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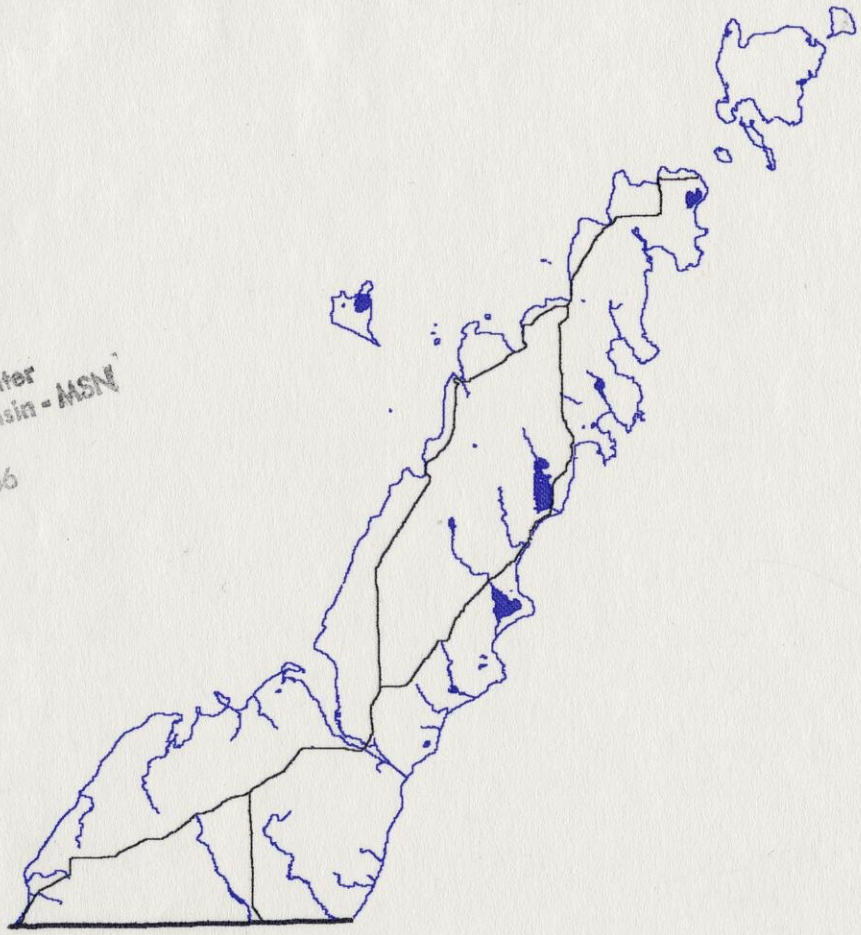

Wisconsin Department of Natural Resources
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GIS Mapping of Groundwater Contaminant Sources Quality and Contamination Susceptibility for Door County.

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Funding

The Wisconsin Department of Natural Resources provided funding for this project through the Groundwater Management Practice monitoring Program which receives appropriations from the Groundwater account.

Introduction/Summary

A multitude of groundwater quality data, spill, and waste disposal practice information exists within WDNR. Since this information is in segregated hard copy files, it is relatively unretrievable by individuals outside the program of interest. This project addresses that massive information management problem with the design of a geographic information system for groundwater associated data.

Lake Michigan District WDNR has produced quality digitized groundwater information with a 36" X 48" digitizing table, 36" plotter, and 486 computer work station with PC ARC/INFO GIS software located in the office. This project has required the examination of numerous spills and groundwater quality monitoring files. This retrieval was rather protracted since, generally, no single file contains all the District's groundwater information. As part of this project much of the WDNR Lake Michigan District spill and groundwater contamination information has been assembled into a relatively updated paper file also. This has been updated and digitized with other information to produce quality maps, which are variable by user request, and provide much improved groundwater resource management capability for district spills and groundwater management concerns.

