The City of Big Rapids Wellhead Protection Area & Contaminant Source Inventory Preliminary Assessment Summer 2000

Environmental Management Studies Center Ferris State University Big Rapids, Michigan

Center Provides for Excellence in Environmental Studies

The Ferris State University Environment Management Studies Center (FSUEMSC) has been in existence since 1972. The Center provides baccalaureate degree, Environmental Health and Safety Management (EHSM) students with a unique opportunity to conduct "real life" field studies and assist area communities and government agencies.

The Center is unique in the United States in its interdisciplinary approach to teaching environmental planning and management. Since 1972, the Center has completed 31 major community and environmental assessment reports, along with 491 background reports.

Some particularly successful projects over the years include:

- A 1979 study of Chippewa Lake that helped justify a lake sewer project.
- A 1992 study which helped Morley Village obtain funds to refurbish a dam and
- Several Muskegon River reports that have been used by the City of Big Rapids in planning for removal of the Big Rapids dam remnant.

In 1972, a three year, \$31,000 grant was obtained to develop the center. Faculty teaching courses in Environmental Conservation (Biology Department), Environmental Engineering, Surveying Engineering (College of Technology), Environmental Management (EHSM Program) and Cultural Geography (Social Sciences Department), were brought together as a team and the FSU campus served as a laboratory and provided real life projects. The course content has changed with the removal of the Cultural Geography course and the modification of the biology course to Environmental Biology. Two new course additions are Environmental Systems Management, and Environmental Assessment and Impact Analysis. Study areas have broadened to include area lakes and hazardous waste sites. Faculty serve as policy makers and professional consultants and students are organized as staff. Students carry out field research, conduct surveys they have developed, and study mapping, photography, surveying, and report writing in addition to classroom studies.

This has proven to be a highly successful educational process, which greatly improves job readiness and develops competencies otherwise, not possible in a traditional academic role. Students improve oral and written presentation skills along with learning teamwork. The process is known as "summer block" and is the environmental health and hazardous materials option student's capstone experience before graduation. Community members interested in receiving a copy of the center's reports may contact the EHSM Department Head in the College of Allied Health Sciences.

Title Page Credits:

Top Center: Post Card Illustration of original dam structure. Undated.

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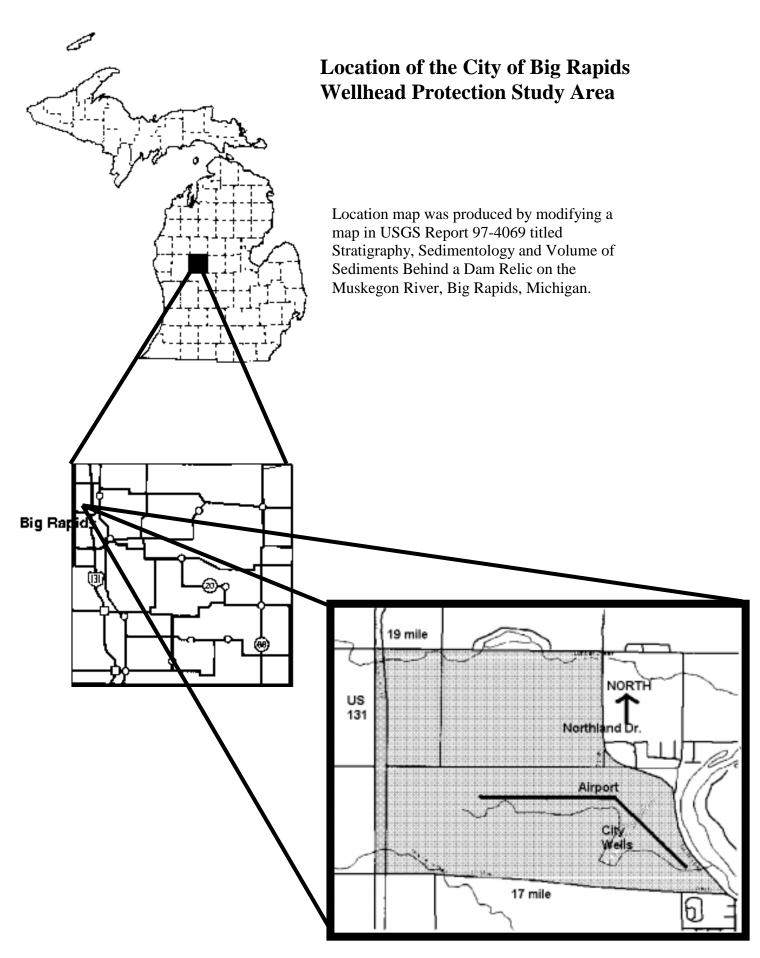
Bottom Left: Remaining 4 ft. of dam remnant, March 20, 2000, facing northeast.

Bottom Center: Demolition of dam remnant, June 23, 2000, facing northeast.

Bottom Right: Dam remnant partially removed with diversion structure, July 11, 2000,

facing northeast.

* All title page images gathered from the City of Big Rapids web site, dam remnant removal section.



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List of Acronyms

AST Aboveground Storage Tanks

GIS Geographic Information System

GPS Global Positioning System

UST Underground Storage Tank

LUST Leaking Underground Storage Tank

MDEQ Michigan Department of Environmental Quality

MDNR Michigan Department of Natural Resources

MDOT Michigan Department of Transportation

USEPA United States Environmental Protection Agency

WHPSA Wellhead Protection Study Area

WHPP Wellhead Protection Program

WHPA Wellhead Protection Area

Executive Summary

During Summer 2000, the Ferris State University Environmental Management Studies Center (FSUEMSC) conducted a contaminant source inventory for the City of Big Rapids municipal wellfield protection area. FSUEMSC assisted the City of Big Rapids in partially fulfilling the Michigan Department of Environmental Quality's (MDEQ) criteria for wellhead protection programs. Wellhead Protection Programs were established to assist cities in the protection of their groundwater source.

The wellhead study group first delineated an estimated wellhead protection study area (WHPSA). The WHPSA is the land located north of 17 Mile Road, south of 19 Mile Road, east of US-131 and west of Northland Drive in Big Rapids Charter Township and Green Charter Township. The wellhead study group worked with the City of Big Rapids, Big Rapids Charter Township, Green Charter Township, District Health Department #10, Michigan Department of Transportation and several MDEQ divisions in order to evaluate the potential and known risks within the WHPSA.

Most of the inventorying of contaminant sources was done through agency contacts, windshield surveys, and property owner surveys. In order to better manage the information collected, a custom built database was used for data entry and sorting. Of the 131 parcels in the WHPSA, sixty-seven percent (89 parcels) of the property owners were surveyed. Assuming an honest response by parcel owners, the high number of survey returns allowed for accurate risk identification. After completing the property owner surveys and agency contacts it was determined that there are no known sites of groundwater contamination within the WHPSA. There are twenty-one potential contamination sources within the WHPSA. Potential Sources included: above and below ground chemical or petroleum storage tanks, abandoned wells, farms, a major expressway (road salt) and hazardous material spill contamination potential along with businesses and farms with a variety of chemical usage.

1.0 Introduction

During Summer 2000, the Ferris State University Environment Management Studies Center (FSUEMSC) conducted a contaminant source inventory to assist the City of Big Rapids in developing a wellhead protection program for the city's new municipal well field. FSUEMSC became involved with this project after Professor Michael Ells held discussions with Big Rapids City Manager, Steve Stilwell. This study was conducted in accordance with guidelines developed by the Michigan Department of Environmental Quality's (MDEQ) Wellhead Protection Program (WHPP).

Wellhead protection is the process of protecting municipal wells from groundwater contaminants. This is accomplished by studying land use history, inventorying chemicals and determining known and possible sources of pollution in a defined Wellhead Protection Study Area (WHPSA). Informing the community about how to protect their water source is also essential to wellhead protection.

The purpose of Michigan's WHPP is to protect groundwater fed public water supply systems. The 1986 amendments to the federal Safe Drinking Water Act spurred the development of the WHPP. Establishing a WHPP is a volunteer project that is administered on a local level. Although establishing a WHPP is voluntary, the MDEQ mandates that if a local Wellhead Protection Committee (WHPC) chooses to implement a WHPP it must follow the established MDEQ guidelines for wellhead protection.

Funds are available for establishing a WHPP through a grant system. The City of Big Rapids is taking advantage of this system and is currently progressing through the grant application process. Up to fifty-percent of the total cost of the project can be paid through grants with the condition that the local governmental unit is contributing the other fifty-percent.

The MDEQ has established seven criteria that a WHPP must meet (4).

- 1. Establish roles and responsibilities.
- 2. Delineate the Wellhead Protection Area.
- 3. Identify potential sources within the delineated WHPA.
- 4. Establish a system for wellhead protection management.
- 5. Develop a contingency plan for emergencies.
- 6. Establish a plan for the development of new wells.
- 7. Implement a public education and participation program about the WHPP.

The participants in this study focused on completing MDEQ criteria number three. Although the project consultant had not yet delineated a specific WHPA, an <u>estimated</u> study area known as the WHPSA was delineated so land use history and potential and known sources of contamination within the area could be identified. Based on preliminary information gathered by Prein & Newhof consultants and past FSU hydrogeology students, the study area is estimated to be five to ten times larger in land area than the anticipated WHPA. Once the study area was established, a windshield survey was conducted, governmental agencies were contacted and property owners were surveyed in order to collect a complete set of information for each parcel of property. The data collected was then entered into a database created for this project.

