LIVING IN KARST

Iowa Geological Survey
Guidebook Series No. 25

IOWA FIELD CONFERENCE FOR PUBLIC POLICY MAKERS
OCTOBER 11-12, 2005

Iowa Department of Natural Resources
Jeffrey R. Vonk, Director
October 2005

COVER

The collapse of rock and soil into underground crevices and caves causes sinkholes (circular pits) in regions of shallow limestone.

Aerial photo over Clayton County by Gary Hightshoe, Iowa State University

Printed in-house on recycled paper.

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Edited by
Robert D. Libra

With contributions by

Paul Berland
Northeast Iowa RC & D

Bruce Blair
Iowa DNR-Forestry

Michael Bounk
Iowa DNR-Geological Survey

Lora Friest
Northeast Iowa RC & D

Scott Gritters
Iowa DNR-Fisheries

Cathy Henry
U.S. Fish and Wildlife Service

John Hogeman
Winneshiek County Landfill

Bill Kalishek
Iowa DNR-Fisheries

Chad Kehrli
Iowa DNR-Field Office #1

Rick Langel
Iowa DNR-Water Monitoring

Bob Libra
Iowa DNR-Geological Survey

Jeff Myrom
Iowa DNR-Solid Waste

Eric O'Brien
Iowa DNR-Water Monitoring

Karen Osterkamp
Iowa DNR-Fisheries

Dave Pahlas
City of Decorah

John Pearson
Iowa DNR-Parks & Recreation

James Ranum
Nat. Res. Cons. Service

LuAnn Rolling
Nat. Res. Cons. Service

Joe Sanfilippo
Iowa DNR-Field Office #1

Mary Skopec
Iowa DNR-Water Monitoring

Mike Wade
Iowa DNR-Field Office #1

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Many people assisted in the preparation of the field conference and guidebook. Those listed herein without affiliation are Iowa DNR staff. Contributors providing written work are listed on the title page. In particular, Joe Sanfilippo, Bill Kalishek, Lora Friest (NE IA RC&D), Luann Rolling (NRCS-Allamakee County), John Pearson, and Bruce Blair provided significant input to the trip design and details. In addition, Paul Van Dorpe organized the logistics for the trip. Jim Janette (Allamakee County Conservation Board) Gary Shawver (Shawver Well Company), and Gene Tinker provided expertise at trip stops. Ray Anderson and Adam Kiel (NEIA RC&D), and in particular Calvin Wolter prepared many of the illustrations. Pat Lohmann formatted the guidebook and provided expertise on the graphics and design. Lois Bair, Chad Fields, Chris Kahle, Eric O'Brien, Lynette Seigley, and Calvin Wolter served as reviewers for the guidebook. Sharon Tahtinen, Mary Pat Heitman, Lois Bair, Karyn Stone, Lisa Ogle, and Tammie Krausman provided administrative support. Wayne Gieselman and Jeff Vonk provided management support. Finally, we acknowledge the numerous landowners who provided access to their property, and to the field conference participants.

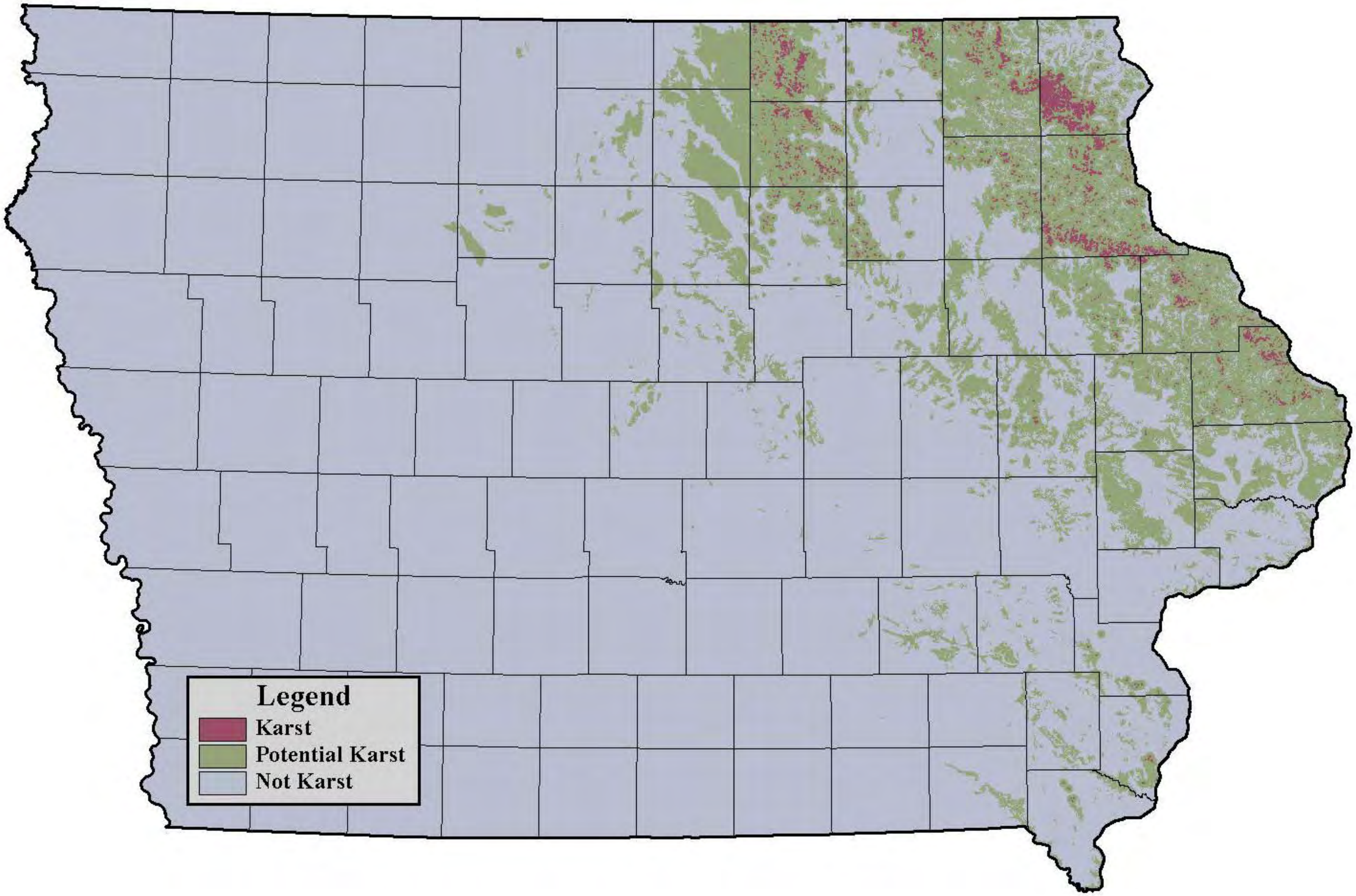


Figure 1. Areas in the state with varying levels of karst development and potential.

