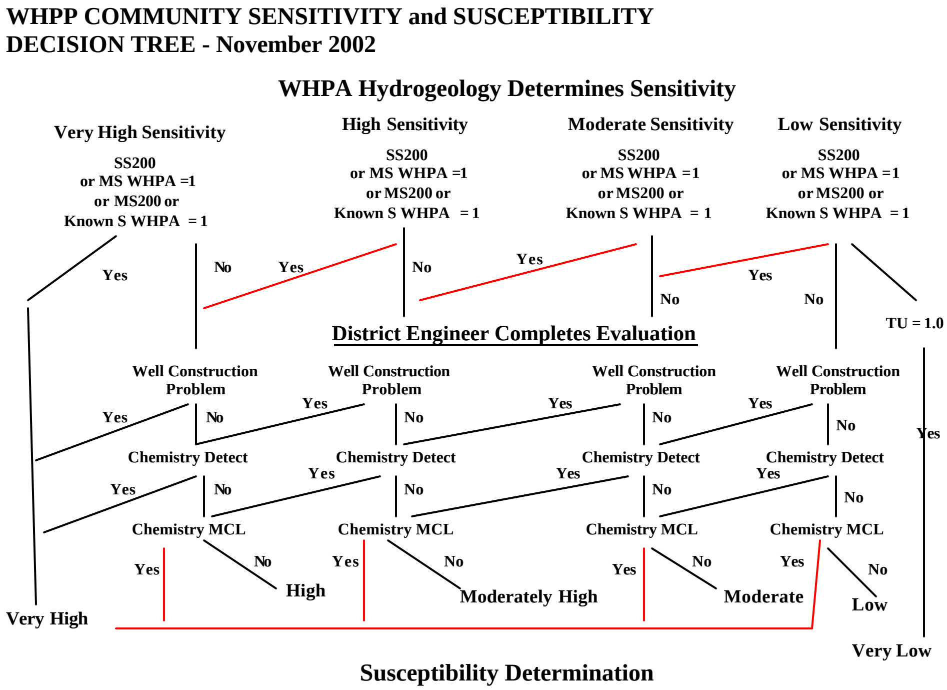
FIGURE 8



The MDEQ and LHDs provided narrative summaries of the assessments by direct mailings to the public water suppliers following a comparative analysis of the data and then completion of the assessment. Copies were sent to LHDs. An example of the Assessment Report and letter sent is included as Appendix D.

For communities with an approved WHPP, the geologic sensitivity was determined from data derived from WHPA delineation reports. Potential sources of contamination were derived from the WHPP report. Susceptibility was defined using the flow chart below. These communities, which have taken an active role in protecting their water supply, were sent a letter summarizing the results of the assessments. This letter emphasized the importance of remaining active with wellhead protection efforts and provided staff of the Wellhead Protection Unit and Michigan Rural Water the opportunity to follow up with community leaders on the status of their program. See Appendix H for an example.

Figure 9



For communities with approved delineations, but no program approval, the potential sources of contamination were identified in the WHPA. The assessments were completed and analyzed as a separate group. Letters to these communities encouraged completion of the wellhead program to help provide protection of the source of their water supply.

The community groundwater systems without WHPPs were completed using state staff or a third party contractor. The assessments on these remaining small systems are similar to those conducted for the noncommunity systems. Source water assessments were performed on CPWS throughout the state that did not participate in wellhead protection. The assessment form used is provided in Appendix H. The source water assessments were completed meeting the following objectives:

- Accurately establish, through the use of a GPS and GIS, the location of CPWS wells.
- Provide for the entry of well drilling records into an electronic data management system.
- Identify the location and proximity of sources of contamination located within 2,000 feet of CPWS wells.
- Establish a SWAS that reflects the “inherent vulnerability” of the CPWS well and source water, assessing the integrity of the well and the geologic setting.

The GPS location and well record information were compiled and incorporated into the statewide GIS for use in the analysis of information and the presentation to the public. Through GIS the results can

be used in protection efforts for public water supplies and also be used to focus groundwater protection efforts for private water supply wells.
In addition to the GPS/GIS phases of the source water assessment, the vulnerability of CPWS wells were evaluated by determining a SWAS. The SWAS has been created as a numeric system that assigns points for situations that represent a “perceived risk” based upon the evaluation of four criteria. The evaluation criteria provide a “qualitative assessment” of groundwater movement and the potential for movement of contaminants into the subsurface. The SWAS is based upon evaluation of the following:

1. The geologic sensitivity of the CPWS well.
2. The construction, maintenance, and use of the CPWS well.
3. Chemistry and/or isotope data from the CPWS well water.
4. Isolation and control of the CPWS well from sources of contamination.

The criteria are evaluated in a manner such that a higher SWAS is equated to a greater perceived risk for the CPWS source water.

The SWAS system has been developed cooperatively among the Environmental Health, Groundwater, and Field Operations Sections within the Water Division, MDEQ. Staff from these sections may utilize the SWAS to assign monitoring requirements and identify CPWSs that should receive follow-up activities.

The SWAS system is based upon the accumulation of points for situations that represent a perceived risk to the CPWS source water. The SWAS is derived from a sum of a geologic sensitivity score ($SWAS_G$); a well construction score ($SWAS_W$); a score for chemistry and isotope data ($SWAS_C$); and isolation and control from sources of contamination score ($SWAS_S$).

Geologic Sensitivity - $SWAS_G$ - The $SWAS_G$ is factored into the SWAS based on the total thickness of Continuous Confining Material (CCM) such as clay, clay-rich till, or shale penetrated in construction of the CPWS well; or the total thickness of Continuous Partially Confining Material (CPCM) such as a mixture of sand and clay or sandstone and shale. The total thickness of CCM and CPCM should be determined from the well record for the CPWS well. Where a well drilling record is not available, well drilling records from adjacent wells or test hole borings may be used. Geologic maps (i.e., lithologic cross-sections) may also be used if they provide adequate coverage of the area in which the CPWS well is located.

Well Construction - $SWAS_W$ - The design, physical condition, and operation of a CPWS well may allow the entrance of contaminants into the well despite a high level of intrinsic geologic protection. To account for this possibility, the SWAS is assigned points through the $SWAS_W$ based upon four criteria related to the construction and use of the CPWS wells. The $SWAS_W$ is assessed points based upon well grouting, the age of the well, the casing depth, and the pumping rate of the well.

Water Chemistry and Isotope Data - $SWAS_C$ - Water chemistry data provides a refinement to the SWAS through the $SWAS_C$ that may increase or decrease the SWAS. As examples, the presence of nitrates, nitrites, volatile organic compounds, or synthetic organic compounds, even at low levels, regulated inorganic chemicals and regulated radionuclides are indicators of source water vulnerability and increase the SWAS; the absence of tritium in the source water indicates the source water is old and not vulnerable, thereby decreasing the SWAS. Review of chemical monitoring records should go back 5 years or more if appropriate. SWASc cannot be less than 0 when tritium is less than 1 tritium unit.

Isolation from Sources of Contamination - $SWAS_S$ - *Isolation from Standard and Major Sources* - The isolation of a CPWS well from sources of contamination is an important criterion in the source water assessment. The maintenance and control of isolation distances can significantly reduce the perceived risk associated with the use of a well. The $SWAS_S$ is assessed points for failure to maintain and/or control adequate isolation between “potential” sources of contamination and “known” sources of contamination. Known sources of contamination include those sources where the groundwater has been impacted as a leaking underground storage tank or other sites of environmental contamination.

Control of Standard Isolation Area - The Michigan Safe Drinking Water Act requires a CPWS to own or control through a lease or easement the defined isolation area around each well. Failure to own or properly control this area affects the future vulnerability of the well.

Community public water supplies that do not participate in wellhead protection were assessed similar to noncommunity groundwater supplies. These supplies were mainly mobile home parks, nursing homes, condominiums, apartments, subdivisions, small community systems, and correctional facilities. These assessments considered regulated contaminants and isolation areas defined by the Michigan SDWA. The assessment area was a 200 foot radius for standard contaminants (sewers, surface water, fuel storage, etc.) and 2,000 feet for major contamination sources (large scale wastewater disposal, landfills, chemical disposal or storage, etc.)

A numerical scoring system, similar to the noncommunity assessments, was used to compile raw data reflecting area geology, well construction, contaminant sources, and water quality. This data was analyzed, then adjusted to reflect assessments that are most useful for prioritizing protection efforts.

An analysis of the scores has been completed. If necessary data was not available, the assumption was made for the “worst-case,” resulting in higher assigned susceptibility of the supply. Information and knowledge from DEQ district staff or the supply owner could be used to make adjustment to the scores.

The susceptibility was determined using a susceptibly flow diagram (Figure 9). Karst Hydrologic Systems were assigned “very high” susceptibility.

The MDEQ provided narrative summaries of the assessments by direct mailings to the public water suppliers following a comparative analysis of the data and then completion of the assessment. An example of the assessment report and letter sent is included as Appendix G. A comparative analysis was conducted to assure uniformity in the assessments completed. In addition, hydrogeological sensitivity and susceptibility determinations were summarized.

The $SWAS_G$ in Figure 10 shows the distribution of scores for the geologic sensitivity. Wells without an available well drilling record were rated as “high sensitivity” unless the district engineer had information supporting lower sensitivity.

Figure 10

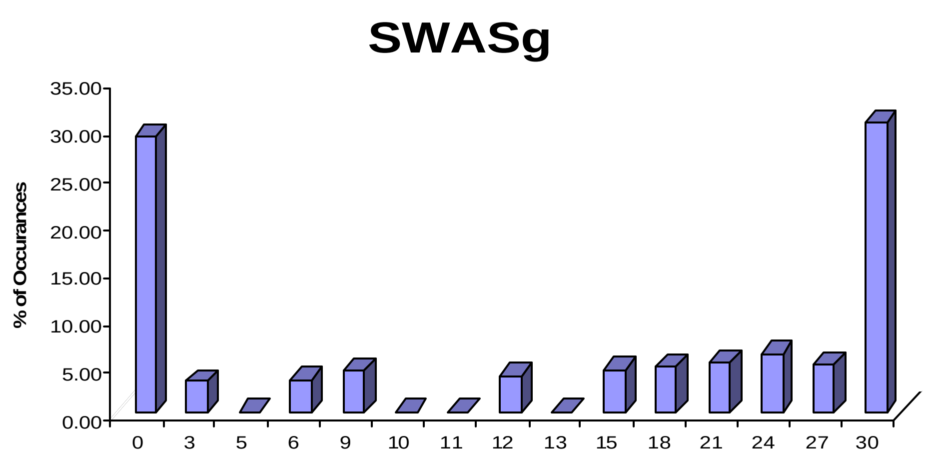


Figure 10: Percent occurrence of geologic sensitivity.

The $SWAS_W$ in Figure 11 shows the distribution of scores for well construction, including evaluation of well grouting, age of well, casing depth, and pumping rates. Figure 11 also shows the distribution of $SWAS_C$ scores from detects of VOC, SOC, Nitrites, and Nitrates.

Figure 11

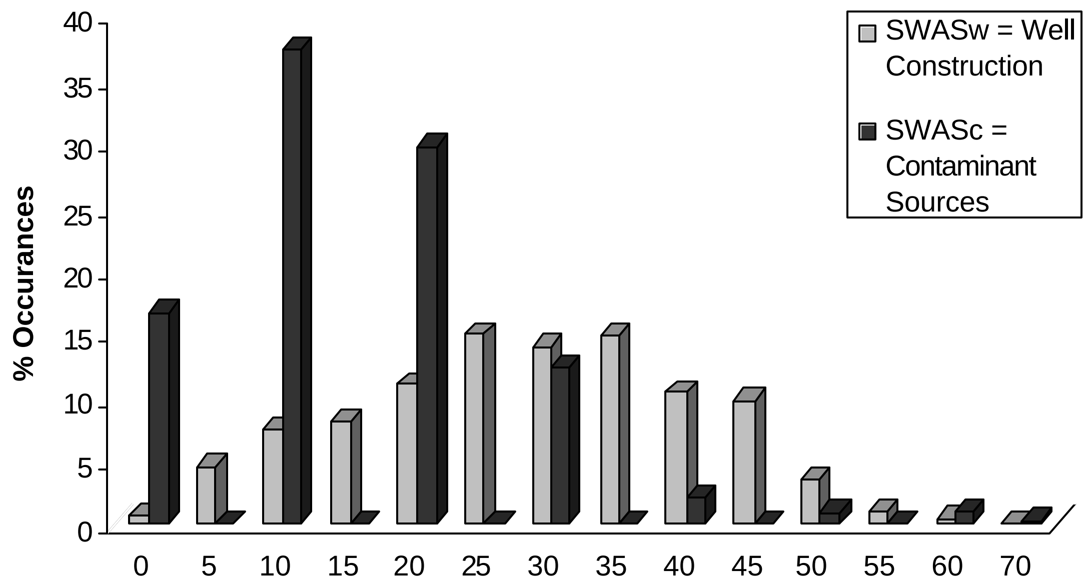
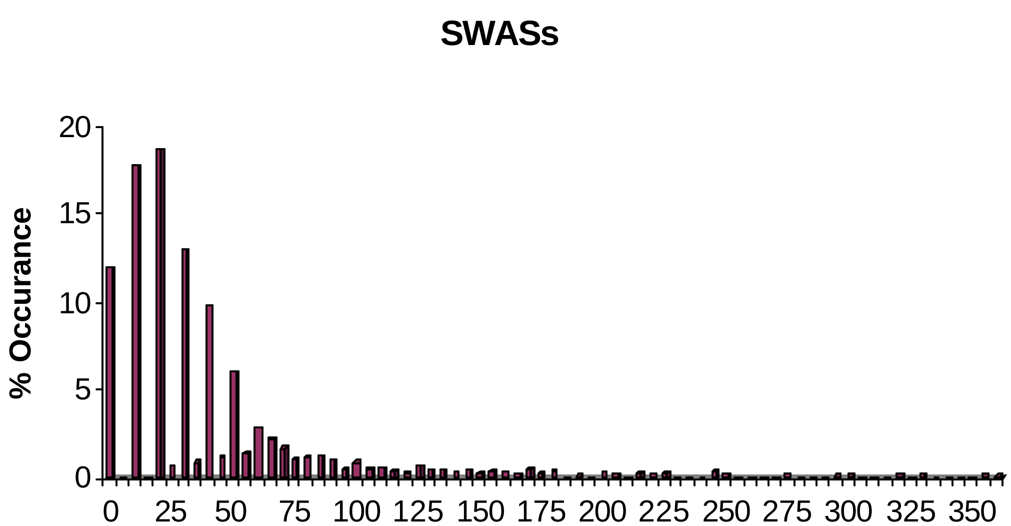


Figure 11: Percent occurrence of the well construction scores and contaminate sources.

The $SWAS_S$ in Figure 12 shows the distribution of scores from well separation from potential or known sources of contamination.

Figure 12



The total SWAS scores are shown in Figure 13. The high values are the result of numerous existing potential sources of contamination within the source water assessment area. The distribution is shown in Figure 13. The final analysis shows an excellent distribution of scores, providing clear distinctions of systems needing priority.

Figure 13

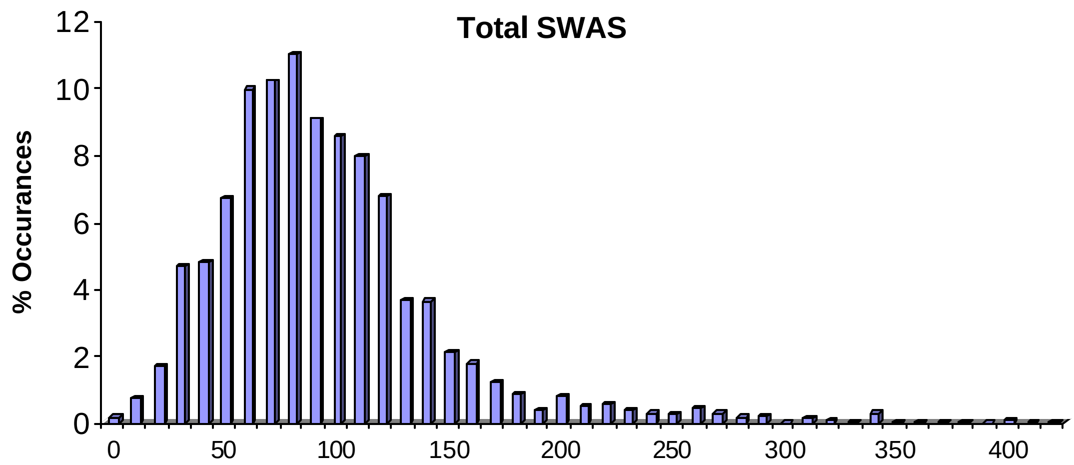


Figure 13: Total SWAS scores.

Figure 14

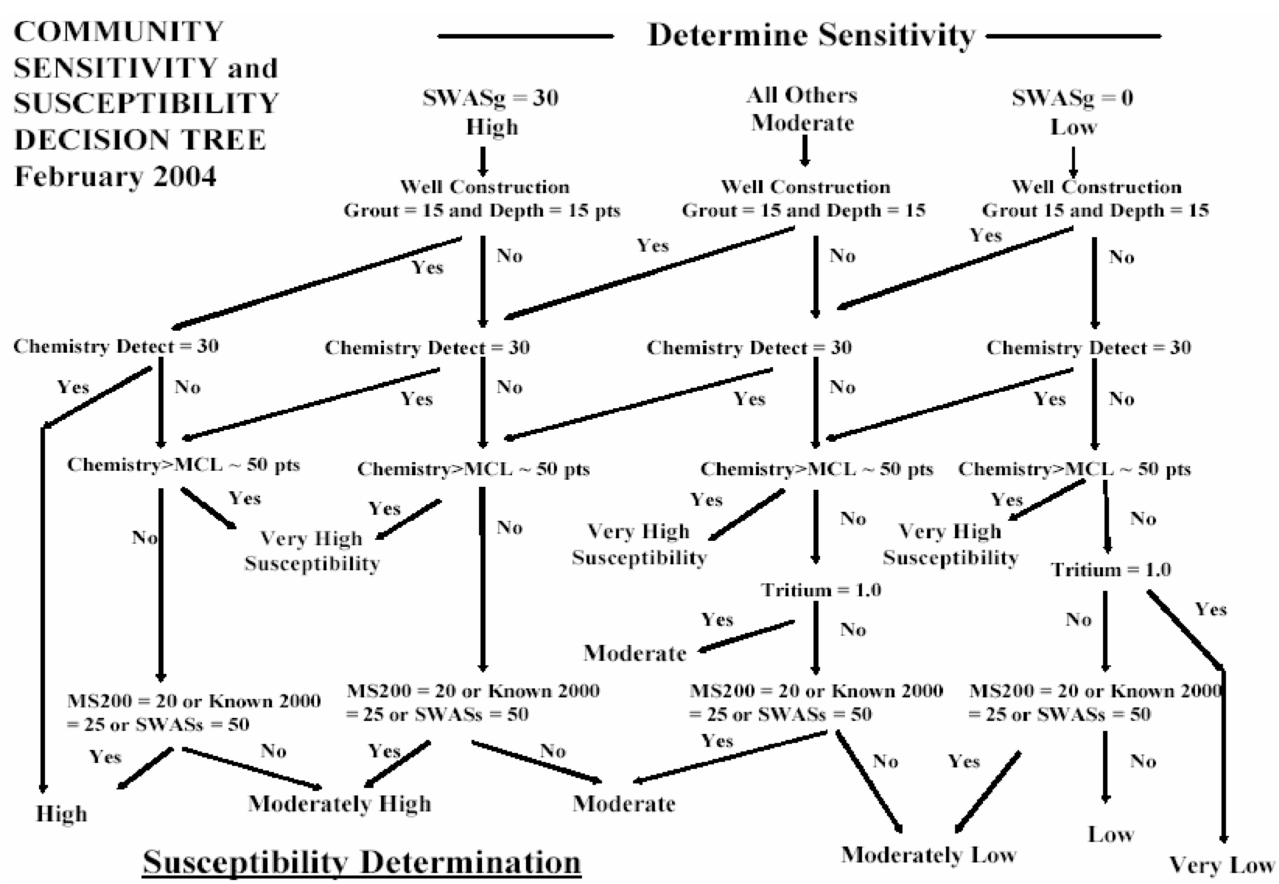
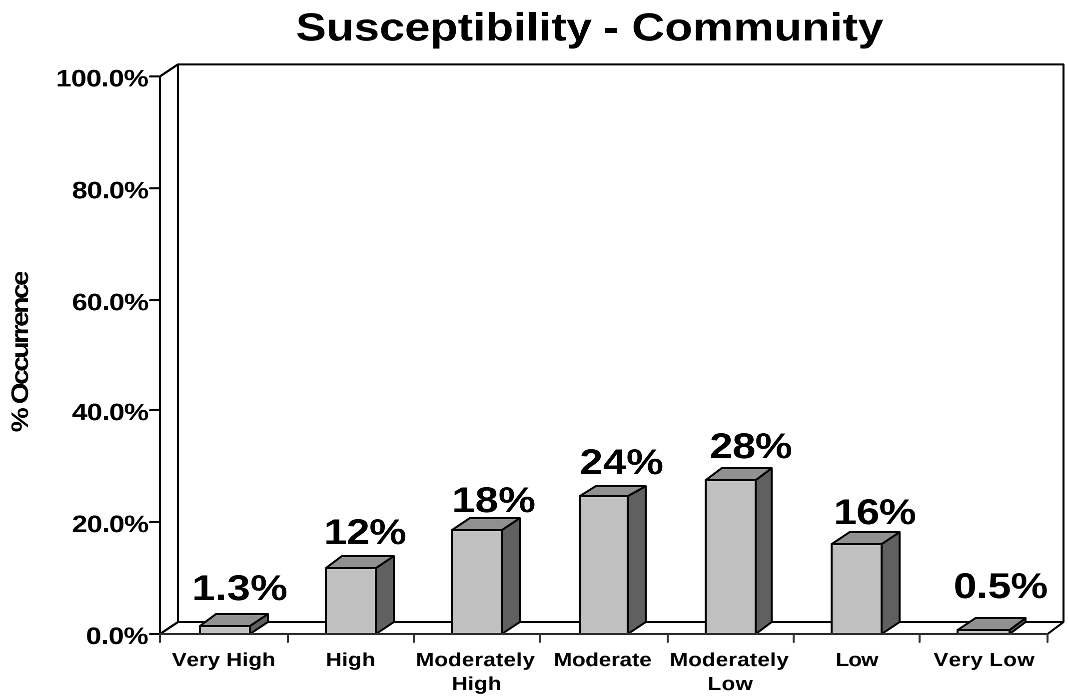


Figure 15


Susceptibility - Community
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
% Occurrence
1.3%
12%
18%
24%
28%
16%
0.5%
Very High
High
Moderately High
Moderate
Moderately Low
Low
Very Low

CHAPTER 4 – PUBLIC WATER SUPPLY SURFACE WATER INTAKE ASSESSMENTS

The MDEQ and the USGS implemented the SWAP in Michigan by assessing 58 community and 2 noncommunity surface water supply sources within the state (Appendix M). These surface water supplies provide drinking water to over 55 percent of the state's population, or about 5.5 million people. Three pilot assessments were initially completed for each of the three surface water intake types. Surface water intake types include Great Lakes, Great Lakes connecting channels, and inland river and/or inland lakes. Experience gained from the nine pilot assessments assisted MDEQ and USGS in refining the methods used to assess the remaining 57 supplies. A Technical Advisory Committee (TAC) and a Public Advisory Committee (PAC) aided in guiding and reviewing the process.