2.0 Understanding Groundwater

2.1 Hydrogeology Basics

97.2% of the water on Earth is in oceans, 2.14% is in icecaps and glaciers, 0.16% is groundwater, 0.009% is surface water, and the other 0.006% is in the atmosphere and soil. The hydrologic cycle is the circulation of water from the oceans, through the atmosphere to the land, and then back into the oceans (1). Figure 1 is an illustration of a typical hydrologic cycle.

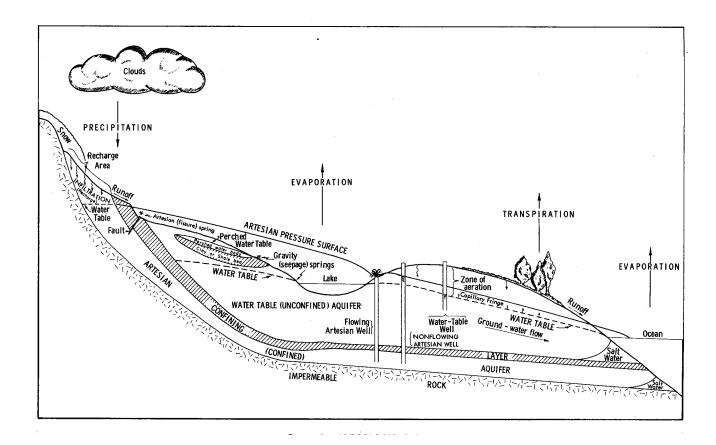


Figure 1: Hydrologic Cycle Illustration (1)

Water enters the atmosphere by evaporation and by plants releasing water through transpiration. This water then falls as precipitation to the land in the form of rain or snow. The precipitation infiltrates into the soil or becomes runoff. Some of the infiltrated water begins to flow to nearby lakes and streams, while the other portion of the infiltrated water enters into the zone of saturation just below the water table (1).

Groundwater is defined as water contained in interconnected pores located below the water table of an aquifer. A water table is the upper-most boundary of an aquifer. An aquifer is a rock and/or sediment formation, group of formations, or part of a formation that is water saturated, and permeable enough to transmit water to wells and or springs. Recharge is the infiltration of precipitation into the soil, eventually reaching an aquifer. Aquifers may be depleted if there is a combination of large amounts of pumping (discharge) with no recharge.

Aquifers also lose water through discharge points such as lakes and streams (1). The total discharge of an aquifer is what flows naturally to the ground surface and what well users pump out. Basically, if discharge exceeds recharge, the water table will fall. If recharge exceeds discharge, the water table will rise.

There are three types of aquifers: confined, unconfined and semi-permeable. An unconfined aquifer has no confining layers above the water table; rather there is a direct path to the water table. A layer with low permeability such as clay overlies a confined aquifer. A semi-permeable aquifer could be described as a combination of a confined and unconfined aquifer or an aquifer confined by a low permeability layer that permits water to slowly flow through it. During pumping a semi-confined aquifer may be recharged across the confining layers (1).

Aquifers may contain different types of flow patterns. Figure 2 is a drawing of the three types of flow systems: local, intermediate, and regional.

Local flow system

Local flow system

Local flow system

Regional flow system

Figure 2: Flow Systems Illustration

Modified from source: (1)

A local groundwater flow system is normally found in an area with well-defined topographical relief. Local groundwater flow systems normally have a small recharge and discharge area. Having infiltrated the soil within a few years, local groundwater flow systems are relatively small and fresh. Wells in local systems are also generally shallow. An intermediate flow system might have local flow systems within its drainage area and wells located within this system are generally deeper. Regional flow systems are much larger, and normally have a recharge area at the basin division and a discharge area at the valley bottom. The water in a regional flow system normally has a higher mineral content because it flows

much slower and is contained in the ground for a much longer period of time than groundwater in local or intermediate flow systems (1). Groundwater in a regional system is sometimes referred to as "geologic water," because it is very old. The aquifer in the study area is a semi-permeable local flow system. Readers seeking more information are directed to the Groundwater Education in Michigan (GEM) internet site at www.gem.msu.edu/gw/tutorials/wells.html, where a tutorial is available.

2.2 Groundwater Contamination

Groundwater is a vital resource to many communities because sometimes it is the only safe source for drinking water. Groundwater contamination is not an uncommon problem throughout the United States. Accidental spills and leaks contribute to groundwater contamination. Groundwater contamination may be point or non-point source (1). An example of point source pollution is one specific underground storage tank leaking. Failure of subsurface sewage disposal systems in a rural subdivision is an example of non-point pollution.

Industry, suburbia, and agriculture have all contributed to groundwater contamination. Multiple industrial sources and gasoline service stations have contributed to benzene, toluene and xylene (BTEX) in groundwater. High nitrate levels have been found in suburban areas due to fertilizer use and subsurface sewage disposal systems. Agriculture has also added synthetic organic chemicals to groundwater in some areas (1).

In some cases, groundwater contamination can be remediated. It is possible for the soil in which the contaminated groundwater is located to act as a natural filter. This physical filtration and chemical reaction with soils, along with biological decay may remediate some types of contamination. Synthetic methods have also been developed to restore the quality of groundwater and remediate contaminated soil (1). The process of remediation can be very expensive and time consuming; therefore it is essential that effective measures be taken to protect groundwater resources to prevent contamination. Past studies have shown it is much less expensive to prevent contamination than to clean it up.

2.2.1 Sources

Groundwater may be contaminated by a variety of sources. Figure 3 lists several types of contamination that may occur in agricultural, residential, industrial, commercial and municipal land use (4).

Figure 3: Potential Sources of Ground Water Contamination (4)

Land use	Possible Contaminants
Agricultural/Forestry (AF)	
Animal feedlots and burial areas	Livestock manure wastes, nitrates, phosphates, chloride, chemical sprays and dips for controlling insect, bacterial, viral, and fungal pests on livestock, coliform and microscopic pathogens.
Manure spreading areas and storage pits	Livestock sewage wastes; nitrates
Livestock waste disposal areas	Livestock sewage wastes; nitrates
Residential (R1 & R2)	
Crop areas and irrigation sites chemical storage areas and containers	Pesticides, fertilizers, gasoline and motor oils from chemical applicators pesticide and fertilizer residues
Farm machinery areas	Automotive wastes; welding wastes
Agricultural drainage wells and canals	Pesticides, fertilizers, bacteria, gasoline and motor oils from chemical applicators
Common household maintenance	Household cleaners: oven cleaners, drain cleaners, toilet cleaners, disinfectants, and hobbies metal polishes, jewelry cleaners, shoe polishes, synthetic detergents, bleach laundry soil and stain removers, spot removers and dry cleaning fluid, solvents, household pesticides and other common products
Lawns and gardens	Fertilizers, herbicides and other pesticides used for lawn and garden maintenance
Swimming pools	Swimming pool maintenance chemicals

Figure 3: Potential Sources of Ground Water Contamination (Continued)		
Land use	Possible Contaminants	
elev	Septage; coliform and pathogens, nitrates, heavy metals, synthetic detergents, cooking and motor oils, bleach, pesticides, paints, paint thinner, swimming of chemicals, septic tank/cesspool cleaner chemicals, vated levels of chloride, sulfate, calcium, magnesium, assium, and phosphate	
Underground storage tanks	Home heating oil	
ant,	Swimming pool maintenance chemicals; pesticides for n and garden maintenance and cockroach, termite, rodent, and other pest control; septic sewage; seehold hazardous wastes	
Commercial (C1 & C2)		
Airports, abandoned airfields Plane fuels, deicers, diesel fuel, chlorinated solvents automotive wastes, heating oil and building wastes		
Auto repair shops	Waste oils, solvents, acids, paints, automotive wastes miscellaneous cutting oils and lubricants	
Car dealerships (especially those with service departments)	Automotive wastes, waste oil, solvents, and miscellaneous wastes	
Storage facilities recreational vehicles stored	Oil from lawn equipment, vehicles, and other household items that make contain hazardous fluids	
Hardware/lumber/parts store/	Hazardous chemical products in inventories; heating oil and fork lift fuel from stores storage tanks; wood staining and treating products; gasoline, motor oils and other lubricants	
Heating oil companies, underground storage tanks	Heating oil; wastes form truck maintenance; diesel and gasoline for company trucks	

Figure 3: Potential Sources of Ground Water Contamination (Continued)		
Land use	Possible Contaminants	
Horticultural practices, garden nurseries, florists	Herbicides, insecticides, fungicides and other pesticides	
Office buildings and office chemicals; gasoline, motor oil complexes	Building wastes; lawn and garden maintenance	
Aboveground and underground storage tanks	Heating oil, diesel fuel, gasoline and other petroleum products; other commercially used chemicals	
Transportation services for passenger transit	Waste oil, solvents, gasoline and diesel fuel from vehicles and storage tanks; fuel oil, other automotive wastes	
Industrial (I1)		
Transport and transfer stations hazardous wastes	Fuel tanks; repair shop waste; other hazardous and non-	
Above-ground and underground	Heating oil, diesel, gasoline fuel and other petroleum products; hazardous and containers non-hazardous material and wastes	
Storage, treatment, and disposal Hazardous and non-hazardous wastes, septage, ponds, lagoons, and other surface sludge, runoff impoundments		
Well drilling operations	Brines associated with oil and gas operations	
Asphalt plants/yards	Petroleum derivatives; gasoline and diesel fuel for commercial equipment; used oil wastes from maintenance	
Foundries and metal fabricators	Paint wastes, acids, heavy metals, metal sludge, plating wastes, oils, solvents, explosive wastes	