INTRODUCTION

The Karst Landscape of Northeast Iowa

Bob Libra, State Geologist, Iowa Department of Natural Resources (DNR)-Geological Survey

A variety of geologic factors have produced the karst, shallow rock, high relief landscape of northeast Iowa. First, Paleozoic age carbonate (limestone and dolomite) rocks form the uppermost bedrock over much of the area. These carbonate strata are broken into various sized "blocks" by vertical fractures and roughly horizontal bedding planes. As groundwater circulates through these cracks, it slowly dissolves the rock away, creating wide fractures, pipes, voids, and caves. Second, erosion has removed much of the glacial deposits that once covered the landscape, leaving the carbonate rocks near the surface, typically within 25 feet, and often within 10 feet. When rock that contains voids and openings is combined with a thin cover of soil, the soil may collapse into the rock openings, producing sinkholes. Finally, the proximity of this area to the deeply-cut Mississippi River Valley has resulted in steep, deep stream valleys.

These solutionally modified karst-carbonate rocks are excellent aquifers. They are capable of transmitting large quantities of groundwater at quite fast rates. However, the presence of sinkholes allows surface runoff and any associated contamination to directly enter these rock strata. When sinkholes or enlarged fractures occur in stream valleys and other drainage ways, entire streams may disappear into the rock. These streams are called "losing streams." In addition, "between the sinkholes," the thin soil cover provides much less filtration of percolating water than occurs elsewhere in the state. These factors make the aquifers, and water wells tapping them, very vulnerable to contamination, and allow any contaminants that reach the aquifer to spread long distances very quickly – especially by groundwater standards.

Water – and any contaminants – enter karst-carbonate aquifers via sinkholes, losing streams, and by infiltration through the shallow soils in flat upland areas. The water travels through cracks and voids to the water table, below which all voids are water-filled. The groundwater then travels "down-flow" through the broken rocks to springs and seeps along the deeply cut stream valleys. These springs and seeps supply much of the stream flow in shallow rock areas. The carbonate aquifers are underlain by less transmissive rocks, called confining beds, which act as the "bottom seal" of the aquifer. Springs and seeps are most prominent where the contact between the aquifer and the underlying confining bed is exposed in valleys.

Karst conditions affect other parts of the state. Figure 1 shows areas in the state with varying levels of karst development and potential. However, the most visibly developed karst occurs in northeast Iowa. Figure 2 is a generalized stratigraphic column for northeast Iowa, showing the sequence of rocks that underlie the area. Figure 3 is a generalized geologic map showing where the various rock units form the uppermost rock. The unit called the Galena Limestone is the most karst-affected unit. In particular, most of the sinkholes and large springs in this area are formed in this unit. The unit called the Prairie du Chien Dolomite is another carbonate unit that exhibits voids and dissolved fractures, but few sinkholes. We will be referring to the rock column and geologic map throughout the trip to keep ourselves geographically and geologically located.

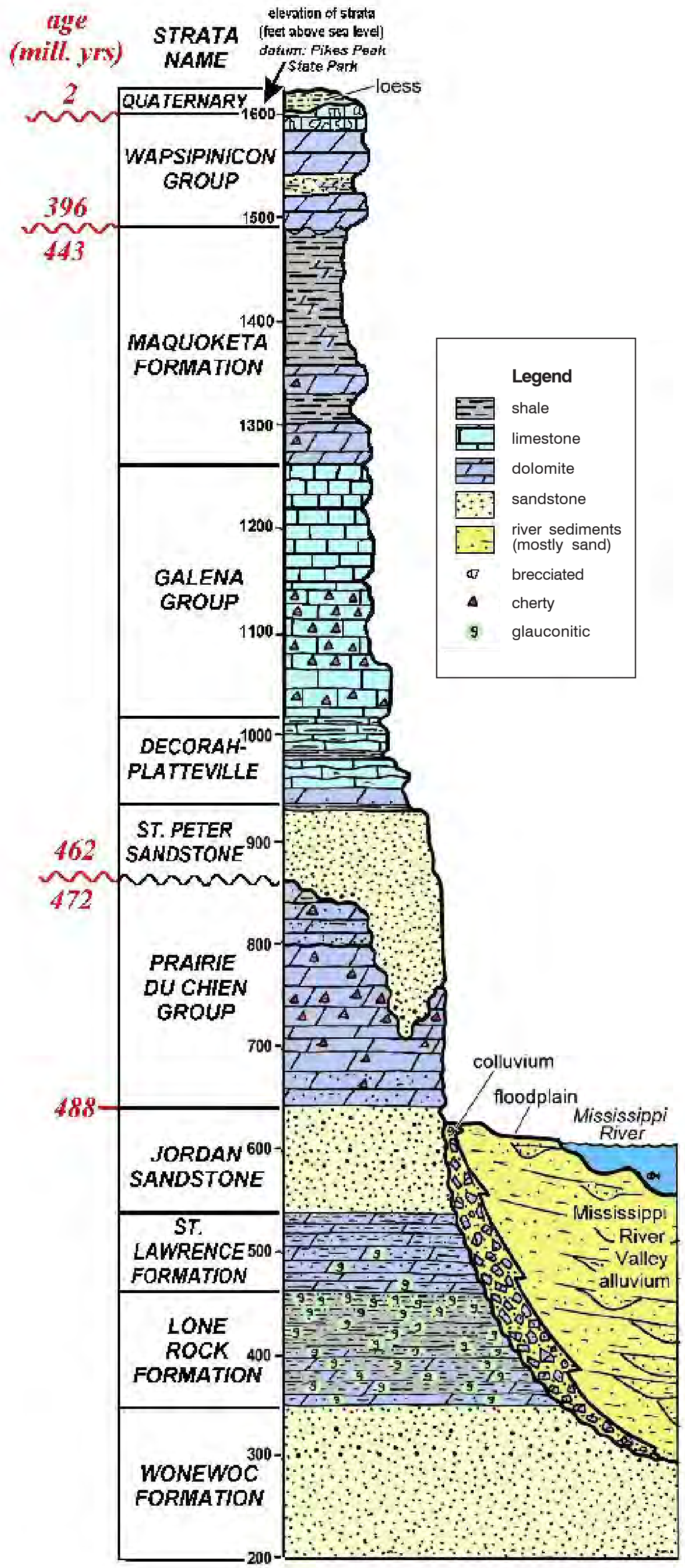


Figure 2. Generalized stratigraphic column of northeast Iowa.