This file of spill locations and associated groundwater quality information has been merged with other existing groundwater contamination susceptibility information for Door County. This includes all the karst geologic features mapped on the Groundwater Pollution Potential and Pollution Attenuation Potential Map for Door

County, (1989 Door County Soil and Water Conservation). All current and past orchard and lead/arsenate pesticide mixing areas have also been mapped and plotted as an overlay with the karst features layer. PC ARC/INFO Software was used to assemble the information at the District level for groundwater resource management and watershed decisions. The final product is a single file package of rapidly retrievable groundwater monitoring and groundwater contamination susceptibility information for the purposes of research, decision making, and comprehensive management. Information users now include Door County governmental agencies such as the Planning Department, Survey Department, and Soil & Water Conservation Department. In addition to WDNR, other major users could be WDILHR, WDATCP, University of Wisconsin researchers, environmental consultants, and realtors. User interest has already been expressed by a number of these parties. Individual spills or improperly located sites have been field identified with the use of a Trimble Transpac II GPS infield geographic location device with an estimated error of 100 feet. However, these spots have been map verified to eliminate gross errors. Hard copy plots of a variety of layers including all present and historical orchard areas can be viewed at either the Door County Soil and Water Conservation Service or WDNR Lake Michigan District Water Supply office.

The final digitized package is an integrated file of active groundwater contamination sources including contaminated soil areas potentially affecting groundwater. These sources include: lead/arsenate pesticide mixing sites, approximately 12,500 acres of apple and cherry orchards, salvage yards and special well casing requirement areas, wastewater land disposal, septic spreading sites, known groundwater contamination cases, wastewater lagoons, spills, leaky underground storage tanks, sludge application sites, salt sheds, abandoned landfills, active landfills, pesticide storage and handling facilities.

This project has been designed to create a complete contamination assessment/groundwater management package. The approach and methods of the project are independently useful and consistent with WDNR Bureau of Information Management (BIM) Geographic Information System (GIS) objectives. Attached with the final project submittal are example map plots from the Door County work. Plots are not limited to these example types only. Unlimited map versions, topics, and areas are obtainable from the digitized file that has been created. The ability to plot this information with GIS has greatly increased its accessibility to other agencies and the private sector. This greater information accessibility will further heighten the private sector's environmental consciousness and ultimately motivate it toward an even greater environmental responsibility.

Objectives

The principal objective of this project was to create a single useable computer file for retrieval of all groundwater contaminant source locations in Door County. This objective was accomplished in the following way.

1. Create computerized base maps for all 23 of the Door County USGS topographic 7½ minute quads. This work was completed by the WDNR Bureau of Information Management (BIM) in Madison.

2. Update a complete hard copy repository file of all Door County groundwater contamination sources (spills, leaky underground storage tanks, abandoned and active landfills, wastewater lagoons, sludge applications sites, salt sheds, salvage yards, wastewater land disposal areas, septic spreading areas, lead pesticide mixing facilities, pesticide storage and handling facilities. This work was completed at LMD Headquarters.

3. Create a detailed dBase file of all groundwater contamination sources for the entire Door County Project area. Pre existing computerized program files were utilized when available (ie. LUST, ERRP). This was determined to be more accurate and would simplify the updating process since this primary file is managed on an ongoing basis by the respective program. This work was completed at the LMD Headquarters.

4. Digitize the thirty most affected private water supply wells from the lead/arsenate contamination study (Stoll 1988) and key them to their well construction reports. This was completed at the LMD Headquarters.

5. Digitize the Door County soil and water conservation data file of 1,700 apple and cherry orchards totaling at least 12,500 acres, from the 1989 UWGB/Door County Soil and Water Conservation Department orchard/pesticide study. This was completed at LMD Headquarters.

6. Digitize all contamination points (#2 above) along with municipal wells, OTM wells, special well casing areas and the Karst Geologic features identified on the Groundwater Pollution Potential and Pollution Attenuation Potential Maps. The digitizing software PC ARC/INFO was used and keyed for all of Door County to the dBase file referenced above. No quad sheets were left partially digitized. This work was completed at LMD Headquarters.