Figure 3: Potential Sources of Ground Water Contamination (Continued)		
Land use	Possible Contaminants	
Machine and metalworking shops	Solvents, metals, miscellaneous organics, sludges, oily metal shavings, lubricant and cutting oils, degreasers (tetrachlorethylene), metal marking fluids, mold-release agents	
Publishers, printers, and allied industries	Solvents, inks, dyes, oils, miscellaneous organics, photographic chemicals	
Welding shops	Oxygen, acetylene, metal wastes	
Municipal (not defined in Mecosta County Zoning Ordinance guide)		
Public utilities (phone, electric, power, gas)	PCBs from transformers and capacitors, oils, solvents, sludges, acid solution, metal plating solutions (chromium, nickel, cadmium), herbicides from utility rights-of-way	
Park lands Public and residential areas infested with mosquitoes, gypsy moths, ticks, ants, or other pests	Fertilizers, herbicides, insecticides, pesticides	
Highways, road maintenance and deicing operations (sodiu	Herbicides in highway rights-of-way, road salt depots, am and calcium chloride), road salt anticaking additives (ferric Ferro cyanide, sodium Ferro cyanide), road salt anticorrosive (phosphate and chromate; automotive wastes	
Storage, treatment, and disposal ponds, lagoons, and other surface impoundments	Sewage wastewater, sludge, treatment chemicals	
Combined sewer overflows (municipal sewers and storm water drains)	Municipal wastewater, sludge, treatment chemicals, urban runoff, gasoline, oil, contaminants	
Open dumping and burning closed dumps	Organic and inorganic chemicals, metals, oils; sites, wastes from household and businesses	

Figure 3: Potential Sources of Ground Water Contamination (Continued)

Land use

Possible Contaminants

Water supply wells, monitoring Surface runoff, runoff from barnyards, feedlots, wells, older wells, domestic and septic tanks or cesspools, gasoline, used motor oil, livestock wells, unsealed and road salt abandoned wells, and test hole wells

As Figure 3 illustrates, there are many potential sources of groundwater contamination. Pesticides, road salt, underground sewage disposal systems, and leaking underground storage tanks are some examples of both point source and non-point source pollution. Because of their significance to this study, these four sources merit further examination.

2.2.1.1 Pesticide Use

Pesticide use and management by manufacturers, distributors, farmers, and the general public provide multiple sources and opportunities for contamination by pesticides of groundwater resources (33). The desired result of pesticides is successful application, followed by rapid breakdown into components such as carbon dioxide and water. This occurs in most cases, but the decomposition process and time varies with the types of pesticides used. The fate of a pesticide can be affected by several factors, some of which are a result of the pesticide itself while others vary with the application process. Soil and plant characteristics along with climatic conditions can affect pesticides following application. The pesticides volatility, solubility, half—life and chemical composition are factors that influence pesticide decomposition (33).

Leaching of pesticides is common when pesticides move into and through the soil as opposed to movement over the surface through runoff. Pesticides can leach through the soil and into groundwater from storage, mixing, equipment cleaning, and disposal areas. Under certain conditions, some pesticides can leach into groundwater from normal pesticide applications (33).

Approximately 67% of pesticide use in the United States is agricultural (33). Pesticide contaminated groundwater would be expected in agricultural areas, more than in residential areas.

Soil permeability is an important factor that influences pesticide leaching. The more permeable the soil, the greater potential there is for pesticide leaching to occur (33).

2.2.1.2 Road Salt Use

The application of de-icing agents such as sodium chloride, is a common practice on many roads in Big Rapids. The presence of road salt could be a threat to groundwater quality in the WHPA. Even though it was believed for many years that the application of salt to roads did not pose a problem to drinking water sources, it has been found that road salt runoff can be responsible for high sodium chloride levels in surface and groundwater. High sodium chloride levels have negative effects on the environment, and groundwater systems (32).

A case study by the University of Toronto, Canada, found that there are several ways that road salt is introduced into the groundwater (32).

- Highway runoff containing dissolved road salt is typically carried into ditches, where water infiltrates into the soil, and eventually into the groundwater.
- Melting piles of snow plowed off salted roads create a means for dissolved road salts to enter the soil and groundwater.
- Vehicular movement on roads that have snow and salt on them creates highly
 mobile brine spray and splash from traffic can carry droplets of this brine farther
 from their sources.
- Open piles of road salt can create a source of groundwater contamination.

2.2.1.3 Underground Sewage Disposal Systems

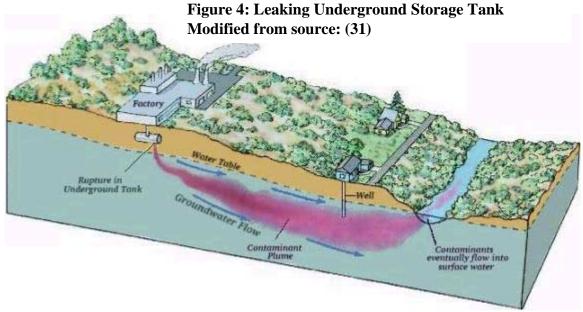
Septic tanks and drainfields are used for the treatment and disposal of domestic wastewater. Before wastewater is filtered by the soil it may contain bacteria, viruses, nitrogen and phosphorus. When septic systems fail, are poorly designed, or are concentrated in a small area there is a potential for groundwater contamination.

Septic tanks are most likely to contaminate groundwater when there is a high density of homes, a thin layer of soil over permeable bedrock, an extremely permeable soil, such as gravel or when there is a high water table. A combination of any of these may lead to earlier or more severe contamination (1).

2.2.1.4 Leaking Underground Storage Tanks

Underground storage tanks are another potential source for groundwater contamination. Chemicals may leak into the surrounding soil if an underground tank is punctured or rusts through. The leaking chemicals, depending on their specific gravity (density), may either infiltrate down and float on top of the water table, or sink to the bottom of the aquifer. While higher density contaminants pose a more direct threat to the aquifer, low-density contaminants can dissolve and eventually seep into the groundwater. Chemicals that mix well with water move when and where the groundwater moves. Other chemicals (i.e. oil) float on water and move more slowly through the ground (1).

Figure 4 is an example of a material leaking from a storage tank and entering into the aquifer.



2.3 Water Wells

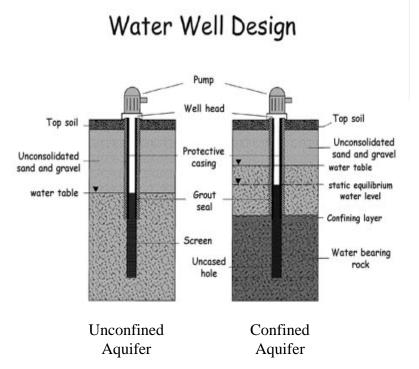
Most water wells are drilled to supply water to homes. These wells penetrate to a depth that allows interception of an aquifer. The depth of a well depends on the underlying geology and the depth to the water table. A water well may be drilled so that it fully or partly penetrates an aquifer. Each can produce a successful well if the aquifer material can support the system. Wells are usually drilled to the desired depth, casing is placed into the hole drilled and grout installed around the casing in order to seal the open space between the casing and the soil. Figure 6 is an example of two typical wells. One of the wells is in a confined aquifer and the other is in an unconfined aquifer (1).

Wells are used to supply water for industrial, municipal, commercial, and residential purposes. Michigan state laws divide water supplies into four categories:

Figure 5: Michigan Well Types (7)

Type I	A community water supply providing year round service to not less than 15 living units or 25 residents.
Type II	A non-community water supply that serves not less than 25 individuals, not less than 60 days out of the year.
Type III	All public water systems that do not fall under Type I or Type II.
Residential	Serves a single family home.

Figure 6: Confined and Unconfined Wells Comparison (26).



Two additional terms used are observation wells and production wells. Although these wells may be similar in structure, observation wells are used strictly for testing and monitoring groundwater, while production wells are used to pump potable water to many homes and businesses. Figure 7 is a photo of a properly constructed well.

Wells provide the convenience of immediate water, but they may become a hazard to groundwater if improperly abandoned. The MDEQ requires that wells are properly plugged and capped if they are no longer in use (29). This capping and plugging is called abandonment.



Figure 7:

Properly Finished Well (34)

2.3.1 Abandoned Wells

Abandoned wells can be a major contributor to groundwater degradation due to their ability to easily transfer surface and near surface contaminants into aquifers or to move water upward into a shallower aquifer. Transfer of material from the ground surface to an aquifer can occur by materials entering directly through faulty well caps or coverings, through uncased portions of bedrock bore holes, through cased portions of well bore holes after the casing has deteriorated, or if inadequate grout is placed around the casing. Natural filtration and degradation processes are bypassed when surface contaminants travel down old well casings instead of through the soil. Abandoned wells also have the potential to contaminate a shallower aquifer through the upward movement of water from an aquifer of high artesian pressure to one of lower pressure. Poor quality groundwater in the high-pressure aquifer can sometimes move up along a well casing into a shallower, higher quality aquifer of lower pressure. Abandoned wells have also been illegally used for the disposal of many types of waste, causing direct contamination of the aquifer (3).

Figure 8 is an example of an improperly abandoned well.



Figure 8:

Photo of an Improperly Abandoned Well (34)

The MDEQ estimates that there are between 1.6 and 2.7 million abandoned wells in Michigan. This is based on the assumption that every generation living on a parcel of land

has developed a well. Many factors contribute to the extremely high number of abandoned wells, including the cost of plugging old wells, the sale of homes without informing new owners of existing wells, and lack of public awareness of the importance of properly abandoning wells (3).