The source water assessment process involved using GIS-based analyses to illustrate relations among potential contaminants in the source water area (SWA) to the water intake, surface water features, land use, soil permeability, and other environmental, political, and geographical features. The first step in this process was to delineate the SWA boundary for each surface water supplied system to limit the extent of the area to be assessed.

The remainder of the assessment process included: performing a water-intake sensitivity analysis; defining the critical assessment zone (CAZ) around the water-intake; identifying potential contaminant sources (PCS) within the SWA; determining susceptible areas within the SWA; compiling an inventory of PCS located within the CAZ and susceptible areas; calculating soil permeabilities; and conducting an intake susceptibility determination. The completed assessments include a map of the SWA; a map of the CAZ and adjacent area; maps showing PCS in relation to land use and soil permeability; a table of PCS, by permit type, located within the CAZ and susceptible areas; results of susceptibility determination; and a narrative of procedures followed for conducting the assessment.

Inland lake and river intake assessments (eight supplies in Michigan) are watershed based. The assessment process for these source waters includes reviewing water-quality monitoring records and identifying PCS. Great Lakes and Great Lakes connecting channels intake assessments (51 sources) follow the "Assessment Protocol for Great Lakes Sources" http://www.michigan.gov/documents/DEQ-swap99_4707_.pdf, Appendix I developed by Great Lakes States in USEPA Region 5.

Assessments of water intakes that use Great Lakes connecting channels as their source (14 supplies) are included in a two-dimensional hydrodynamic flow model of the St. Clair River–Lake St. Clair–Detroit River waterway (Appendix J). The flow model was used to define the SWA, track contaminant source water quality concerns and assist in developing contingency plans. A partnership established among the USGS, MDEQ, USEPA, U.S. Army Corps of Engineers, and the Detroit Water and Sewerage Department, with assistance from Environment Canada, developed this model. The American Water Works Association Research Foundation is supporting the partnership to enhance the contaminant-tracking model capabilities.

Assessment methods evolved as the concept was developed and different approaches were used for different surface-water supply types. Each assessment included an initial contact with the surface-water treatment facility supervisor or operator, by either phone or mail. A SWAP inventory form (Brogren, 1999; http://www.michigan.gov/documents/ DEQ-swap99_4707_.pdf, p. 105-106, December 2002) was sent to each surface water treatment facility with a request that it be completed before MDEQ and USGS personnel visited. A meeting was scheduled with each surface water treatment facility supervisor at which the inventory was discussed and a rough-draft assessment, including text and site-specific illustrations, was presented and explained. Surface water treatment and intake facilities were toured and intake locations verified and documented.

The data was entered into a GIS database using USEPA's Better Assessment Science Integrating point and Nonpoint Sources (BASINS) program (USEPA, 1997a; 1997b; 1998) upon completion of the meeting. The data was analyzed for correlation of water-quality parameters with atmospheric conditions, lake currents, discharge magnitudes, and other variables as appropriate. Additional data was requested from the surface water facility as needed, and previous studies, where available, were incorporated into the assessment. A preliminary draft assessment was completed about 3-6 months after each plant visit and sent by the USGS to MDEQ for review.

Draft assessments were modified, as needed, and forwarded by MDEQ to the respective surface water supply supervisor, city or governmental authority, and MDEQ field offices, for a 30-day review and comment period. Comments were reviewed by MDEQ and USGS at the end of the comment period and incorporated into the assessment as appropriate. The term “final draft” was added to the assessment title, and the completed final draft assessment was distributed to the surface water supply. Final draft assessments were considered complete after the comment period. Discrepancies noted by the water supplier were resolved to assure acceptance of the assessment by the water supplier.

All surface water, source water assessments followed the same general protocols for determining sensitivity, defining a CAZ, calculating soil permeability, inventorying PCS, and source water intake susceptibility determinations. There were subtle differences, however, among intake types regarding the SWA and susceptible area delineations.

Inland river assessments were less complicated than others considered, with the least amount of variation in methods among surface water supplies. In general, the watershed upstream of the intake defined the SWA.

Rivers with multiple surface water supplies (intakes) at various locations resulted in the upstream extent of one SWA coinciding with the downstream extent of the next SWA located upstream. Surface water suppliers then could concentrate management efforts on their own smaller areas and encouraged surface water suppliers to maintain communication with adjacent surface water supplies. This communication provided opportunities to share information regarding changes in source water characteristics with other surface water suppliers located downstream.

The generally shallow and narrow nature of inland rivers resulted in all intakes for these sources being defined as highly sensitive, with their CAZ defined as a 3,000 feet radius oriented upstream of the intake. The susceptible area included all shoreline upstream of the intake within the SWA. The PCS inventory included the SWA for the intake of interest, and by reference, any upstream SWAs. By definition, the intake was either very highly susceptible (PCS were located in the susceptible area) or highly susceptible (no PCS were located in the susceptible area) to contamination.

Great Lakes connecting channel intakes are similar to inland rivers in that the SWA is readily identified as a part of the watershed upstream of the intake. However, these intakes usually are located farther from shore than inland river intakes, in deeper water, and tend to have greater flow volumes and velocities, making these intakes generally less sensitive than inland river intakes.

The contaminant source inventory for these intakes is more involved and complex than the inventory for inland rivers. Flow and mixing characteristics in the connecting channels can result in preferred flow paths along which contaminants may reach an intake. Simply identifying the watershed upstream of the intake may include PCS that are not likely to contribute to the intake. This method also might preclude PCS with a high likelihood of contributing to the intake. All connecting channels assessments will be reevaluated upon completion of a two-dimensional hydrodynamic model and particle tracker for the St. Clair-Lake St. Clair-Detroit River waterway (Holtschlag and Koschik, 2001).

Water depth, distance from shore, and flow volumes all contributed to connecting channels intakes generally being highly to moderately sensitive and highly to moderately susceptible. Time-of-travel (TOT) estimates for St Clair and Detroit Rivers were based on generalized velocities of 2 to 4 ft/s (David Holtschlag, U.S. Geological Survey, oral communication, 2002). The St. Clair River is about 29 miles from its head at the outlet of Lake Huron to its mouth at the distributary delta to Lake

St. Clair, and TOT ranged from 14 to 28 hours. The shipping channel in Lake St. Clair is about 35 miles from the distributary delta of the St. Clair River to the head of the Detroit River, with TOT ranging from 13 to 26 hours. The Detroit River is about 32 miles from its head at the outlet of Lake St. Clair to its outlet to Lake Erie, and TOT ranged from 12 to 23 hours. These values were generalized TOT and actual values may be faster or slower depending on actual velocities. It is likely that these values underestimated the TOT in Lake St. Clair, as velocities through this reach were appreciably slower than in the rivers. Average water exchange in Lake St. Clair varies from hours in the shipping channel to days in some bays.

Great Lakes intakes were categorized in one of four ways: near shore, shallow-water intakes; near shore, deep-water intakes; offshore, shallow-water intakes; and offshore, deep-water intakes. Each intake had unique characteristics that affected the assessment. Hydraulic and hydrologic conditions differed for each lake and each intake, making it difficult to apply uniform assessment methods to these intakes. Methods described in the Great Lakes Protocol (Appendix I) and this report worked well in assessing these types of intakes, with some modifications, described below.

Near shore, shallow-water intakes are those that, generally, are less than 1,000 ft from shore and in less than 20 ft of water. These intakes are most likely to be categorized as highly sensitive and highly susceptible. Lake currents and passing boat traffic can disturb bottom sediments, causing high turbidity. Storms and changes in wind patterns can disrupt the flow of water over these intakes, causing rapid changes in water quality, which in turn create treatment difficulties for operators (Jerry Plume, Alpena Water Treatment Plant, oral communication, 1999). Overland runoff and shoreline discharges are more likely to affect these intakes because of their limited isolation from land and smaller water volumes available for dilution. Recreational boaters, fishers, and divers often are aware of the location of these intakes and they are favored anchoring locations because of their relative ease of access.

These shallow-water intakes often are located in bays or other sheltered areas, which isolates them from large-lake currents. This isolation limits the amount of water exchange near the intake, which in turn affects water quality. Water temperatures rise more rapidly in shallow water during warm periods and rise higher than in deeper water. Water temperatures also fall more rapidly during cold periods than they might in deeper water, and the formation of frazil ice can become a problem. The emergency intake at Alpena Michigan is an example of this type of intake. The emergency intake is located approximately 1,000 ft from shore in about 5 ft of water. The emergency intake is used in the winter to mitigate the effects of frazil ice formation. This assessment was based on the intake nearest to the shore.

Near shore, deep-water intakes are those that, generally, are less than 1,000 ft from shore, and in more than 20 ft of water. These intakes are most often categorized as highly sensitive though, if deep enough, they might be only moderately sensitive. They are under hydrologic conditions similar to those of near shore, shallow-water intakes, except that they are less likely to be under the full range of conditions of shallower intakes. Overland runoff and shoreline discharges are the most prevalent issues, followed by atmospheric changes and recreational water uses. An example of this type of intake is L'Anse, Michigan, where the primary intake is almost 1,000 ft from shore in about 50 ft of water.

Offshore, shallow-water intakes are those that, generally, are greater than 1,000 ft from shore, and in less than 20 ft of water. These intakes are most often categorized as highly sensitive though, if far enough from shore, they might be only moderately sensitive. These intakes are not as susceptible to overland runoff and shoreline discharges because of their distance from shore. Their location, however, can result in higher susceptibility to discharge from inland rivers. Discharge from inland rivers generally enter a lake and is incorporated in the prevailing lake current. These currents occasionally carry river water over an intake prior to dilution and absorption of a contaminant into lake water. This action causes change in turbidity, temperature, general chemistry, and biologic conditions of the source-water, especially during times of high overland runoff and discharge from inland rivers.

These intakes are also potentially susceptible to disturbances in water quality caused by recreational boating and commercial ship traffic. A ship with sufficient draft could strike the intake directly, disturb lake-bottom sediments that could affect influent water quality, or disturb water flow near the intake, perhaps through ballast exchange or prop wash. The primary intake at Alpena, Michigan is a good example. This intake is approximately 2,000 ft from shore in about 10 ft of water, and source water chemistry indicates effects from the Thunder Bay River under certain atmospheric conditions (Sweat and others, 2000b).

Offshore, deep-water intakes are those that, generally, are greater than 1,000 ft from shore, and in more than 20 ft of water. These intakes usually are categorized as moderately sensitive. Because of their distance from shore, they are isolated from overland runoff and shoreline discharges. They generally are located such that lake currents and lake volume provide the potential for large volumes of dilution in the event of a spill or contaminant event and of inland river discharge. Atmospheric conditions are less likely to affect water quality at these depths and distances from shore. The greatest potential for change to water quality is from occasional shifts or changes in currents. Thermal mixing can result, requiring the water treatment plant (WTP) to compensate by adjusting treatment methods.

Offshore, deep-water intakes are less susceptible to disturbances in water quality caused by recreational boating and commercial ship traffic, although commercial ship traffic does pose some threat to these intakes in the form of ballast water exchange, illegal dumping, accidental discharge, and collision. The Saginaw Midland Municipal Water Supply Corporation, Michigan is an example of this intake type. This primary intake is more than 6,000 ft from shore in about 35 ft of water.

Buried collectors or infiltration beds terminate in a lake or river bottom, using lateral collectors beneath gravel and sand to prefilter the water. Laterals generally are located between 5 and 10 ft below the lake bottom. Sensitivity is not affected by this intake type, but the susceptibility determination improves because of the inherent filtering capacity of this collector type. Surface-water intakes located in Mt. Pleasant, Bridgman, Grand Haven, Ludington, Charlevoix, Lexington, Harbor Beach, and Caseville,, Michigan are examples of surface-water supplies using buried collectors.

The SDWA Amendments require that completed source water assessments be made available to each public water supply (PWS), as well as by each PWS to their customers after assessments are completed. PWSs are provided copies of the assessment for their supply after MDEQ and USGS complete the assessment. Assessments, titled “Source-Water Assessment Report” for each public surface water supply contained the following:

1. Map of the SWA.
2. Results of sensitivity determination shown on a map (CAZ).
3. Tables of PCS by type and location.
4. Locations of PCS shown on soil permeability and land use maps.
5. Results of susceptibility determination shown on soil permeability and land use maps.
6. Narrative of procedures for conducting the assessment.

The USGS developed general GIS-based methods to assist in the source water assessment process. The software used to perform these GIS-based methods primarily was ArcView GIS 3.3 (Environmental Systems Research Institute, Inc. (ESRI), 1992-2002), with some additional processing in ArcInfo Workstation 8.2 (ESRI, 1982-2002). This GIS software was chosen because of the capacity to integrate the BASINS program with the ArcView 3.3 framework. BASINS, version 2.0, is a multipurpose environmental analysis system that operates on a watershed-based context 9 (USEPA, 1997a; 1997b; 1998).

The BASINS system is instrumental in the source water assessment process. Beneficial features of BASINS include a Watershed Delineation tool and the ability to generate soil permeability maps and soil permeability reports using the State Soil Characteristics Report tool.

The BASINS system also supplies digital data from local, state, and nationally derived databases in the ArcView shapefile format. The BASINS data layers used in the source water assessment process included: drinking water supply sites; hydrologic unit boundaries; land use and land cover; State Soil and Geographic (STATSGO) database; river reach files (RF3) - version 3 alpha; Resource Conservation and Recovery Information System (RCRIS) sites; Industrial Facilities Discharge (IFD) sites; Permit Compliance System Database (PCSD) sites and Computed Loadings; Superfund National Priority List (NPL) sites; Toxic Release Inventory (TRI) sites; digital elevation models (DEM); state and county boundaries; and urbanized areas.

The BASINS data was available in various scales, and the metadata is available through the BASINS Web site at http://www.epa.gov/waterscience/BASINS/ metadata.htm (accessed 10/09/02). Additional data used in the assessment process included National Pollutant Release Inventory (NPRI) for Canadian contaminant sources upstream of Great Lakes connecting channel intakes (Environment Canada, 2001), 1:24,000 USGS digital raster graphics (DRG), and georeferenced LandSat Thematic Mapper imagery (30-meter resolution) for surface feature verification.

The preferred projection for this area of study was Michigan GeoRef, because of the minimal distortion across the entire state of Michigan. Thus, all digital data used in the GIS was converted from original projections into Michigan GeoRef using the Project command in ArcInfo Workstation 8.2. Parameters for this projection can be accessed at http://www.michigan.gov/documents/DNR_Map_Proj_and_ MI_Georef_Info_20889_7.pdf (accessed 10/09/02). A projection suited to the specific area of study should be chosen prior to adopting these methods.

The source water assessment process began by locating the water supply intake to be studied in the assessment. Water supply intake locations were determined from the public water supply intake database provided in the BASINS software package. Latitude and longitude locations in this database were compared to the state drinking water intake database supplied by MDEQ. Both databases were found to have inaccurate locations in some cases. All latitude and longitude locations were provided to the water supply operator for verification and, where needed, corrected. During site visits by MDEQ and USGS personnel, surface water intake locations for the public surface water supplies were field checked by using a GPS receiver.

Surface water intake locations were verified using as-built specifications, blueprints, sanitary surveys, water plant operator descriptions, and/or estimates on the USGS DRG using the ArcView Measure tool. Latitude and longitude coordinates were determined from the DRG with the offshore distance and angle provided by water plant blueprints or the water plant operator. Accurately mapped intake locations were required to assess which watershed(s) to include in the delineation of the respective SWA.

The SWA delineation process was based on available watershed boundary data. The extent of the SWA was determined by identifying the watershed, or portion thereof, that discharges toward a known surface water intake (Lanier and Falls, 1999). The SWA delineation process is facilitated in BASINS using the Watershed Delineation tool. Accurate SWA delineation required the available digital watershed boundaries, surface water intake locations, DEMs (variable scale), and river-reach data (USEPA, 1997a, 1997b, 1998). Intake location data was incorporated into the GIS framework to determine the downstream limit of each source water area.

In cases where the SWA was so large that adjacent watersheds would overlap, the watersheds were subdivided using elevation, TOT, and distance from the intake to delineate contiguous areas unique to the up current area of each intake. Different watersheds, or portions of watersheds, that qualified collectively as drainage areas directly affecting the intake, were combined into one SWA using the ArcView Dissolve 10 Terms in courier text identify specific software commands or tools. This combination resulted in a SWA unique to the intake, preserving the attributes necessary for BASINS to recognize the data as a watershed, and enabling the SWA to function with other modules within BASINS. Refinements to SWA delineation can stem from water plant supervisors who are able to indicate specific effects on their intake, such as increased turbidity or increased alkalinity, caused by wave action or changes in lake currents. Great Lakes intakes, where water may be diverted from one watershed to another, involve the delineation of source water areas to include all applicable watersheds that potentially contribute water to the intake.

A two-dimensional, hydrodynamic flow model of the St. Clair River—Lake St. Clair—Detroit River waterway was developed to define source water areas for the Great Lakes connecting channels surface water supplies (Holtschlag and Koschik, 2001). Model-simulation results will allow for determination of contributing areas from watersheds tributary to the Great Lakes connecting channels. The model is being developed through a partnership among MDEQ, USGS, USEPA, U.S. Army Corps of Engineers, and Detroit Water and Sewerage Department, with assistance from Environment Canada (Holtschlag and Brogren, 2000). A particle-tracking routine used in model-simulation to aid in determining travel mechanisms and origins of potential contaminants (American Water Works Association Research Foundation, 2001), and began in September 2003. SWAs and assessments for Great Lakes connecting channel intakes are also redefined.

The Adrian, Michigan intake in Lake Adrian on Wolf Creek is an example of SWA delineation for inland river intakes. The Detroit—Belle Isle intake in the Detroit River is an example of SWA delineation for Great Lakes connecting channel intakes. Determination of sensitivity and critical assessment zone Sensitivity to contaminants is a measure of the protection afforded to the SWA by its environment (Brogren, 1999). Sensitivity was determined for each water supply by multiplying the distance the intake lies offshore by the depth of the intake underwater (Brogren, 1999). Larger values indicate intakes that are farther offshore, in deeper water, or both. Thus, the larger the result of this calculation, the less sensitive an intake is to its environment. Sensitivity values were used to determine the area around the intake, called the critical assessment zone (CAZ), which received the most focus during the assessment. This area is defined in the Assessment Protocol for Great Lakes Sources (Brogren, 1999, Appendix I), and was delineated for each intake.

The CAZ for Great Lakes intakes is determined by the distance of the intake from shore (L) in feet, and the water depth of the intake structure (D) in feet. Multiplying L and D yields a sensitivity value (Brogren, 1999) that determines the CAZ radius, resulting in a 1,000; 2,000; or 3,000-ft radius around the intake. For example, a Great Lake intake with an offshore distance of 200 ft and a water depth of 40 ft has a sensitivity value of 8,000 (unitless), and a CAZ radius of 3,000 ft (Brogren, 1999, p. 100). Great Lakes intakes were considered less vulnerable to contamination than inland river intakes and/or inland lake intakes given that the Great Lakes contain large volumes of water relative to inland rivers and lakes, and that Great Lakes intakes generally are located farther away from land effects.

The same method was used to determine the CAZ for Great Lakes connecting channels intakes. Connecting channel CAZs will be modified using the results of the hydrodynamic flow model planned by USGS (Holtschlag and Koschik, 2001).

The CAZ determination for both the Great Lakes and Great Lakes connecting channels intakes was facilitated using GIS. Because offshore distance and depth of water supply intake(s) were vital to the delineation of the CAZ, these parameters were estimated when incomplete or inaccurate data was in the databases. Overlaying USGS DRGs with the water supply intake data facilitated this determination.

To estimate offshore distance, the ArcView Measure tool was used to determine the distance from the intake to the nearest shore position shown on the DRG. Depth was estimated using the near-shore bathymetric contours on a 1:24,000-scale DRG.

A buffer zone with the appropriate radius was generated around the surface water supply intake using the ArcView Buffer wizard, once the intake depth and offshore distance were determined, and the radius of the CAZ was calculated. The CAZ and the intake location were overlain on a DRG, denoting the area where the CAZ intersected the shoreline. If the CAZ did not intersect the shoreline, the zone remained circular. In situations where the CAZ did intersect the shoreline, the circular buffer zone was modified into a conical shape, extending from the intake, to where the CAZ intersected the shoreline, and inland to the full radius of the CAZ. This modification was done to limit the focus of the CAZ to identify those PCS located near the intake. The intake usually was rated highly sensitive for Great Lakes and Great Lakes connecting channels intakes if the CAZ intersected the shoreline. If the CAZ did not intersect the shoreline, the intake was rated moderately sensitive. Therefore, Great Lakes and Great Lakes connecting channels intakes generally were rated with moderate or high sensitivity, depending upon the depth of the intake and distance of the intake offshore. Inland river intakes, which usually are in shallow waters at relatively close proximity to land, tend to be more vulnerable to contaminants and generally were rated as very highly sensitive.

The CAZ for inland rivers is 3,000 ft, given their generally shallow and narrow channels. Similar assumptions apply to inland lake intakes as they typically are near shore in relatively shallow water. For these two types of intakes, the CAZ was delineated in the same manner as the Great Lakes and Great Lakes connecting channels and clipped to the SWA.

Susceptible areas were established around surface water features within the SWA after determining the radius of the CAZ. Susceptible areas were used to focus PCS inventories where higher potential of contamination by spills or other contaminant releases were present. These areas varied in size based on site-specific data, and where available, TOT calculations were performed by the public water supply. Ultimately, the areas in close proximity to surface water features within the SWA, as well as the CAZ were designated as susceptible areas.

Determining the CAZ and susceptible areas by the radius and setback methods involved using a fixed horizontal distance from the intake (Brogren, 1999) and a 300-ft setback from the shores of all perennial tributaries within the SWA. The setback is consistent with the designation of riparian buffers by MDEQ. The 300-ft susceptible areas were generated in the GIS using the ArcView Buffer tool to create buffer zones around RF3 data within the SWA. Where TOT information was available, the upstream extent of the susceptible area from the intake was constrained using TOT limits suggested by MDEQ.

The susceptible area for river intakes is a 3,000-ft CAZ, from the center of the intake to the intersection of each shore, and a 300-ft buffer on each side of the shores of the intake stream and all perennial tributaries within the SWA.

