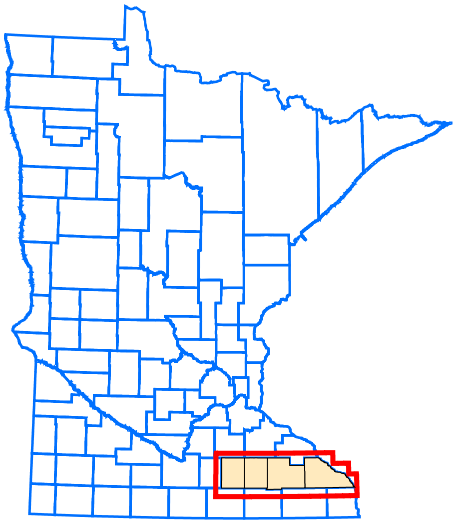


319/CWP Final Project Report
Contaminant Management in the Karst Region Contract with MGS, also includes summary information for 319 Karst Demonstration Project (contract with DNR)

Reporting Year: 2004

October 20, 2004

Introduction

Regulating contaminant sources and addressing remediation of contaminated sites is difficult in sensitive karst areas because of the unpredictable nature of groundwater movement in solution-weathered bedrock. In this project, the Minnesota Departments of Health, Natural Resources and the Minnesota Pollution Control Agency partnered with the Minnesota Geological Survey and the Department of Geology and Geophysics – University of Minnesota, to develop better tools to understand and manage point and non-point sources on contamination in karst terrains.

An important aspect of managing contaminants in a karst region is to have an understanding of the physical setting. Factors such as the depth to bedrock, lithology of uppermost bedrock (carbonate or non-carbonate), lithology of unconsolidated materials on top of bedrock, absence of surface water runoff, presence of stream sinks, sinkholes and springs, all must be considered when planning the installation of sewage or manure treatment facilities, determining best management practices for agriculture, or emergency response to accidental spills. The goals of this project, to increase interdepartmental coordination, develop protocols for GIS based decision making, development of useful datasets that can be applied to contaminant management, identification of potential contaminant sources, and implementation of cross-training between regulatory staff, were addressed by providing uniform coverage of geologic conditions in the study area, the lithology of the uppermost bedrock, bedrock topography and structure, and depth to the bedrock surface. In addition, a karst features database was developed, combined with a karst features inventory that provided information on the location and attributes of karst features such as sinkholes, stream sinks and springs. Information on the hydrology of the study area was provided by dye-trace and quarry investigations that show the time and direction of travel in shallow ground-water systems, and the impact of quarry operations on hydraulic gradient and ground-water quality. This data was used to develop interpretive maps designed to provide information on the spatial variability of aquifers to contamination from activities at the land surface. Finally, a web site was developed to provide easy access to all products from this demonstration project; this site includes karst information in surrounding counties, links to other agencies involved with water use and contaminant management in the karst region and an interactive map server providing up-to-date information on the location and attributes of karst features in southeastern Minnesota.

Methods

Geology of the study area

Construction of geologic maps first required up-to-date water well record information and geologic interpretation of their driller's descriptions. Well locating tasks were carried out in Dodge, Steele, Olmsted and Winona Counties, with the assistance of county staff. Locations on well records were verified by visiting the each site and then plotted on 1:24,000 U.S.G.S quadrangle maps. Verified locations were entered into the GIS-based, state water well database, plotted on base maps and geologic contacts were drawn and digitized. Earlier mapping of bedrock geology and topography in Olmsted County (Olsen, 1988; Runkel, 1996) and bedrock geology of Winona County (Mossler and Book, 1984) was revised and combined with new mapping in Steele and Dodge Counties (this study) to construct uniform 1:100,000 maps of bedrock geology and bedrock topography for the project area. A 1:100,000 depth to bedrock map for the 4 county area was created by constructing a digital elevation model (DEM) of the bedrock surface from the bedrock topography map. This DEM was then subtracted from the U.S.G.S 30 meter landsurface DEM. Twenty-five foot contours from the resultant grid were checked for accuracy with water well record and outcrop data, revised as necessary. Polygon topology was added to identify areas of equal depth to bedrock in 25 foot increments.

Karst feature inventory

An extensive karst feature inventory was carried out by the Minnesota Department of Natural Resources (MNDNR), in cooperation with the Department of Geology and Geophysics, University of Minnesota (UMNGEO). Field identification and descriptions of sinkholes, springs and stream sinks in the 4-county area were added to a state-wide karst features database that was developed and expanded during the course of this project. (Gao, 2002).

Hydrology of the study area

Hydrologic conditions of shallow aquifer systems were investigated using several different methods. Dye tracing was used to measure residence time and direction of flow in two basins within the 4-county area. A total of seventeen traces were conducted by MNDNR and UMNGEO by introducing fluorescent dyes in or near sinkholes, and measuring dye concentrations at nearby springs. Dye was flushed into sinkholes both under natural conditions (spring snowmelt) and artificially, using a water discharged from a tank.

Regional hydrologic conditions were investigated by the MDH by re-evaluating boundary conditions well head protection groundwater models. Specifically, relationships between hydraulic head and watershed boundaries for groundwater in the Prairie du Chien Group and Jordan Sandstone were evaluated to determine if watershed boundaries provide suitable boundary conditions for aquifers in a karst terrain.

The relationship of geologic structure on the formation of sinkholes was also investigated. Records for water wells from the updated water well database CWI were combined with natural gamma logs for wells for a township in Olmsted County to produce a structure map for the top of the Decorah formation. (Lopez Burgos and others, 2003).