   All final maps were plotted with PC ARC/INFO software and an HP Draftmaster SX 36" plotter.

With the completion of this project scope and objectives a single comprehensive groundwater data package was created with visual outputs by subject or locale, for future and current users of data acquired through groundwater investigations within Door County.

Results

The completed products of this project include:

A. Quality base maps with user control over scale, detail, and subject of each.

B. A computerized, digitized, spill/groundwater contamination file that can be added to:

1. new spills;
2. newly contaminated wells;
3. and new topics (soils, depths, lithology, etc.).

C. An integrated computer format that allows groundwater quality data to be plotted, interfaced and retrieved with soil samples, sediment samples, surface water samples, geologic features, apple and cherry orchards, etc.

D. A system that is additive and need not be bounded by the geography of the Door County Project alone. Edge matching to adjacent counties will be simplified since all base maps and plotted points are relative to USGS 7½ minute quad sheets.

Attached with this report are five plots comprising northern and southern Door Counties. These plots have been updated as of December 31, 1993 and indicate the known potential groundwater contamination sources described in this report, overlaid with the karst geology. Also included is a plot depicting land use by orchards and overlaid with the same Karst Geologic features. An orchard land use map is included for an area just north of Sturgeon Bay, Wisconsin which comprises the same area as its respective USGS 7½ minute quadrangle. This map represents one quadrangle of the 16 total that make up Northern Door County. Included in addition is a plot which shows the WDNR Water Supply program special well casing requirement areas for all of Door County. All these wells are completed and available for viewing through the WDNR LMD Water Supply office.

The mapping of potential groundwater contamination sources in Door County with GIS is very successful. Maps and digital data can be viewed at the WDNR - LMD Office. Updating these maps can be simplified by accurate and systematic documentation of new potential sources as they occur. This point is paramount to maintaining the most complete and accurate mapping database. In Lake Michigan District WDNR the following categories were selected as important to maintaining a file of potential groundwater contamination sources:

1. Leaking Underground Storage Tanks (LUST) Sites
2. Environmental Repair and Restoration Program (ERRP) Sites
3. Municipal Wells (Potential Receptors)
4. Other-than-Municipal Wells (Potential Receptors)
5. Special Well Casing Areas
6. Pesticide Storage/Handling Sites
7. General Discharge Sites (WPDES)
8. Municipal Discharge Sites
9. Industrial Discharge Sites
10. Abandoned Landfills
11. Active Landfills
12. Auto Salvage Yards
13. Wastewater Lagoons

This list is not an all inclusive inventory of potential groundwater contamination sources. For example other sources may include: salt sheds, land disposal of liquid waste and past or present septic waste spreading sites. This list contains information that can be obtained in a reasonable period of time and has a reliable amount of accuracy to the data. Statewide lists are available and may be identified through the Groundwater Coordinating Councils "Directory of Groundwater Databases" (February 1994). However, for the most specific information, the WDNR District office files should be referred to.

Data Sources and Collection Techniques

Bureau of Information Management GEO Section

The Door County Potential Groundwater Contamination Sources, Door County Orchards, Door County Special Well Casing Areas maps were produced using PC Arc/Info at the Lake Michigan District (LMD) Water Supply office. Base layers used on these maps were obtained from the Bureau of Information Management (BIM) Geo Section and consisted of:

1. Roads
2. Hydrology
3. Land Network
4. Municipal and Township Boundaries
5. County Boundaries
6. Geographic Names

These layers were obtained or created by the BIM GEO Section from various sources. The roads, hydrology, and land network layers were derived at a 1:100,000-scale from United States Geological Survey (USGS) Digital Line Graphs (DLG). These layers reflect the currency of USGS source maps dating from the early-to-middle 1980's. Road network is periodically upgraded and new construction may not accurately represent what appears on the digital road network in a given area. Land network is based on the Public Land Survey System (PLSS). It should be noted that PLSS lines are added on the maps for cartographic reference purposes only, and are not intended to be official. The official land survey is the only legal basis for determining land boundaries. County boundaries, municipal and township boundaries are derived from 1:100,000-scale U.S. Census Bureau Topologically Integrated Geographic Encoding and Referencing (TIGER) files. Geographic names are a digital collection of geographic features and associated locations of the USGS Geographic Names Information System (GNIS) at a scale of 1:24,000. All references made to the above digital layers were obtained from the BIM/GEO GIS Database User's Guide.

Lake Michigan District and Door County Soil and Water Conservation Department

Data layers created by the LMD Water Supply office in cooperation with the Door County Soil and Water Conservation Department were Door County apple and cherry orchards, and karst features including fracture traces, caves, swallets, springs and crevices. Orchards were interpreted from historical air photos taken in 1938, 1954, 1961, and 1974 by the Door County Soil and Water Conservation Department. Field sheets were used as base maps and the orchards were outlined on translucent mylar film and subsequently digitized by LMD in 1992. Due to the age and nature, large scale black and white air photos, of these source documents inaccuracies may occur. Karst features were also transferred from air photos to mylar and subsequently digitized. Since, karst features have a very subtle appearance on air photos inaccuracies may also appear. Fracture traces are recognized on air photos where vegetation appears to be flourishing or abundant in a linear aspect. Digitized fracture traces are thus only identified at the surface and give no indication as to depth or width of fracture. As shown on the two maps apple and cherry orchards are delineated as to the year each was recognized on the air photos, these were then overlain by fracture traces to give an indication as to where pesticide application and susceptible groundwater contamination tracts may be located. The different scales of maps enhance an important feature of PC ArcInfo which allows an investigator to apply regional and local considerations to determine the effects of problems. Currently

these maps are reproduced at a 1:24,000 scale at the LMD Water Supply office and at Door County Water and Conservation Department Sturgeon Bay, WI.

Lake Michigan District Water Supply Program

Special well casing areas of Door County were also added to the base layers. This layer was requested by many personnel in the LMD Water Supply office and well drillers. Door County has strict regulations concerning minimum casing depth throughout the county. The only map that depicted the regulations in the district was located at the Water Supply office and was created by pasting together ten 15 minute topographic maps of Door County. Well drillers phoned in requests for minimum casing requirements creating an inconvenience to them and Water Supply personnel. Several requests were made by well drillers to obtain copies of the map which was infeasible to reproduce without GIS technology because of the complexity of the original version.

Using PC ArcInfo the original map was traced onto separate topographic maps and digitized. Digitizing was done using the Door County hydrology and road layers when these layers acted as boundaries to the special well casing areas. The map was sent to a WDNR Water Supply Program Hydrogeologist and checked for accuracy. Several copies were then reproduced and sent to all well drillers in Door County consequently reducing the workload for all parties involved.

Historical Door County lead arsenate pesticide mixing and handling sites were also digitized. Lead arsenate was the staple pesticide used prior to 1960. Investigations revealed that soils around the mixing sites were heavily contaminated with lead and arsenic and groundwater around the sites were often lead contaminated. Maps with the sites shown and a 1200' radius around the site to inform well drillers of possible high lead contamination were sent to all drillers who may be affected.