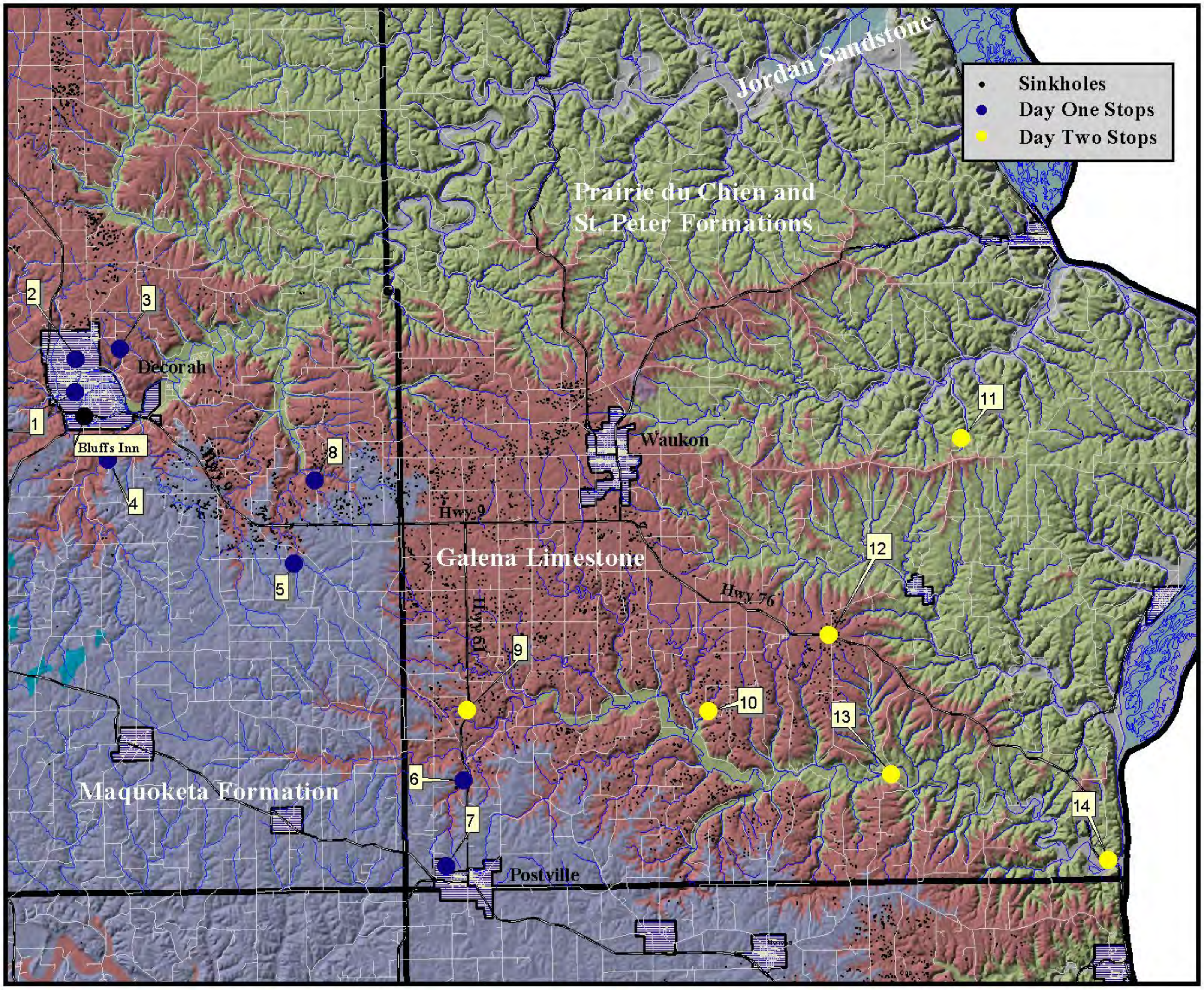


Figure 3. Generalized geologic map of northeast Iowa showing field conference stops.

Table 1-1. Algific slope snails and plants.

Common Name	Scientific Name	State Status[1]	Federal Status[2]
SNAILS			
Iowa Pleistocene Snail	*Discus macclintocki*	Endangered	Endangered
Frigid Ambersnail	*Catinella gelida*	Endangered	
Minnesota Pleistocene Ambersnail	*Novisuccinea sp. A*	Endangered	
Iowa Pleistocene Ambersnail	*Novisuccinea sp. B*	Endangered	
Briarton Pleistocene Vertigo	*Vertigo briarensis*	Endangered	
Midwest Pleistocene Vertigo	*Vertigo hubrichti*	Threatened	
Bluff Vertigo	*Vertigo meramecensis*	Threatened	
Occult Vertigo	*Vertigo occulta*	Threatened	
Iowa Pleistocene Vertigo	*Vertigo new species*	Threatened	
PLANTS			
Balsam Fir	*Abies balsamea*	Special Concern	
Northern Wild Monkshood	*Aconitum novaboracense*	Threatened	Threatened
Moschatel	*Adoxa moschatellina*	Special Concern	
Golden Saxifrage	*Chrysosplenium iowense*	Threatened	
Bunchberry	*Cornus canadensis*	Threatened	
Limestone Oak Fern	*Gymnocarpium robertianum*	Special Concern	
Northern Lungwort	*Mertensia paniculata*	Endangered	
Bog Bluegrass	*Poa paludigena*	Special Concern	
Northern Currant	*Ribes hudsonianum*	Threatened	
Prickly Rose	*Rosa acicularis*	Endangered	
Rosy Twisted-stalk	*Streptopus roseus*	Threatened	

1) *State status definitions*. Endangered: likely to become extinct in state, protected by state law; Threatened: likely to become Endangered in state, protected by state law; Special Concern: in need of study of distribution and status in state, not protected by state law.
2) *Federal status definitions*. Endangered: likely to become extinct in all or a significant portion of its total range. Threatened: likely to become Endangered in all or a significant portion of its total range. Threatened and Endangered plants are protected by federal law on federal lands; Threatened and Endangered animals are protected by federal law throughout their national range.

STOP 1.

Phelps Park – The Northeast Iowa Landscape and Water Quality

Geologic Setting

Our first stop, Phelps Park, overlooks the Upper Iowa River Valley from a cliff-like hillside formed by Galena Limestone. These rocks are also visible in numerous road cuts through the hills in the Decorah area. From river level to the top of the bluffs at Phelps Park, most of the Galena Limestone is on display. Unlike the roadcuts, the exposures here are natural, formed by the down cutting of the Upper Iowa River. Natural exposures are often vegetated, and because of the karstic nature of the Galena Limestone, this vegetation may be quite unique – as is the case in Phelps Park.

Algific Talus Slopes: A Special Natural Habitat
in the Karst Landscape of Northeast Iowa
John Pearson, Botanist, Iowa DNR-Parks & Recreation Division

Karst – the fractured limestone and dolomite bedrock that underlies the landscape across much of northeast Iowa – displays interesting geologic, topographic, and hydrologic features. Under specialized circumstances, it can also support a rare biological habitat known as an "algific talus slope." To understand this term, let's examine its components:

- "Slope"– in this case, the term is referring to steep, rocky hillsides, usually north-facing, forested, and deeply shaded.