The impacts of quarry operations on local hydraulic gradient and groundwater quality were investigated the MNDNR. Hydraulic response and changes in temperature and conductivity was recorded in monitoring wells drilled near selected quarry sites.

Preparation of interpretive maps

MDH staff has constructed a series of county maps designed to assess the potential for nitrate contamination to groundwater. One of these maps, for Winona County, falls within the project study area and used the karst database and newly developed geologic maps as part of its mapping procedure. Aquifer sensitivity was represented by data bases illustrating landforms, geologic susceptibility, the percent of less permeable materials above the total depth of well, and the frequency of karst features. A detailed explanation of construction methods for the Winona County map can be found at http://www/health.state.mn.us/divs/eh/water/swp/nitrate/winona.pdf.

Data Access/Education and training

Each of the project partners participated in activities related to data access, education and training. Educational materials such as posters, project tools for teachers and web animations were produced to illustrate karst processes to a general audience. Separate workshops and meetings organized by MNDNR, MPCA and MDH were held to train local staff on how to recognize potential for groundwater contamination in a karst terrain. Construction of guidance documents that incorporate the geologic maps and karst feature database developed as part of this project was has begun at the MPCA, and is expected to be completed by Spring 2005.

Access to the products of this project, including karst feature locations and geologic mapping, along with educational materials and links for additional state agency information on karst was provided by the creation of a karst features web site (http://156.98.153.12/karst) . The web site was designed to provide local information on karst investigations and reports (organized by county), along with more general information on regional karst conditions. Its goal is to provide ongoing, timely access to data used in karst investigations, along with educational materials and links that help illustrate how karst systems work.

Results

Geology of the study area

As part of the project, 1389 wells were newly interpreted or had their geologic interpretations revised, including approximately 850 wells newly located wells in Dodge and Steele. 46 wells were gamma logged and interpreted. 1,386,445 (2166 square miles) acres of new or revised bedrock geologic mapping in the project area, including 557582 acres (871 square miles) of new mapping in Dodge and Steele Counties.

Karst feature inventory

As a result of this project, 2670 karst features have been identified in the project area, and are part of the state karst features database. Of this total, 898 are springs, 1704 are sinkholes and 19 are stream sinks. The remaining 49 items are tile inlets or outlets, or miscellaneous features that reduce overland flow. 1073 karst features were either newly located or had their previously identified locations verified or adjusted based on field maps and air photos. The state karst features database was moved to a network server as part of the project, and its user interface modified to provide remote network access and editing capability. The database and associated feature locations are now available on the karst features website (http://156.98.153.12/karst) and through the MNDNR's GIS data distribution site (deli.dnr.state.mn.us).

Hydrology of the study area

Much of the karst feature inventory work focused on Dodge County, where few karst features had been identified before the project began. Locations and supplementary information of 28 new springs were added to the database, focusing on a 30 square mile area in the northwestern part of the county where karst dominated drainage was previously undocumented. In Olmsted County, dye traces linked surface runoff into sinkholes with springs in two basins. In addition, detailed structural contour mapping in one of the basins indicated that a subtle change dip of the underlying bedrock strata was a factor in sinkhole development. The relationship between bedrock structure and sinkhole development, while common in karst terrains in other parts of the country was previously undocumented in Minnesota, where bedrock strata are relatively flat lying. Other studies initiated as part of this project on the hydrology of the study area, including regional hydraulic head mapping and quarry hydrology are still underway.

Preparation of interpretive maps

By combining geologic information provided as part of this study along with other datasets, the MDH prepared draft reports and maps showing the results of nitrate probability mapping in Dodge and Winona Counties. These maps, along with nitrate maps for other counties in Minnesota outside of the study area are available at http://www.health.state.mn.us/divs/eh/water/swp/nitrate/nitratemaps.html.
As part of the mapping process, MDH assisted county staff with establishing well water quality databases at

the local level. In this way, county staff was able to assemble water quality data in a way that is consistent data sets from neighboring counties. In addition to the nitrate probability maps, MDH prepared draft maps for Dodge and Olmsted Counties, showing areas sensitive to Class 5 automotive waste disposal wells.

Data Access/Education and Outreach

Over the course of this project, the Minnesota Pollution Control Agency (MPCA) developed an web-based, interactive map server to provide information on leaky underground storage tanks, both within the project study area and elsewhere in the state. (http://pca-gis04.pca.state.mn.us/website/lust/lustfin/entry.htm) The site is used in conjunction with the karst features database and state waterwell database to construct site risk assessments in the project area. A poster was constructed, illustrating karst features and the impact of land use on water quality. Copies of this poster has been distributed to schools, local units of government and extension services. In addition, the MPCA sponsored several karst education seminars, attended by land-use planners, regulators and local citizens. The MPCA is in the process of revising its Karst Guidance document. The purpose of this document is to provide MPCA staff with clearly defined requirements for site assessment in a karst terrain.

The Minnesota Department of Health (MDH) assisted in MPCA-sponsored karst education workshops, by providing staff as instructors and participants. Other outreach and education activities conducted by MDH as part of this project included meetings with the Basin Alliance for the Lower Mississippi committee to integrate source water protection goals into basin planning. MDH also made presentations to county water planning staff regarding how to integrate wellhead protection efforts with county water planning efforts. Several activities addressed problems related to motor vehicle waste disposal as part of this project: MDH worked with county staff and joint powers board staff to integrate Class 5 injection well inventory efforts with mapping of sensitive areas to motor vehicle waste disposal wells; county staff were briefed on the protocol for mapping areas sensitive to this type of disposal. Resulting maps for Dodge and Olmsted Counties were presented to county staff.