Another major contributor to the large number of abandoned wells in Michigan is the state's growing suburban population. When suburbs grow, residents occasionally choose to be connected to a city water supply, leaving many unused wells. Historically, the water line between a well and a building was severed and forgotten when a city water connection was made. The MDEQ is currently attempting to assure that all abandoned wells are properly plugged (3).

3.0 History

3.1 Glacial History

During the Pleistocene Era 12,000 to 10,000 years ago, the Wisconsin glacier covered Mecosta County. The present topography exists due to glacial deposits left by the melting of the Wisconsin Glacier (2). The Wisconsin Glacier had two lobes, the Saginaw Lobe and the Lake Michigan Lobe, located in the east and west of Mecosta County, respectively. As these two lobes melted, they left mounds, ridges, moraines, and other distinct accumulations of non-stratified glacial drift throughout most of the county. The water flowing from those lobes formed an outwash plain roughly two to three miles wide. These glaciers left deposits between 450 and 825 feet thick on top of the original bedrock of shale and limestone. The Muskegon River is in this outwash plain and discharges into Lake Michigan (2).

3.2 Big Rapids Water Source

The Muskegon River is 212 miles in length, originating in Roscommon County in the north central part of Michigan's Lower Peninsula. The Muskegon River runs through several cities, including Big Rapids and Newaygo, before it empties into Muskegon Lake and then eventually Lake Michigan (32).

In the past this area of the river has been used for a variety of purposes, including the transportation of logs downstream and hydroelectric power. The river is still used for recreation purposes. The community of Big Rapids used a dam for the purpose of log capture and sorting, and for the purpose of hydroelectric power. The most recent dam was used for hydroelectric power, the Big Rapids Dam was built in 1914 and partially removed in 1966 (11). It is currently under demolition (2000).

Since 1936, the City of Big Rapids has utilized the river as a municipal water supply. An intake line carries the water from the river directly to the Big Rapids Water Treatment Plant (BRWTP) located at 730 North Osceola Avenue, just south of the Baldwin Street Bridge (10).

Changes in the river's natural flow have caused many problems for the City of Big Rapids. Between 1985 and 1986, an oxbow began to form in the Muskegon River 200 yards downstream from the Big Rapids Water Treatment Plant (19). This oxbow caused increased erosion of the west riverbanks near the Big Rapids High School (now the Middle School) and

nearby houses. The City Council determined there was a need for some action to prevent further erosion of the west riverbanks. City Council had two options: to hire an engineering firm to solve the problem for \$70,000 or to hire a contractor to solve the problem for only \$3,000. The city chose the second option for financial reasons. The proposed plan to stop erosion on the west bank of the Muskegon River near the Big Rapids High School and nearby houses was to change the course of the river by digging a new course through the midstream islands, which had initially caused the formation of the oxbow (19). This plan seemed to be successful, as the oxbow was eliminated, and the properties along the west riverbanks were safe from erosion (19).

In the Winter 1987, operators of the Water Treatment Plant noticed that the previously buried water main, serving the east part of Big Rapids, was exposed and oscillating in the river current. This was a result of the project to stop erosion on the west riverbanks the previous year. The contractor originally hired to correct the erosion problem, Fenstermacher, had removed the hardpan from the bottom of the river creating a head cut (a process in which the original river bottom is disturbed causing a build-up of water flowing in a backwards motion, slowly eroding the river bottom) in his efforts to excavate the center section of the river's island. This head cut slowly eroded the riverbed and progressed upstream over time.

The results of this included the dislodgment of the water main connecting to the eastside of the city, and the lowering of the river level by approximately 3 feet. Officials were worried that the water main would be damaged and severed, and that the Big Rapids Water Treatment Plant intake, which pumped water out of the Muskegon River to provide the city water supply, would become exposed (19).

The City of Big Rapids took action and developed a plan to temporarily solve the problem. The plan called for a sediment trap directly downstream from the water main to collect sediment and partially stabilize it; and the use of large rocks and boulders to create a 125 ft. rock berm (cofferdam) across the river, tapered on both ends, 45 feet wide, and 3 to 4 feet high (13). This rock berm was to be completely submerged in the river, and to be gently sloped on the downstream side so that it would not be a hazard for recreationalists.

Unfortunately, the plan was not followed completely, and the rock berm (cofferdam) was not submerged, or sloped on the downstream side as the plan dictated. This rock berm is currently known as the cofferdam, and it can be seen protruding from the river to this day. While the rock berm, or cofferdam, solved the problem concerning the water main, there were still problems with the Water Treatment Plant intake. Water levels continued to drop as the rocks from the cofferdam eroded. In order to keep the river water levels high enough to cover the intake, additional rocks are added to the cofferdam each year (19).

The cofferdam was only intended to be a temporary fix (9). The Big Rapids dam remnant and the cofferdam are both hazards to recreationalists and disrupt the natural flow of the river. With the removal of the Big Rapids dam remnant it was imperative that the city find a new water source so that the cofferdam could also be removed.

3.3 Wellfield Site Selection

The need for a new water system for the City of Big Rapids has become obvious in recent years. The city had two options; to find a new source of supply or to perform major construction improvements to the BRWTP intake line.

Several options were discussed on where and how to get ample water to supply the growing City of Big Rapids. Some of these options included the construction of a timber crib, digging a channel along the west bank of the Muskegon River from which an intake line could be installed, construction of an infiltration bed, the use of screw pumps, converting to a ground water source or take no action. All of the options involved negative and positive returns, but the ground water source option was determined to be the most realistic and beneficial (10).

The decision for the City of Big Rapids to convert to a groundwater source will save the city and taxpayers money. In addition to establishing a permanent solution to their present water intake problem, raw water from a river is a very easily and quickly contaminated water source. Groundwater has a permanent filtration system that works to degrade surface spills and slow down contaminants, which allows for ample time to respond. The soils' ability to filter groundwater is much more efficient than any filtering system used for surface water treatment (10). Groundwater as a source, would require less chemical additives, but the process of aeration would need to be incorporated.

The City of Big Rapids Water Treatment Plant investigates the groundwater in the area approximately every fifteen years (19). Test wells had initially been drilled in 1987 at the Northend Riverside Park, and the Roben-Hood Airport. These sites were temporarily abandoned until the city became aware of the MDNR plans to encourage the removal of the dam remnant in Big Rapids in 1996. Additional test wells were drilled and developed for test pumping, at Northend Park on the eastside of the river, and Roben-Hood Airport. Water from both test wells had a similar chemical composition with a few exceptions. When the engineering firm of Prein & Newhof performed a water feasibility study in March 1996, results showed high concentrations of hydrogen sulfide at the Northend Park site. After a field survey of the area was performed, an up-gradient junkyard (Phil's Auto) and an unlicensed landfill area just south of the test well were discovered. Those two sites are believed to be the major contributing sources for the hydrogen sulfide detected in the Northend Park test wells (10).

The landfill, located near the southern end of the City Park, has a variety of possible hazards ranging from general household waste to demolition debris. Phil's Auto has debris ranging from rusting car parts to leaking oil and fuel from once full automobile fuel tanks. Although aeration or chemical oxidation can remove the hydrogen sulfide, the city instead chose to develop a well field on the west side of the Muskegon River (10). Another benefit of the groundwater on the west side of the river is that it was noticeably better tasting (10).

The Roben-Hood Airport is a city owned-airport that is located in Big Rapids Charter Township and therefore governed by township ordinances. The test wells located at the airport were originally drilled in 1987. A hydrological study was performed later in 1996, determining the groundwater flow to be northwest to southeast. At the time the first well was

drilled, the property north of the airport was zoned residential, but new zoning ordinances put in place in November, 1999, rezoned this area as industrial (22). The new zoning ordinance does not mean that a well field cannot be developed at the airport, but that care must be taken to prevent contamination from new industry.

The semi-permeable aquifer at Roben- Hood Airport best met the chemical property standards and needed volume of water established by the City of Big Rapids. The well field includes three production wells and twelve observation wells with one additional production well planned. Information regarding individual well depth, diameter, and completion date can be seen in Figure 9. If all the planned wells were to ever run simultaneously they would produce an estimated 3.5 million gallons of water a day (10).

Figure 9: Wells located in the City of Big Rapids Wellfield (16)

Well	Well	Well	Date Well
Number	Casing	Depth	Completed
	Diameter	(ft)	
	(in)		
PW 1	12	210	12-15-98
PW 2	9.75	120	8-1-99
PW 3	16	221	7-22-99
PW 4	Not yet	drilled	
OW 1	5	184	3-25-98
OW 2	5	102	3-30-98
OW 3	5	99	3-20-98
OW 4	5	189	3-17-98
OW 5	5	193	3-26-98
OW 6	5	193	3-26-98
OW 7	12	211	5-2-98
OW 8*	9	345	6-22-99
OW 9	9	342	6-23-99
OW 10	9	230	7-1-99
OW 11	9	260	7-15-99
OW 12	9	280	7-2-99

Kev:

PW = Production Well,

OW= Observation Well

4.0 Procedures

4.1 Delineation of WHPSA

Step two in developing a WHPP is to delineate the area that the municipal wells will pull water from over the next ten years. The static water levels from area wells were used to

^{*} OW 8 is an off set well due to the original well collapsing during production.

determine the direction of groundwater flow. By determining the direction of groundwater flow the proposed protection area can be established. Figure 10 is a map of the wellfield area with groundwater flow lines.