- "Talus"– rock piles comprised of cobbles and boulders that have tumbled from rock outcrops and accumulated at the bottom of cliffs and steep hillsides. When talus is composed of large, irregularly shaped rocks, air can move through vents formed by gaps and holes.

- "Algific"– a technical term meaning "cold air." During winter, shallow groundwater in fractured bedrock freezes; during summer, cold air from the slowly melting ice seeps outward from bedrock, flows through talus, and emerges onto the surface, especially through vents.

The flow of cool, moist air over the surface of algific talus slopes creates an unusual microclimate, simulating the regional climate that prevailed over Iowa and the Midwest at the end of the Pleistocene ice age thousands of years ago. As the regional climate warmed at the end of the ice age, Iowa became uninhabitable for plants and animals adapted to the cold climate; many of these species are now found in the boreal forests of Canada. However, due to their unique geologic setting, algific talus slopes (each generally less than one acre in size) maintained small pockets of cold microclimate within the warming macroclimate. Although not large and contiguous enough to support the full flora and fauna of the original boreal forest, algific talus slopes do harbor relict populations of several plant and animal species, mainly snails and wildflowers, typical of colder climates.

In the United States, algific talus slopes are rare, primarily occurring as small, scattered remnants. Many of the snail and plant species of algific talus slopes are found solely in this habitat (Table 1-1). Reflecting their national rarity, two of them are also federally listed: the Iowa Pleistocene Snail (Endangered) and Northern Wild Monkshood (Threatened).

Maintaining these plants and animals as viable members of Iowa's flora and fauna will require protection of their unique algific habitat. Fortunately, due to their locations on steep, rocky hillsides, most algific talus slopes are generally unsuited for roads, houses, and cropfields and are naturally "safe" from development. However, some algific talus slopes have been unknowingly damaged by construction of roads, powerlines, and fences, as well as by roadside spraying and heavy grazing. In addition to the algific talus slopes themselves, sinkholes on nearby uplands also need protection from dumping of wastes because water entering sinkholes can re-emerge in algific talus slopes.

A cooperative effort among the Iowa Department of Natural Resources, the U.S. Fish and Wildlife Service, The Nature Conservancy, and various county conservation boards to protect algific talus slopes has resulted in the acquisition of several high-priority sites. In particular, several key properties have been purchased from willing landowners and placed under the protective stewardship of the Driftless Area National Wildlife Refuge, a unique refuge dedicated to federally listed species of algific talus slopes. As one of its environmental protection efforts, the Iowa Department of Natural Resources maintains a statewide database on the known locations of endangered, threatened, and special concern species – including those inhabiting algific talus slopes – and uses this information to alert developers of potential conflicts before work commences. Experience has shown that minor adjustments to the design of projects generally avoid impacts to rare natural habitats. Increasing awareness of the value and fragility of algific talus slopes among land managers and the public in general will ensure the perpetuation of these interesting natural features into the future.

Decorah's Water Supply

Dave Pahlas, Supervisor, City of Decorah Water and Sewer

The City of Decorah has endorsed and supported the goals of the Upper Iowa Watershed Protection Project since its inception in 1999. This support is evidenced by assistance from City employees in collecting water samples and annual monetary contributions.

There are several significant concerns that have propelled the City's interest in working cooperatively with State and Federal agencies on water issues. One prime example involves the increasing nitrate levels in the Upper Iowa River and our city wells over the last thirty years. Although analysis of the data does not indicate a direct correlation between nitrate levels in the river to levels within the City wells, the importance of continuous intergovernmental cooperation leading to highly credible conclusions may very well enable the implementation of more effective preventive measures.

An experience that began in 1992 with the PCE contamination of two City wells also serves to illustrate the success resulting from solid cooperation and meaningful communication. Arrangements with the Iowa DNR led to the availability of resources from the Hazardous Remediation Fund. Through a clear but sufficiently flexible agreement, the City managed the cleanup while working closely with the DNR in monitoring the effectiveness of this effort. By 1997, one well was placed back in service while the second well was producing water with no detectable levels of the PCE within two years.

A third example of beneficial cost-sharing arrangements can be found in the City's on-going relationship with the U.S. Geological Survey in our mutual need for stream-flow data and river stage information. This kind of cooperative venture encourages interested parties to share valuable data. In that process, those parties charged with various responsibilities involving watershed management avail themselves of greater amounts of data with concomitant cost-saving measures.

Of course, many water quality concerns require a medium to long-term horizon with regard to the collection and verifiable analysis of the data. The general Decorah area perhaps warrants extraordinary diligence due to the shallow aquifers, the karst topography with its particular vulnerabilities, and the unique characteristics of our aquifers. While appreciated along with other features of our surrounding environs, these distinctions cause us to perhaps more vividly recognize the challenges and rewards that cooperative efforts can bring in monitoring and preserving water quality.

Sources of Bacteria in the Upper Iowa River: Water Quality and DNA

Eric O'Brien, Biologist, Iowa DNR-Geological Survey Water Monitoring
Mary Skopec, Supervisor, Iowa DNR-Geological Survey Water Monitoring

The Upper Iowa River and its watershed are valuable natural and economic resources located in extreme northeast Iowa and southeast Minnesota. The Upper Iowa River watershed is a 1,005-square-mile watershed recognized by the U.S. Environmental Protection Agency and the State of Iowa as a priority watershed for water quality protection. This river system is heavily utilized for swimming, tubing, and canoeing. The river has a variety of water quality issues. Some reaches of the river were placed on Iowa's Impaired Waters List in 2004. Concentrations of the indicator bacteria *E. coli* exceed state standards for body contact in recreational waters. Efforts to lower bacteria levels need information on the source(s) of the bacteria. In the Upper Iowa Watershed, this involves knowing where the water sources are. The presence of sinkholes and losing streams, which may contribute bacteria-laden runoff to the complex groundwater system, complicates the question of where the bacterial sources are located. Further, in all our watersheds, there are questions as to the biological sources of bacteria. Are they from human waste, livestock manure, or wildlife? In an attempt to address the latter question, the DNR's Water Monitoring Program, in conjunction with the University of Iowa Hygienic Laboratory and Upper Iowa River Watershed Alliance, began efforts to use DNA identification techniques to determine the sources of bacteria impairing the river.

One such technique is DNA ribotyping**,** which involves comparing DNA patterns or "fingerprints" of *E. coli* bacteria from affected waters to DNA fingerprints of *E. coli* from known sources of fecal material in the watershed. Researchers believe that the DNA of bacteria taken from fecal matter may vary substantially from one watershed to the next. Therefore, the collection of known sources of fecal material in a particular watershed is necessary to generate a DNA fingerprint database or library for the watershed for comparison with unknown bacteria in the water.