Conclusions

The goal of increasing coordination between agencies was met by providing web-accessible, up-to-date information on depth to bedrock, uppermost bedrock lithology and distribution of sinkholes, springs and stream sinks in the form of GIS datasets. The goal to develop protocols was started, but not completed. Efforts are underway at the Minnesota Pollution Control Agency and the Minnesota Departments of Health to develop protocols for regulation decisions, but have not been completed at the time of this report. While there is agreement that better information is available as a result of this project, finalizing protocols for using this information is still underway. Other project goals to develop uniform data sets throughout the study area and accelerate efforts to automate data was met by the development of the 4-county geologic maps and incorporation of karst feature information into the state karst features database. The final goal of implementing cross-training between regulatory staff is currently being formalized.

In summary, the project succeeded in providing the tools necessary for making informed decisions with regard to point and non-point source contaminant management. It began, but did not complete the process of establishing decision making protocols. One of the lessons learned was that the goal of achieving an inter-agency, coordinated protocol addressing contaminant source management during the project time-frame may not have been realistic given the variability in regulatory requirements in each agency. None the less, karst as factor in regulatory management decisions is now included in draft protocols for MDH and MPCA, where it did not exist before. If the project was repeated, more time would have been spent addressing this goal by organizing additional workshops that apply the tools developed as part of the project. This seems to be a likely outcome, now that these datasets are established and readily available, but it was not accomplished in the time frame of this project. All products of the project are available on the web, at http://156.98.153.12/karst. Illustrations and photographs from the project are included at the end of this report.

References cited:

Olsen, B.M, 1988, Bedrock geology of Olmsted county, Plate 3 in Balaban, N.H., ed., Geologic Atlas of Olmsted County, Minnesota Geological Survey County Atlas Series C-3.

Gao Y, 2002, Karst Feature Distribution in Southeastern Minnesota: Extending GIS-Based Database for Spatial Analysis and Resource Management. [Ph.D. thesis] University of Minnesota.

Lopez Burgos, Viviana, Alexander, Scott, Nagle, Adam, Alexander, E. Calvin Jr., Green, Jeffrey, and Pavelish, Jeremy, 2003 Recent advances in springshed mapping using dye tracing, GIS and structural geology tools. Geological Society of America Abtracts with Programs, v34, no. 7 Paper No. 151-7.

Mossler, J.H. and Book, P.R., 1984, Bedrock geology (Plate 2) in, Geologic Atlas of Winona County, Minnesota Geological Survey County Atlas Series C-2.

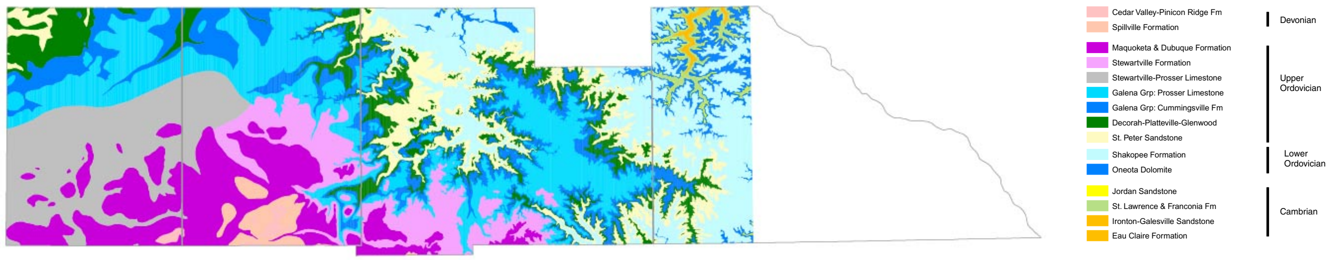
Runkel, A.C., 1996, Bedrock topography (Plate 2) and bedrock geology (Plate 3) *in* Runkel, A.C., Geologic investigations applicable to ground-water management, Rochester metropolitan area, Minnesota., Minnesota Geological Survey Open File Report 96-1.

Final Budget Summary

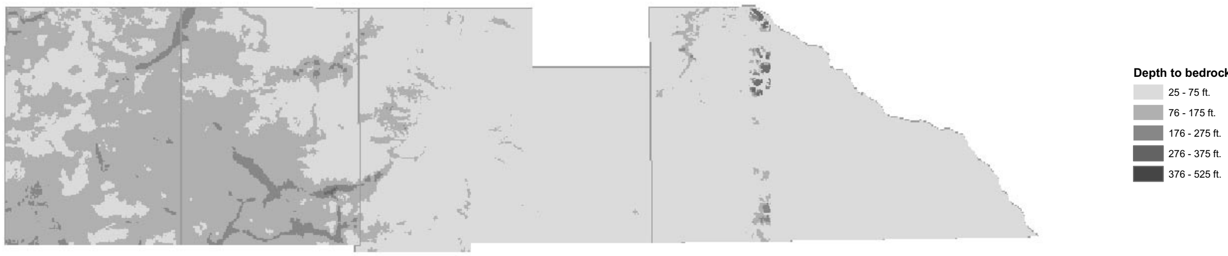
A detailed budget summary is included at the end of this report.