Not to scale

Figure 10: Groundwater Flow

Adapted from source (10)

It was essential that an estimated protection area be determined so data collection could proceed. Based on the ten-year time of travel and distance based on groundwater flow direction, Dr. Fred Heck, FSU Geologist and a Wellhead Protection Team member concluded that the wellhead area should have a radius extending approximately three to six thousand feet northwest from the well field. With these conditions in mind a wellhead protection study area was established with assistance from Don Greiner, Big Rapids City Engineer. Figure 11 is a map of the WHPSA.

Dalziel Creek flowing east

US
131

Northland Dr.

N

Airport Reneways

Not to Scale

City
Wells

Drain

Figure 11: Wellhead Protection Study Area

Modification, U.S. Census Tiger File.

Main roads and highways were used to simplify boundaries of the WHPSA. The final study area was determined to be the land north of 17 Mile Road, south of 19 Mile Road, east of US-131, and west of Northland Drive. The study area is believed to be much larger than the WHPA will be, once the project consultant establishes it.

4.2 Agency Contacts

Once a study area was determined, the process of locating all known and potential sources of contamination began. A number of agencies were contacted to determine if any known contamination sources exist in the study area. For example, various MDEQ divisions provided information on leaking underground storage tanks, oil & gas contaminated sites, and groundwater discharge permitted areas. Michigan Department of Transportation (MDOT) was contacted for road emergency response information and road salt use. The City of Big Rapids, Green Charter Township, and Big Rapids Charter Township officials provided information on land uses, property history, zoning ordinances, property ownership, and aerial photos along with various maps and photographs. Public services, including the Mecosta County Health Department and local fire departments, were contacted for well logs, soil and water studies in the surrounding area, and chemicals used by commercial businesses in the WHPSA.

4.3 Database Development

A database management program can be used for collection and organization of large amounts of data. A database management program may also be used to sort and group data by fields. A Microsoft Access database was designed to organize and manage information collected during the study. The fields that are included in this database cover the minimum requirements established by the MDEQ and information that is beneficial to the protection of the wellhead area. The database fields were reviewed and approved by Don Greiner, City Engineer.

Figure 12 discusses the fields, data type and description of how the information is to be entered into the database.

Figure 12: Database Layout

Field Name	Data Type	Description
ID	AutoNumb	
	er	
Map No	Text	Unique number assigned to each parcel in the study
		area
Structure	Yes/No	Check= structure(s) or remnants of structures on
		property
Risk Rating	Text	A-E A being least risk E being greatest risk
TWP	Number	15= Big Rapids Charter Twp. 16= Green Charter
		Twp.
Section	Number	
Property Address	Text	If available
Property City	Text	
Property	Text	
State		
Property Zipcode	Text	
Tax ID No.	Text	Example: 01 032 007 000
Property Owner	Text	Name listed on tax records
Owners Phone No.	Text	
Street Address	Text	If different than property address
City	Text	
State	Text	
Zip Code	Text	
Property Use	Text	A=Agricultural R=Residential C=Commercial
		B=Residential&Commercial F=Farm&Residential
No Survey	Yes/No	check= no survey conducted with property owner
Well	Text	Example: 12 in
Diameter		
Well Depth	Text	Example: 120 ft
Well Abandonedment	Text	1=wells abandoned properly 2=potential improperly
		abandoned

Figure 12: Database Layout (Contd.)

Field	Data Type	Description
Name		
Past Land Use	Text	A=Agricultural R=Residential
		C=Commercial
		B=Residential&Commercial F=Farm&Residential
Chemical Usage	Memo	Chemical name and volume used per
		year
Chemical Storage	Text	Amount currently or seasonally stored
Chemical	Text	Description of chemicals
Classification		known
Chemical Applicator	Text	Who applies or uses the chemicals? Owner or
		Contractor?
Abovegroun	Yes/No	Storage tanks aboveground? Check
d		for yes
Aboveground Notes	Memo	Any important info. such as: # active/inactive, age,
		construction
		materials, leaks, replacemtments, chemicals &
		volumes
Undergrou	Yes/No	Storage tanks underground? Check for
nd		yes
Underground Notes	Memo	Any important info. such as :# active/inactive, age,
		construction
		materials, leaks, replacements, chemicals and
		volume
Memo	Memo	Any additional notes or
		comments

After the database fields were designed, an Access data entry form was added to simplify data processing. Figure 13 is a capture screen of the database form.

Microsoft Access - [wellheadform] | 🖭 🔍 🔍 🧱 EN File Edit Yew Insert Format Records Tools Window Help _ [#] X 太阳阳矿田 7 Section Property Address Tax ID No 4 21886 17 mie Rd 05004007000 Humphreys, Thorse Property Us: Well Type Well Diameter Well Depth Well Abandonmer Contact Address R 2.0in Chemical Usage Petroleum Products Chemical Storage Chemical Applicator 300 cal. Gasoline Map No Risk Rating Abov C3 **Aboveground Notes** 300 gallons of gasoline 1 | | | | | | | | of 132 Record: I4 ← Chemical name and volume used per year. Start 📝 overlay - Paint Microsoft Po... RV Microsoft Wor... Q Microsoft

Figure 13: Capture Screen of Database Form

4.4 Survey Questionnaire Development

To locate additional potential sources of contamination, property owners in the WHPSA were surveyed. Survey questions were developed to provide the information necessary to complete the database. Developing the questionnaire was a sensitive matter. Questions had to be written in a way to obtain the information needed and at the same time not offend any property owners or take up too much of their time. Two different styles of questionnaires were developed, one for residential property owners and one for commercial property owners in order to keep the questionnaires simple and related to the type of information involving the property use. This also kept the records more organized and saved time during the actual conducting of the survey.

The questionnaires could not be administered until the Big Rapids city engineer, both township supervisors, and consulting firm project manager reviewed them for accuracy and completeness. The two township supervisors and the city engineer approved a letter, which was mailed to the property owners explaining the purpose and reason why they were chosen for this survey. Appendix C contains a copy of each township letter. Once the surveys were finalized a dry run consisting of two residential and two commercial questionnaires was performed to double-check the quality of the survey and personal responses of the property owners. Appendix C contains copies of both the residential and commercial surveys along with instructions for conducting the survey. After reviewing the results of the dry run the surveys were administered to the property owners in the study area. Fifteen students, working in pairs, helped administer the surveys. Students working on another City of Big Rapids project administered the residential surveys, while the students from the wellhead

protection group completed the commercial surveys. Once the surveys were completed, the information was entered into the database.

4.5 Susceptibility Analysis and Risk Rating

To effectively implement a management strategy, it is important to evaluate the day to day activities in the WHPA and the degree of risk associated with each known or potential source of contamination. An USEPA risk rating system was adopted to rate each property's risk. A value is assigned to each potential source based upon their proximity to the ground water supply, toxicity of contaminant, daily or yearly amount used, and the intended use of the ground water supply (municipal). Figure 14 lists the categories of land uses and then ranks them according to the degree of threat they pose to the ground water.

- **LEAST RISK A. 1.** Land surrounding a well or reservoir, owned by a water company.
 - 2. Permanent open space dedicated to passive recreation.
 - **3.** Federal, sate, municipal, and private parks.
 - **4.** Woodlands managed for forest products.
 - **5.** Permanent open space dedicated to active recreation.
 - **B. 1.** Field crops: pasture, hay, grains, vegetables, empty lots.
 - **2.** Low density residential: lots larger than 2 acres. (Most residential)
 - **3.** Churches, municipal offices, home businesses.
 - **C.1.** Residential home with tanks: above ground, underground.
 - **2.** Agricultural production: dairy, livestock, poultry, nurseries, orchards, berries.
 - **3.** Golf course, quarries, and abandoned wells not plugged.
 - **4.** Medium density residential: lots from $\frac{1}{2}$ acre to 1 acre, trailer parks with < 60 units. Major roadways.
 - **D. 1.** Institutional uses: schools, hospitals, nursing homes, prisons, garages, salt storage, sewage treatment facilities.
 - 2. High-density housing: lots smaller than ½ acre, subdivisions.
 - **3.** Commercial uses: limited hazardous material storage only municipal sewage.
 - **4.** Commercial uses: limited hazardous material storage only septic sewage.
 - **E. 1.** Retail commercial: gasoline, farm equipment, automotive, sales and services; dry cleaners; photo processor; medical arts; furniture strippers; machine shops; radiator repair; printers; fuel oil distributors, and asphalt yards.
 - 2. Industrial: all forms of manufacturing and processing, research facilities.
 - 3. Underground storage of chemicals, petroleum

GREATEST RISK

4. Waste disposal: pits, ponds, lagoons, injection wells used for hazardous waste disposal; bulky waste and domestic garbage landfills; waste treatment, storage and disposal sites.

Source: adapted from U.S. EPA, 1989a (Modifications were made to section C & D for Big Rapids ground water use)

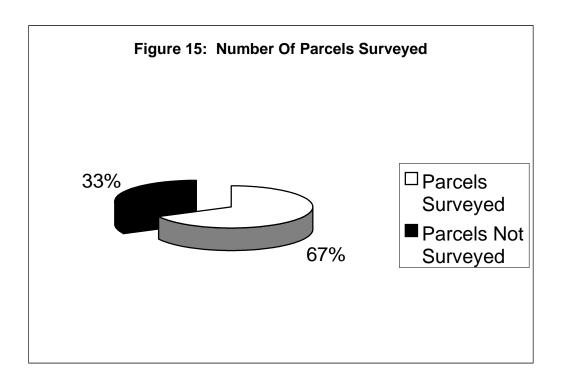
Having identified the land uses in the WHPSA and assigning its associated risk will help determine which zones within the study area pose the greatest potential threat to groundwater. Furthermore, by having the associated risks plotted on a map of the study area, long-term preventative planning can be completed.