The Upper Iowa River Watershed Alliance has monitored 39 stream sites throughout the Upper Iowa River Watershed since 1999 in an effort to identify sub-watersheds that are contributing elevated levels of fecal indicator bacteria to the Upper Iowa River. The water quality monitoring identified six sub-watershed tributaries that had elevated bacteria levels. Three of the six tributaries were selected for a bacteria source tracking project: Coldwater

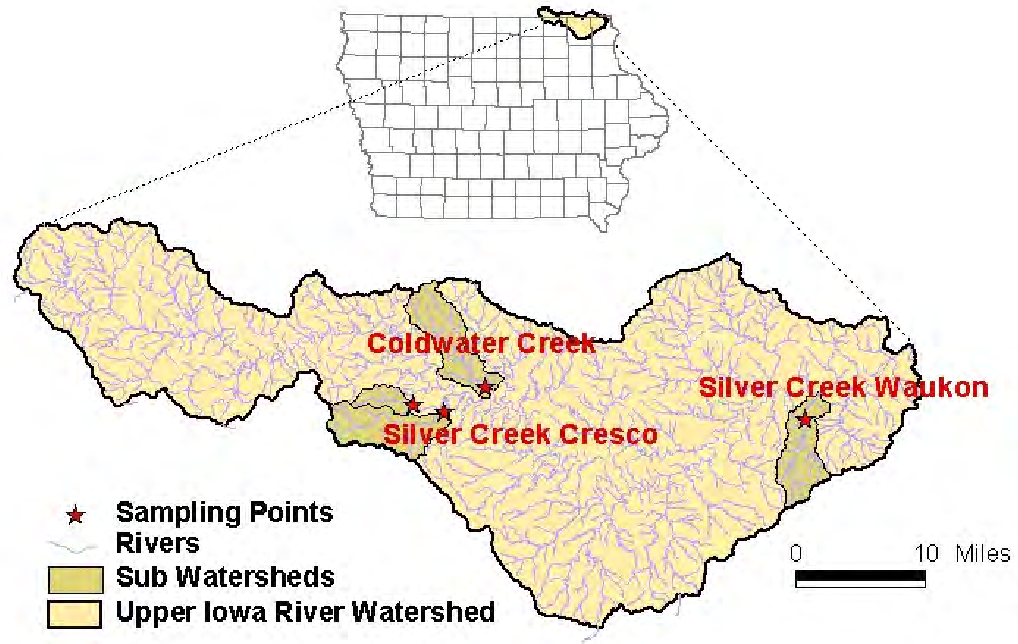


Figure 1-1. Water monitoring locations for DNA source tracking analyses.

Creek, Silver Creek near Cresco, and Silver Creek near Waukon. Potential bacteria sources in these sub-watersheds include runoff from feedlot and manure-amended agricultural lands, inadequate septic systems, and wildlife.

The Upper Iowa Bacteria Source Tracking Project, begun in 2002, used DNA ribotyping to identify sources in the Upper Iowa River Watershed and initiated the establishment of a statewide *E. coli* bacteria DNA database. A total of 259 *E. coli* isolates from known manure sources (e.g., hog, cattle, sheep, goose, raccoon, deer, and human) were collected and analyzed to build a statewide ribotyping library with patterns from known Iowa strains. After obvious outliers were removed, the following *E. coli* strains were used in the identification of sources in the three Upper Iowa sub-watersheds: cattle (88), deer (35), human (27), geese (26), and swine (24). DNA ribotyping was performed on 50 *E. coli* strains from water samples taken from the three sub-watersheds in Coldwater Creek, Silver Creek near Cresco and Silver Creek near Waukon (see Figure 1-1). When looking at the bacteria in the water and comparing it to the DNA database, it was noted that human, cattle, and other animal fecal material were all present in the water. DNA ribotyping successfully discriminated between human and cattle bacterial sources. However, the number of *E. coli* strains was insufficient to distinguish between the other animal sources.

STOP 2.

Dunning Spring Park – Karst, Water Quality, and Economics

Geologic Setting

Dunning Spring issues from near the base of the Galena Aquifer. The much less permeable Decorah Shale - the confining bed “floor” for the aquifer - is near the land surface, forcing the water to discharge from the wall of the Upper Iowa River Valley. The result is the picturesque falls. The groundwater issuing from the spring is flowing through an open, cavernous conduit, formed by the solutional enlargement of fractures. Solutionally modified fractures and cracks are the most common characteristic of karst. The water from this (and most larger springs in the area) maintains a fairly constant temperature of about 45 degrees F most of the year. Exceptions occur after snowmelt or heavy rains when colder or warmer water rapidly enters the aquifer via sinkholes and losing streams. About 50 feet below our feet is the contact between the Decorah confining bed and the underlying St. Peter Sandstone. Figure 2-1 shows the area around Dunning Spring, with sinkholes mapped to the north. Our next stop, Skyline Quarry, is also visible.

Northeast Iowa Economics: Tourism, Agriculture, and Water Quality
Lora Friest, Northeast Iowa Resource Conservation and Development (RC&D)

Northeast Iowa communities balance the economics of agriculture and tourism everyday. On one side of the scale is a strong agricultural community with a rich heritage that includes hundreds of small livestock and dairy producers managing hay and pasture on steep highly erodible slopes. On the other side of the scale is a burgeoning recreation and tourism industry that capitalizes on the beautiful and unique features found in the rolling hills of Northeast Iowa, and the coldwater fisheries and streams that flow through them. The marriage of these two industries creates a balanced, diverse economy, but it also creates an environment for conflict when one industry tries to dominate the resources or when shifts in one industry negatively impact the other. This stop will give you some food for thought, provide hard numbers about the economic benefits of each industry, and open discussion on how easily shifts in one can significantly impact the other. It will also give participants an opportunity to think about the potential future of recreation/tourism and agriculture in a landscape where surface water and groundwater moves through watershed systems faster than anywhere else in the state.

Northeast Iowa Trout Streams
Bill Kalishek, Biologist, Iowa DNR-Fisheries

All of Iowa’s 105 trout streams are located in 10 counties in the northeastern part of the state. Trout have a water temperature requirement that restricts their distribution in Iowa. In general, trout cannot survive in water greater than 75 degrees. Most Iowa waters will reach maximum summer water temperature of greater than 80 degrees. The only waters that stay cold enough during the summer to support trout are the spring-fed streams that drain from the karst topography of northeast Iowa.

A coldwater trout stream is a very complex natural system. The quality of the stream is affected by the underground aquifer that forms the spring flow, the surface watershed that drains into the stream, the land use immediately along the stream and the physical characteristics in the stream itself. High quality trout streams result from successful partnerships between private landowners and conservation agencies in the management of these natural resources.

Trout fishing is a major economic force in northeast Iowa. It is estimated that angler expenditures for all Iowa coldwater trout fisheries total $13.9 million per year. This estimate is based on data from the U.S. Fish and Wildlife Service and Iowa DNR surveys of Iowa trout anglers that were conducted in 2001. The American Sportfishing Association's report "Sportfishing in America" indicated the retail sales related to all fishing in Iowa was $356 million and total economic output from these sales was $728 million.