PRODUCTS

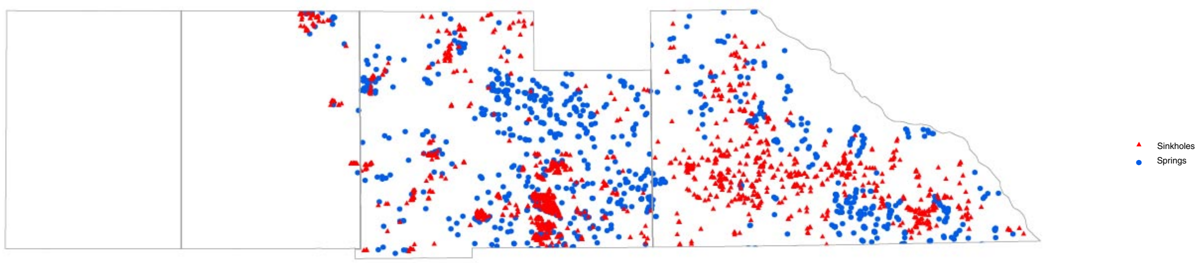
Bedrock Geology



Drift Thickness



Karst Feature Distribution

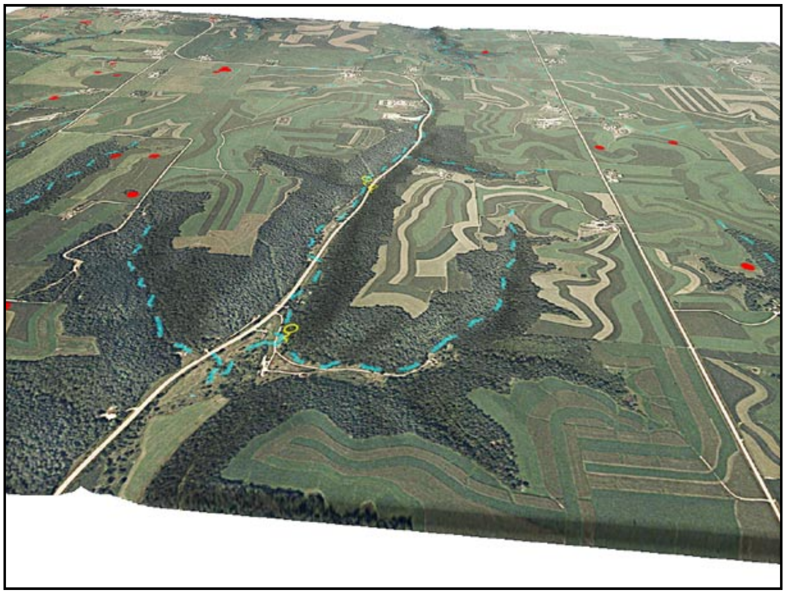


Geologic Mapping/Karst Features Inventory:

One of the most important factors in understanding sensitivity of aquifers to surface contamination in a karst terrain is the geologic setting. In particular, depth to bedrock and the lithology of the uppermost bedrock layer impacts runnoff, infiltration rates, and the formation and distribution of sinkholes. As part of this project, 1:100,000 scale bedrock geology and depth to bedrock (drift-thickness) maps were created for the four-county study area. Geologic layers range in age from Devonian in the west to Upper Cambrian in the east, spanning two distinct karst systems (Devonian/Upper Ordovician Galena-Spillville and the Lower Ordovician Prairie du Chien systems). Depth to bedrock ranges from greater than several hundred feet in the west less than 50 feet in the east.

The state karst feature inventory was significantly expanded as part of this project, including identification of previously unlocated sinkholes and springs in Dodge County, along with springs in Olmsted and Winona Counties. Attributes for sinkholes in Olmsted County were added to the karst feature database. In addition, locations of all previously mapped features were verified from field maps and air photos and adjusted as necessary. As can be seen by comparing drift thickness to karst feature distribution, sinkholes are typically found in areas less than 75 feet to bedrock. Sinkholes in the Galena-Spillville karst system are typically clustered, whereas sinkholes in the Paririe du Chien karst are more randomly distributed (Gao, 2002). Additional mapping of bedrock dips at the minor watershed scale are providing insites into sinkhole occurence and springshed delineation (Lopez Burgos and others, 2003).

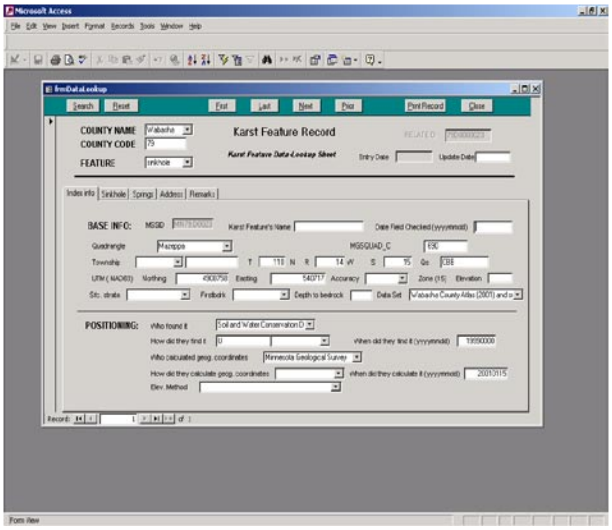
LINKS: bedrock geology - depth to bedrock - karst features database - karst feature locations