Leaking underground storage tanks (LUST) and Environmental Repair and Restoration Program (ERRP) sites were digitized from 1:24,000 7.5 minute USGS topographic maps. The location of the LUST and ERRP site was found by searching through the Solid and Hazardous Waste LUST and ERRP program files to obtain a site map. When a site map was not located, field investigation with a hand-held Global Positioning System (GPS) satellite based radio navigation system was used. GPS gives a latitude-longitude position on the location of the leaky tank or hazardous spill. These coordinates are downloaded into the computer with software that is purchased with the GPS unit. Accuracy of the GPS varies but all locations are checked with field maps to ensure correct location. LUST and ERRP locations in the WDNR files is not verified as to the accuracy of its original map, often a circle is drawn around a site that is bisected by a road and interpolation is required to find the most accurate location of the site. Since LUST and ERRP sites are continuously being added to the files updates of these sites are undertaken every three months. Each LUST and ERRP site digitized is joined with the tabular database that the LUST and ERRP programs

maintain. This allows a spatial assessment of all LUST and ERRP cases that have affected ground water or surface water and the type of contaminant involved along with locational information such as responsible party, address and consultant handling the case.

Municipal and Other-than-Municipal wells were digitized from USGS 7.5 minute topographic maps. Locations of these wells were obtained from the WDNR Water Supply program's Well Vulnerability Assessment Project. This prior project was to locate most wells and photocopy topographic maps with their location. These locations were subsequently placed on the original 7.5 minute topographic map and digitized. Locations were also verified by Water Supply engineers who manage the facilities. These locations also assist Water Supply personnel with the 1995 Wellhead Vulnerability Assessment. ArcView maps are produced and given to municipal well systems operators to aid in locating various potential groundwater contamination sources that have not been previously identified. This information can be received and added to our computerized files. Each well is also connected to the Groundwater Retreival Network (GRN) by the unique well identification number. GRN allows each municipal well site to be joined to its well construction report and water quality information.

Industrial, municipal and general Wisconsin Pollution Discharge Elimination System (WPDES) permit sites were also digitized. These sites were digitized based on where they input into a surface water or seep into the groundwater, this may be at a different location than where the discharge originated. Location was determinated by a record search. Some sites have a map with the location and other sites have a description of the location which was then verified through field investigation. General discharge permits greatly outnumbered the municipal and industrial permit locations that had site maps. General discharge permit sites were joined to a tabular database located in the LMD Water Supply office and maintained by the District Hydrogeologist. This database contains various information about the discharge permitted such as the type of contamination, compliance status, receiving waters and other locational information such as responsible party name and address. Municipal and industrial permits were digitized but due to the nature of the Wastewater programs files these sites are very inconsistent regarding the accuracy of the information. Municipal and industrial sites may be point or areal discharges. Point discharges are more accurate than areal discharges. Landspreading operations are located by the PLSS description and subsequently located to a 40 acre site. For example, the actual landspreading area may only occupy five acres on this 40 acre site. Consequently the location that is digitized on the map is only accurate to a 40 acre area in some locations. These sites also do not contain a database that can accurately depict the type of contaminant discharge that is being allowed.

Abandoned and active landfills were also digitized. These facilities were located using the Registry of Waste Disposal Sites in Wisconsin. This list is compilation of information regarding licensed landfills in the state and sites that obtained one-time demolition disposal permits or land-spreading permits. These sites are located using

the PLSS with a 40 acre accuracy. The nature of the list does not provide an accurate description of the type of facility it was previously but does indicate if it is still operational. The site digitized by the LMD is chosen by interpolating the topographic map as to the sites most representative location within the 40 acre area. Therefore the map has approximately a 40 acre accuracy for most sites. Although this is a very large error, it coincides with much of WDNR locational information and is therfore too important to forsake. In addition, locating these sites with GIS does save time when searching potential contamination sources with ArcView software. These sites do not have a database associated to their location.