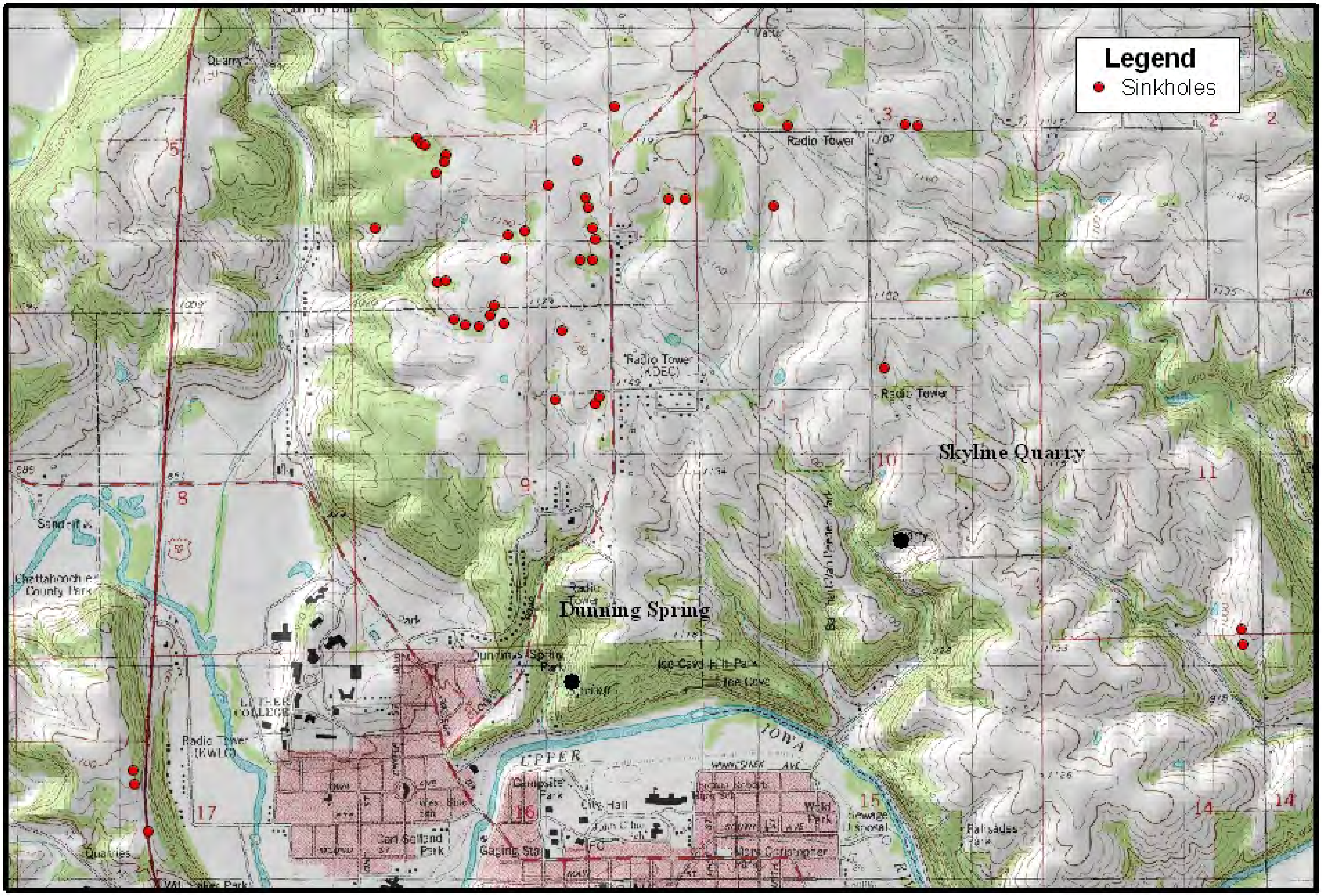


Figure 2-1. Topographic map of Dunning Spring–Skyline Quarry area with sinkholes.

STOP 3.

Skyline Quarry – The View from Inside an Aquifer

Bob Libra, State Geologist, Iowa DNR-Geological Survey

Skyline Quarry is owned and operated by Bruening Rock Products Inc. The Galena Limestone is quarried here. As you enter the quarry, you are in essence "stepping into" the Galena Aquifer. Visible in the quarry walls are nearly vertical fractures and nearly horizontal bedding planes that have been solutionally enlarged to varying degrees. These are the pathways that groundwater flows through. The rock "matrix" itself has little permeability and transmits little groundwater. As the groundwater is forced to flow through only a small percentage of the rock, it moves relatively fast. Where large, open, cavernous conduits are present, dye traces have shown flow rates ranging from miles per hour following rainstorms to thousands of feet per day during dry periods. The larger voids act as drains for the aquifer, and groundwater within smaller openings and fractures follows the path of least resistance, moving towards the larger voids. Geologists spend much time explaining that groundwater isn't contained in underground rivers. However, in karst aquifers the underground river analogy isn't that far off; major conduits are like the main stem of a river, and the smaller voids and fractures are like a three-dimensional web of tributaries. This is in contrast to sand, gravel, and sandstone aquifers, where groundwater movement is more uniform throughout the aquifer, and much slower as it works its way between the individual sand and gravel particles.

At the top of the quarry walls, only a thin cover of unconsolidated soils are present. Beneath this thin soil mantle, fractures widen. This is the result of void formation near the top of the bedrock, a common occurrence in karst that marks the first steps towards sinkhole formation. A larger sinkhole is also exposed in cross-section by the quarry walls. The combination of a thin soil cover that offers limited filtration and protection from any contamination in downward-percolating soil water, sinkholes which capture surface runoff and direct it into the aquifer, and essentially no removal of contaminants from the fast moving groundwater in the fractures results in common water quality problems in the Galena Aquifer. As this aquifer supplies much of the "baseflow" for area streams, any contamination is delivered to the streams as well.

Long-term groundwater monitoring has been conducted at Big Spring, which drains a 100-square-mile area underlain by the Galena Limestone in Clayton County. On average over 15,000 gallons per minute of groundwater discharges from Big Spring to the Turkey River. For comparison, this is a little over one-half of the average amount of water produced by the Des Moines Water Works. Land use in Big Spring's "groundwater-shed" is essentially all agricultural. Typically, 45-50% of the land is in corn production and 35-40% is used to raise alfalfa. Small dairy and hog operations are common. Concentrations of nitrate-N at Big Spring commonly are near the 10 mg/L U.S. EPA drinking water standard. Low levels of atrazine (0.1 to 1.0 ug/L) are typically present, along with 200 to 300 ug/L of phosphorus. Fecal bacteria levels are commonly in the hundreds to thousands of colonies/100 ml. Concentrations of phosphorus, bacteria, and herbicides are generally 1-2 orders of magnitude greater following major rainfall events. These data point out the vulnerability to contamination of this productive karst aquifer.