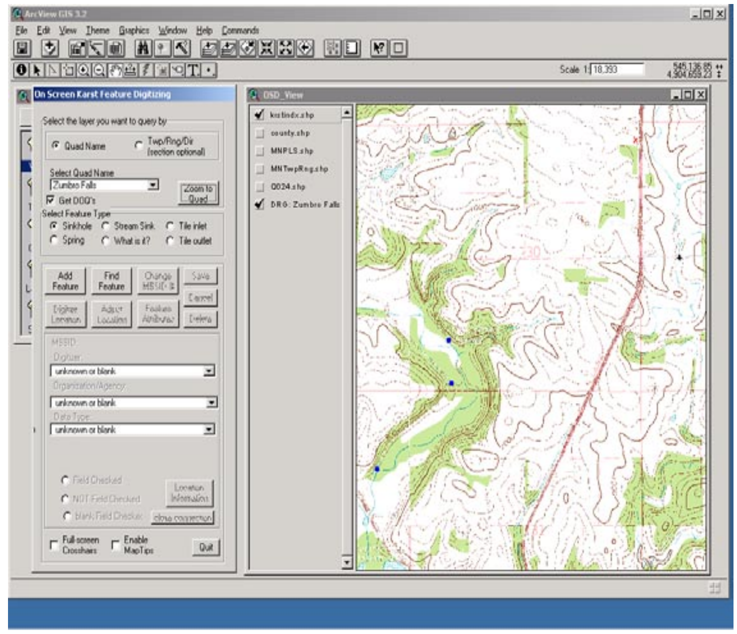
An educational outreach component is also included as part of the project. Products include a webpage providing access to the database, and information and visual representation of karst processes. The figure on the left is a quasi - three dimensional image from Winona County, showing the landscape position of sinkholes (red) relative to intermittent streams (blue dashes) and springs (yellow circles). The figure on the right is a frame from an animation, showing a sinkhole forming by subsidence processes. Addtional animations includes a sinkhole formed by collapse processes. This information is used to illustrate how karst condtions impact the movement of water through the landscape, and the close connection between landuse and surface water/groundwater in a karst terrain.

LINKS: karst features web page - sinkhole subsidence animation - sinkhole collapse animation
(requires QuickTime viewer)

A



B



A major component of this project was the development of a karst feature database. The database consists of a tabular part, managed using Microsoft Access (A), and a spatial part, managed using ESRI Arcview (Gao, 2002) (B). Interfaces were written in Visual Basic and Arcview Avenue scripting language. Location and attributes of karst features are updated as new points were found, and historical paper records were merged into the database.

The establishment of a state karst features database provides the means to inventory karst features into the future. Cooperation between the Minnesota Department of Natural Resources and the Department of Geology and Geophysics - University of Minnesota has resulted in a database that provides up to date information on karst features that includes information gathered from both contributors. This information is accessible through the Minnesota Karst Features Web page, both through download options or by spatial inquiry using an interactive mapping tool.

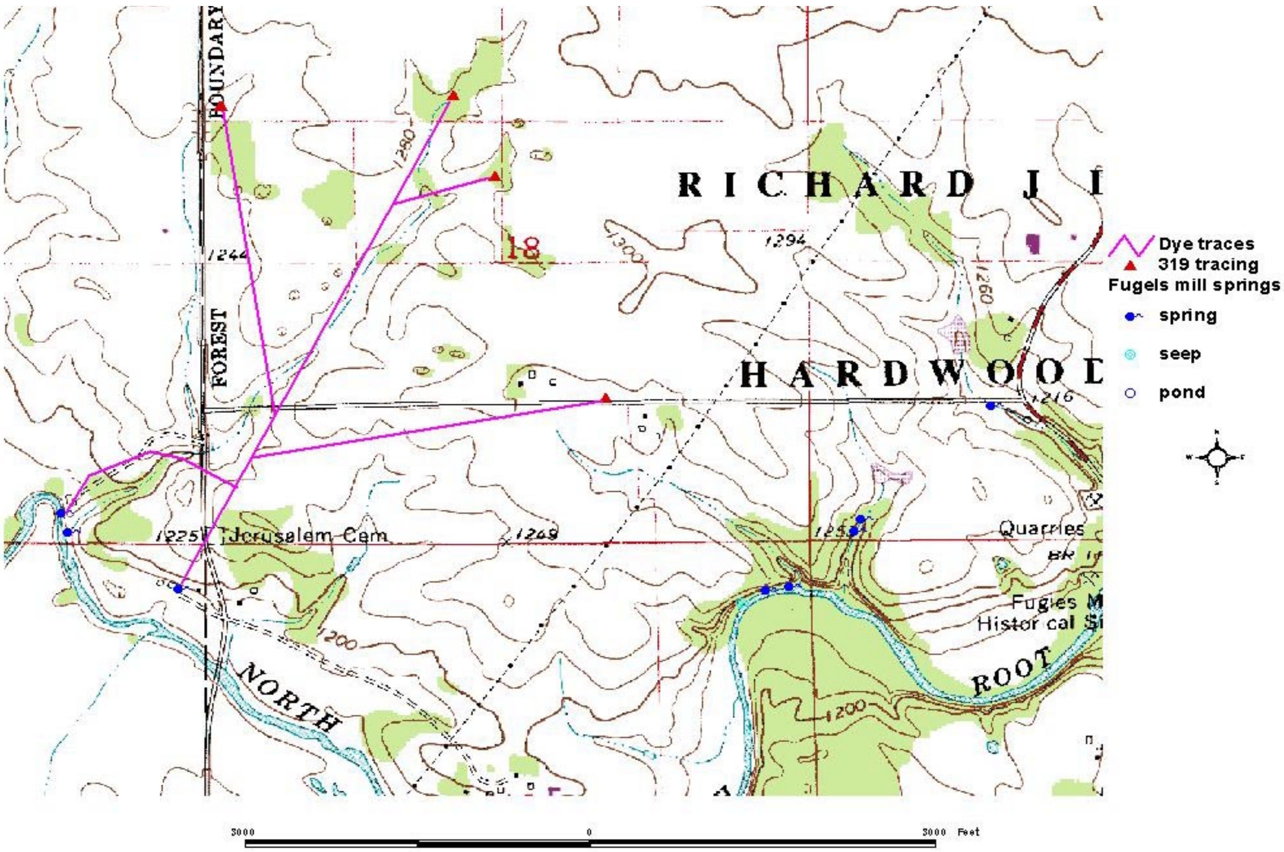
LINKS: karst features database - karst feature locations - interactive map server