4.6 Uniform Parcel Numbering System

Parcel numbering was developed to organize the property parcel with a number that correlates with the information on the database. Every parcel in the WHPSA is given a number; this number is called the parcel number. Each of these identification numbers is entered into the database and placed on well logs, parcel maps and other property related documents. The numbered parcel maps provided a quality check to confirm that all properties listed in the database are actually within the study area and to determine that no parcels were overlooked. The numbered parcel maps are included in Appendix B as Figures 103-111 on pages 115-123.

5.0 Results and Discussion

There are 131 parcels in the WHPSA. Sixty-one (47%) parcels are located in Big Rapids Charter Township and seventy parcels (53%) are in Green Charter Township. Figures in Appendix B are numbered parcel maps of the WHPSA. Property owners of 98 parcels were surveyed. Of the eighty-eight surveys conducted 68 (54%) of the residential and agricultural parcels were completed and 21 (75%) of the commercial and industrial parcels were completed. Of the forty-three surveys (33%) that could not be completed; six were commercial parcels and thirty-seven were residential parcels. The high percentage of completed surveys provided a solid database for characterizing the level of potential hazards within the study area.



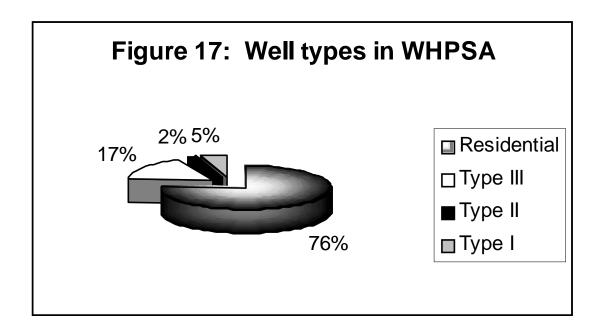
Fifty-six water wells were estimated to be in the study area. An active well was determined to be on a parcel if a well log was available or a property owner reported one or more active wells on his or her property. All wells currently in use have the potential of becoming

abandoned wells in the future. Well logs furnished by the Mecosta County Health Department and by the MDEQ are found in Appendix A. See figure 16 for a map of the water wells in use within the study area and figure 17 for a graph of well types.

19 mile rd. Dalziel Creek flowing east US Northland Dr. 131 <u>51</u> <u>15 •</u> 18 mile rd. <u>144</u>+ 10 10A Airport Runways Not to Scale City Drain <u>73</u> • 17 mile rd.

Figure 16: Map of Active Well Locations (Assigned by Parcel Number)

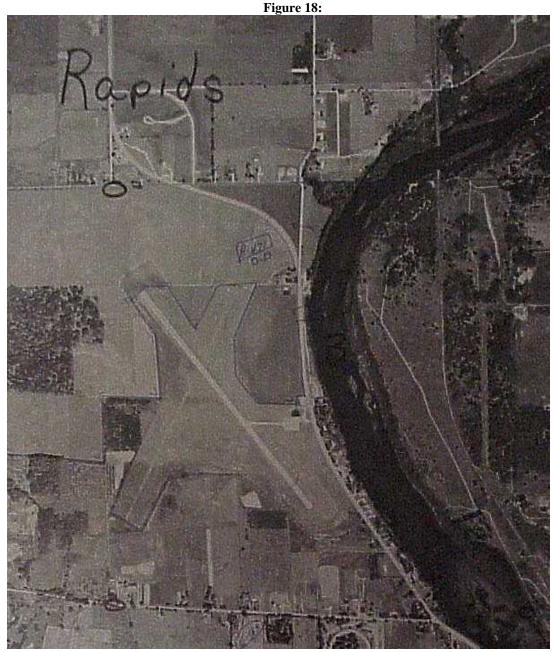
Note: Map Includes Locations of Residential/Commercial, Public Type II and III wells. Map Excludes Public Type I City Wells. Source: Modification, U.S. Census Tiger File.



Parcels 28A and 9F within the study area are the estimated parcels to have permits to drill oil and gas wells. Exploratory wells have been drilled on the parcels; these were discovered to be dry holes and have been reported to be plugged. No verification could be obtained that the wells have been properly plugged (12).

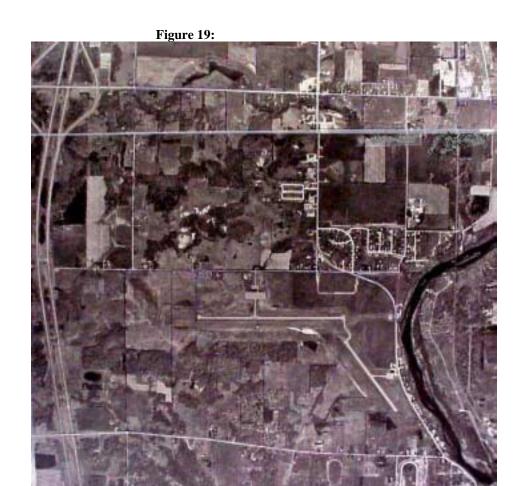
5.1 Land Use

Aerial photographs were used to develop a land use history of the study area. Photographs taken in 1958, 1965 and 1993 indicated that ninety- percent of the land was used for agriculture until 1965 when the area became more commercial. See figure 18 for an aerial photograph of 1965.



Section of a 1965 photograph showing the Roben-Hood Airport (27).

The majority of commercial businesses exist on the west side of Northland Drive. There is one farm located on the north side of 18 Mile Road and west of 220th Avenue. Additionally, the northeast portion of the airport property is leased for agricultural purposes. An industrial park is being developed at the west end of 18 Mile Road. A new airport hanger has been constructed on 18 Mile Road just north of the city's new well field. A used car storage area is located on the corner of Northland Drive and 18 Mile Road. See figure 19 for 1993 aerial photograph. See figures 20-24 for photos of various land uses. See figures 25-26 for graphs summarizing land use.



Section of a 1993 aerial photo showing the Roben-Hood Airport (28).





Farm field and farmstead Photo taken facing West, 7/14/00.

Figure 21:



U.S. 131. Photo taken facing North, 7/14/00.

Figure 22:



Oil distribution company in the study area. Photo taken facing Northwest, 7/14/00.

Figure 23:

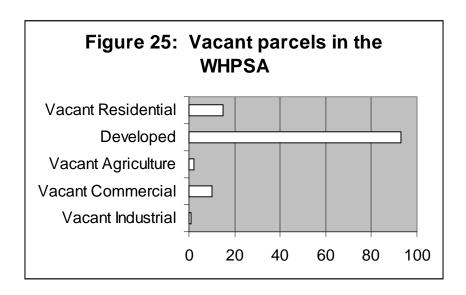


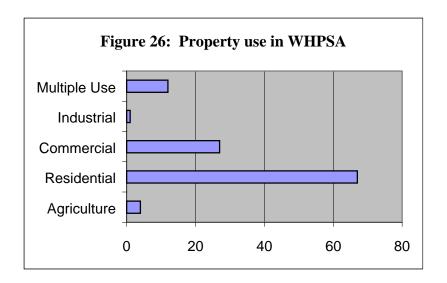
New airport hanger on 18 mile Rd. Photo taken facing Southeast, 7/14/00.

Figure 24:

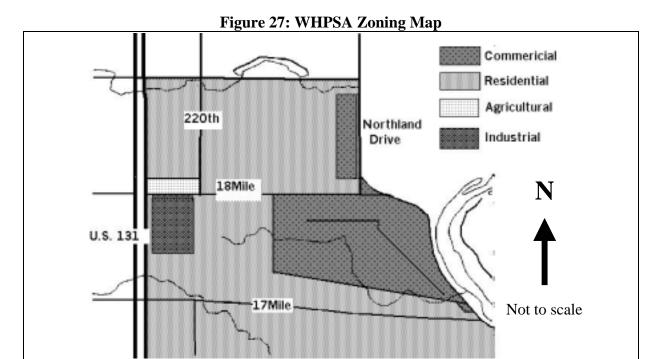


Study Area Residence. Photo taken facing Northeast, 7/14/00.





With the exception of the industrial park, which is located on the northwest of the wellfield and zoned industrial, the area immediately up-gradient of the wellfield is vacant and zoned agricultural/forestry (AF). See figure 27 for a study area zoning map and figure 28 for a photograph of the area immediately up-gradient of the well field.



Source: Modification, U.S. Census Tiger File.





Airport runway Photo taken facing East, 7/14/00.

5.2 Agency Contacts and Results

When developing a WHPA, the MDEQ requires that most of the following agencies be contacted (29):

Figure 29: MDEQ Potential Source Contact List

Agency	Information Requested
MDEQ	Sites of environmental contamination
MDEQ	Underground storage tank list
MDEQ	Leaking underground storage tank sites
MDEQ	Oil and gas contamination sites
MDEQ	Hazardous waste generators
MDEQ	Groundwater discharge permits
MDEQ	Landfill list
Environmental Protection Agency (EPA)	Federal National Priority List
EPA	Federal permits for Class V wells
(Recommended but not required)	(underground injection control program)

All of the agencies on this list were contacted in this study, as well as several additional local and regional governmental agencies. Agency contact results are listed in figure 30. The agency contacts were complete and thorough and assured that all known and potential sites in agency records were located. The City of Big Rapids must update its wellhead protection program at least once every three years (3/WHPP). During the next WHPP update, the information from figure 30 can be used as an agency contact guide.