Licensed automobile salvage yard dealer locations and previous salvage yard dealer locations have also been digitized. These sites are not as numerous as abandoned landfills and can be field located without a great time expenditure. Upon field location the boundary is outlined on the 7.5 minute topographic map to be digitized. These sites are located from the Wisconsin Department of Transportation, Division of Motor Vehicles (WDMV) Licensed Dealers, Wholesalers, Distributors & Manufacturers 1992 Edition book. The book provides basic information on every licensed motor vehicle, motorcycle, recreational vehicle and salvage dealer. Salvage dealers are given three types of licenses and are distinguished by their ranges and prefixes:

SL1 - SL699	Type 1 Salvage Dealers (Facilities conducted within a building)
SL700 - SL899	Type 2 Salvage Dealers (Business conducted within a building)
SL900 - SL999	Type 3 Salvage Dealers (Scrap metal recycling/shredding)
SL1000 - SL1250	Type 4 Salvage Dealers/"Scavengers" (Pick up and deliver to shredder)

Each digitized salvage yard is given its license number as an identification number in the GIS database which represents the type of facility, name and address. All previously licensed salvage yard dealers no longer in operation are found through searches of files located at the WDNR Bureau of Solid and Hazardous Waste office.

Pesticide storage and handling locations that have become a known spill have also been computerized. An important database that has not yet been attainable is the location of pesticide storage and handling operations where spills have not been reported. It is important that all pesticide storage and handling facility locations be identified regardless of known problems present. Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP) licenses these sites and a list of locations with correct addresses is not available. These sites are maintained in a system where the facilities name is accurate but the location of many sites are inaccurate because the address of the supplier to the facility has been used instead of the facility address. This list is currently being updated and WDATCP will also begin using GIS to locate licensed pesticide facilities, pesticide mixing and loading areas, agrichemical spills, land spreading sites for agrichemically contaminated soils and similar features.

LMD Applications and ArcView

The Lake Michigan District uses this information very frequently. Recently GIS has enabled the location of many files and maps to be accessible to anyone with the knowledge of ArcView software. ArcView is a user-friendly software program that brings geographic information to the desktop. It creates the power to visualize, explore, query and analyze data spatially. LMD has frequently used the Door County information and ArcView to analyze areas where potential for groundwater contamination can and does occur. Figure 1 is an example where the LMD GIS project enhances the WDNR wellhead vulnerability project to make an assessment on the Village of Sister Bay's vulnerability to contamination. The figure shows where municipal wells have been located and the calculated fixed radius (CFR) buffered around the well. The CFR is a radius around a certain well obtained form DNR hydrogelogists working on wellhead vulnerability. Fracture traces and all leaking underground storage tanks with their file identification number have also been added. These leaking underground storage tanks can be readily assessed regarding their potential impact to the villages municipal wells by locating the appropriate file. Figure 2 is an example where the database associated with leaking underground storage tanks has been queried to determine if any tanks have affected groundwater. Upon analysis ArcView flags all leaking underground staorage tanks that affected groundwater near Sturgeon Bay by changing the case location symbol color to yellow. All other case symbols remain red. These are two examples of a multitude of different spatial analysis that can be performed with ArcView software.

Updating, Enhancements and Recommendations

Lake Michigan District has realized the benefits of GIS in the Door County project and has begun to apply GIS to the rest of the district. Each county will be digitized in regards to potential groundwater contamination sources. Upon completion an updating schedule of approximately three months would proceed. The reliable static information such as abandoned landfills and salvage yards has been located so that considerable time can be saved with consistent upadating. Further enhancements in program computer adeptness will also occur throughout the district benefiting GIS. Programs should require exact site maps be placed into all permit and case reports to aid in the precise location and mapping of all potential ground water contamination sources. Consultants should also send diskettes with the reports that give the information contained in charts and tables and identify the software used. Downloading this data and information could also be utilized with GIS to further enhance its capabilities.