References cited:

Gao Y, 2002, Karst Feature Distribution in Southeastern Minnesota: Extending GIS-Based Database for Spatial Analysis and Resource Management. [Ph.D. thesis] University of Minnesota.

Lopez Burgos, Viviana, Alexander, Scott, Nagle, Adam, Alexander, E. Calvin Jr., Green, Jeffrey, and Pavelish, Jeremy, 2003 Recent advances in springshed mapping using dye tracing, GIS and structural geology tools. Geological Society of America Abtracts with Programs, v34, no. 7 Paper No. 151-7.

EPA 319 Final Report - DNR Waters



DNR Waters role in this project consisted of four primary parts, karst feature inventory, karst hydrology investigations, educational outreach, and hydrogeologic evaluations at several limestone quarries.

Karst feature inventory- DNR Waters staff located previously unmapped karst features in Dodge, Olmsted, and Winona Counties. These features included sinkholes, springs, stream sinks and the first recorded blind valley in Olmsted County. The inventory work in Olmsted and Winona was done to update the existing karst feature coverage for those counties. The inventory work in Dodge County was the first attempt to locate karst features on an organized basis.

Karst hydrology Investigations- In cooperation with the University of Minnesota Dept. of Geology and Geophysics, DNR Waters staff conducted 17 dye traces in Olmsted County. These traces were done to begin the process of groundwater basin mapping and to learn more about the nature of the karst system. Two areas were investigated, the Jerusalem basin south of Rochester and the eastern end of the Orion sinkhole plain, the largest sinkhole area in the county.

Educational outreach- DNR Waters staff conducted several public information meetings in Milton Township in Dodge County and Wilson Township in Winona County. These meetings were done in cooperation with the University of Minnesota-Extension. Waters staff also lectured on karst to public school students in Rochester. An additional presentation was made to the environmental subcommittee of the Zumbro Valley Medical Society in Rochester.

Limestone Quarry Hydrology- Waters staff investigated the impacts of two limestone quarries in the study area. These on-going studies have gathered valuable data on groundwater movement during dewatering at the quarries and the impacts associated with quarry blasting.

Looking back, there are several things that DNR staff would do differently next time. One, we would have instrumented one of the springs that we know drain a sinkhole plain area to learn more about the hydrology of the conduit systems. Dye tracing would have been implemented earlier in the project so as to maximize the time available. More township boards would have been brought in as the two we did communicate with (Wilson in Winona and Milton in Dodge) were able to provide a number of contacts for locating previously unmapped karst features.

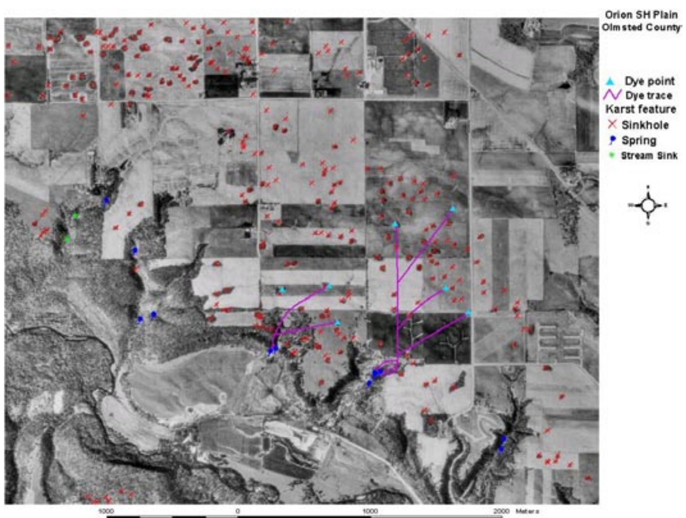
In summary, through this project a significant number of new features have been mapped, we are developing a better understanding of the hydrology of the shallow limestone aquifers, and this information is being included in the statewide karst database so it is available to all the citizens of Minnesota.

ADDITIONAL ILLUSTRATIONS OF KARST FEATURES AND KARST FEATURE MAPPING WITHIN THE STUDY AREA:

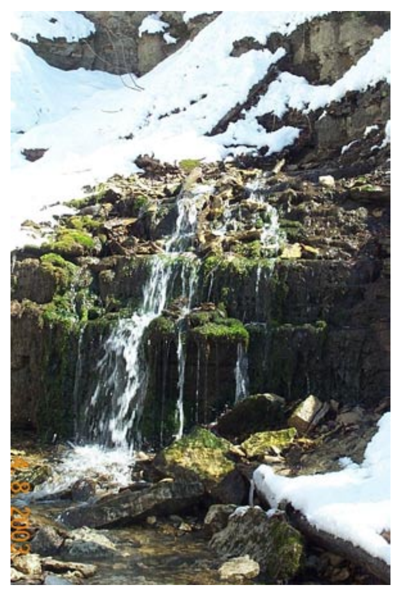
Sinkholes in the Galena karst, Olmsted County - mapped as part of this project

Stream sink in the Prairie du Chien Group, Winona County

Stream sink in the Prairie du Chien Group, Winona County, mapped as part of this project. Information on the location of these features is important for contaminant source managment, particularly in the case of accidental spills.