The susceptible area for Great Lakes intakes is the CAZ, as determined by the intake depth and distance offshore (Brogren, 1999), a 300-ft buffer around surface water features within the SWA, and a Great Lakes shoreline buffer that is equal to the distance inland that the CAZ overlaps the shoreline if at all. The CAZ and surface water buffers were generated in the same manner used for the inland river intake assessments. The shoreline buffer, created in the GIS using the ArcView Buffer tool, was calculated by subtracting the offshore distance of the intake from the radius of the CAZ. The result was the distance the CAZ extended inland, hence, the inland distance of the shoreline buffer. The linear extent of this buffer followed the shoreline to the nearest stream(s) that potentially could transport contaminants to the intake based upon offshore currents and or historical reports from the WTP operators.

The SWA was constrained further by applying TOT restrictions to the analysis for larger watersheds, where TOT information was available. Currently (2004), no state or federal regulatory agencies have TOT restrictions or limitations for Great Lakes intakes, but as assessment results are used to formulate source water protection plans, it is likely that, where available, TOT data will be used to prioritize source water protection areas and activities.

The CAZ and susceptible area were determined for Great Lakes connecting channels intakes in a manner similar to Great Lakes intakes. Once the two-dimensional, hydrodynamic flow model and particle tracker are completed, assessments for Great Lakes connecting channels intakes will be refined to incorporate the contributing areas defined by the model and particle tracker results (Holtschlag and Brogren, 2000; Holtschlag and Koschik, 2001). SWA and PCS inventories, modified from these results, could differ appreciably from draft SWA and PCS inventories.

PCS are any facility or activity that stores, uses, or produces contaminants of concern at levels that could contribute to the detectable concentration of these contaminants in the source waters of the public water supply (Brogren, 1999). PCS inventories were created with assistance from public water supply operators, watershed councils, drinking water protection committees, and local citizens. Inventories were compiled from available federal, state, and local databases using a GIS for database manipulation and illustration production. This approach focused on facilities, activities, and broad land use categories that MDEQ and LHDs considered high or moderate risks to drinking water, and that, in general, a federal or state discharge permit had been issued.

Each inventory consisted of identifying and locating PCS and included the following steps:

1. Creating a land use map for the SWA.
2. Conducting data base queries and plotting applicable data on a land use map.
3. Creating a soil permeability map for the SWA.
4. Conducting data base queries and plotting applicable data on a soil permeability map.
5. Compiling anecdotal and other sources of information as made available on a per water supplier basis.
6. Providing a preliminary inventory form, land use map, soil permeability map, and PCS inventory to the public water suppliers, planners, and community teams.
7. Field locating (optional) and verifying potential high-risk activities.
8. Finalizing the inventory form and the base maps.

The PCS inventory provided location information about potential contaminants used or stored within the SWA, with emphasis placed on collecting information on those that presented the greatest risks to a water supply. PCS inventory results were available for map display, depicting the spatial relation between PCS and receiving waters, salient soils, general land use, and the drinking water intake. The PCS inventory served as an effective means of educating the public about potential contaminants in their area. Finally, the PCS inventory provided a reliable basis for developing a local management plan to reduce identified risks to water supplies.

The PCS inventory identified the general location of PCS of concern within a SWA. Contaminants can reach surface water bodies from activities at or below the land surface, and may be attenuated, amplified, or altered during transport.

Operating practices and environmental awareness vary among landowners and surface water facility operators. Regardless of the quality of management practices or pollution-prevention processes, the highest potential risks generally are from facilities or land-use activities that use, store, or generate high-risk chemicals. High-risk chemicals are defined by USEPA as chemicals having either an MCL or a secondary maximum contaminant level goal (MCLG) for drinking water.

Inventoried areas were limited to a subset of the entire watershed, focusing on the highest risk areas identified through the delineation of a CAZ and susceptible area. Upon completion of the contaminant source inventory, communities were encouraged by MDEQ and USEPA to develop a management plan to protect their public water supply. The purpose of developing a management plan based on inventory results is to address business and land use activities that pose risks to the water source. In this process, PCS that pose little threat to the public water supply can be excluded. If business activities are conducted in ways with little likelihood of contaminant release, for example, pollution abatement or waste-reduction practices, a facility would not need to reevaluate its activities. Some examples, which show the relation among PCS and types of contaminants in Oregon, are available online at http://www.deq.state.or.us/wq/dwp/SWAPCover.htm (accessed June 24, 2002).

Contaminants can be released to water bodies from a variety of sources. PCS can include, but are not limited to, industrial facilities, sewage or waste disposal sites, managed forest or agricultural lands, accidental transportation spills, small businesses, and residential activities. Principal contaminants of concern from nonpoint sources in Michigan include sediments, nutrients, microorganisms, and pesticides. Principal contaminants of concern from point sources in Michigan include volatile organic compounds (VOCs), synthetic organic compounds (SOCs), microorganisms, and petroleum compounds. Contaminant source inventories focused on PCS that are regulated under the SDWA. These inventories included contaminants with an MCL or MCLG, contaminants regulated under the USEPA surface water treatment rule, and the microorganisms Cryptosporidium and Giardia lamblia. Contaminants that affect the quality of water resources in Michigan include microorganisms (viruses such as Hepatitis A, Norwalk type; protozoa, such as Cryptosporidium, Giardia lamblia; and bacteria such as coliform Escherichia coli, fecal, Enterococcus), turbidity, inorganics (such as nitrates and metals), organics (such as VOC, SOC, petroleum compounds, and semivolatiles), and aesthetic parameters (such as taste, odor, and color).

Land use maps were created for each SWA and categories were defined for the contaminant source inventory. Mapping land use allowed the delineated SWA to be divided into four broad land use categories: urban or built-up; agricultural, range or forest; water or wetland; and barren. Maps at the SWA scale allowed accurate plotting of each potential source point within the SWA. The land use map, coupled with the locations of PCS, soils, rivers, and drains, for example, assisted in identifying threats from current land uses to the quality of the water supply.

Current, historical, and planned land uses were considered when associating land use with PCS. Historical land uses usually had an effect on present water quality. For example, on agricultural land, it was necessary to identify chemicals, such as regulated pesticides, that were used, stored, or disposed of on site. Former gasoline stations and dumpsites were considered potential risks to groundwater, which can constitute an appreciable amount of surface water flow. Searching records and/or interviewing long-time residents identified past sources of contamination that might otherwise have been overlooked.

Aerial photographs also were helpful in identifying both present and historic land uses. Aerial photographs were available from the county seat or transportation officials. Photographs also were obtained from the U.S. Army Corps of Engineers, Natural Resources Conservation Service, local flood-control districts, or from commercial sources. Other resources for aerial photographs included colleges and universities. For example, the Center for Remote Sensing and GIS at MSU has an extensive collection of aerial photographs in their photogrammetric library (http://ims.rsgis.msu.edu) that were used to identify changes in land use.

Geographic databases were collected and/or created to facilitate the contaminant source inventory. Federal, state, and local data bases (including Canadian) were searched for available contaminant source data for each SWA. Databases from various government levels may contain information and/or available permits related to water quality, such as the 303(d) list of impaired water bodies (MDEQ, 2002), underground injection, underground storage tanks, water rights, water supply wells, hazardous waste, irrigated areas, pesticide records, solid waste, air quality, and toxic release inventories. Data bases that may provide information about PCS within a SWA are listed in Sweat and others (2000a).

Public water supply officials, planners, and interested citizens were contacted to supplement the database information. At the local level, a substantial amount of information on historical, current, or future PCS was available in the form of routine records or documents in county or city files. Local citizens also had knowledge of potential sources that were not listed elsewhere in databases or on maps. Some specific sources of information for local data on land use may include: planning departments; public works; chambers of commerce; city or county permit files; health departments; business licenses; and aerial photographs.

MDEQ developed a comprehensive inventory form to identify PCS and ensure a consistent assessment approach. The inventory form (Appendix F) is available on MDEQ's Web site at http://www.michigan.gov/documents/DEQ-swap99_4707_7.pdf, p. 105-106 (accessed October 9, 2002). This form, along with maps showing the SWA boundary, land use, PCS, and the location of the water supply intake, was sent to officials of each water supply with a request to verify and complete the inventory at the local level. Because of variations in land use and activities across the state, especially in agricultural areas, the list of PCS was adapted to each supply based upon the completed inventory form. Field reconnaissance depended on the complexity of land use and PCS within the SWA, and the size of the SWA. In some cases, the entire inventory was completed with local community assistance, without the need for any field work. However, in more densely developed areas, it was necessary to conduct an in-depth survey where GIS methods were not sufficient to identify individual PCS. This survey included driving through portions of the SWA and noting any unreported PCS. The survey also provided verification of the location of PCS identified during previous data collection.

PCS within the susceptible area and CAZ were identified once the potential contaminant inventory process was completed. This identification was accomplished using the ArcView Select by Theme tool, assigning the CAZ and susceptible areas layers as the target layers and the PCS data as the selection layer. The Select by Theme tool then was used to capture those PCS data points that intersected any portion of the CAZ and susceptible area. Selecting by theme also allowed for selected components within the PCS tables to be exported as a data base from ArcView. Identifying high-risk contaminant sources provides input for developing a protection strategy based on prioritized areas or individual sources.

The land use data was overlain with the RF3 data, the CAZ, the susceptible area, and the PCS data. This procedure produced a map showing the location of PCS in the SWA, which was used to determine the susceptibility of the intake. Additionally, this procedure produced a complete list of PCS by type. A typical contaminant source inventory is shown for the Ann Arbor, Michigan SWA. A summary of PCS, by type, is given for the Alpena, Michigan SWA.

The overall success of each assessment depends upon identifying PCS to public water suppliers so that communities can identify methods to reduce risks from these sources. As communities move into planning how to protect their public water supply (source water protection), they may want to revisit high-risk activities and land use areas to conduct a more thorough, area specific assessment.

MDEQ defined susceptibility determination as: "the potential for a public water supply to draw water contaminated by inventoried sources within their SWA at concentrations that would pose concern" (Brogren, 1999). The susceptibility determination was designed to be a relative comparison among PCS within the SWA. The objective was to provide meaningful assessment results to public water supplies and communities. This objective was accomplished by providing maps and a table of PCS identified within the CAZ and susceptible areas of each SWA.

Data collected during the delineation and inventory can be used by communities to develop a management strategy to protect their drinking water supply. The susceptibility analysis provided tools, such as maps and PCS tables, to help MDEQ and communities develop protection plans that direct management toward high and moderate risks in the most susceptible areas, with low risk areas as a lesser priority. Assessments included a map that displayed vertical soil permeability and PCS.

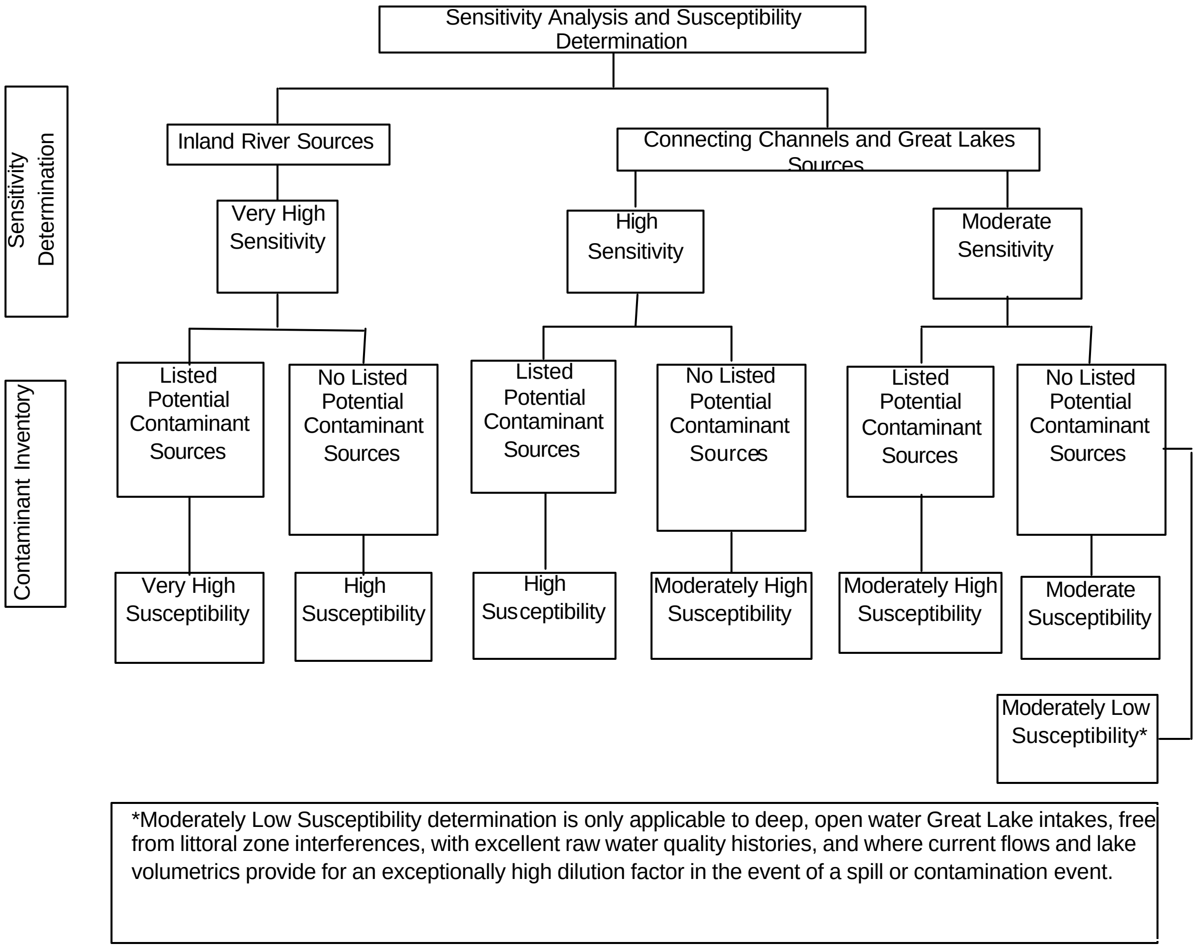
This map was provided to supply the community with information of some of the physical characteristics of the SWA. Soil permeability was based on the calculated TOT, in inches per hour (in/hr), for water to move vertically through a saturated soil zone. Soil thickness and permeability values are available in soil survey reports published by the U.S. Department of Agriculture and National Cooperative Soil Survey (variable dates). Permeability ranged 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 appreciably reduce the movement of water through the soil zone and, as a result, may allow greater time for natural degradation of contaminants during infiltration. However, these soil types also provide for rapid overland transport of contaminants directly to receiving waters, which in turn may affect the water supply intake. Erosion and transport of soils by surface waters also can cause an increase in turbidity.

In contrast, very rapidly permeable soils allow for rapid infiltration and passage through the soil zone from the surface. These soil types potentially allow rapid transport of contaminants with minimal contact time available for contaminant breakdown. Providing soil permeability maps displaying the PCS in the SWA can help target management and protection efforts accordingly. Soil permeability maps were generated in ArcView using the BASINS State Soil Characteristics Report tool. The STATSGO soil data, SWA boundary data, RF3 data, and elevation data are available in the tool to create a new data layer that characterizes each soil polygon by mean, area-weighted, depth-integrated permeability in in/hour. The soil permeability data was then classified according to National Resources Conservation Service (NRCS) soil reports and overlain with the PCS data. The permeability data was queried for values greater than or equal to 2 in/hr to isolate soils that were classified as moderately rapid to very rapidly permeable. Determining which PCS were located on moderately rapid to very rapidly permeable soils was achieved by using the ArcView Select By Theme tool. This process involved assigning the selected soils (moderately rapid to very rapidly permeable) as the target areas and the PCS points as the selection data. Those PCS that intersected moderately rapid to very rapidly permeable soils were then depicted on the map in a red symbol, and PCS located on very slow to moderately permeable soils were depicted in yellow. This procedure produced maps showing the location of PCS in relation to soil permeability within the SWA.

The susceptibility determination illustrated potential threats to a community's drinking water, and assisted communities in prioritizing their efforts to protect their drinking water supply. Final susceptibility maps for completed assessments along with a table of PCS within the susceptible area, resulted in a susceptibility determination for each intake. The susceptibility determination, along with susceptible area map and table of PCS, provided a basis to begin a source water protection plan.

The following decision tree was used for surface water sources.



Contents of Chapter 3 compiled from U.S. Geological Survey, Water Resources Investigation Report 03-4134; The Michigan Source Water Assessment Program: Methods Used for the Assessment of Surface Water Supplies.

Conclusions

The Safe Drinking Water Act amendments of 1996 required each state to assess the sources for all of its public water supplies. After the passage of the act and once funding was made available, Michigan developed plans and initiated its source water assessment program in early 1998.

Michigan has more noncommunity public water supplies than any other state. Because of the large number of supplies, it was determined early on that the most efficient method for completing the noncommunity assessments would be to conduct them during the required 5-year sanitary survey cycle. Since assessments had to be completed by early 2003, Michigan initiated the program by early 1998. This was done even though final United States Environmental Protection Agency (USEPA) program approval was not received until late 1999.

Michigan had over 10,500 noncommunity systems at the time the assessments were initiated. There were approximately 1,340 community groundwater systems, with only 9 that had approved wellhead protection programs. There were 60 surface water systems. The state contracted with local health departments and Michigan State University (MSU) to assist in completing the noncommunity assessments. The state also contracted with the United States Geological Survey (USGS) to assist in completing the surface water and karst assessments.

The assessment methodology is detailed in the report. The program focused on geology, monitoring history, well construction, and location of potential contaminant sources for the groundwater systems and on intake location, raw water quality, and potential contaminant sources for the surface water systems.

As the program was developed, an advisory committee made up of individuals from utilities, local health departments, universities, local interest groups, and the general public was formed. This advisory committee met regularly during the course of the assessment process. Once the program was completed, the group re-formed as a source water protection advisory committee.

The source water assessment program in Michigan would not have achieved the success it did without the efforts of Bradley Brogren, Source Water Assessment Program manager, and Steve Miller, Wellhead Protection manager, at the state of Michigan. The state is also indebted to the local health departments, the USGS, and MSU.

Michigan is moving forward into a Source Water Protection Program and will focus on obtaining resources to work in this area. After the heavy investment it made in the assessment process, it is hopeful that the USEPA will provide continuing funding for source water protection to follow the source water assessment process. The state hopes to prioritize the assessments as to relative risk to the resource and work on site specific protection efforts. This work is evolving at this time and there are many exciting challenges for the program into the future.

APPENDIX A

DEFINITIONS

COMMUNITY PUBLIC WATER SUPPLY - A water supply that provides year round service to not fewer than 15 living units or not fewer than 25 residents.

DELINEATED AREA -The capture zone for a drinking water source. For groundwater, the area is defined through modeling for wellhead protection or fixed radius approach for an assessment. Surface water sources are delineated by a watershed or subwatershed basis.

KARST HYDROLOGIC SYSTEM - A continuum of vertical and horizontal conduits formed by dissolution of geologic materials (limestone, dolomite, gypsum halite, sylvite, and other soluble rocks and minerals), in which groundwater flow is typically much faster than groundwater flow in porous media. Vertical conduits usually are closely spaced joint sets and open fractures (sometimes faults), and horizontal conduits are usually bedding plane partings or openings, all of which are hydrologically enhanced by dissolution of soluble rocks and minerals.

NONCOMMUNITY PUBLIC WATER SUPPLY - a water supply that has not less than 15 service connections or that serves not less than 25 individuals on an average daily basis for not less than 60 days per year.

SENSITIVITY - Relative ease at which a contaminant can migrate to a water supply source. Measures inability of natural materials or hydrologic conditions to protect the source. For groundwater, a function of intrinsic characteristics of the geologic materials that compose the land surface and the saturated and unsaturated zones. Independent of land use or contaminant characteristics.

SUSCEPTIBILITY -Likelihood of a contaminant impacting a source of drinking water considering source water protection area and sensitivity. Determines if a contaminant could reach the source at concentrations that could affect the system's ability to meet all regulatory requirements. Also includes consideration of well construction and abandoned wells for groundwater sources and intake construction for surface water sources.

WELLKEY - A Software Program that stored well drilling record information and provided for the automated entry, storage, and retrieval of data. This program was not year 2000 compliant and was replaced by Wellogic.

Wellogic - Software Program that allows well drilling record information for the automated entry, storage, and retrieval of well information. The program allows data to be recorded over the internet and stores data in an SQL database. This program replaced WELLKEY.

APPENDIX B

Source Water Assessments for
NONCOMMUNITY PUBLIC WATER SUPPLY SYSTEMS

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January 1, 2000 Version

INTRODUCTION

Source water assessments are to be performed on approximately 10,500 NCPWS throughout the state. The source water assessments will be completed in accordance with the provisions described herein and have, as objectives, the following:

- Accurately establish through the use of a GPS and GIS the location of NCPWS wells.
- Provide for the entry of water well and pump records into an electronic data management system.
- Identify the location and proximity of sources of contamination located within 800 feet of NCPWS wells.
- Establish a SWAS that reflects the "inherent vulnerability" of the NCPWS well and source water.

GLOBAL POSITIONING SYSTEM LOCATIONS AND WATER WELL DRILLING RECORDS

Obtaining accurate location information and water well drilling record information for NCPWS wells is an essential first step in the state SWAP. The location and well record information will be entered into the Statewide Groundwater Data Base (SGDB). The collection of location and well record information will be built upon the technical expertise and networking developed by the Kellogg Foundation, GEM grant program. Training of county staff and the compilation of data will be done by GEM regional centers located at major universities around the state. The effort will be coordinated by the Institute of Water Research, MSU, as they were the coordinators for the original GEM grant.

Global Positioning System

Location information will be collected for each NCPWS well using a GPS. The ultimate goal is to obtain accurate GPS locations on all NCPWS wells for entry into the SGDB. Local health departments, at their option, will be contracted for site visits to obtain GPS locations on all NCPSW wells. The GPS locations must be "corrected" to provide accurate well locations before the locations are entered in the SGDB. Corrected locations may be obtained through the "real time" acquisition of accurate locations, or postprocessing of the collected location information to provide accurate locations.

Local health departments will be offered additional funds for corrected and accurate well locations. The supplemental funds may be used to purchase new GPS units or upgrade existing GPS capabilities, provided the local health department provides corrected and accurate GPS locations for entry into the SGDB. Local health departments collecting GPS locations but not providing corrected and accurate GPS locations for entry into the SGDB will be loaned GPS units. The state has purchased 12 Trimble Geo Explorer II GPS units with a differential accuracy of 2 to 5 meters that will be rotated between counties. Local health departments accepting additional funds for providing accurate location will not be eligible for the use of loaner GPS units. The Institute of Water Research will be responsible for correcting location information obtained from counties not taking the supplemental funds.

Well Drilling Records and *Wellogic*

Information from well drilling records is critical to the SWAP. As part of SWAP, available well records for NCPWS wells will be compiled. The SGDB contains location verified well information compiled from well drilling records to which the information for NCPWS wells will be added. ***Wellogic*** is the software program that allows well drilling record information to be stored in a data base format and provides for the automated entry, storage, and retrieval of well information. Local health departments, at their option, will be contracted to enter the well drilling record information for NCPWS wells in ***Wellogic***. Local health departments, which do not enter well drilling record information into ***Wellogic*** will locate well drilling records for NCPWS wells as part of the source water assessment procedure. Well drilling records that are not entered into ***Wellogic*** shall be forwarded to a GEM center for entry into ***Wellogic*** and inclusion in the SGDB.