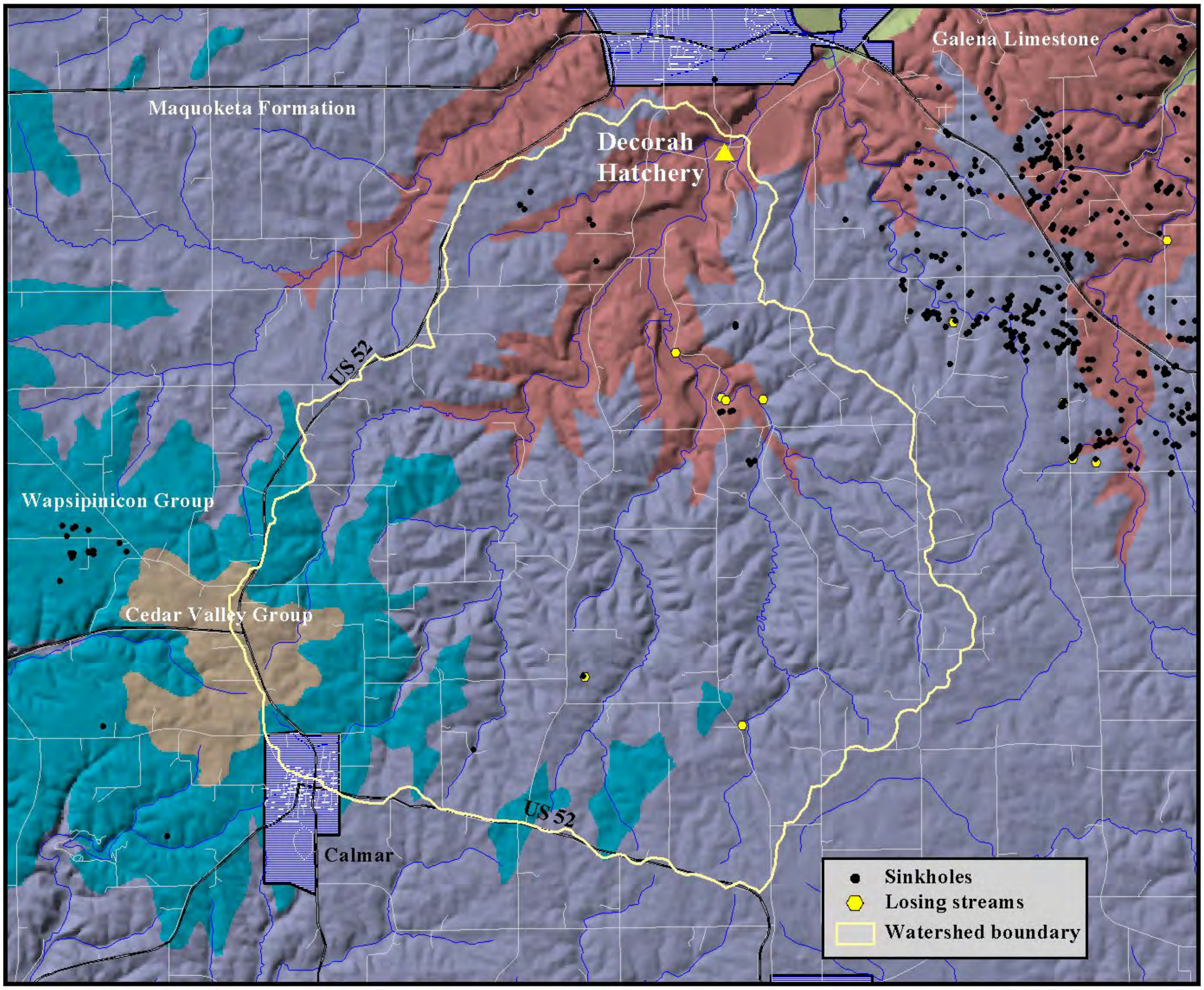


Figure 4-1. Geologic map of the Trout Run watershed area.

STOP 4.

Decorah Hatchery – Trout Production and Water Quality

Geologic Setting

The Decorah Hatchery is fed by Siewers Spring, which discharges groundwater from the Galena Limestone to Trout Run Creek. The Trout Run watershed is shown in Figure 4-1. Relatively few sinkholes are shown on the county soil survey for the watershed, although more are known to exist. Losing stream segments have also been observed, some which drain into sinkholes. Many more sinkholes occur in the watershed to the east, and these may contribute water to the spring as well.

The Decorah Hatchery

Karen Osterkamp, Biologist, Iowa DNR-Fisheries

Decorah State Trout Hatchery, built in the early 1930s, was originally “Siewers Spring Bass Hatchery.” Smallmouth bass and northern pike were reared in earthen ponds and trout in concrete raceways. Beginning in 1978, the hatchery concentrated entirely on producing catchable–sized trout. Today, nearly 300,000 trout pass through the hatchery each year.

Siewers Spring is also the source of Trout Run Creek, a high priority coldwater stream. Civilian Conservation Corps constructed a retaining dam of masonry rock impounding the spring in 1934. A flume connecting the impounded water diverted water into ten one-acre earthen ponds. The underground water source of Siewers Spring supplies 48-50 degree water year round at a rate of 3,000 to 5,000 gallons per minute, yielding ideal temperatures and quantity for trout rearing. The approximately 23,000-acre watershed south of the hatchery recharges the spring. Although the quantity of water from Siewers Spring has always been dependable, during rainfall events the sinkhole-driven water source can be contaminated by heavy silt loads and high concentrations of nitrogen gas. These runoff events plagued the hatchery causing severe fish mortality and health problems, and fish production and efficiency was greatly impacted.

The hatchery was renovated in 1988-1989 with Sport Fish Restoration and Iowa Fish and Wildlife Trust funds. Approximately 2.4 million dollars was spent to build a spring water clarifier basin, degassing tower and oxygen injection system to compensate for the poor water quality emerging from Siewers Spring. In addition, four vertical turbine pumps were installed to supply twenty-four new concrete raceways and three lined ponds. The new facility is capable of mitigating some of the water quality problems by allowing much of the silt to settle out before entering the rearing raceways. However, compared to the original gravity flow hatchery, the new facility needs more maintenance and has increased demand for electricity because of the additional equipment required to run it.

Problems with fish health are still directly related to runoff events and necessitate costly treatments to minimize disease outbreaks. It is apparent that additional improvements in the watershed will have a positive impact on fish health, which is closely tied to the quality of Siewers Spring’s water as it enters the facility.