Figure 30: List of Agency and Person Contacts, Reason for and Results of Contact

Contact Agency	Contact Person	Reason for and Results of Contact
Drinking Water and Radiological Protection Division, MDEQ	Lisa Chadwick	Sites of Environmental Contamination; none in WHPSA
City of Big Rapids Engineers Office	Don Greiner	Maps of WHPA; received
Mecosta County Health Department	Ron Shoemaker	Type II Wells; only one type II public well, type I and 8 type III wells. Landfill Deeds; no response as of July 20, 2000, Well logs of Properties in WHPSA; received June 2000, Septage Application Sites; none in WHPSA
Drinking Water and Radiological Protection Division, MDEQ	James McEwan	Abandoned Water Wells; two known properly abandoned wells
Waste Management Division, Groundwater Permits Section, MDEQ	Jim Janiczek	Dates and Locations of Sludge Injection Sites; Recommended to contact Synagro Mid-West, Inc.
Synagro Mid-West Inc.	Lena Torbet	Dates and Locations of Sludge Injection Sites Within WHPSA; phone interview confirmed were in the area still waiting for mailed documents
City of Big Rapids Fire Department	Randy Bell, Big Rapids City Fire Chief	Chemical Inventory List for local Companies; list of chemical class received June 2000
Michigan Department of Environmental Quality State Biosolids Coordinator Surface Water Quality Division	Jim Johnson	Sludge injection sites within the WHPSA; recommended contact Synagro Mid-West Inc.

Figure 30: List of Agency and Person Contacts, Reason for and Results of Contact Continued

Contact Agency	Contact Person	Reason for and Results of Contact
Big Rapids Charter Township Volunteer Fire Department	Rex Richardson, Assistant Volunteer Fire Chief	Chemical Inventory List for Local Companies; particle information received June 24, 2000 remaining information still pending
Mecosta County Historical Society	Maxine Sofaulis	History research for the WHPSA
Big Rapids Charter Township	Maxine McCellend	Tax Information of Parcels in WHPSA; copies of necessary tax roles received June 2000
Ferris State University Geology Department	Dr. Fred Heck	Estimated area to establish as WHPSA; personal interview and maps acquired
County Extension Office, Michigan State University Extensions Office.	Thomas Rorabaugh, County Extension Director	Local Pesticides and Herbicides used in WHPSA; personal interview which gave most commonly used
Michigan Consolidated Gas Company		Visual Identification of an Underground Gas Pipe Line; No location confirmed
MDEQ	Matt Doty	Leaking Underground Storage Tank Sites; unknown to be in SHPWA
MDEQ		Hazardous Waste Generators; none found to be with the WHPSA
MDEQ		Landfill list; No landfills
MDEQ		Federal National Priority List; any known sites of contamination; none as of July 20 nothing

Figure 30: List of Agency and Person Contacts, Reason for and Results of Contact Continued

Contact Agency	Contact Person	Reason for and Results of Contact
Mecosta County Soil Conservation		Aerial Photos of WHPSA; optained aerial photos for 1956, 1965 & 1993
Mecosta County Local Emergency Planning Committees	Sheriff John Sontag	Spill management plans for U.S. 131;no response as of July 24, 2000
Roben-Hood Airport	Pete Chesebrough	Airport History; multiple types of information pertaining to airport history
Roben-Hood Airport	John Griffeity	Past Airplane Accidents; no major accidents to his knowledge
Big Rapids Water Treatment Plant	Carmen Johnson	Contacted for information regarding water treatment plant history; received information regarding coffer dam and water treatment plant intake lines
Michigan Department of Transportation Center	Karl Koivisto	Information pertaining to highway spills and cleanup plans; not received as of July 24, 2000
Michigan Department of Transportation	Bart Lowery	Information pertaining to road salt on highway; received confirmation of total amount of road salt Mecosta County used for winter 1999/2000
Big Rapids Farm & Garden Supply	Ron Mills	Information on general insecticides and pesticides used in the WHPSA; obtained list
MDEQ		Underground Storage Tank List; no sites within WHPSA
Mecosta County Drain Commission	Sherry Samuals	Any information pertaining to WHPSA

5.3 Known Contamination Sites

None of the property owner surveys, windshield surveys, or agency contacts resulted in new known contamination sites. A known site was defined as a site where the groundwater has been contaminated, or at high risk of becoming contaminated (i.e. leaking underground storage tank). The agency contact list, Figure 30, is believed to be a thorough and complete list of all agencies that monitor environmental problems within the study area.

5.4 Potential Contamination Sites

There are 26 potential contamination sites in the study area (figure 31). This represents 20% of the 131 total parcels. Each parcel has also received a risk rating. A summary of these ratings can be seen in figure 32. Risk ratings were subjective and if a parcel of property had multiple potential sources of contamination, the highest rating took precedence. Distances and quantities are also taken into consideration when determining a parcel's risk rating. There are no parcels within the WHPSA that are low enough in contamination risk to be considered for an A1- A5 risk rating. Most residential properties were considered to be two acres and therefore received a B2 risk rating.

Figure 31: Potential Contamination Sites*

CategoryNumber of sites foundUnderground storage tanks2Aboveground storage tanks6Potentially unplugged abandoned wells6Commercial chemical usage and residential usage (beyond normal household)11

Figure 32: Risk Ratings for Potential Contamination Sites

Risk Level	Risk Rating	Number (%) of Parcels
Highest Risk	E1- E4	5 (24%)
	D1- D4	5 (24%)
	C1- C4	11(52%)
	B1- B4	0 (0%)
Least Risk	A1- A4	0 (0%)

^{*}For the purpose of this figure some parcels are counted more than once due to the parcel falling into multiple categories (with the exception of parcels with storage tanks), and are not included in commercial chemical usage category.

Figure 33 is a listing of all the potential sites of contamination, based on agency contact information and completed surveys, found to be in the study area as of July 24, 2000.

Figure 33: Potential Contamination Sites in Study Area

Parcel Number	Risk Rating	Property Use	perty Use Reason	
13	C2	Residential &	Thiodine (fog) Malathion	
13	C2	Commercial	Tillodine (log) Malatilloli	
24	C3	Residential	Abandoned well &	
24		Residential	aboveground storage tank	
26	C3	Residential	Improperly abandoned well	
42A	C3	Residential	Improperly abandoned well	
53A	C3	Residential	·	
	C3		Improperly abandoned well	
48,48A (US 131)	C4	Commercial	Freeway; road salt, spills	
23	C4	Residential	Aboveground storage tank	
28	C4	Residential &	VOC's	
		Commercial		
19 Mile	C4	Commercial	Road salt, spills	
22	C4	Residential	Improperly abandoned well	
Northland	C4	Commercial	Road salt, spills	
Drive			, 1	
09C, 09I	D1	Commercial	Airport	
60	D1	Commercial	Multiple cars on property	
77	D3	Residential &	Body shop; chemicals	
		Commercial		
09H	D3	Commercial	Aboveground storage tank	
06	D4	Commercial	Abandoned well &	
			aboveground storage tank	
30, 30A	E1	Commercial	Automotive repair & sales	
15C, 15D	E1	Commercial		
100, 102		Committee Com	1 10011111	
10	E1	Industrial	Industrial park	
12	E1	Commercial Automotive repair & sale		
51	E3	Commercial Abandoned well &		
			aboveground/underground	
			storage tank	
	·			

^{*}A = Least risk, E = Highest risk (See Fig 14 for risk rating table).

The following, maps and their corresponding tables show the locations of all potential sources of contamination that have been identified.

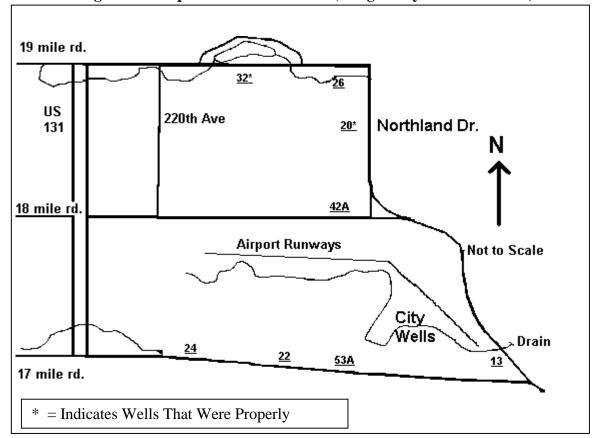


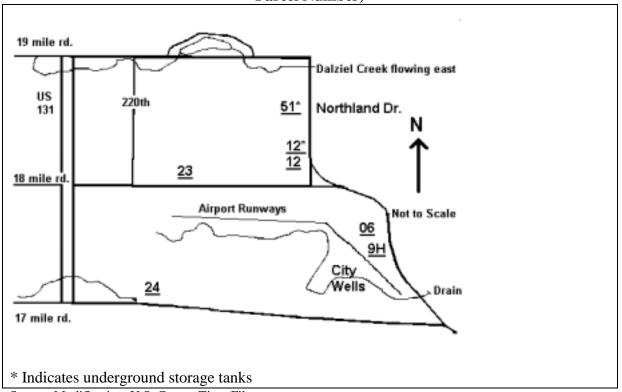
Figure 34: Map of Abandoned Wells (Assigned by Parcel Number)

Source: Modification, U.S. Census Tiger File.