Geographic Information System

The use of GIS for analysis and display of location and well record information is necessary in the state SWAP. ArcInfo coverage is the MDEQ standard for GIS applications. ArcView and ArcInfo are the standard software packages for departmental information analysis and applications.

To the extent staffing and contract activities allow, the SWAP will provide maps to LHDs that include the following information:

- Maps showing the locations of wells derived by address matching using the Type II data base and base maps developed from the Michigan Information System.
- County vulnerability maps based upon a statewide vulnerability map to be developed by Dr. Dave Lusch, MSU.
- Potential sites for contaminant sources based upon state lists.

The GPS location and well drilling record information obtained by the counties will be compiled and incorporated into the statewide GIS for use in the analysis of information and the presentation to the public. Through GIS the results can be used in protection efforts for public water supplies and also be used to focus groundwater protection efforts for private water supply wells.

OVERVIEW OF SOURCE WATER ASSESSMENT SCORES

In addition to the GPS/GIS phases of the source water assessment, the vulnerability of NCPWS wells will be evaluated by determining a SWAS. Ideally a source water assessment would entail a critique of the rate at which groundwater moves both horizontally and vertically in the subsurface. Unfortunately, hydrogeologic studies that document the rate of groundwater movement are scarce, difficult to conduct, and expensive. The SWAS has been created as a numeric system that assigns points for situations that represent a "perceived risk" based upon the evaluation of four criteria. The evaluation criteria provide a "qualitative assessment" of groundwater movement and the potential for movement of contaminants into the subsurface. The SWAS is based upon evaluation of the following:

1. The geologic sensitivity of the NCPWS well.
2. The construction, maintenance, and use of the NCPWS well.
3. Chemistry and/or isotope data from the NCPWS well water.
4. Isolation of the NCPWS well from sources of contamination.

The criteria are evaluated in a manner such that a higher SWAS is equated to a greater perceived risk for the NCPWS source water.

Establishing a SWAS provides a rationale for identifying NCPWSs that should receive a priority in the NCPWS program. The SWAS system has been developed cooperatively with the Noncommunity Unit, Groundwater Section, Water Division, MDEQ. The Noncommunity Unit may utilize the SWAS to assign monitoring requirements and identify NCPWSs that should receive priority in the performance of sanitary surveys.

SOURCE WATER ASSESSMENT SCORE SYSTEM

The SWAS system is based upon the accumulation of points for situations that represent a perceived risk to the NCPWS source water. The SWAS is derived from a sum of a geologic sensitivity score ($SWAS_G$); a well construction score ($SWAS_W$); a score for chemistry and isotope data ($SWAS_C$); and an isolation from sources of contamination score ($SWAS_S$).

Geologic Sensitivity - $SWAS_G$

The $SWAS_G$ is factored into the SWAS based on the total thickness of CCM such as clay, clay-rich till or shale, penetrated in construction of the NCPWS well; or the total thickness of CPCM such as a mixture of sand and clay or sandstone and shale. The total thickness of CCM and CPCM should be determined from the well drilling record for the NCPWS well. Where a well drilling record is not available, well drilling records from adjacent wells or test hole borings may be used. Geologic maps (i.e., lithologic cross-sections) may also be used if they provide adequate coverage of the area in which the NCPWS well is located.

Thirty points (30) are initially assigned to the $SWAS_G$ to represent a well lithology with an associated "high geologic sensitivity." From the thirty points, three points are then deducted from the $SWAS_G$ for each **5 feet of CCM** or **10 feet of CPCM** indicated on the well drilling record. The greater the amount of CCM or CPCM, the greater the intrinsic geologic protection provided the NCPWS well, the greater the number of points deducted, and the lower the resulting $SWAS_G$. The following table provides a breakdown of geologic sensitivity, feet of CCM, feet of CPCM, and the points deducted from the 30 points to provide the resultant $SWAS_G$:

Geologic Sensitivity, CCM, CPCM, and Points Deducted

Geologic Sensitivity	High Sensitivity		Moderate Sensitivity						Low Sensitivity		
Amount of CCM (feet)	0	5	10	15	20	25	30	35	40	45	50 or greater
Amount of CPCM	0	10	20	30	40	50	60	70	80	90	100 or greater
Points Deducted	0	3	6	9	12	15	18	21	24	27	30

It is important to note the CCM and/or CPCM must be equal to or greater than 5 feet and 10 feet, respectively, to provide a deduction in the $SWAS_G$. The CCM and/or CPCM less than 5 feet and 10 feet, respectively, shall not be summed to provide a deduction to the $SWAS_G$. Further, where the amount of CCM and/or CPCM indicated on the well drilling record results in a deduction of more than 30 points, the $SWAS_G$ shall be assigned a score of zero (0).

Well Construction - $SWAS_W$

The design, physical condition, and operation of a NCPWS well may allow the entrance of contaminants into the well despite a high level of intrinsic geologic protection. To account for this possibility, the SWAS is assigned points through the $SWAS_W$ based upon four criteria related to the construction and use of the NCPWS wells. The $SWAS_W$ is assessed points based upon well grouting, the age of the well, the casing depth, and the pumping rate of the well.

Well Grouting - The well grouting criteria provides an evaluation of the condition of the well relative to current requirements set forth in the Groundwater Quality Control Act, Part 127, 1978 PA 368, as amended and rules, 1994 Revision (Act 368), for sealing the annular space of a water well. Points are added to the $SWAS_W$ in accordance with the following:

0 pts. - The well record indicates the casing has been sealed from bottom to top in accordance with R 325.1634a, Construction of wells; grouting rotary-bored and augered wells, Rule 134a of Act 368.

5 pts. - The well drilling record indicates the casing has been sealed to an unknown depth or to a depth of 25 feet, in accordance with R 325.1635, Construction of wells; grouting driven casing wells, Rule 135, of Act 368.

10 pts. - The well record indicates the well was grouted, but the date of construction precedes the 1994 revisions to Act 368, and available evidence suggests the well is not in compliance with current grouting requirements.

15 pts. - The well drilling record indicates the well was not grouted, no well drilling record is available, or other information suggests the well was ineffectively grouted.

Well Age - The age of a well provides an overall indication of probable conformity to current code requirements for the construction of a well, and an indication of the probable integrity of the well due to deterioration of materials used in the construction of the well. The $SWAS_W$ is assessed a greater number of points as the age of the well increases in accordance with the following criteria:

0 pts. - A well drilling record is available that indicates the well was constructed after the 1994 revisions to Act 368, or a well record is available that indicates the well was constructed in accordance with the 1994 requirements.

5 pts. - A well drilling record is available that indicates the well was constructed prior to 1994 and after 1976, the year the state of Michigan, SDWA was adopted as the standard for the regulation of public water supply systems.

10 pts. - A well drilling record is available that indicates the well was constructed prior to 1976 but after 1967, the year Act 368, was originally adopted as the standard for the construction of wells.

15 pts. - A well drilling record is not available, the age of the well is unknown or it is determined that the construction of the well precedes the 1967 inception of Act 368.

Casing Depth - The depth to which a well is cased is a factor in determining the amount of earth material available to provide for natural attenuation of potential contaminants. The $SWAS_W$ is assessed a greater number of points as the casing depth is decreased in accordance with the following criteria:

0 pts. - The well drilling record, or a physical determination of the casing depth, indicates the well is cased to a depth of 200 feet or greater.

5 pts. - The well drilling record, or a physical determination of the casing depth, indicates the well is cased to a depth between 100 and 199 feet.

10 pts. - The well drilling record, or a physical determination of the casing depth, indicates the well is cased to a depth between 25 and 99 feet.

15 pts. - The well drilling record, or a physical determination of the casing depth, indicates the well is cased less than 25 feet, the casing terminates below grade, or the casing depth is not known.

Pumping Rate - The pumping rate has considerable impact on the “cone of depression” and “area of influence” of a well. In generalized terms, the area of influence is greater at higher pumping rates, thereby, increasing the potential for contamination of a NCPWS well. Accordingly, the $SWAS_W$ is assessed additional points based upon the following criteria for the pumping rate of the permanent pump:

0 pts. - The well drilling record, or a physical determination of the pumping rate of the permanent pump, indicates the well is pumped at less than or equal to 20 gallons per minute (gpm).

5 pts. - The well drilling record, or a physical determination of the pumping rate of the permanent pump, indicates the well is pumped at a rate of 21 to 50 gpm.

10 pts. - The well drilling record, or a physical determination of the pumping rate of the permanent pump, indicates the well is pumped at a rate of 51 to 100 gpm.

15 pts. - The well drilling record, or a physical determination of the pumping rate of the permanent pump, indicates the well is pumped at a rate greater than 100 gpm.

Water Chemistry and Isotope Data - $SWAS_C$
Water chemistry data provides a refinement to the SWAS through the $SWAS_C$ that may increase or decrease the SWAS. As examples, the presence of nitrates, nitrites, volatile organic compounds, or synthetic organic compounds, even at low levels, is an indicator of source water vulnerability and increases the SWAS; the absence of tritium in the source water indicates the source water is old and not vulnerable, thereby decreasing the SWAS.

Nitrates and Nitrites - Water chemistry data that indicates nitrate-nitrogen (NO_3-N) or nitrite-nitrogen (NO_2-N) concentrations are present in the well water are an indication of vulnerability and result in points being added to the $SWAS_C$. The NO_3-N and NO_2-N data should be evaluated and points assigned the $SWAS_C$ based upon the most recent sample results. Water chemistry data for NO_3-N or NO_2-N concentrations in the well water shall result in the assignment of points to the $SWAS_C$ in accordance with the following:

0 pts. - NO_3-N and NO_2-N not detected in the well water.

10 pts. - NO_3-N or NO_2-N detected in the well water at a concentration that is less than one-half the drinking water standard.

20 pts. - NO_3-N or NO_2-N detected in the well water at a concentration that is less than the drinking water standard, but the concentration is one-half or more than one-half the drinking water standard.

50 pts. - NO_3-N or NO_2-N detected in the well water at a concentration that exceeds the drinking water standard.

Presence of Organic Chemicals - The presence of a VOC or SOC is a clear sign of source water vulnerability. Points will be added to the $SWAS_C$ if water chemistry data indicates the presence, with confirmation, of a VOC or SOC in accordance with the following:

0 pts. - No VOC or SOC has been detected in the well water.

5 pts. - VOC or SOC sample has never been collected.

20 pts. - VOC or SOC has been detected in the well water at a concentration that is less than the drinking water standard, or no drinking water standard has been established for the VOC or SOC in question.

50 pts. - VOC or SOC has been detected in the well water at a concentration that exceeds a drinking water standard.

Tritium - The analysis of NCPWS well water that indicates no tritium is present indicates the source water is not vulnerable and results in a negative assignment of points to the $SWAS_C$:

-30 pts. - Added to the $SWAS_C$ where isotope data indicates the tritium concentration in the source water is less than 1.0 tritium units.

+30 pts. - Added to the $SWAS_C$ where isotope data indicates the tritium concentration in the source water exceeds 10 tritium units.

Isolation from Sources of Contamination - $SWAS_S$

The isolation of a NCPWS well from sources of contamination is an important criteria in the source water assessment. The maintenance of isolation distances can significantly reduce the perceived risk associated with the use of a well. The $SWAS_S$ is assessed points for failure to maintain adequate isolation between "potential" sources of contamination and "known" sources of contamination. Known sources of contamination include those sources where the groundwater has been impacted as a leaking underground storage tank or other sites of environmental contamination. The $SWAS_S$ is assessed points based upon isolation as follows:

10 pts. - Each "standard source" of potential contamination within 75 feet of the NCPWS well.

10 pts. - Each "major source" of potential contamination located from 75 to 800 feet of the NCPWS well.

20 pts. - Each "major source" of potential contamination located within 75 feet of the NCPWS well.

25 pts. - Each "known" source of contamination located within 800 feet of the NCPWS well.

APPENDIX C

Source Water Assessment Worksheet - Noncommunity

Data collection to complete the source water assessment worksheet is an extension of the Sanitary Survey conducted as part of the Noncommunity Public Water Supply Program. Please complete the following as appropriate.

Name of Supply: ______________________________ **WSSN:** ____________

Address: ______________________________ **County:** ____________

Well Log and Location

Well Record Available ☐ Yes ☐ No
Well Record Entered in ***Wellogic*** ☐ Yes ☐ No (If No, attach copy)
If Well Record Entered in ***Wellogic*** ***Wellogic*** # ____________,
GPS Location Obtained for Well(s) ☐ Yes ☐ No

Geologic Sensitivity - $SWAS_G$

Geologic sensitivity is determined based upon the total thickness of Continuous Confining Material (CCM) or Continuous Partially Confining Material (CPCM). Beginning with a $SWAS_G$ of 30 points, 3 points are deducted for each 5 feet of CCM or 10 feet of CPCM. The CCM must be reported on the well record as 5 feet of continuous material and the CPCM 10 feet of continuous material to provide for a deduction. The summing of CCM layers thinner than 5 feet or CPCM layers thinner than 10 feet is not allowed. Where the point deduction exceeds 30 points, the $SWAS_G$ shall be assigned zero (0) points.

CCM Table: Utilize where well log reports just "clay" or "shale"

CCM (feet)	0 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 to 44	45 to 49	50 or greater	**CCM Pts. Deducted**
Pts. Deducted	0	3	6	9	12	15	18	21	24	27	30	

CPCM Table: Utilize where well log reports mixture of "sand/clay" or "sandstone/shale"

CPCM (feet)	0 to 9	10 to 19	20 to 29	30 to 39	40 to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 or greater	**CPCM Pts. Deducted**
Pts. Deducted	0	3	6	9	12	15	18	21	24	27	30	

30 Points minus the CCM pts. deducted and the CPCM pts. deducted - **$SWAS_G$**	

Version: January 1, 2000

Well Construction, Maintenance and Use - $SWAS_W$

This portion of the source water assessment score provides an evaluation of the NCPWS relative to the grouting, age, casing depth and pumping rate for the well.

Well Grouting

Casing sealed entire length in accordance w/1994 Revisions	Casing sealed by driven casing method - 1994 Revisions	Casing sealed in accordance with 1967 code	Casing not sealed or status unknown	Enter Points Below
0 pts.	5 pts.	10 pts.	15 pts.	

Well Age

Constructed 1994 or after	Constructed 1976 - 1993	Constructed 1967 - 1975	Constructed 1966 or before	Enter Points Below
0 pts.	5 pts.	10 pts.	15 pts.	

Casing Depth

Well cased 200 feet or greater	Well cased from 100 – 199 feet	Well cased from 25 - 99 feet	Well cased <25 feet or not known	Enter Points Below
0 pts.	5 pts.	10 pts.	15 pts.	

Pumping Rate

20 gpm or less	21 – 50 gpm	51 - 100 gpm	Greater than 100 gpm	Enter Points Below
0 pts.	5 pts.	10 pts.	15 pts.	

Sum of pts. from grouting, age, casing depth, and pumping rate - **$SWAS_W$**	

Water Chemistry and Isotope Data - $SWAS_C$

This portion of the source water assessment score provides an evaluation of the NCPWS relative to the presence of nitrates and nitrites, organic chemicals and tritium.

Nitrate and Nitrites

Not Detected	Detected Less than ½ MCL	Detected ½ MCL to <MCL	Detected Exceeds the MCL	Enter Points Below
0 pts.	10 pts.	20 pts	50 pts.	

VOCs and SOCs

Not Detected	Not Sampled	Detected @ less than MCL	Detected Exceeds the MCL	Enter Points Below
0 pts.	5 pts.	20 pts	50 pts.	

Tritium Results

No Test	Tritium @ < 1 TU	Tritium @ > 10 TU	Enter Points Below
0 pts.	-30 pts.	30 pts.	

Sum of pts. from nitrate/nitrite, organic chemicals and tritium result- **$SWAS_C$**	

Isolation from Sources of Contamination - $SWAS_S$

This portion of the source water assessment score provides an evaluation of the NCPWS relative to the wells isolation from "major" and "standard" sources of contamination. Sources of contamination are also evaluated dependent upon whether they are "potential" or "known" sources of contamination.

"Potential" Major Sources of Contamination from 75 to 800 feet

Source of Contamination	Number of Sources	Distance from Well (feet)	
Large Scale Waste Disposal			
Land Application of Sanitary Wastewater or Sludge			
Landfill			
Bulk Chemical or Chemical Waste Storage			
Underground Storage Tank			
Other			**Enter Points Below**
Number of Major Sources from 75 to 800 feet		**x 10**	

"Potential" Major Sources of Contamination within 75 feet

Number of Major Sources within 75 feet		**x 20**	

"Potential" Standard Sources of Contamination within 75 feet

Source of Contamination	Number of Sources	Distance from Well (feet)	
Storm or Sanitary Sewers			
Pipe Lines			
Septic Tank or Septic Drain Field			
Cesspools, Seepage Pits, or Dry Wells			
Leaching Beds			
Barnyards			
Surface Water			
Other			**Enter Points Below**
Number of Standard Sources within 75 feet		**x 10**	

"Known" Sources of Contamination within 800 feet

Source of Contamination	Number of Sources	Distance from Well (feet)	
Act 201 Sites (formerly 307 sites)			
Superfund Sites			
Leaking Underground Storage Tanks			**Enter Points Below**
Number of Known Sources within 800 feet		**x 25**	

Sum of pts. from sources of contamination - $\mathbf{SWAS_S}$	

Source Water Assessment Score - SWAS

Sum of $SWAS_G$, $SWAS_W$, $SWAS_C$ and $SWAS_S$ = **SWAS**	

NONCOMMUNITY, PUBLIC WATER SUPPLY SOURCE WATER ASSESSMENT REPORT FOR

LAKE POINTE MANOR 2004247

What is SWAS? - The Source Water Assessment Score (SWAS) is a process that factors geologic and water well attributes, water chemistry, and potential contaminant sources for each drinking water source into a ranking system to determine the relative potential for contamination. Sources with low scores are considered to be less susceptible to contamination than those with high scores. This assessment is required by the Michigan Source Water Assessment Program under the provisions of the 1996 amendments to the Federal Safe Drinking Water Act.	**WSSN:** 2004247 **Well No.** 1 **System:** **Name:** LAKE POINTE MANOR **Address** 5768 E. GRAND RIVER **City:** HOWELL MI 48843 **Owner** **Name:** LAKE POINTE MANOR/PETER KOSM **Address:** 5768 E. GRAND RIVER **City:** HOWELL MI 48843
Well Log and Location - A well log is a legal document describing the well location, construction, depth, soil formations penetrated, and capacity. It has been required to be completed by the drilling contractors and copies submitted to the owner, local health department and State since 1967. ***The lack of information from a well log will increase the SWAS.*** If the worksheet indicates no well log was available for this assessment, it is recommended you contact the well drilling contractor to locate a copy. Wellogic is an electronic databasefor well logs. GPS stands for global positioning system. Eventually, all noncommunity, public water supply wells will have their locations determined by GPS.	**Well Log and Location** Well log is available Y Well log entered in Wellogic Y
Geologic Sensitivity - This score represents the degree of natural protection afforded by the soil materials above the drinking water supply. Lower scores indicate more protection. Points are deducted based on the thickness and type of geologic material that overlies the source of water. Surface contaminants migrate downward at varying rates dependent on geologic material and thickness. CCM stands for continuous confining material (eg. clay). CPCM indicates continuous partially confining material (eg. mixture of sand and clay). More points are deducted for a thick clay layer than a thick sand layer, or a thinner clay layer. Point Range 0-30. ***Sensitivity increases one level if well construction or water chemistry reflects an adverse condition.***	**Geologic Sensitivity – SWAS (G)** CCM Pts. Deducted: 12 CPCM Pts. Deducted: 9 **Total SWAS(G) Points:** 9 ***Geologic Sensitivity Rating –*** ***Moderate***
Well Construction - Points are minimized when a well has features that help protect the water supply from contamination. These include whether the well was grouted (sealing the annulus that is created between the casing and the soil formations during construction); the well age, how deep the casing extends into the ground, and how much water the well pumps since larger volumes can pull contaminants from greater distances. Point Range 0-15 (each category). Lower scores indicate better well construction.	**Well Construction** Well Grouting Points: 10 Well Age Points: 5 Casing Depth Points 10 Pumping Rate: 5 **Total SWAS(W) Points:** 30

SOURCE WATER ASSESSMENT REPORT for WSSN 2004247 (Continued)

Water Chemistry and Isotope Data – Points are added if water sample results indicate nitrates, or detectable levels of volatile organic chemicals (solvents, fuel components) or synthetic organic chemicals (pesticides or herbicides). Points are also added if these analyses have never been completed. Tritium monitoring is a voluntary means of age dating the water. Generally, the older the water the more protected the source. Point Range 0-50 (each category). ***Susceptibility is very high if contaminants at or above Maximum Contaminant Level (MCL).***	**Water Chemistry and Isotope Data – SWAS(C)** Nitrate and Nitrites Points: 0 VOCs and SOCs: 5 Tritium Results: 0 **Total SWAS(C) Points: 5**
Isolation From Sources of Contamination – Points are added based on the number and type of potential contaminant sources within the regulated distance (75 feet from standard or 800 feet from major contaminant sources). Examples of the 75 foot distance are septic tanks, sewer lines, storm sewers, etc. The 800 foot distance is for chemical waste or storage such as fuel tanks, landfills, lagoons, or known plumes of groundwater contamination. Point Range – indefinite. ***Susceptibility increased an additional level if standard source within 75' or major source within 800' and two levels if major source within 75' or known source within 800'.***	**Isolation from Contamination – SWAS (S)** Major sources from 75 to 800 feet: 0 x 10 = 0 Major sources within 75 feet: 0 x 20 = 0 Standard sources within 75 feet 0 x 10 = 0 Known sources within 800 feet: 0 x 25 = 0 **Sum of points from sources of contamination: 0**
Source Water Assessment Score – The total SWAS factored with the Geologic Sensitivity are used to determine the overall Susceptibility.	**Source Water Assessment Score – SWAS** **SWAS(G)+SWAS(W)+SWAS(C)+SWAS(S)=SWAS** 9 30 5 0 **44**
Susceptibility Determination – Susceptibility is a means to identify the relative potential of contamination for public water supply sources.	**Susceptibility Determination** Based on the above compilation of source geology, well construction, water chemistry and potential contaminant sources for this public source of drinking water, this assessment determines its: ***Susceptibility is*** ***Moderate***

LIVINGSTON COUNTY
DEPARTMENT OF PUBLIC HEALTH
2300 East Grand River Avenue, Suite 102, Howell, Michigan 48843-7578
www.lchd.org

LAKE POINTE MANOR/PETER KOSMAS
5768 E. GRAND RIVER
HOWELL, MI 48843

Dear Public Water System Owner/Operator:

This is your notification of the result of the assessment of **LAKE POINTE MANOR, WSSN# 2004247,** with regard to susceptibility to contamination. This assessment is required under the Michigan Safe Drinking Water Act, 1976 PA 399, as amended. Michigan has over 11,000 noncommunity public water systems drawing their water from wells. Conducting Source Water Assessments (SWAs) on each well provides a means to broadly characterize sources with respect to the relative risk of contamination. This initial assessment was conducted by your local health department (LHD) in cooperation with the Department of Environmental Quality. It is intended to assist owners and regulatory agencies in making decisions affecting their drinking water system, future sampling, and ground water protection efforts.