Dye tracing map - East Orion Twp, Olmsted County



Olmsted County spring traced as part of this project

Cave near the Platteville Fm. St. Peter contact in the city of Rochester, Olmsted Couty

Cost Category	Unit Cost	Quantity (Hours/Amount)	Budget Expended	Units	IA. Subtotals In-Kind	IB. Subtotals Cash	IC. Total Budget	IVA. Cumulative Inkind Expend.	IVB. Cumulative Cash Expend.	IVC. Cumulative Total Expend. (IIC. + IIIC.)	VA. Inkind Budget Balance (IA. - IVA.)	VB. Cash Budget Balance (IB. - IVB.)	VC. Total Budget Balance (IC. - IVC.)
Element 1 - 1:100,000 scale karst bedrock map													
A) Contributing Sponsors													
UM-MN Geological Survey				Amount	0	15,000	15,000	3,158	14,400	17,558	(3,158)	600	(2,558)
Element Subtotal		**0**	**0**		**0**	**15,000**	**15,000**	**3,158**	**14,400**	**17,558**	**(3,158)**	**600**	**(2,558)**
Element 2: 1:100,000 scale bedrock topography map													
A) Contributing Sponsors													
UM-MN Geological Survey		0		Amount	0	13,000	13,000	0	13,350	13,350	0	(350)	(350)
Element Subtotal		**0**	**0**		**0**	**13,000**	**13,000**	**0**	**13,350**	**13,350**	**0**	**(350)**	**(350)**
Element 3 - 1:100,000 scale depth to bedrock map													
A) Contributing Sponsors													
UM-MN Geological Survey		0		Amount	0	11,000	11,000	6,900	13,350	20,250	(6,900)	(2,350)	(9,250)
Element Subtotal		**0**			**0**	**11,000**	**11,000**	**6,900**	**13,350**	**20,250**	**(6,900)**	**(2,350)**	**(9,250)**
Element 4 - overburden stratigraphy, (mgs)													
A) Contributing Sponsors													
UM-MN Geological Survey				Amount		11,200	11,200	0	5,040	5,040	0	6,160	6,160
Element Subtotal		**0**	**0**		**0**	**11,200**	**11,200**	**0**	**5,040**	**5,040**	**0**	**6,160**	**6,160**
Element 5 - Well locating													
A) Contributing Sponsors													
UM-MN Geological Survey				Amount	2,000.00	8,800	10,800	0	8,036	8,036	2,000	764	2,764
Element Subtotal		**0**	**0**		**2,000**	**8,800**	**10,800**	**0**	**8,036**	**8,036**	**2,000**	**764**	**2,764**
Element 6: Karst database development													
A) Contributing Sponsors													
UM Geology and Geophysics							0	10,750	0	10,750	(10,750)	0	(10,750)
UM-MN Geological Survey				Amount	4,000	20,000	24,000	12,180	20,000	32,180	(8,180)	(0)	(8,180)
MN Department of Health					8,000		8,000	600	0	600	7,400	0	7,400
MN Pollution Control Agency					26,400	25	26,425	0	0	0	26,400	25	26,425
Element Subtotal		**0**	**0**		**38,400**	**20,025**	**58,425**	**23,530**	**20,000**	**43,530**	**14,871**	**25**	**14,895**
Element 7: Karst Features Inventory													
A) Contributing Sponsors													
UM Geology and Geophysics		0		Amount	11,000	37,775	48,775	21,875	32,985	54,860	(10,875)	4,790	(6,085)
MN Department of Natural Resources					26,100	39,000	65,100	27,110	27,350	54,460	(1,010)	11,650	10,640
Element Subtotal		**0**	**0**		**37,100**	**76,775**	**113,875**	**48,985**	**60,335**	**109,320**	**(11,885)**	**16,440**	**4,555**
Element 8: Well Record Verification/Data Entry													
A) Contributing Sponsors													
UM-MN Geological Survey				Amount	2,000	10,000	12,000	2,600	10,000	12,600	(600)	0	(600)
MN Department of Health				Hours			0	0	0				
Element Subtotal					**2,000**	**10,000**	**12,000**	**2,600**	**10,000**	**12,600**	**(600)**	**0**	**(600)**
Element 9: Hydraulic Head Mapping													
A) Contributing Sponsors													
MN Department of Health		0		Hours	14,000		14,000	14,000	0	14,000	0	0	0
Element Subtotal		**0**	**0**		**14,000**	**0**	**14,000**	**14,000**	**0**	**14,000**	**0**	**0**	**0**
Element 10: Karst Limestone Quarry Hydrology													
A) Contributing Sponsors													