Figure 1. Village of Sister Bay Wellhead Vulnerability Assessment

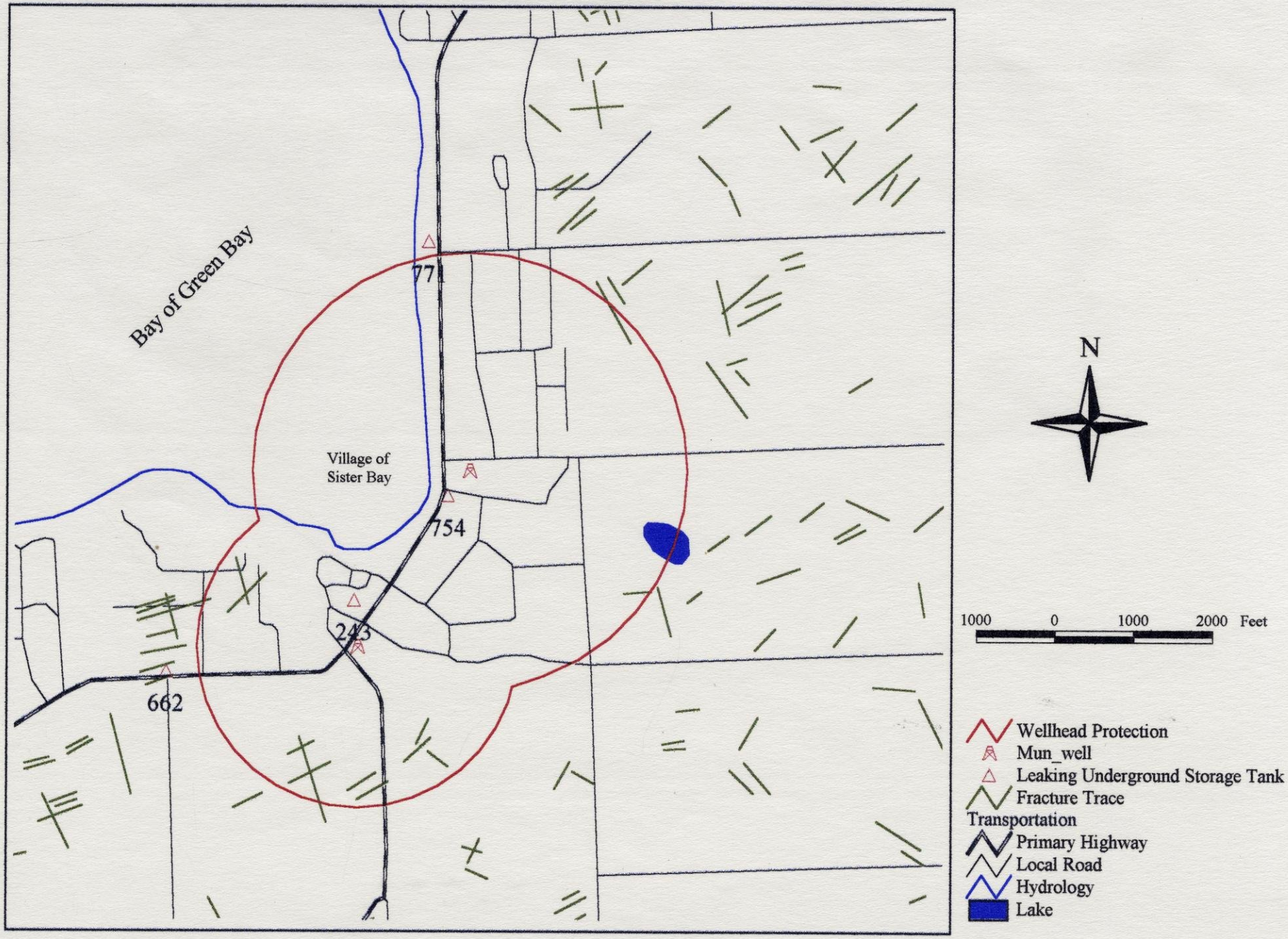
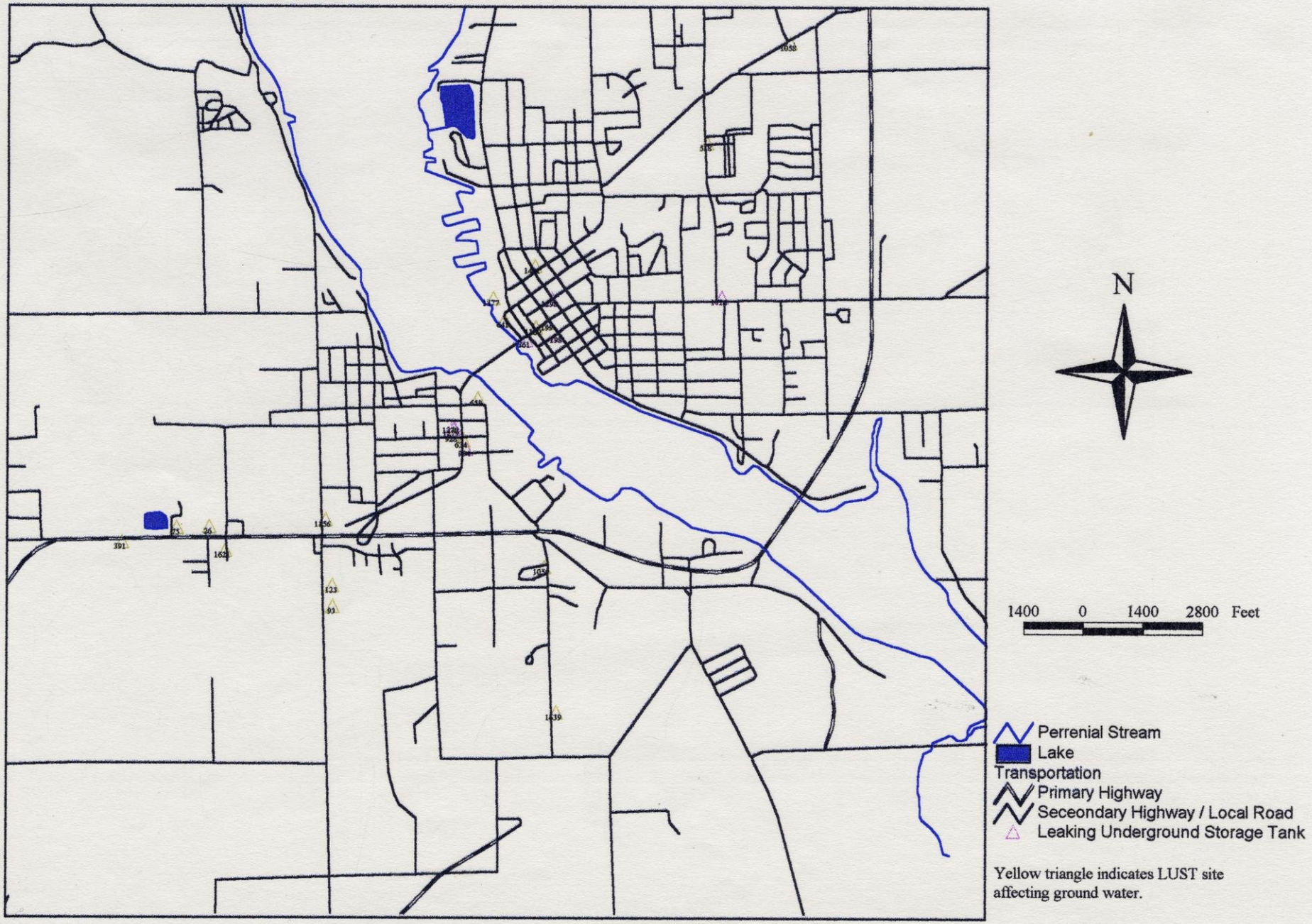


Figure 2. City of Sturgeon Bay LUST Sites That Have Affected Ground Water



Conclusions

The LMD geographic information system has proven to be a benefit to many programs throughout the district. It has taken information from various programs and other state agencies and conveniently put it on the desktop. However, the District use of GIS has not yet become funded on a permanent basis even though its utility is proven to be paramount to improved operational quality and efficient district function. As WDNR program budgets are revised efforts should be made to permanently fund GIS operations in LMD.