Source Water Assessment Results

- The Geologic Sensitivity rating for your well is **Moderate**.
- The overall Susceptibility rating for your well is **Moderate**.

Enclosed is the report for your source indicating how it was assessed. This process is structured to evaluate the degree of natural protection afforded by the permeability of geologic material like sands, gravels, clays, silts, or rock that overlay the source of water. This is called the Geologic Sensitivity. The Sensitivity categories go from low to very high.

Factors considered in addition to the natural features of the site have to do with how the location has been affected by human activities. This includes the well attributes such as depth, grouting, age, pumping rate, historic water quality results, and proximity to various sources of potential contamination such as septic systems, sewer lines, fuel storage tanks, or actual groundwater contamination sites. These factors combined with the Geologic Sensitivity determine the overall Susceptibility. If you have more than one well, your system is rated on the most susceptible one.

What does this mean?

These terms are a means of categorizing thousands of drinking water sources for better long-term management of this valuable resource. Typically, there is little that can be done to improve a Geologic Sensitivity to afford more protection. However, it may be possible to decrease Susceptibility (lessen the potential for contamination) over time by certain actions. Generally, this might mean installing a new deeper or grouted well, properly abandoning an unused well, or eliminating a potential source of contamination such as fuel storage tank, sewer line, or a septic system. Any effort to improve the protection of your water supply should be based on site specific information and consultation with your LHD.

What should I do now?

You are not required to take a specific action at this time as a result of this notification. The purpose of this notification is to inform you of this assessment. Please maintain this notice on file with your water sample results, sanitary survey report, and other required water system documents. Thank you for your assistance in protecting and maintaining a safe drinking water supply.

If you wish to discuss the raw scoring for your source or if you have any questions regarding your water system, please contact me at (517) 546-9858.

Sincerely,

Amy Hiipakka
Non-Community Public Water Supply
Program Coordinator

Enclosures
cc: DEQ Noncommunity File

APPENDIX E

Source Water Assessments
For
Community Public Water Supply Systems
On Groundwater Sources

Table of Contents

INTRODUCTION

Source water assessments are to be performed on CPWS throughout the state that do not participate in wellhead protection. The source water assessments will be completed in accordance with the provisions described herein and have, as objectives, the following:

- Accurately establish through the use of a GPS and GIS the location of CPWS wells.
- Provide for the entry of water well drilling records into an electronic data management system.
- Identify the location and proximity of sources of contamination located within 2,000 feet of CPWS wells.
- Establish a SWAS that reflects the “inherent vulnerability” of the CPWS well and source water.

GLOBAL POSITIONING SYSTEM LOCATIONS AND WATER WELL DRILLING RECORDS

Obtaining accurate location information and water well drilling record information for CPWS wells is an essential first step in the state SWAP. The location and well drilling record information will be entered into the Statewide Groundwater Data Base (SGDB).

Global Positioning System

Location information will be collected for each CPWS well using a GPS. The ultimate goal is to obtain accurate GPS locations on all CPWS wells for entry into the SGDB. The GPS locations must be “corrected” to provide accurate well locations before the locations are entered in the SGDB. Corrected locations may be obtained through the “real time” acquisition of accurate locations or postprocessing of the collected location information to provide accurate locations.

Well Records and *Wellogic*

Information from well drilling records is critical to the SWAP. As part of SWAP, available well drilling records for CPWS wells will be compiled. The SGDB contains location verified well information compiled from well drilling records to which the well drilling record information for CPWS wells will be added. Wellogic is the software program that allows well record information to be stored in a data base format and provides for the automated entry, storage, and retrieval of well information.

Geographic Information System

The use of GIS for analysis and display of location and well drilling record information is necessary in the state SWAP. ArcInfo coverage is the MDEQ standard for GIS applications. ArcView and ArcInfo are the standard software packages for departmental information analysis and applications.

To the extent staffing and contract activities allow, the SWAP will provide maps to district offices that include the following information:

- Maps showing the locations of wells derived by address matching using the Type I data base and base maps developed from the Michigan Information System.
- County vulnerability maps based upon a statewide vulnerability map to be developed by Dr. Dave Lusch, MSU.
- Potential sites for contaminant sources based upon state lists.

The GPS location and well drilling record information will be compiled and incorporated into the statewide GIS for use in the analysis of information and the presentation to the public. Through GIS the results can be used in protection efforts for public water supplies and also be used to focus groundwater protection efforts for private water supply wells.

OVERVIEW of SOURCE WATER ASSESSMENT SCORES

In addition to the GPS/GIS phases of the source water assessment, the vulnerability of CPWS wells will be evaluated by determining a SWAS. Ideally a source water assessment would entail a critique of the rate at which groundwater moves both horizontally and vertically in the subsurface. Unfortunately, hydrogeologic studies that document the rate of ground water movement are scarce, difficult to conduct, and expensive. The SWAS has been created as a numeric system that assigns points for situations that represent a "perceived risk" based upon the evaluation of four criteria. The evaluation criteria provide a "qualitative assessment" of groundwater movement and the potential for movement of contaminants into the subsurface. The SWAS is based upon evaluation of the following:

1. The geologic sensitivity of the CPWS well.
2. The construction, maintenance, and use of the CPWS well.
3. Chemistry and/or isotope data from the CPWS well water.
4. Isolation and control of the CPWS well from sources of contamination.

The criteria are evaluated in a manner such that a higher SWAS is equated to a greater perceived risk for the CPWS source water.

The SWAS system has been developed cooperatively with the Environmental Health and Field Operations Sections in the Water Division, MDEQ. Staff from these sections may utilize the SWAS to assign monitoring requirements and identify CPWSs that should receive follow-up activities.

Source Water Assessment Score System

The SWAS system is based upon the accumulation of points for situations that represent a perceived risk to the CPWS source water. The SWAS is derived from a sum of a geologic sensitivity score ($SWAS_G$); a well construction score ($SWAS_W$); a score for chemistry and isotope data ($SWAS_C$); and isolation and control from sources of contamination score ($SWAS_S$).

Geologic Sensitivity - $SWAS_G$

The $SWAS_G$ is factored into the SWAS based on the total thickness of CCM such as clay, clay-rich till, or shale, penetrated in construction of the CPWS well; or the total thickness of CPCM such as a mixture of sand and clay or sandstone and shale. The total thickness of CCM and CPCM should be determined from the well drilling record for the CPWS well. Where a well drilling record is not available, well drilling records from adjacent wells or test hole borings may be used. Geologic maps (i.e., lithologic cross-sections) may also be used if they provide adequate coverage of the area in which the CPWS well is located.

Thirty points (30) are initially assigned to the $SWAS_G$ to represent a well lithology with an associated "high geologic sensitivity." From the thirty points, three points are then deducted from the $SWAS_G$ for each 5 feet of CCM or 10 feet of CPCM indicated on the well drilling record. The greater the amount of CCM or CPCM, the greater the intrinsic geologic protection provided the CPWS well, the greater the number of points deducted, and the lower the resulting $SWAS_G$. The following table provides a breakdown of geologic sensitivity, feet of CCM, feet of CPCM, and the points deducted from the 30 points to provide the resultant $SWAS_G$:

Geologic Sensitivity, CCM, CPCM, and Points Deducted

Geologic Sensitivity	High Sensitivity		Moderate Sensitivity						Low Sensitivity		
Amount of CCM (feet)	0	5	10	15	20	25	30	35	40	45	50 or greater
Amount of CPCM	0	10	20	30	40	50	60	70	80	90	100 greater
Points Deducted	0	3	6	9	12	15	18	21	24	27	30

It is important to note the CCM and/or CPCM must be equal to or greater than 5 feet and 10 feet, respectively, to provide a deduction in the $SWAS_G$. The CCM and/or CPCM less than 5 feet and 10 feet, respectively, shall not be summed to provide a deduction to the $SWAS_G$. Further, where the amount of CCM and/or CPCM indicated on the well drilling record results in a deduction of more than 30 points, the $SWAS_G$ shall be assigned a score of zero (0).

Well Construction - $SWAS_W$

The design, physical condition, and operation of a CPWS well may allow the entrance of contaminants into the well despite a high level of intrinsic geologic protection. To account for this possibility, the SWAS is assigned points through the $SWAS_W$ based upon four criteria related to the construction and use of the CPWS wells. The $SWAS_W$ is assessed points based upon well grouting, the age of the well, the casing depth, and the pumping rate of the well.

Well Grouting - The well grouting criteria provides an evaluation of the condition of the well relative to current requirements set forth in the Groundwater Quality Control Act, Part 127, 1978 PA 368, as amended and rules, 1994 Revision (Act 368), for sealing the annular space of a water well. Points are added to the $SWAS_W$ in accordance with the following:

0 pts. - The well drilling record indicates the casing has been sealed from bottom to top in accordance with R 325.1634a, Construction of wells; grouting rotary-bored and augered wells, Rule 134a of Act 368.

5 pts. - The well drilling record indicates the casing has been sealed to an unknown depth or to a depth of 25 feet, in accordance with R 325.1635, Construction of wells; grouting driven casing wells, Rule 135, of Act 368.

10 pts. - The well drilling record indicates the well was grouted, but the date of construction precedes the 1994 revisions to Act 368, and available evidence suggests the well is not in compliance with current grouting requirements.

15 pts. - The well drilling record indicates the well was not grouted, no well drilling record is available, or other information suggests the well was ineffectively grouted.

Well Age - The age of a well provides an overall indication of probable conformity to current code requirements for the construction of a well, and an indication of the probable integrity of the well due to deterioration of materials used in the construction of the well. The $SWAS_W$ is assessed a greater number of points as the age of the well increases in accordance with the following criteria:

0 pts. - A well drilling record is available that indicates the well was constructed after the 1994 revisions Act 368, or a well drilling record is available that indicates the well was constructed in accordance with the 1994 requirements.

5 pts. - A well drilling record is available that indicates the well was constructed prior to 1994 and after 1976, the year the state of Michigan, SDWA was adopted as the standard for the regulation of public water supply systems.

10 pts. - A well drilling record is available that indicates the well was constructed prior to 1976 but after 1967, the year Act 368, was originally adopted as the standard for the construction of wells.

15 pts. - A well drilling record is not available, the age of the well is unknown, or it is determined that the construction of the well precedes the 1967 inception of Act 368.

Casing Depth - The depth to which a well is cased is a factor in determining the amount of earth material available to provide for natural attenuation of potential contaminants. The $SWAS_W$ is assessed a greater number of points as the casing depth is decreased in accordance with the following criteria:

0 pts. - The well drilling record, or a physical determination of the casing depth, indicates the well is cased to a depth of 200 feet or greater.

5 pts. - The well drilling record, or a physical determination of the casing depth, indicates the well is cased to a depth between 100 and 199 feet.

10 pts. - The well drilling record, or a physical determination of the casing depth, indicates the well is cased to a depth between 25 and 99 feet.

15 pts. - The well drilling record, or a physical determination of the casing depth, indicates the well is cased less than 25 feet, the casing terminates below grade, or the casing depth is not known.

Pumping Rate - The pumping rate has considerable impact on the "cone of depression" and "area of influence" of a well. In generalized terms, the area of influence is greater at higher pumping rates, thereby, increasing the potential for contamination of a CPWS well. Accordingly, the $SWAS_W$ is assessed additional points based upon the following criteria for the pumping rate of the permanent pump:

0 pts. - The well drilling record, or a physical determination of the pumping rate of the permanent pump, indicates the well is pumped at a rate of less than 200 gpm.

5 pts. - The well drilling record, or a physical determination of the pumping rate of the permanent pump, indicates the well is pumped at a rate of 200 to less than 500 gpm.

10 pts. - The well drilling record, or a physical determination of the pumping rate of the permanent pump, indicates the well is pumped at a rate of 500 to less than 1,000 gpm.

15 pts. - The well drilling record, or a physical determination of the pumping rate of the permanent pump, indicates the well is pumped at a rate greater than 1,000 gpm.

Water Chemistry and Isotope Data - $SWAS_C$

Water chemistry data provides a refinement to the SWAS through the $SWAS_C$, which may increase or decrease the SWAS. As examples, the presence of nitrates; nitrites; volatile organic compounds or synthetic organic compounds, even at low levels; regulated inorganic chemicals; and regulated radionuclides are indicators of source water vulnerability and increase the SWAS; the absence of tritium in the source water indicates the source water is old and not vulnerable, thereby decreasing the SWAS. Review of chemical monitoring records should go back 5 years or more if appropriate. $SWAS_C$ cannot be less than 0 when tritium is less than 1 tritium unit.

Nitrates and Nitrites - Water chemistry data that indicates nitrate-nitrogen (NO_3-N) or nitrite-nitrogen (NO_2-N) concentrations are present in the well water are an indication of vulnerability and result in points being added to the $SWAS_C$. The NO_3-N and NO_2-N data should be evaluated and points assigned the $SWAS_C$ based upon the most recent sample results or historical trends. Water chemistry data for NO_3-N or NO_2-N concentrations in the well water shall result in the assignment of points to the $SWAS_C$ in accordance with the following:

0 pts. - NO_3-N and NO_2-N not detected in the well water.

10 pts. - NO_3-N or NO_2-N detected in the well water at a concentration that is less than one-half the MCL.

20 pts. - NO_3-N or NO_2-N detected in the well water at a concentration that is less than the drinking water standard, but the concentration is one-half or more than one-half the MCL.

50 pts. - NO_3-N or NO_2-N detected in the well water at a concentration that exceeds the MCL.

Presence of Organic Chemicals - The presence of a volatile organic compound (VOC) or synthetic organic compound (SOC) is a clear sign of source water vulnerability. Points will be added to the $SWAS_C$ if water chemistry data indicates the presence, with confirmation, of a VOC or SOC in accordance with the following:

0 pts. - No VOC or SOC has been detected in the well water.

10 pts. - VOC or SOC detected in the well water at a concentration that is less than one-half the MCL.

20 pts. - VOC or SOC detected in the well water at a concentration that is less than the MCL, but the concentration is one-half or more than one-half the MCL.

50 pts. - VOC or SOC detected in the well water at a concentration that exceeds the MCL.

Inorganic Chemicals - Water chemistry data which detects the presence of regulated inorganic chemical contaminants in the well water from man made or natural sources indicates either a vulnerable source and/or the sources possible inability to meet maximum contaminant levels (MCL). Fluoride is exempt from this scoring unless natural concentrations exceed ½ the MCL or 2 mg/l. Points will be added to the $SWAS_C$ if water chemistry data indicates the presence, with confirmation, of a inorganic contaminants in accordance with the following:

0 pts. - Regulated inorganic contaminants not detected in the well water.

10 pts. - Regulated inorganic contaminants detected in the well water at a concentration that is less than one-half the MCL.

20 pts. - Regulated inorganic contaminants detected in the well water at a concentration that is less than the drinking water standard, but the concentration is one-half or more than one-half the MCL.

50 pts. - Regulated inorganic contaminants detected in the well water at a concentration that exceeds the MCL.

Radionuclides - The presence of regulated radionuclides indicates the well is susceptible to natural or manmade contaminants that may effect the supply's ability to meet drinking water standards. Points will be added to the $SWAS_C$ if water chemistry data indicates the presence, with confirmation, of a regulated radionuclide in accordance with the following:

0 pts. - Regulated radionuclides not detected in the well water.

10 pts. - Regulated radionuclides detected in the well water at a concentration that is less than one-half the MCL.

20 pts. - Regulated radionuclides detected in the well water at a concentration that is less than the drinking water standard, but the concentration is one-half or more than one-half the MCL.

50 pts. - Regulated radionuclides detected in the well water at a concentration that exceeds the MCL.

Tritium - The analysis of CPWS well water that indicates no tritium is present indicates the source water is not vulnerable and results in a negative assignment of points to the $SWAS_C$: Sources with tritium levels between 1.0 and 10 tritium units are of questionable vulnerability and receive no points.

-30 pts. - Added to the $SWAS_C$ where isotope data indicates the tritium concentration in the source water is less than 1.0 tritium units.

+30 pts. - Added to the $SWAS_C$ where isotope data indicates the tritium concentration in the source water exceeds 10 tritium units.

Isolation from Sources of Contamination - $SWAS_S$
Isolation from Standard and Major Sources - The isolation of a CPWS well from sources of contamination is an important criteria in the source water assessment. The maintenance and control of isolation distances can significantly reduce the perceived risk associated with the use of a well. The $SWAS_S$ is assessed points for failure to maintain and/or control adequate isolation between "potential" sources of contamination and "known" sources of contamination. Known sources of contamination include those sources where the groundwater has been impacted as a leaking underground storage tank or other sites of environmental contamination. The $SWAS_S$ is assessed points based upon isolation as follows:

10 pts. - Each "standard source" of potential contamination within 200 feet of the CPWS well.

10 pts. - Each "major source" of potential contamination located from 200 to 2,000 feet of the CPWS well.

20 pts. - Each "major source" of potential contamination located within 200 feet of the CPWS well.

25 pts. - Each "known" source of contamination located within 2,000 feet of the CPWS well.

Control of Standard Isolation Area - The Michigan SDWA requires a CPWS to own or control, through a lease or easement, the defined isolation area around each well. Failure to own or properly control this area effects the future vulnerability of the well. Additional points will be added to the $SWAS_S$ based on the following schedule:

0 pts. - CPWS owns or controls the entire isolation area.

10 pts. - CPWS owns or controls one-half or more of the isolation area.

20 pts. - CPWS owns or controls less than one-half the isolation area.

NOTE: Comments, maps, and well drilling records included with or attached to the score sheet will benefit the review of this assessment and future source water assessment related activities.

APPENDIX F

Community Ground Water Supply
Source Water Assessment Worksheet

4-3-01

Data collection to complete the source water assessment worksheet is an extension of the Sanitary Survey conducted as part of the Community Public Water Supply Program. Please complete the following as appropriate.

Name of Supply: ______________________________ **WSSN:** ____________

Address: ______________________________ **County:** _____________

Well No.(s):____________________ **Approved Standard Isolation Area:**_____ **Feet**

Well Location(s):______________________________ **Source Code(s)**____________

Well Drilling Record Available	☐ Yes	☐ No
Well Drilling Record Entered in WELLOGIC	☐ Yes	☐ No (If No, attach copy)
If Well Drilling Record Entered in WELLOGIC	WELLOGIC # ____________,	
GPS Location Obtained for Well(s)	☐ Yes	☐ No

Geologic Sensitivity - $SWAS_G$

Geologic sensitivity is determined based upon the total thickness of Continuous Confining Material (CCM) or Continuous Partially Confining Material (CPCM). Beginning with a $SWAS_G$ of 30 points, 3 points are deducted for each 5 feet of CCM or 10 feet of CPCM. The CCM must be reported on the well drilling record as 5 feet of continuous material and the CPCM 10 feet of continuous material to provide for a deduction. The summing of CCM layers thinner than 5 feet or CPCM layers thinner than 10 feet is not allowed. Where the point deduction exceeds 30 points, the $SWAS_G$ shall be assigned zero (0) points.

CCM Table: Utilize where well drilling record reports just "clay" or "shale"

CCM (feet)	0 to 4	5 to 9	10 to 14	15 to 19	20 to 24	25 to 29	30 to 34	35 to 39	40 to 45	45 to 49	50 or greater	**CCM Pts. Deducted**
Pts. Deducted	0	3	6	9	12	15	18	21	24	27	30	

CPCM Table: Utilize where well drilling record reports mixture of "clay/sand" or "shale/sandstone"

CPCM (feet)	0 to 9	10 to 19	20 to 29	30 to 39	40 to 49	50 to 59	60 to 69	70 to 79	80 to 89	90 to 99	100 or greater	**CPCM Pts. Deducted**
Pts. Deducted	0	3	6	9	12	15	18	21	24	27	30	

30 Points minus the CCM pts. deducted and the CPCM pts. Deducted - **$SWAS_G$**	

Well Construction, Maintenance and Use - SWAS$_W$

This portion of the source water assessment score provides an evaluation of the well(s) relative to the grouting, age, casing depth, and pumping rate.

Well Grouting

Casing sealed entire length in accordance w/1994 Revisions	Casing sealed by driven casing method -1994 Revisions	Casing sealed in accordance with 1967 code	Casing not sealed or status unknown	Enter Points Below
0 pts.	5 pts.	10 pts.	15 pts.	

Well Age

Constructed after 1994	Constructed 1976 - 1994	Constructed 1967 – 1976	Constructed Pre-1967	Enter Points Below
0 pts.	5 pts.	10 pts.	15 pts.	

Casing Depth

Well cased 200 feet or greater	Well cased from 100 - 199 feet	Well cased from 25 - 99 feet	Well cased <25 feet or not known	Enter Points Below
0 pts.	5 pts.	10 pts.	15 pts.	

Pumping Rate

100 gpm or less	101 - 500 gpm	501 – 1,000 gpm	Greater than 1,000 gpm	Enter Points Below
0 pts.	5 pts.	10 pts.	15 pts.	

Sum of pts. from grouting, age, casing depth, and pumping rate - **SWAS$_W$**	

Water Chemistry and Isotope Data - SWAS$_C$

This portion of the source water assessment score provides an evaluation of the well(s) relative to the presence of nitrates and nitrites, VOC's, SOC's, inorganic chemicals, radionuclides, and tritium.

Regulated Contaminants	Not Detected	Detected to < ½ MCL	Detected ½ MCL to MCL	Detected Exceeds MCL	*Enter Points* Below
Note sample date(s)	0 points	10 points	20 points	50 points	
Nitrates and Nitrites					
VOC's					
SOC's and Pesticides					
Inorganics *except Fluoride*					
Radionuclides					

Tritium Results

No Test	Tritium @ < 1 TU	Tritium @ > 10 TU	Enter Points Below
0 pts.	-30 pts.	30 pts.	

Sum of pts. from nitrate/nitrite, VOC's, SOV's, inorganic chemicals, radionuclides, and tritium result (cannot be less than 0) - **SWAS$_C$**	

Isolation from Sources of Contamination - SWAS$_S$

This portion of the source water assessment score provides an evaluation of the CPWS relative to the wells isolation from "major" and "standard" sources of contamination. Sources of contamination are also evaluated dependent upon whether they are "potential" or "known" sources of contamination.