Figure 35: Abandoned Wells

Parcel #	Property Use	Abandoned Wells
13	Business	Improperly abandoned well
22	Residential	Improperly abandoned well
24	Residential	Improperly abandoned well
26	Residential	Improperly abandoned well
42A	Residential	Improperly abandoned well
53A	Residential	Improperly abandoned well

Figure 36: Underground/Aboveground storage tanks in the study area (Assigned by Parcel Number)



Source: Modification, U.S. Census Tiger File.

Figure 37: Underground/Aboveground Storage Tanks Located in the WHPA

Parcel #	R/C	Tank Type	Amount Stored	Chemical
6	С	AST	AST/55 gal	Paint & Solvent
9Н	С	AST	AST/1000 gal	Aviation Fuel, 1000 Gal.
12	С	UST/AST	UST/Unknown AST/500 gal	UST, Oil (used) AST, Oil 10w-30
23	R	UST	UST/225 gal	Heating Oil
24	R	AST	AST/300 gal	Gasoline
51	С	UST	UST/76,000 gal	Gasoline

Note: R/C refers to Residential or Commercial; UST/AST refers to Under/Aboveground Storage Tanks.

19 mile rd. 48A Dalziel Creek flowing east <u>77</u> <u>51</u> US Northland Dr. 131 <u>15D</u> 220th <u>12</u> <u>30A</u> <u>30</u> 18 mile rd. <u>10</u> <u>60</u> Airport Runways Not to Scale <u>48</u> <u>91</u> City Wells Drain <u>28</u> 17 mile rd.

Figure 38: Map of Chemical Storage/Use Locations (Assigned by Parcel Number)

Note: US 131, 19 Mile Road and Northland Drive Surrounding the WHPSA are potential sources. Source: Modification, U.S. Census Tiger File

Figure 39: Chemical use in WHPSA*

Parcel Number	Property Use	Chemical Name	Amount
06	Commercial	Paints & adhesives	Approx. 55 gal.
15C, 15D	Commercial	Asphalt	Unknown
10	Industrial	Film ink	Unknown
13	Residential	Thiodine (fog)	Few cans
	Commercial	malathion	
28	Residential	Volatile organic	Unknown
	Commercial	chemicals	
19 Mile	Commercial	Road salt, spills	Unknown
Northland Drive	Commercial	Road salt, spills	Unknown

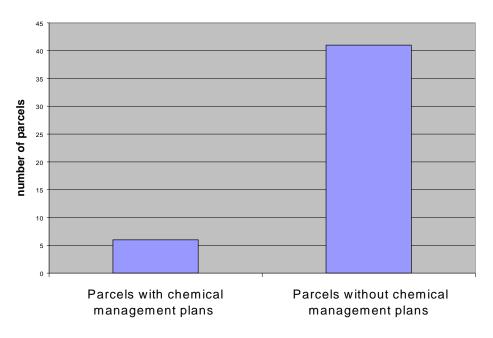
Figure 39: Chemical use in WHPSA* Continued

Parcel Number	Property Use	Chemical Name	Amount
77	Residential/	Body Shop;	Unknown
	Commercial	chemicals	Cinniowii
30, 30A	Commercial	Unknown	Unknown
60	Commercial	Multiple Cars	Unknown
09C, 09I	Commercial	Unknown	Unknown
12	Commercial	Used Engine Oil	Unknown
48,48A	Commercial	Road salt, spills	Unknown
51	Commercial	Petroleum products,	Unknown
		antifreeze	

^{*}Excludes material in storage tanks.

To protect groundwater, facilities must be able to detect any chemical losses. See Figure 40 for the number of commercial parcel owners with chemical use that state that they have a chemical management plan that will detect chemical losses.

Figure 40: Parcels with chemical management plans



According to the leaching potential map produced by the Michigan Department of Natural Resources (see Figure 41), the pesticide leaching potential of the study area is "slight" (26).

The most common type of herbicides used by farm owners in Mecosta County are 2-4-D, Amine, Atrazine, and Accent. Lasso[®] and Round Up[®] are commercial herbicides frequently used by homeowners for weed control (24). The most frequently used insecticide in Mecosta County is an organophospate called Dimethate (Cygon). Before Dimethate was used, other toxic pesticides like DDT, Asana[®], and Chlorodane[®] were used in the 1950's and 1960's to control pests. Pesticide laws progressively restricted the use of these pesticides. Generally, insecticides have a greater potential for groundwater contamination than herbicides. In most cases, herbicides are absorbed by the targeted plants and do not penetrate the ground (24).

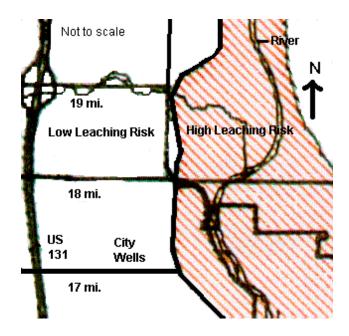


Figure 41: Pesticide Leaching Potential (23)

Southeast groundwater flow, indicating low potential for pesticides to leach into the aquifer that feeds the City of Big Rapids municipal wellfield. (26)

The farm on 18 Mile Road is reported to use herbicides. This farm parcel is primarily used for corn and hay. The soil type of both farmed areas is Coloma sand, a soil which is highly permeable, has slow surface runoff potential and low organic matter. Based on these soil characteristics, there is a small contamination potential. High soil permeability is the only factor that would promote leaching.

lv

It can be estimated that most of the ninety-five parcels with a structural building have a sewage disposal system. No evidence was found that any type of sewage system exists other than residential and small business septic tanks and drainfields.

6.0 Summary

The proper agencies were contacted to ensure that all known and potential sites in agency records were recorded. The high percent of completed property owner surveys (67%) provided a solid database for characterizing the amount and type of potential hazards within the study area, assuming honest and complete responses from property owners.

Twenty-eight percent of the parcels in the study area are currently undeveloped. The number of commercial properties is gradually increasing, but clustered along the eastern side of the study area. The majority of the developed property is single-family, low-density residential. No known contamination sites were found. Twenty-one potential contamination sites were found which represents sixteen percent of the total parcels. Only four parcels are being farmed. These farmed parcels have low pesticide use and therefore a small pesticide leaching potential. A new industrial park is being developed immediately northwest of the wellfield. Sewage systems in the area consist of small residential and commercial septic tanks and drainfields.

7.0 Conclusions

- There is a slight risk for potential contamination of the groundwater supplying the City of Big Rapids municipal wells.
- The groundwater feeding the wells for the next ten years is estimated to come from the northwest at a distance of 3,000-6,000 feet up-gradient.
- Past land usage of up-gradient land was agricultural.
- Due to its location on airport property, the wellfield is secluded from other structures in the study area.
- Multiple parcels northwest of the wellfield are owned by the City of Big Rapids and are free of structures, except for the new airport buildings.
- The closest up-gradient ground water flow potential contamination sources include: hazardous materials spills from aircraft or US 131, industrial park development, and road salt application on US 131.
- The location of most commercial developments in the area are likely to be out of the wellfield's radius of influence and down-gradient of the WHPA.
- Sewage systems in the area consist of a low density of small residential and commercial septic tanks and drainfields, making wastewater contamination of the groundwater a low risk.

• The final WHPA, when established by the consultant, is expected to be smaller than the area studied, resulting in a reduction of the number of potential contamination sites.

8.0 Recommendations

The first priority for the continued development of a WHPA for the City of Big Rapids is establishing a delineated area to protect based on the ground water time of travel, aquifer characteristics and the wells own draw down parameters. Following the official delineation of the WHPA by the environmental consulting firm, Prein & Newhof, the following recommendations should be completed if necessary.

- Complete remaining property owner surveys to update the parcel database.
- Create a copy of the database containing <u>only</u> those WHPA parcels that lie in whole or in part within the delineated area.
- Reevaluate the number of potential contamination sites in the WHPA.
- Confirm the existence of emergency response plans for hazardous materials spills along US 131. 19 Mile Road and Northland Drive.
- Work with industrial park business owners on pollution prevention activities. Contact MDEQ's Pollution Prevention Division for further assistance in establishing a proactive, cooperative groundwater prevention program.
- Confirm proper plugging of abandoned gas and oil wells, if possible.
- Assist property owners in locating and properly plugging abandoned water wells in and around the WHPA.
- Determine the location of any Mich-Con buried gas lines in the WHPA. Signs indicating
 the presence of a line exist on 17 Mile Road and on Northland Drive near 18 Mile Road.
 No response from Mich-Con was received by the end of the study.
- Update the database on an ongoing basis. Recommend the local wellhead protection committee meet periodically to update the contaminant source inventory. Update activities could include:
 - The use of windshield surveys.
 - Maintaining contact with both Big Rapids Charter Township and Green Charter Township officials to keep up to date on land use, zoning and property owner changes.
 - Utilizing Michigan Sate University, Cooperative Extension and District #10 Health Department, Environmental Health Division staff to assure proper plugging of wells that are abandoned in the future.

- Utilize materials and information from this study in development of the consumer education portion of the WHPP.
- Periodically conduct testing of water wells between US 131 and the wellfield to determine if any sodium chloride contamination exists as a result of road salting in the winter.
- Use a Global Positioning System (GPS) and a Geographic Information Mapping System (GIS) to more accurately locate and map the location of potential sources of contamination.
- Review the risk rating for each parcel in the WHPA and adjust as needed to maintain a parcel rating that accurately reflects the level of risk the parcel represents.

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