Cost Category	Unit Cost	Quantity (Hours/Amount) Expended	Budget	Units	IA. Subtotals In-Kind	IB. Subtotals Cash	IC. Total Budget	IVA. Cumulative Inkind Expend.	IVB. Cumulative Cash Expend.	IVC. Cumulative Total Expend. (IIC. + IIIC.)	VA. Inkind Budget Balance (IA. - IVA.)	VB. Cash Budget Balance (IB. - IVB.)	VC. Total Budget Balance (IC. - IVC.)
MN Department of Natural Resources		0		Hours	22,500	0	22,500	38,900	0	38,900	(16,400)	0	(16,400)
Element Subtotal		**0**	**0**		**22,500**	**0**	**22,500**	**38,900**	**0**	**38,900**	**(16,400)**	**0**	**(16,400)**
Element 11: Preparation of Interpretive Maps													
A) Contributing Sponsors													
MN Department of Health		0		Hours	3,800	0	3,800	5,000	0	5,000	(1,200)	0	(1,200)
Element Subtotal		**0**	**0**		**3,800**	**0**	**3,800**	**5,000**	**0**	**5,000**	**(1,200)**	**0**	**(1,200)**
Element 12: Education and Training													
A) Contributing Sponsors													
UM-MN Geological Survey					2,000		2,000	2,000	1,380	3,380	0	(1,380)	(1,380)
MN Department of Health					8,000		8,000	2,000	0	2,000	6,000	0	6,000
MN Pollution Control Agency					9,600		9,600	13,500	1,380	14,880	(3,900)	(1,380)	(5,280)
MN Department of Natural Resources					2,400		2,400	2,600	0	2,600	(200)	0	(200)
Element Subtotal		**0**	**0**		**22,000**	**0**	**22,000**	**20,100**	**2,760**	**22,860**	**1,900**	**(2,760)**	**(860)**
Element 13: Project Management													
A) Contributing Sponsors													
UM-MN Geological Survey		2,000		Amount	4,000	0	4,000	5,399	2,757	8,156	(1,399)	(2,757)	(4,156)
Element Subtotal		**2,000**	**0**		**4,000**	**0**	**4,000**	**5,399**	**2,757**	**8,156**	**(1,399)**	**(2,757)**	**(4,156)**
Element 14: Interagency Advisory Committee													
A) Contributing Sponsors													
UM Geology and Geophysics		0			4,000	0	4,000	600	0	600	3,400	0	3,400
UM-MN Geological Survey					4,000		4,000	600	0	600	3,400	0	3,400
MN Department of Health					4,000		4,000	600	0	600	3,400	0	3,400
MN Pollution Control Agency					4,000		4,000	1,500	0	1,500	2,500	0	2,500
MN Department of Natural Resources					4,000		4,000	1,750	0	1,750	2,250	0	2,250
Element Subtotal		**0**	**0**	**0**	**20,000**	**0**	**20,000**	**5,050**	**0**	**600**	**14,950**	**0**	**19,400**
PROGRAM ELEMENT 1 - TOTAL					**0**	**15,000**	**15,000**	**3,158**	**14,400**	**17,558**	**(3,158)**	**600**	**(2,558)**
PROGRAM ELEMENT 2 - TOTAL					**0**	**13,000**	**13,000**	**0**	**13,350**	**13,350**	**0**	**(350)**	**(350)**
PROGRAM ELEMENT 3 - TOTAL					**0**	**11,000**	**11,000**	**6,900**	**13,350**	**20,250**	**(6,900)**	**(2,350)**	**(9,250)**
PROGRAM ELEMENT 4 - TOTAL					**0**	**11,200**	**11,200**	**0**	**5,040**	**5,040**	**0**	**6,160**	**6,160**
PROGRAM ELEMENT 5 - TOTAL					**2,000**	**8,800**	**10,800**	**0**	**8,036**	**8,036**	**2,000**	**764**	**2,764**
PROGRAM ELEMENT 6 - TOTAL					**38,400**	**20,025**	**58,425**	**23,530**	**20,000**	**43,530**	**14,871**	**25**	**14,895**
PROGRAM ELEMENT 7 - TOTAL					**37,100**	**76,775**	**113,875**	**48,985**	**60,335**	**109,320**	**(11,885)**	**16,440**	**4,555**
PROGRAM ELEMENT 8 - TOTAL					**2,000**	**10,000**	**12,000**	**2,600**	**10,000**	**12,600**	**(600)**	**0**	**(600)**
PROGRAM ELEMENT 9 - TOTAL					**14,000**	**0**	**14,000**	**14,000**	**0**	**14,000**	**0**	**0**	**0**
PROGRAM ELEMENT 10 - TOTAL					**22,500**	**0**	**22,500**	**38,900**	**0**	**38,900**	**(16,400)**	**0**	**(16,400)**
PROGRAM ELEMENT 11 - TOTAL					**3,800**	**0**	**3,800**	**5,000**	**0**	**5,000**	**(1,200)**	**0**	**(1,200)**
PROGRAM ELEMENT 12 - TOTAL					**22,000**	**0**	**22,000**	**20,100**	**2,760**	**22,860**	**1,900**	**(2,760)**	**(860)**
PROGRAM ELEMENT 13 - TOTAL					**4,000**	**0**	**4,000**	**5,399**	**2,757**	**8,156**	**(1,399)**	**(2,757)**	**(4,156)**
PROGRAM ELEMENT 14 - TOTAL					**20,000**	**0**	**20,000**	**5,050**	**0**	**600**	**14,950**	**0**	**19,400**
PROJECT TOTAL					**165,800**	**165,800**	**331,600**	**173,622**	**150,028**	**341,162**	**(7,822)**	**15,772**	**12,400**