"Potential" Major Sources of Contamination from 200 feet to 2000 feet

Source of Contamination	**Number of Sources**	**Distance From Well (feet)**	
Large Scale Waste Disposal			
Land Application of Sanitary Wastewater or Sludge			
Landfill			
Bulk Chemical or Chemical Waste Storage Sites			
Underground Storage Tank Sites			
Other – Describe			**Enter Points Below**
Number of Major Sources from 200 ft. to 2000 ft.		**X 10**	

"Potential" Major Sources of Contamination within 200 feet

Number of Major Sources within 200 feet		**X 20**	

"Potential" Standard Sources of Contamination within 200 feet

Source of Contamination	**Number of Sources**	**Distance From Well (feet)**	
Storm or Sanitary Sewers			
Pipe Lines			
Septic Tank or Septic Drain Field			
Cesspools, Seepage Pits, or Dry Wells			
Parking Lots/Roads			
Surface Water			
Other			**Enter Points Below**
Number of Standard Sources within 200 feet		**x 10**	

"Known" Sources of Contamination within 2,000 feet

Source of Contamination	**Number Of Sources**	**Distance From Well (feet)**	
Act 201 Sites (formerly 307 sites)			
Superfund Sites			
Leaking Underground Storage Tank Sites			**Enter Points Below**
Number of Known Sources within 2000 feet		**x 25**	

Control of Standard Isolation Area

Own/Lease Entire Area	**Own/Lease >1/2 Area**	**Own/Lease <1/2 Area**	**Enter Points Below**
0 pts.	10 pts.	20 pts.	

Sum of pts. From control and sources of contamination – **SWAS$_S$**	

Source Water Assessment Score - SWAS

Sum of $SWAS_G$, $SWAS_W$, $SWAS_C$ and $SWAS_S$ = **SWAS**	

Data Sources____

Comments:	Sketch or Attach Map of Source Water Area(s):

Water Supply Contact:____

Title ______________________________Telephone No.________________

Assessment Completed by_________________________Date________________

COMMUNITY, PUBLIC WATER SUPPLY SOURCE WATER ASSESSMENT REPORT FOR

City of Bessemer-Black River Well Field 1 **00660**

What is SWAS? - The Source Water Assessment Score (SWAS) is a process that factors geologic and water well attributes, water chemistry, and potential contaminant sources for each drinking water source into a ranking system to determine the relative potential for contamination. Sources with low scores are considered to be less susceptible to contamination than those with high scores. This assessment is required by the Michigan Source Water Assessment Program under the provisions of the 1996 amendments to the Federal Safe Drinking Water Act.	**WSSN:** 00660 **Well No.** 1 **County:** GOGEBIC **Administrative Contact** **Name:** CHATEL, TOM **Address:** 411 South Sophie Street **City:** BESSEMER **State:** MI **Zip:** 49911
Well Log and Location - A well log is a legal document describing the well location, construction, depth, soil formations penetrated, and capacity. It has been required to be completed by the drilling contractors and copies submitted to the owner, local health department and State since 1967. **The lack of information from a well log will increase the SWAS.** If no well log was available for this assessment, the SWAS may be higher than if one were available. Wellogic is an electronic database for well logs.	**Wellogic ID Number:** 270000000344
Geologic Sensitivity - This score represents the degree of natural protection afforded by the materials overlying the water-bearing formation. Lower scores indicate more protection. Points are deducted based on the thickness and type of geologic material that overlies the source of water. Surface contaminants migrate downward at varying rates dependent on geologic material and thickness. CCM stands for continuous confining material (eg. clay). CPCM indicates continuous partially confining material (eg. mixture of sand and clay). More points are deducted for a thick clay layer than a thick sand layer, or a thinner clay layer. Point Range 0-30.	**Geologic Sensitivity – SWAS (G)** CCM Pts. Deducted: 0 CPCM Pts. Deducted: 30 **Total SWAS(G) Points:** 0 ***Geologic Sensitivity Rating –*** *Low*
Well Construction - Points are added when a well lacks features that help protect the water supply from contamination. These include whether the well was grouted (sealing the annulus that is created between the casing and the soil formations during construction); the well age, how deep the casing extends into the ground, and how much water the well pumps since larger volumes can pull contaminants from greater distances. Point Range 0-15 (each category) Lower scores indicate better well construction. **Susceptibility increases one level if well construction reflects an adverse condition.**	**Well Construction** Well Grouting Points: 0 Well Age Points: 0 Casing Depth Points: 5 Pumping Rate: 5 **Total SWAS(W) Points:** 10

APPENDIX G

SOURCE WATER ASSESSMENT REPORT for WSSN 00660 (Continued)

Water Chemistry and Isotope Data – Points are added if water sample results indicate detectable levels of nitrates or nitrites, volatile organic chemicals (solvents, fuel components), synthetic organic chemicals (pesticides or herbicides), inorganics (metals) or radionuclides. Tritium monitoring is included as a voluntary means of age dating the water. Generally, the older the water the more protected the source. Point Range 0-50 (each category). **Susceptibility is very high if contaminants exceeds the Maximum Contaminant Level (MCL). The MCL used for arsenic and radionuclide scores were those in effect prior to May 2003.**	**Water Chemistry and Isotope Data – SWAS(C)** Nitrate and Nitrites 0 Socs: 0 VOCs: 0 Inorganics: 10 Tritium Results: 0 Radionuclides: 0 **Total SWAS(C) Points: 10**
Isolation From Sources of Contamination – Points are added based on the number and type of potential contaminant sources within the isolation distance (200 feet from standard or 2000 feet from major contaminant sources). For delineated wells, the delineated area is substituted for the 2000 foot radius. Examples of the 200 foot distance are septic tanks, sewer lines, storm sewers, etc. The 2000 foot distance is for chemical waste or storage such as fuel tanks, landfills, lagoons, or known plumes of groundwater contamination. Point Range – indefinite. **Susceptibility increases an additional level if there is a major source within 200' or a known source within 2000'. Points are also added if the water supplier does not own or control the approved standard isolation area.**	**Isolation from Contamination – SWAS (S)** Major sources from 200 to 2000 feet: 1 x 10 = 10 Major sources within 200 feet: 0 x 20 = 0 Standard sources within 200 feet 0 x 10 = 0 Known sources within 2000 feet: 0 x 25 = 0 Control of Isolation 0 Delineated Area Y **Sum of points from sources of contamination: 10**
Source Water Assessment Score – The total SWAS factored with the Geologic Sensitivity are used to determine the overall Susceptibility.	**Source Water Assessment Score – SWAS** **SWAS(G)+SWAS(W)+SWAS(C)+SWAS(S)=SWAS** 0 10 10 10 **30**
Susceptibility Determination –Susceptibility is a means to identify the relative potential of contamination for public water supply sources. The Michigan SWAP evaluated 2442 community groundwater sources and determined susceptibility to be **Very Low** for 1.6%, **Low** for 16.2%, **Moderately Low** for 34.5%, **Moderate** for 26.9%, **Moderately High** for 15.3%, **High** for 4.8%, and **Very High** for .7%.	**Susceptibility Determination** Based on the above compilation of source geology, well construction, water chemistry and potential contaminant sources for this public source of drinking water, this assessment determines its: ***Susceptibility is*** *Low*

JENNIFER M. GRANHOLM
GOVERNOR

STEVEN E. CHESTER
DIRECTOR

March 22, 2004

Mayor and Council
411 South Sophie Street
Bessemer, MI 49911

ATTN: Mr. Tom Chatel
Acting City Manager

Dear Mr. Chatel:

Subject: Source Water Assessment

Enclosed are source water assessment reports completed by the Department of Environmental Quality (DEQ) for each active well providing source water to your community water supply.

The 1996 amendments to the federal Safe Drinking Water Act (SDWA) require each state to develop and implement a source water assessment program (SWAP) to assess the susceptibility of all public water supply sources to contamination. The Michigan SWAP was developed through an advisory committee, approved by the U. S. Environmental Protection Agency in October 1999 and is currently being implemented. This program requires the DEQ to analyze source sensitivity (natural protection available), delineate source water areas, inventory contaminant sources, determine susceptibility, and assure the public is notified of this determination. Enclosed for your reference is a brochure which further explains the Michigan SWAP.

Community ground water supplies which do not have an approved Wellhead Protection Program (WHPP) were assessed using a numerical scoring procedure which provided a Source Water Assessment Score (SWAS) for each well. The SWAS is composed of four parts; geology or SWAS(G), well construction or SWAS(W), chemistry or SWAS(C), and source isolation or SWAS(S) for each public water supply well. DEQ staff completed worksheets with data obtained from the DEQ files and on-site observations which scored these 4 categories and respective subcategories. The basis for scoring each category is noted in the left column of the report with the respective scores for each category or sub-category in the right column.

Your water supply's susceptibility determination noted in the lower right corner on the second page of the report is based primarily on geologic sensitivity, water chemistry, and contaminant sources. If a well record was not available, the source was considered highly sensitive due to the lack of geologic information. Failure of source water to meet chemical Maximum Contaminant Levels (MCL) caused an increase of susceptibility as did the location of a potential major contaminant source with 200 feet of a well or known contamination source within 2000 feet of the well. Please note the contaminant specific MCL used for this assessment were those in effect prior to May 2003. This assessment did not utilize the future arsenic and radionuclide drinking water standards.

The public notification provisions of the SDWA require communities to inform the public of the state's susceptibility determination and announce the availability in its next Consumer Confidence Report (CCR). You may utilize language which includes the susceptibility determination and where this assessment letter and report is available to satisfy the CCR requirement. We also suggest you use this opportunity to inform your customers of wellhead protection activities if your community is pursuing approval of a wellhead protection program (WHPP).

We encourage all community water supplies to pursue wellhead protection to safeguard this valuable drinking water resource. Please contact Chuck Thomas, Ground Water Engineer, Water Division, DEQ Upper Peninsula District Office at 906-346-8534, Scott Ross, Wellhead Protection Unit Chief, Water Division, DEQ Lansing at 517-335-3385, or Kelly Hon, Michigan Rural Water Association at 989-539-4111, if assistance is desired in implementing your wellhead protection program.

Thank you for your commitment to protect your water supply's source water. We hope this assessment serves as a tool to safeguard this valuable drinking water resource.

Sincerely,

Douglas B. Pascoe, P.E.
District Engineer
Water Division
906-346-8531

CT:DP:DN
Enclosure
cc/encl: Mr. Dennis Gustafson, Superintendent of Water
Mr. John Cox, Western U.P. District Health Dept., Bessemer

Appendix H

Letter to Wellhead Protection Communities

Dear Mr. Letter:

SUBJECT: Source Water Assessment

Thank you for all of your efforts in working with the Department of Environmental Quality (DEQ) for the city of Example's Wellhead Protection Program (WHPP). Your voluntary commitment to protect the source water for the city of Example water supply by an approved WHPP is very encouraging.

The 1996 amendments to the federal Safe Drinking Water Act (SDWA) require each state to develop and implement a Source Water Assessment Program (SWAP) to assess the susceptibility of all public water supply sources to contamination. The Michigan SWAP was developed through an advisory committee, approved by the U. S. Environmental Protection Agency in October 1999, and is currently being implemented. This program requires the DEQ to analyze source sensitivity (natural protection available), delineate source water areas, inventory contaminant sources, determine susceptibility, and assure the public is notified of this determination. The assessments consist of a "geologic sensitivity" analysis and an overall source water "susceptibility" determination. The geologic sensitivity is inherent to the aquifer from which the production wells obtain groundwater. Susceptibility is determined in large part by the number and type of contamination sources within the wellhead protection area (WHPA), with additional consideration to aspects of well construction and the chemical monitoring history of individual production wells. Enclosed for your reference is a brochure that further explains the Michigan SWAP.

Since the city of Example has already addressed many of the SWAP requirements, the DEQ utilized this information to complete a source water assessment of your water supply. The following paragraphs summarize information from your WHPP for the geologic sensitivity of your wells and contaminant source inventory within the delineated source water areas.

<u>Sensitivity</u>
Individual supply's Sensitivity is shown here.

<u>Contaminant Source Inventory</u>
Individual supply's Contaminant Source Inventory is shown here.

Wells PW-1, PW-3, and PW-5 have "high" susceptibility based on the above mentioned geologic sensitivity analysis, listed potential contaminant sources within the WHPA, and on the following:

- No Maximum Contaminate Level (MCL) violations have occurred.
- The well construction meets standards.
- There are no potential contamination sources within the standard isolation area.
- Your community has an active WHPP that supports management of existing or potential sources of contamination in the WHPA.
- Known sources of contamination within the WHPA are being remediated to prevent movement of contamination to the municipal wells.

We are asking the city of Example, the DEQ's Field Operation Section staff, and the Local Health Department to consider these issues and respond within 30 days if there are concerns that may change the susceptibility determination and affect the ability of the city of Example's production wells to meet existing drinking water standards now or in the future. You may respond to me at the telephone number below or e-mail brogrenb@michigan.gov.

If there are no responses after 30 days, the source water assessment for the city of Example will be considered complete.

Public notification provisions of the SDWA require communities to inform the public of the state's susceptibility determination and announce the availability of the source water assessment in its next Consumer Confidence Report (CCR). We suggest that the city of Example also use this opportunity to inform the public of your efforts in your local WHPP.

We encourage the city of Example to continue WHPP activities to safeguard this valuable drinking water resource. DEQ staff or the Wellhead Protection Specialist for Michigan Rural Water Association may aid in support implementation of your WHPP. Please contact Mr. Scott Ross, Chief, Wellhead Protection Unit, Groundwater Section, Water Division, DEQ, at 517-335-3385 or Ms. Kelly Hon of the Michigan Rural Water Association at 989-539-4111, if you want assistance to support your program.

Thank you for your commitment to protect the city of Example's source water.

Sincerely,

Bradley B. Brogren, P.E.
Program Manager
MDEQ Affiliate Center
Michigan Public Health Institute
517-241-1361

BBB:ckp
Enclosure
cc: Mr. Example Letter, Water Superintendent, City of Example
Ms. Kelly Hon, Michigan Rural Water Association
Local Health Department, Example County
Mr. Scott Ross, DEQ
Example District Office, DEQ

Appendix I

Assessment Protocol for Great Lakes Sources

August 17, 2000

Introduction

Recently there has been concern over the protection of the nation's drinking water sources. This issue has been debated nationally and eventually was addressed in federal legislation. In 1996 when the federal Safe Drinking Water Act was reauthorized, legislation was added that requires source water assessments be performed on all sources of public drinking water supplies. The assessments must consider the vulnerability of these public drinking water sources. Assessments of intakes that extend into the Great Lakes present a unique challenge in determining the scope and magnitude of these assessments with limited resources. The intakes for some of these sources extend far enough into a lake to receive no effects from specific shoreline contaminant sources (except possibly air borne contaminants) while others closer to shore do. To provide guidance on how source water assessments should be performed it will be necessary to address this very basic premise. USEPA may be able to give some assistance by providing access to data bases, developing screening methods and areawide monitoring for general contaminants, general lake responses to airborne contaminants, and other areawide general assistance.

A workgroup from the Great Lakes States has been organized to develop these parameters. This workgroup includes representatives of the Great Lakes States, water utilities with intakes on the Great Lakes, USEPA Region V, and other interested parties. There should be consensus among the states and USEPA on the make up of the group. USEPA and the Region V states met on June 16, 1999, to develop a mission statement and a final draft of this protocol. The Region V states concurred on the protocol at a workgroup meeting on August 17, 2000. The following mission statement defined the intent of the workgroup.

> *The mission of the Great Lakes Protocol Workgroup is to develop a consensus amongst the states for a consistent procedure allowing the flexibility necessary to properly conduct source water assessments of our Great Lakes drinking water sources. This flexibility will take into account the variability of these sources and site specific concerns for determination of source sensitivity and susceptibility.*

<u>Initial Survey</u>

An initial survey will be performed at each Great Lakes source to assess local source water impacts. Any criteria or studies that were performed to locate the intake should be reviewed. Senior operators and the plant superintendent at the treatment plant plus other local officials should be interviewed to gain knowledge of the raw water quality fluctuations. Past water quality records from files or existing data bases would need to be reviewed and also any data collected through the Information Collection Rule (ICR). Bacteriological quality, alkalinity, and turbidity levels are good indicators of localized impacts. If this review indicates that only minor fluctuations occur in raw water quality compared to the lake's background quality, the source is probably not impacted from localized contaminants and the assessment would parallel a general water quality assessment of the total lake with some consideration for potential emergency spills.

The "Great Lakes Surface Water Assessment Survey" form developed with this protocol can be utilized as a screening tool to assist in determining localized impacts. The initial survey should be used to assist with determining procedures to follow in conducting the survey. The assessment procedures will depend upon the type of local impacts, the availability and quality of local data, weather conditions, runoff, etc.

Critical Assessment Zone

To provide some continuity for assessing the Great Lakes intakes, the concept of a "Critical Assessment Zone" (CAZ) around each intake was developed. The two factors used for this zone, which effect the sensitivity of Great Lakes intakes, are the perpendicular distance from shore or length of the intake pipeline (L) in feet and the water depth (D) of the intake structure in feet. The shallower, near shore intakes are more sensitive to shoreline influences than the off shore, deep intakes. The factor for sensitivity (S) can be calculated by the formula:

$$L \times D = S$$

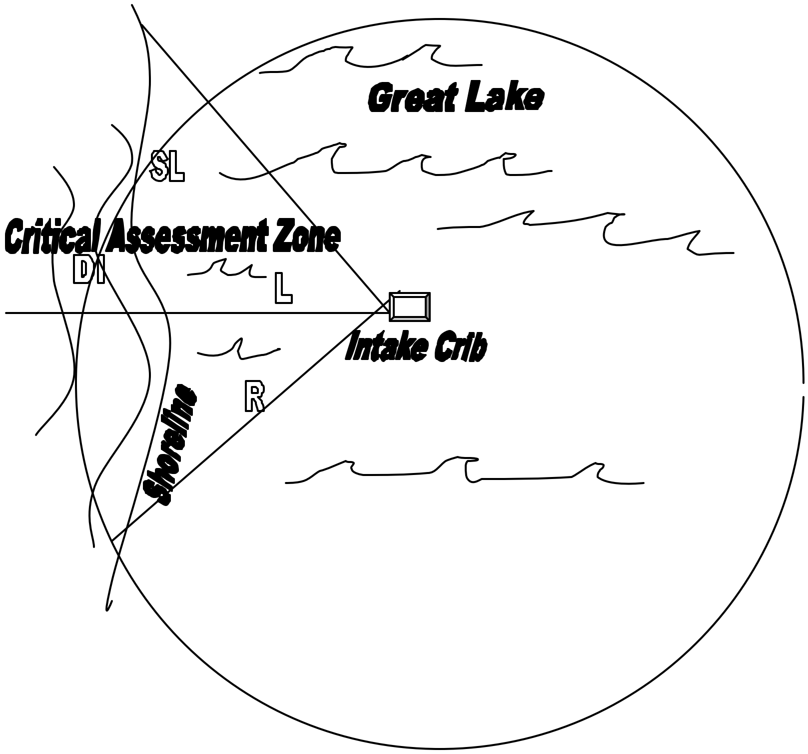
Generally, S values less than 25,000 represent highly sensitive intakes while S values greater than 125,000 indicate lower sensitivities. This degree of sensitivity can be used by the states as a tool to prioritize assessment activities and assist with the susceptibility determination after taking contaminant sources into account.

The intake's degree of sensitivity combined with information obtained from the survey form and local data such as intake construction, lake bottom characteristics, localized flow patterns, thermal effects and benthic nepheloid layers can be used to complete a sensitivity analysis. The benthic nepheloid layer is a zone of suspended sediment kept suspended by the interactions of current and sedimentation. The layer's characteristics around an intake depend on sediment density, water temperature, bottom currents, and animal activity.

The following columns represent Great Lakes intakes with high, medium, and low sensitivities. A CAZ is defined as the area from the intake structure to the shoreline and inland. This area includes 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. The shoreline distance (SL) is measured in feet <u>in both directions</u> from the intake pipe location on shore while the distance inland (DI) in feet is determined by subtracting the submerged intake pipe length (L) from the critical assessment zone radius (R). The drawing, which follows, illustrates an example of the Critical Assessment Zone.

Note: v indicates square root of parenthesized calculations.

Sensitivity Value	Critical Assessment Zone	Shoreline Distance	Distance Inland
<25,000	3,000 foot radius	SL=v(3000^2-L^2)	DI=3000-L
25,000-125,000	2,000 foot radius	SL=v(2000^2-L^2) L>2000;SL=0	DI=2000-L L>2000;DI=0
>125,000	1,000 foot radius	SL=v(1000^2-L^2) L>1000;SL=0	DI=1000-L L>1000;DI=0



Along with the sensitivity analysis, an initial inventory should be completed by a combination of a simple survey form followed by an on site interview.

Attached to this document is a survey form the states could use to conduct this interview.

Completing the Assessment

If the assessment indicates the intake is not impacted by potential shoreline contaminants, the assessment should reference general Great Lakes water quality and trends within the source water assessment area. This information has been compiled by several sources such as the USEPA's Great Lakes National Program Office (GLNPO) and the Great Lakes Mass Balance Studies done by the USEPA, the states, and the USGS. GLNPO has conducted water and sediment modeling activities using National Oceanic and Atmospheric Administration 5 kilometer grids that should be useful for modeling potential spill scenarios, from sources such as pipelines, and for assessing tributary impacts. Another source could be the Remedial Action Plans for Great Lake Areas of Concern and the Lakewide Management Plans. Some of these sources address contaminants brought forth by air deposition. Total Maximum Daily Loads (TMDLs) should also be referenced if available.

For systems where the initial survey indicates a potential for shoreline impacts, the assessment becomes more difficult and site specific. The next step would be to provide a delineation of the area that contributes potential impacts through the use of local data and/or the CAZ concept. It would then be necessary to assess the impacts in the area and their relative impact on the quality and treatability of the raw water. If a river or stream that discharges into the lake near the intake causes a significant impact, a partial watershed assessment of that river or stream would be necessary. These impacts may not be continual, but may arise only as a result of certain events such as a specific wind direction and intensity, or a river or stream discharge into the lake at a certain flow level. The USEPA BASINS software and USGS SPARROW software may provide data for this determination. There may also be impacts from certain thermal or seasonal conditions. These issues are site specific and will require extensive review of the water quality records and in depth interviews with plant personnel.

If the water quality impact is due more to a general lake condition, such as proximity to a shallow bay, wind direction, or localized current patterns, the degree of these impacts must be assessed. Interviews with the plant personnel, with extensive experience at the plant, would be essential. Once the impacts are categorized, assessments must be made for each impact. For example, if a shallow bay causes water quality impacts, these impacts should be noted along with the change in water quality anticipated and the degree and frequency of change. If the quality change results from an algae bloom, the conditions that promote the bloom should be listed, along with the resulting water quality changes and the degree and frequency of the changes. Each impact should be listed in the narrative portion of the assessment.

If the impact results from a discharge on the shoreline, runoff from the shoreline, local tributary or location of a facility near the intake, these potential impacts should be listed and assessed. It may be necessary to delineate an additional area extending beyond the CAZ, determine the impacts in this area and then assess these impacts. This could become complex depending upon the shoreline assessment. If the impact were from runoff, it would first have to be assessed to determine the degree of impact due to the volume and concentration of contaminants in the runoff. Is the runoff significant? If it were, the potential makeup of the runoff would need to be assessed. For example, is the runoff from farmland? If so, the time of the year would be critical. If it were urban runoff, the types of commercial and industrial establishments in the area would be important. These assessments will be complex and must be designed so they can be altered and expanded, as more information becomes available. The assessment must be dynamic in nature and be designed to be expanded in the future.

Many bays and tributary mouths in urban or industrialized areas hold deposits of sediment contaminated by metals and organic toxicants. Records of EPA and state environmental management agencies, as well as the U.S. Army Corps of Engineers Harbor Dredging Programs should be evaluated to determine whether an increase in turbidity due to material suspended in such sites might pose a risk.

Wind direction, thermal effects, and local current patterns affect many intakes. The affects may be due to a shallow bay, or proximity to a shallow bay, where the bottom sediments are resuspended into the intake water column or it may direct shoreline runoff over the intake. These impacts can be surveyed by delineating an additional area that contributes water to the general area and checking the potential contaminants in the area. Extensive interviews with plant personnel and review of historical records will be necessary. Once the impact has been determined, the assessment of the impact must be made.

Remote sensing, including aerial photography and satellite imagery, can be extremely revealing both in analyzing a history of events and near real time tracking of tributary and near shore phenomena. Three-dimensional hydraulic models can be valuable tools for use in areas where they have been developed.

To complete the assessment, the susceptibility determination should include a general map of the area, the sensitivity analysis, delineation of the contributing areas, and listing of the locations of the various contaminant sources.

Before public release of the completed assessment, it should be reviewed with the water supplier for agreement of its contents.

Spill Assessments

Large volumes of materials are transported on the Great Lakes by shipping. Some of these materials are toxic in nature and are subject to accidental spillage during transit and loading. Ships also pose potential risks to intakes through accidental spills of fuel and lubricants. When doing vulnerability assessments of the intakes, this traffic should be considered. If ships pass in close proximity to an intake, or if there is a nearby commercial loading facility or harbor, procedures should be established by the water supplier to react to spills from these ships. It would not be possible to predict many specific contaminants from general shipping, but proximity of a particular industry serviced at a local harbor would indicate heightened risk potentials for specific products or supplies. Procedures could be developed for reaction to families of contaminants, such as volatile organic chemicals, pesticides, etc. Previous spills in the vicinity, if any, should be reviewed and assessed. The water supplier should have a contingency plan for guidance in an emergency.

Spills along lakeshores or connecting river shorelines should also be assessed along with potential spills from pipelines, docking facilities, railroad lines, etc. For example, there are numerous chemical plants along the St. Clair River, which connects Lake Huron to Lake St. Clair. These potential sites should first be identified and located on a map if the initial survey indicates there may be impacts from these areas. Procedures then should be developed for assessing and reacting to these types of emergencies. Where possible on the connecting rivers, modeling of the river flows could be used to assess potential impacts on intakes. In these cases, the specific contaminant would normally be known and this information could be used in the assessment.

For intakes located close to the lake shore lines, again the areas that could significantly impact the intake should be delineated. Potential spill sources in these areas such as industries; disposal facilities, highways, railroads; pipelines, etc., should be located, mapped and assessed. Depending upon the type of potential risk, the specific contaminant may be identifiable, but this may not always be the case. These spills should be considered differently from the routine discharges that may exist. A spill is a unique event, and emergency reaction would be necessary to deal with the potential impact.

Surveys of fixed facilities, pipelines, highway and rail corridors, and shipping routes have generally been completed and may be obtained by contacting the local emergency planning committee or the area planning committee. These two groups should have inventories of oil and hazardous materials at fixed facilities and along transportation routes.

The impacts from treatments at the intake should also be included in the assessments. Continual treatment for zebra mussels may cause development of other impacts on the finished water quality. Short-term treatments or impacts such as intake cleaning, dredging, construction, etc., should also be included in the assessment.

Summary

An outline of the general methodology to be used for Great Lakes intakes should be a main part of the source water assessment program for states in the Great Lakes Region. Due to the unique nature of each intake, each assessment will be site specific. Assessments of the Great Lakes water quality in general have been done by various agencies and these efforts should be referenced not duplicated. The site-specific assessments, if done in close cooperation with the treatment plants and local surface water protection agencies, become valuable tools to future operations and planning.

APPENDIX J

A Two-Dimensional, Transient Flow Model of the St. Clair – Detroit River Waterway

A Cooperative Program of the Michigan Department of Environmental Quality, Detroit Water and Sewerage Division, U.S. Geological Survey, U.S. Army Corps of Engineers, and National Oceanic and Atmospheric Administration

Flow simulations will provide a basis for understanding the effects of dredging on flow and sediment transport; predicting the movement of discharges from combined sewer overflows, tributaries, treatment plants, and spills; identifying source areas for public water supply intakes; and analyzing lake circulation patterns affecting critical habitats.

St. Clair River, Lake St. Clair, and Detroit River form part of the international boundary between the United States and Canada. This waterway is major navigational and recreational resource of the Great Lakes region that connects Lake Huron with Lake Erie. A mathematical model of flow in the St. Clair – Detroit River waterway is being developed to help assess the susceptibility of public water-supply intakes to contaminants and to better understand the water-quality characteristics and sediment movements in the waterway.

St. Clair River extends about 39 mi (miles) from its head at the outlet of Lake Huron near Port Huron, Michigan, to an extensive delta area. Through its length, water-surface elevations fall about 5 ft (feet) as it discharges an average of 182,000 ft^3/s (cubic feet per second) from a drainage area of 222,400 mi^2 (square miles). Lake St. Clair receives water from St. Clair River, and lesser amounts from Clinton River in Michigan and Thames River in Ontario. Along the 25-ft deep navigational channel, the lake has a length of about 35 mi. The lake's round shape, with a surface area of 430 mi^2, and shallow depths that average about 11 ft, make it highly susceptible to winds and water-level changes in the connecting channels. Detroit River receives water from Lake St. Clair, where it courses 32 mi to Lake Erie. Water levels fall about 3 ft though Detroit River, which has an average discharge of 186,000 ft^3/s.

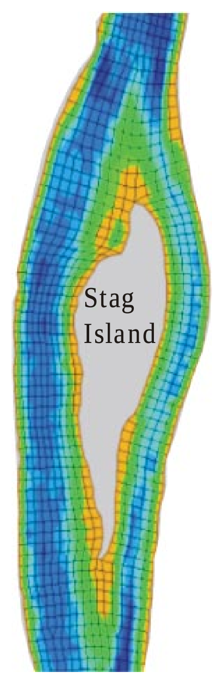
The mathematical model is being developed to compute stream velocities and water-surface elevations (stage) within the waterway. The model is based on the physics of fluid flow and the geometry of the system. Flow resistance and mixing characteristics will be inferred from direct measurements of flow and stage.

Computations are driven by continuously changing stage data at the upstream and downstream limits of the waterway and by available wind information. When completed, the model will provide detailed information on the horizontal (vertically averaged) variations of flow and stage throughout a wide range of hydraulic conditions.

The Michigan Department of Environmental Quality recognized the need for a model as part of the Source Water Assessment Program (SWAP). This program's responsibilities include evaluation of the susceptibility of public water supply intakes to contaminants. The St. Clair-Detroit River waterway contains 13 intakes that supply water to about one third of the residents of Michigan. The Detroit Water and Sewerage Department also is supporting the development of the model because of their interest in maintaining and improving the water quality in Detroit River.

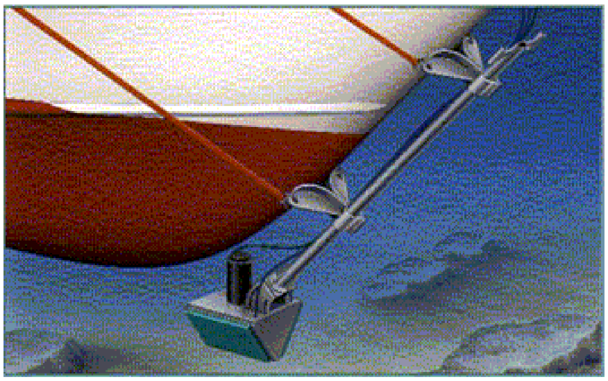
Technical development of a model was initiated in 1998 though a cooperative agreement between the MDEQ, U.S. Geological Survey (USGS) and the Detroit District, U.S. Army Corps of Engineers (USACE). The model is based on a prototype created by the Waterway Experiment Station of USACE in Vicksburg, Mississippi for the Detroit District. The prototype uses an open-source non-proprietary hydrodynamic numerical model for computations, which is referred to as RMA2.

The RMA2 code is a finite-element formulation that is widely used for far-field hydrodynamic problems in which vertical accelerations of flow are negligible and averaged vertical velocities are needed. Detroit District and Environment Canada have recently adapted the prototype to meet the special needs associated with investigating potential effects of channel encroachments on water levels on Lake St. Clair and Lake Huron.



Model development to support the SWAP also requires several major refinements of the prototype. First, the density of the finite-element grid was increased throughout the waterway to provide more detail on flow paths in the vicinity of water-supply intakes. To illustrate the grid density, part of the model for St. Clair River near Stag Island is shown to the right. In the image, shallow areas in the channel are depicted in yellow and deeper areas are depicted in blue.

Second, a new bathymetry (streambed elevation) survey is planned for the summer of 2000 within the connecting channels. The bathymetry of the prototype is based on a 1955 hydrographic survey. This survey, however, preceded a 2-ft deepening of the navigational channel in 1962. The National Oceanic and Atmospheric Administration (NOAA) is scheduled to conduct the hydrographic survey using a single-bean echo sounder, (as depicted in the image below), according to International Hydrographic Organization Chart accuracy standards. Approximately 1139 cross sections will be collected at a 100-meter line spacing. The new bathymetry data will be available by September of 2000 to more accurately describe the current flow geometry.



Finally, a formal parameter estimation analysis will be conducted to quantify the reliability of flow simulation results. This analysis will utilize a series of Acoustic Doppler Current Profile (ADCP) velocity measurements and corresponding stage data. The Detroit Office of the USACE has obtained a series ADCP measurements at numerous locations within the St. Clair and Detroit Rivers. Measurement sets have been obtained at about 6-week intervals during the open-water periods since 1996. Each set contains about 7,000 point measurements of flow velocity. Together with stage data, the velocity measurements will allow estimation of the magnitude and uncertainty of model parameters describing flow resistance and mixing characteristics. Possible seasonal variability of model parameters, perhaps caused by aquatic growth, will be analyzed.

A U.S. Geological Survey report will be prepared in spring of 2001 to document the development process and the capabilities of the flow model. The model is expected to provide a basis for further studies of particle movements, water chemistry, and sediment transport within the waterway. An electronic version of the report and model input will be accessible for public information.

Development and on-going utilization of the flow model will depend on the continued availability of stage data at the model boundaries and interior points. In 1999, however, six of the gaging stations in the St. Clair – Detroit River waterway were targeted for elimination. Loss of these stations would have diminished the accuracy and limited extent to which the model could have been applied. Through the efforts of the Great Lakes Commission and other organizations, however, funding was obtained to modernize the stations so that NOAA could effectively continue maintenance and operations.

Wind has a major effect on the circulation of water in Lake St. Clair, much like water-surface elevations control the movement of water within the connecting channels. Continuous wind data for Lake St. Clair, however, is not currently available. One potentially suitable location for the establishment of a wind monitoring station is on the Lake St. Clair Lighthouse (pictured to the right). This lighthouse is situated near the middle of the lake, just off the navigational channel in United States territorial waters. Such a station would provide data needed for this and other research activities on Lake St. Clair. Further, availability of this data in real time through the Internet would help improve the safety of recreational activities and commercial navigation on the Lake.

For Further Information:
To obtain information on the Source Water Assessment Program in Michigan, please contact
Wm. Elgar Brown, P.E.,
Water Bureau, Michigan Department of Environmental Quality,
525 W. Allegan
P.O. Box 30273
Lansing, MI 48909-7773 or
access the Internet at:
http://www.michigan.gov/deqwd

To obtain additional information on the development of the flow model, please contact
Dave Holtschlag
U.S. Geological Survey, 6520 Mercantile Way, Suite 5,
Lansing, MI 48911 or access the Internet at:
http://mi.water.usgs.gov

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APPENDIX K

Michigan SWAP Water Table Mapping Protocol
(November 2003)

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The reauthorization of the federal Safe Drinking Water Act (SDWA) of 1996 [P.L. 104-182, Section 1453 (a)] required federal guidance and defined state requirements for a source water assessment program (SWAP). These amendments required states to:

- Identify the areas that supply public tap water.
- Inventory contaminants and assess water system susceptibility to contamination.
- Inform the public of the results.

Michigan has almost 12,000 public water supplies (PWS) with over 18,000 sources. Of these, about 10,650 are noncommunity PWS with ground water as the source. These noncommunity, groundwater-based PWS include both transient and nontransient types:

- Schools (Nontransient)
- Businesses (Nontransient)
- Motels / Lodges (Transient)

A noncommunity PWS regulatory program has been operational within the Drinking Water Division of the Michigan Department of Environmental Quality (MDEQ) for many years. This noncommunity PWS program includes a sanitary survey of each system every five years, done through contracts with local health departments (LHDs).

Michigan's SWA Program builds upon this preexisting relationship with LHDs.

A new, on-site assessment protocol was developed for these sanitary surveys which included the:

- Capture the geographic location of the wellhead using GPS.
- Entry of the *water well and pump installation record* for the well into an electronic data management system called *Wellogic*.
- Determination of a Source Water Assessment Score (SWAS) that reflects the "inherent vulnerability" of the well and the source water.

This numeric system assigns points for situations that represent a "perceived risk" based on the evaluation of four criteria. The evaluation criteria provide a "qualitative assessment" of ground-water movement and the potential for movement of contaminants into the subsurface.

The Source Water Assessment Score is based on the evaluation of:

- The geologic sensitivity of the well ($SWAS_G$).
- The construction, maintenance and use of the system ($SWAS_W$).
- Chemistry and/or isotope data from the PWS well water ($SWAS_C$).
- Isolation of the PWS well(s) from sources of contamination ($SWAS_S$).

$$\mathbf{SWAS = SWAS_G + SWAS_W + SWAS_C + SWAS_S}$$

Preliminary results, based on a sample of about 2000 noncommunity PWS, show:

- SWAS ranged from 0 (Great) to 205 (Bad)
- 24.4 % of the PWS ranked as having Low Susceptibility: SWAS = 0 – 30
- 63.8 % of the PWS ranked as having Moderate Susceptibility: SWAS = 31 – 90
- 11.8 % of the PWS ranked as having High Susceptibility: SWAS > 90

Although the potential and known sources of contamination were assessed during the SWA Scoring process (the $SWAS_S$ score), several critical evaluation factors were not taken into account:

1) How deep is the water table (the receiving ground water for most contaminants, abandoned wells notwithstanding)?

2) Relative to the sources, is the water table sloping toward the well or away from the well?

3) What is the gradient of the water table?

These questions can be addressed using an interpolated water table map.

The water table mapping protocol developed for the Michigan SWA Project uses several different existing, digital, geospatial data sets. These include:

- Michigan Framework vector base map data digitized from U.S.G.S. 7.5-minute quadrangle maps. (http://www.dnr.state.mi.us/spatialdatalibrary/metadata/base24k_metadata.htm).
- Digital elevation data (DEM) – 7.5-minute, 30-meter postings. (http://rockyweb.cr.usgs.gov/elevation/dpi_dem.html) (http://www.state.mi.us/webapp/cgi/mgdl/?rel=thext&action=thmname&cid=13&cat=Digital+Elevation+Model+%28DEM%29)
- SSURGO or MIRIS digital soil data. (http://www.dnr.state.mi.us/spatialdatalibrary/metadata/SSURGO_metadata.htm).
- National Wetlands Inventory (NWI) digital data. (http://www.dnr.state.mi.us/spatialdatalibrary/metadata/NWI_Data.htm).

Step 1. Surface Hydrography

A. Extract the perennial streams and lakes from the Michigan Framework Base Map data set (Figure 1). These vector data are then intersected with the DEM data (Figure 2) to extract all those DEM grid cells (30 x 30 meters) that contained a perennial hydrographic feature. The centroids of these grid cells were subsequently extracted; their elevation attribute is set to the DEM cell value.

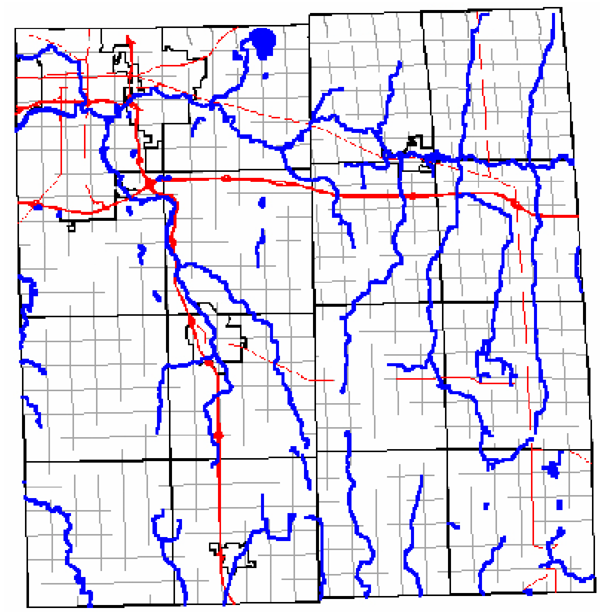


Figure 1. Perennial hydrography in Ingham County from Michigan Framework Data.

B. Extract the intermittent streams and drains from the Michigan Framework Base Map data set (Figure 3). These vector data are then intersected with the DEM data (Figure 2) to extract all those DEM grid cells (30 x 30 meters) that contained an intermittent hydrographic feature. The centroids of these grid cells were subsequently extracted; their elevation attribute is set to the (DEM cell value – 6.5 feet). This is an arbitrary depth setting, but it was chosen for two reasons: 1) to be below the soil data in order to avoid overweighting these spots in the landscape; and 2) to ensure that the valley form of the intermittent features would be represented in the point data set, something that is less likely in the raw 30 x 30 meter DEM data

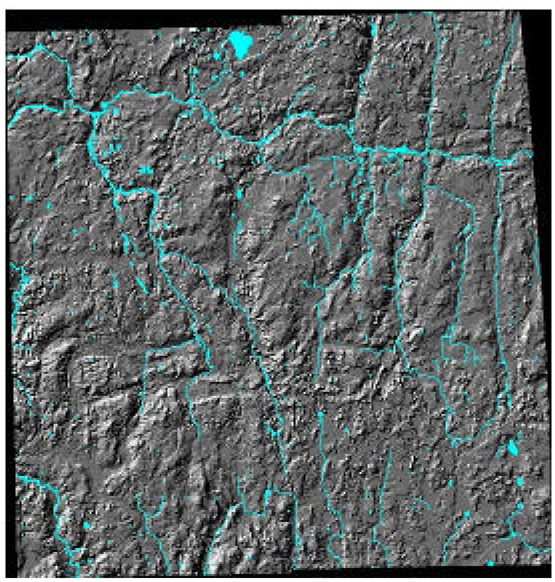


Figure 2. Hillshade presentation of the Ingham County 30-meter DEM.

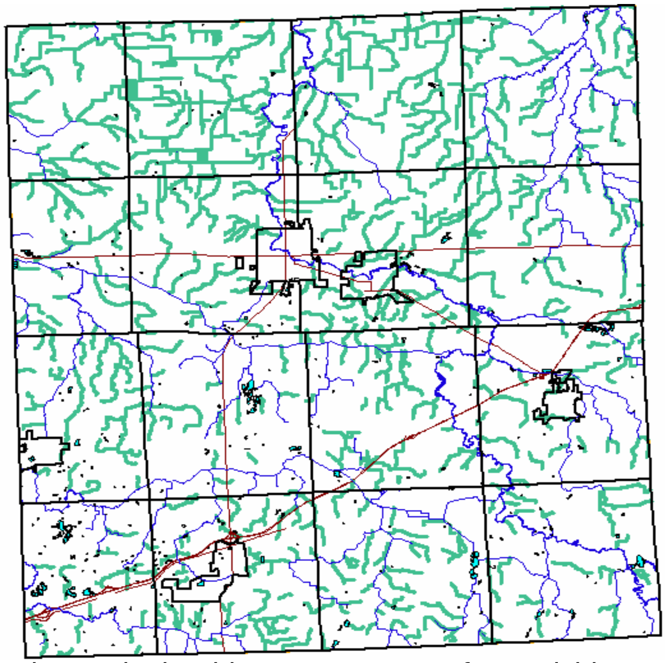


Figure 3. Intermittent hydrography in Shiawassee County from Michigan Framework Data. Thick (green) lines = intermittent features; thin (blue) lines = perennial features.

Step 2. Near-surface Water Table Observations.

A. Process the SSURGO soil data, if available; otherwise the NWI data are used (see Step 2B). The SSURGO soils database contains information about the nature and depth of the seasonally high water table. The field ***wtkind*** contains information about whether the water table data refers to **perched** or **apparent** conditions (NRCS refers to the non-perched water table as "apparent"). All soil map units where "***wtkind*** = apparent" are extracted from the data set. These vector polygons are rasterized at a 30-meter spacing to match the DEM data and the grid centroids (i.e., point data) are extracted (Figure 4). In addition to the surface elevation Z-value which they inherit from the DEM grid cell, each of these points receives an additional attribute from the field ***wtdeph*** that contains the maximum value for the range in depth to the seasonally high water table during the months specified. These data from the ***wtdeph*** field (i.e. the deepest water table depth) where selected in order to capture a mid-growing-season record of the depth to the water table. The final attribute used for subsequent processing is the subtraction of these two attributes: Soil Point Value = [(DEM_Value) – (***wtdeph***_value)].

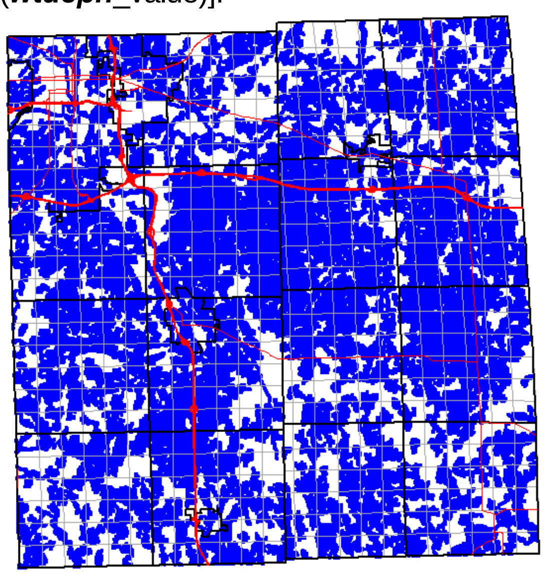


Figure 4. Points (30-meter spacing) extracted from SSURGO soils data recording the depth to the water table.

B. If SSURGO data are unavailable, the NWI wetlands data are processed. All NWI polygons where ***System*** = "Palustrine" in the database are extracted. These vector polygons are rasterized at a 30-meter spacing to match the DEM data and the grid centroids (i.e. point data) are extracted (Figure 5). The surface elevation Z-value that they inherit from the DEM grid cell is reduced by 1.0 foot to create an approximated water table depth. This constant was determined by a test that overlaid all the NWI Palustrine polygons onto the SSURGO soils data in four selected counties in Michigan. The percentage of the coincident areas (i.e., palustrine wetland *and* SSURGO map unit where ***wtkind*** = apparent), by water table depth, is shown in the table below.

wtdeph value	**Antrim County**	**Ingham County**	**Kent County**	**Monroe County**
0 ft.	9.05 %	-	9.03%	58.37%
1 ft.	71.35%	68.97%	63.68%	13.86%
2 ft.	10.61%	17.27%	24.99%	17.22%
3 ft.	2.37%	8.54%	1.14%	4.58%
5 ft.	-	-	1.16%	-
6 ft.	6.62%	5.22%	-	5.97%

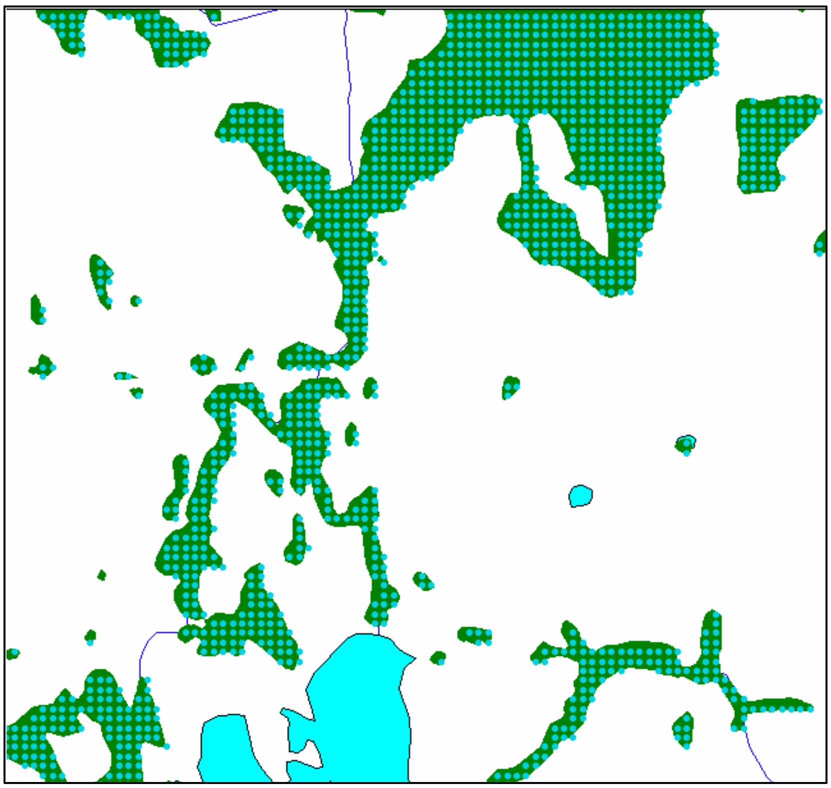


Figure 5. Points (30-meter spacing) extracted from the palustrine polygons in the National Wetlands Inventory data (2 sq. mile area from Bennington Twp., Shiawassee County).

SSURGO soils data from NRCS and non-SSURGO-certified digital soil data from MIRIS were used in this project. Combined, these two sources of digital soil data were available for 50 of the 83 counties of the state (Figure 6). For the remaining 33 counties, National Wetland Inventory (NWI) data were used.

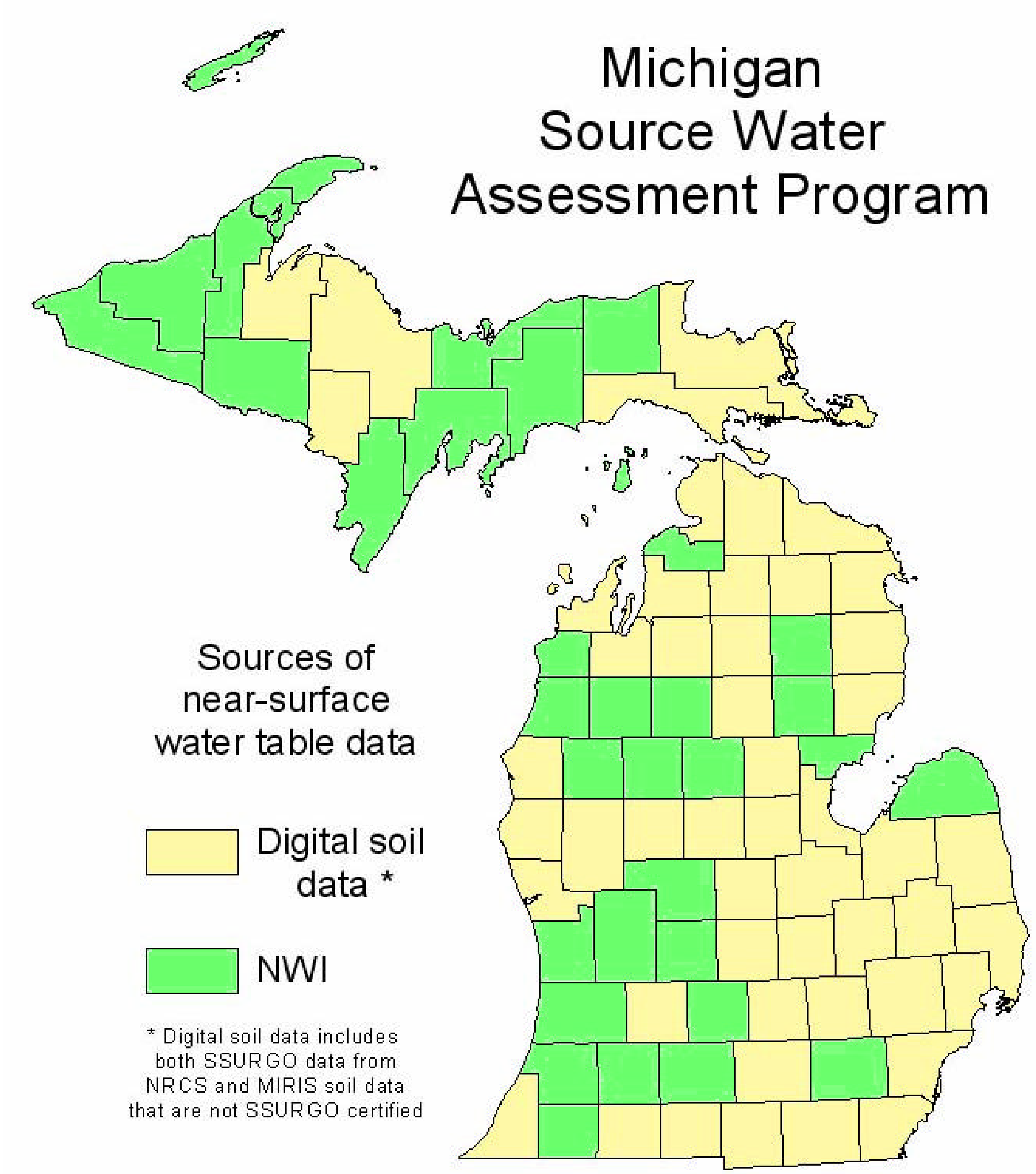


Figure 6. Sources of near-surface water table data.

Step 3. Merged Point File Creation and Water Table Interpolation.
The three point files from steps 1 and 2 are merged (Figure 7). These data are submitted to Kriging interpolation using the *Surfer* software program from Golden Software, Inc. This interpolation generates a water table elevation for each point in a regular grid of points spaced 30 meters apart across the whole county (Figure 8).

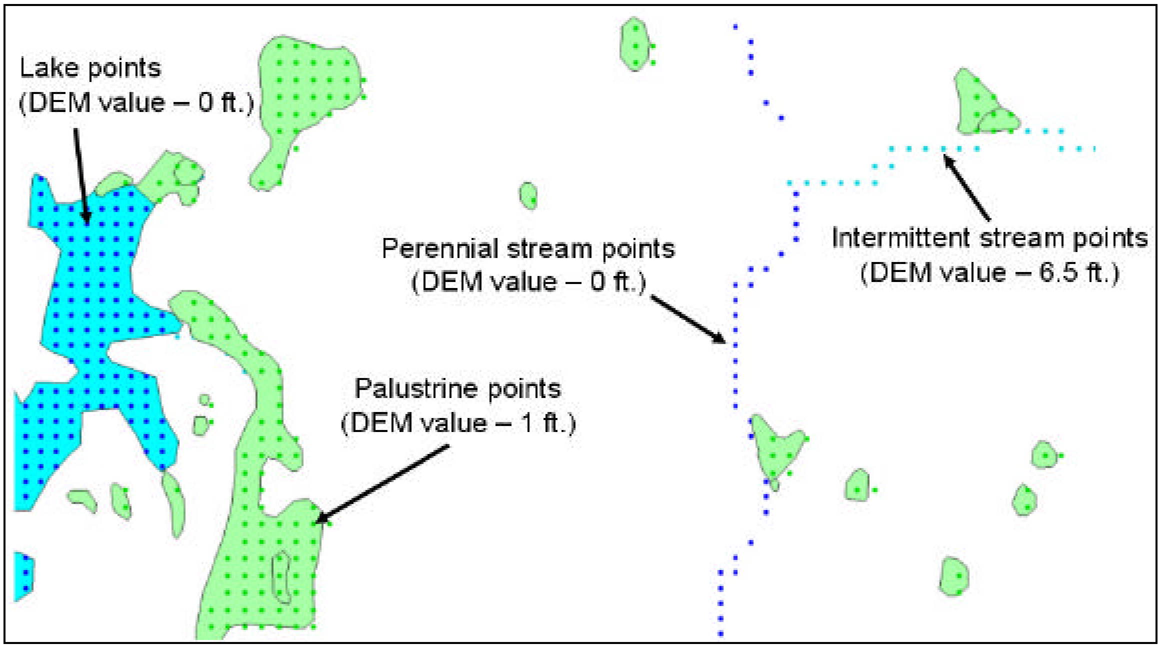
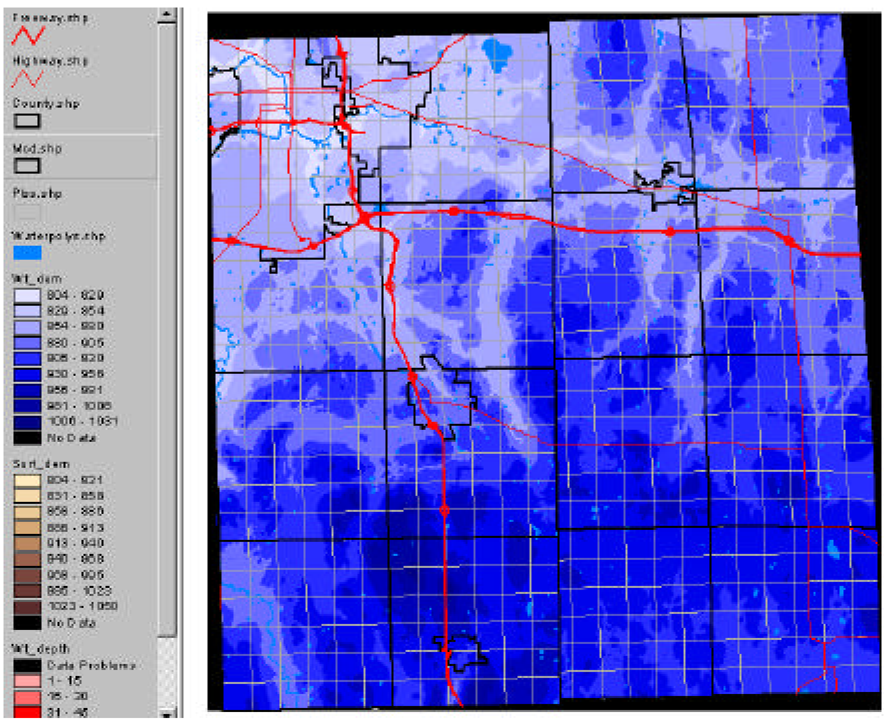


Figure 7. Merged file of water-table points from surface hydrography and NWI data.



Step 4. Depth to the Water Table

The 30-meter, water-table surface grid is subtracted from the 30-meter DEM surface to calculate the depth to the water table (Figure 9).

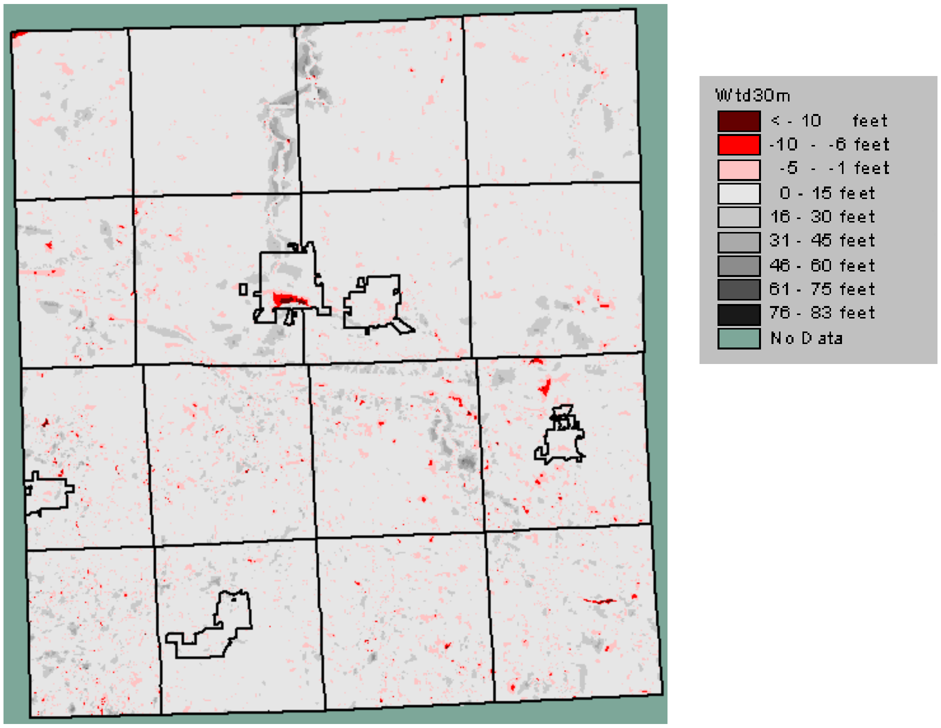


Figure 9. Interpolated depth to the water table, classed in 15-foot ranges.

Step 5. Isoline Presentation of Water Table Surface.
A second water-table surface using a 90-meter grid spacing is interpolated using linear Kriging. These raster data are then converted into isoline contours (using a 10 ft. contour interval), in order to better portray the gradient and direction of flow on the water table surface (Figure 10). The contours generated from the 90-meter water-table surface are smoother with fewer irregularities in comparison to those that can be generated from the 30-meter water-table surface.

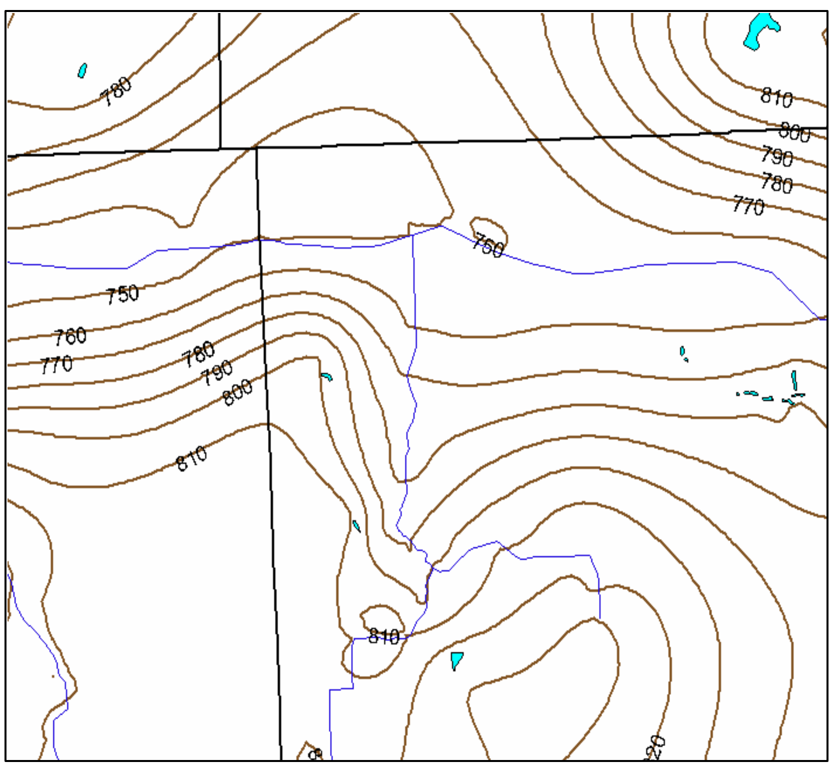


Figure 10. Isoline presentation of the interpolated water table surface (10 ft contours).

APPENDIX L

Michigan MapImage Viewer

The Michigan MapImage Viewer is a GIS software program that provides geographic data and mapping capabilities in a low -cost, easy-to-use format.

The Data:

The Michigan MapImage Viewer comes with a collection of data including the Michigan Geographic Framework data, the statewide collection of MSU LandScan CD aerial images, topographic maps and other GIS data and digital imagery from the MDNR, MDEQ and federal sources. Additionally, the Viewer allows the user to customize the product by importing map files, digital imagery, and point data from coordinate files.

The Functionality:

The Michigan MapImage Viewer provides a set of mapping functions to find, display, measure, identify and query map features. A point-digitizing tool can be used to capture the geographic location (Latitude/Longitude) of selected points. The user can click on a map location to display LandScan aerial photos of the surrounding area. Image controls include a magnifying glass, image enhancement functions, zoom map to active photo and image annotation tools for drawing text, lines, symbols and other graphic objects.

Effective July 1, 2004, the Michigan MapImage Viewer software, developed at Michigan State University (MSU) Remote Sensing and GIS, is being distributed and supported by GeoPathway LLC. The MSU license agreement allows GeoPathway to reproduce, sell and distribute the MapImage Viewer products, make derivatives, and to sub license the product and product derivatives to third parties. GeoPathway will provide technical support to the end-user community and continue to develop new versions of the software.

MSU RS&GIS will continue to provide Michigan MapImage Viewer training and undertake MapImage Viewer research and development projects. Current RS&GIS MapImage Viewer projects include:

- **Critical Dune Management**
  A GIS decision support tool is being built within the MapImage Viewer to help Michigan Department of Environmental Quality staff assess and manage critical dune areas in Michigan. For a proposed dune development site, the viewer searches data themes to collect site information and extract soils database information and topographic data (including LIDAR elevation values).

- **Statewide Groundwater Mapping**
  RS&GIS is developing new MapImage Viewer functions and related software to analyze the lithology information (strata formations) on water well records to assist MSU, USGS, and MDEQ scientists who are compiling a statewide groundwater inventory and constructing a groundwater aquifer map of Michigan.

- **Health Impact Assessment**
  New site analysis protocols and GIS tools are being developed and integrated with existing and new geospatial data to construct a Health Impact Assessment (HIA) tool for reviewing proposed land development site plans. The HIA tool can be used by local and regional planners to evaluate current development project plans based on their impact on community health. The HIA tool will be pilot-tested with local planning bodies in the Tri-County area of Ingham, Clinton, and Eaton counties.

- **Source Water Protection**
  MapImage Viewer Custom tools are being developed to facilitate source applications of GIS technology and water protection planning by the MDEQ, local health departments, water suppliers and the communities they serve. RS&GIS is also providing training and technical assistance to the MDEQ and several pilot County Health Departments that are using the MapImage Viewer Network Edition

More Information:

- Contact us at mapimage@rsgis.msu.edu.
- Order individual copies of the Michigan MapImage Viewer.
  - You will be redirected to the Geopathway LLC website: http://www.geopathway.com/
  - Geopathway LLC is licensed by MSU to sell, distribute, support, and develop new versions of the Michigan MapImage Viewer.

APPENDIX M


Community Water Supplies Using Surface Water
Dots show water intake location
Isle Royale National Park
Gay
White Pine
Keweenaw Bay Indian Community
L'Anse
Baraga
Marquette
Sault Ste. Marie
Manistique
DeTour
St. Ignace
Mackinac Island
Gladstone
Escanaba
Charlevoix
Menominee
Alpena
Traverse City
East Tawas
Saginaw-Midland
Port Austin
Ludington
Caseville
Harbor Beach
Mt. Pleasant
Bay City
Alma
Lexington
Muskegon
Detroit
Muskegon Heights
Port Huron
Grand Rapids
Flint
Grand Haven
St. Clair
Marysville
Wyoming
Ira Twp.
East China Twp
New Baltimore
Marine City
Holland
Mt. Clemens
Algonac
Grosse Pointe Farms/Highland Park
Detroit
South Haven
Ann Arbor
Wyandotte
St. Joseph
Deerfield
Benton Harbor
Bridgman
Adrian
Monroe
Blissfield
New Buffalo

APPENDIX N

ACRONYMS

Act 368 – Groundwater Quality Control Act 1978, P.A. 368, as amended, and rules.

BASINS – Better Assessment Science Integrating point and Nonpoint Sources

CAZ – Critical Assessment Zone

CCM – Continuous Confining Material

CPCM – Continuous Partially Confining Material

CPWS - Community Public Water Supply

DEM – Digital Elevation Models

DRG – Digital Raster Graphics

ESRI – Environmental Systems Research Institute, Inc.

GEM - Groundwater Education in Michigan

GIS – Geographic Information System

GLNPO – Great Lakes National Program Office

GPM – Gallons Per Minute

GPS - Global Positioning System

ICR – Information Collection Rule

IFD – Industrial Facilities Discharge

in/hr – Inches Per Hour

KHS – Karst Hydrologic Systems

LHD - Local Health Department

MCL - Maximum Contaminant Level

MCLG – Maximum Contaminant Level Goal

MDEQ - Michigan Department of Environmental Quality

MSU - Michigan State University

NCPWS - Noncommunity Public Water Supply

NPL – National Priority List

NPRI – National Pollutant Release Inventory

NRCS – National Resources Conservation Service

PAC – Public Advisory Committee

PCS – Potential Contaminant Source

PCSD – Permit Compliance System Database

PWS – Public Water Supply

RCRIS – Resource Conservation and Recovery Information System

RF3 – River Reach files

SDWA - Safe Drinking Water Act

SGBD – Statewide Groundwater Data Base

SOC – Synthetic Organic Compounds

STATSGO – State Soil and Geographic

SWA – Source Water Area

SWAP - Source Water Assessment Program

SWAS - Source Water Assessment Score

$SWAS_C$ – Score for chemistry and isotope data

$SWAS_G$ – Sum of a geologic sensitivity score

$SWAS_S$ – Isolation and control from sources of contamination score

$SWAS_W$ – Well construction score

TAC – Technical Advisory Committee

TMDL – Total Maximum Daily Loads

TOT - Time-of-Travel

TRI – Toxic Release Inventory

USEPA - United States Environmental Protection Agency

USGS - United States Geological Survey

VOC – Volatile Organic Compounds

WHPA - Wellhead Protection Area

WHPP - Wellhead Protection Program

WTP – Water Treatment Plant