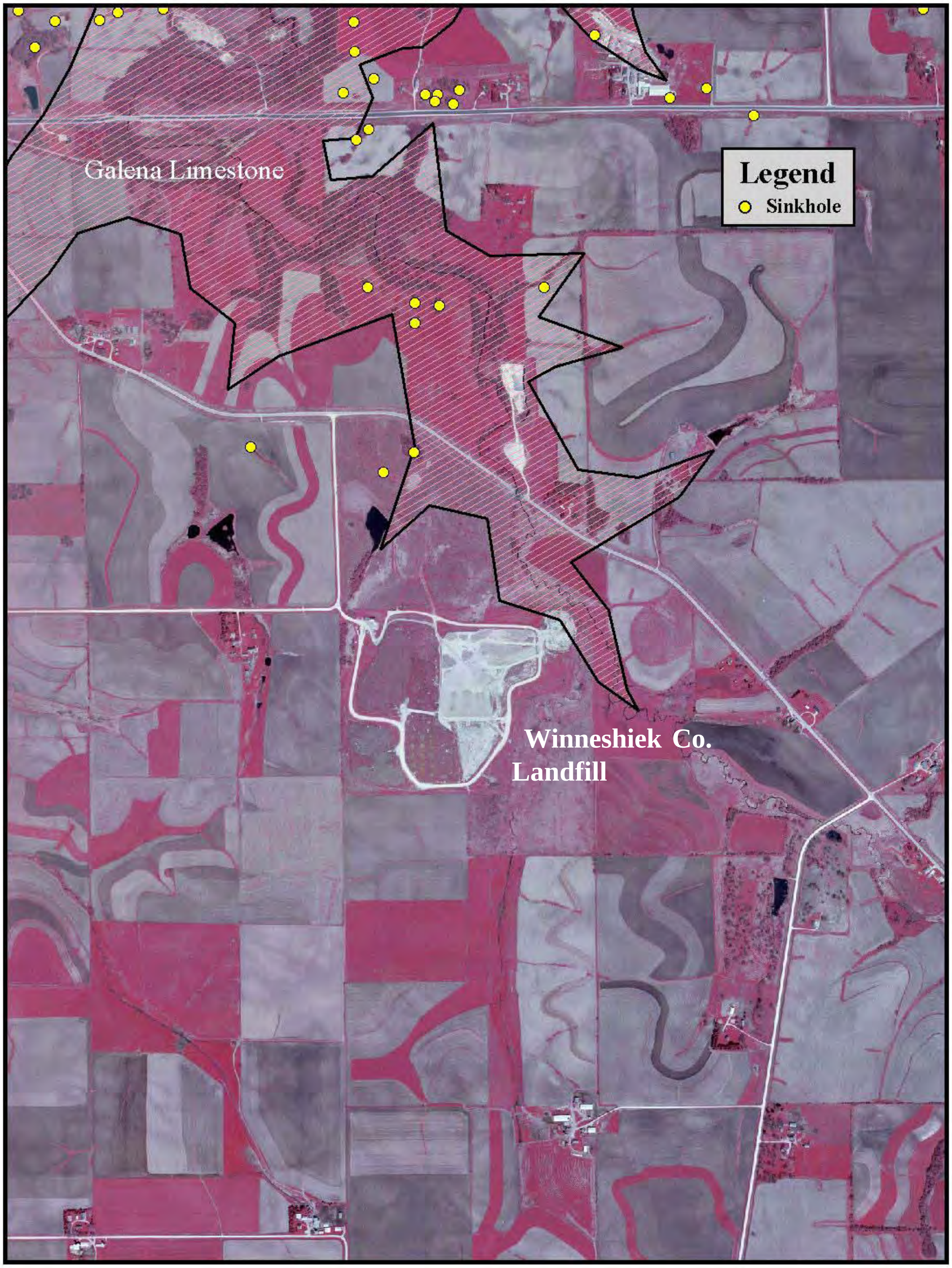


Figure 5-1. Color infrared photo of landfill area.

STOP 5.

Winneshiek County Landfill – Solid Waste in Karst

Geologic Setting

The Winneshiek County landfill lies within a few miles of some of the most karst-affected areas in the state. We passed sinkholes as we approached the landfill driveway. How can a landfill be in such a setting? Relatively subtle changes in the underlying geology occur as we reach the landfill area. Here, more slowly permeable shale and shaley carbonate rocks of the Maquoketa Formation overlie the Galena Limestone. The Maquoketa rocks are less prone to fracturing and karst formation, although the lowermost part of the formation does exhibit some sinkholes. Also, there is a somewhat greater thickness of glacial deposits here. Taken together, these deposits provide suitable materials for the landfill cells. Figure 5-1 shows the landfill, nearby sinkholes, and the outcrop area of the Galena Limestone.

Landfills in Iowa

Jeff Myrom, Iowa DNR-Solid Waste

Iowa has 59 permitted Municipal Solid Waste Landfills (MSWLFs). Of these, 5 are privately owned and 54 are owned by cities, counties, or a collection of local governments through a 28E agreement. No new MSWLF has been sited in Iowa since the 1980s. To increase disposal capacity, most MSWLFs now pursue a combination of vertical and horizontal expansions from existing disposal cells.

Approximately half of Iowa's 59 MSWLFs meet the minimum federal standards for liners and leachate collection systems specified in 40 CFR 258, commonly referred to as RCRA Subtitle D standards. However, by October 1, 2007, all operating MSWLFs in Iowa must have a composite liner (2 feet of clay compacted to 1x10-7 cm/sec permeability and a flexible plastic liner over top of that) or an approved alternative liner (typically 4-5 feet of clay compacted to 1x10-7 cm/sec permeability).

Of the 29 RCRA Subtitle D compliant MSWLFs, 16 use composite liners and 13 use alternative liners. Furthermore, it appears that most of the 30 non-compliant MSWLFs will construct new, adequately lined disposal cells before the October 1, 2007 deadline. At this time, only 3 non-compliant MSWLFs have elected to close.

Landfill Operations

John Hogeman, Winneshiek County Landfill Operator
Joe Sanfilippo, Supervisor, Iowa DNR-Manchester Field Office

The Winneshiek County Sanitary Landfill opened for business in 1974 as a private operation. The landfill property, including the ground, equipment and landfill engineering plans were the property of Nishna Sanitary Service. Nishna operated in Winneshiek County under limited control by the Winneshiek County Board of Supervisors. In 1991 Winneshiek County decided that increased control of the landfill was needed and the landfill was purchased from Nishna. Since that time, Winneshiek County has leased the landfill to the Winneshiek County Area Solid Waste Agency for operating purposes.

The Winneshiek County Sanitary Landfill is a regional landfill serving the counties of Winneshiek, Howard, and Clayton, the municipality of Postville, and Fillmore County in Minnesota. The population served by the Winneshiek County Sanitary Landfill is approximately 63,000.

The tipping fee at the landfill is $56.00 per ton. All items accepted at the landfill, with the exception of appliances and brown goods, are charged by the ton. Appliances are charged $18.00 each with the exception of commercial appliances, which are charged at $1.50 per cubic foot of total unit size. Brown goods, which include TV's and computer monitors, are charged $18.00 each. Fluorescent light ballasts are charged $5.00 each. There is no minimum charge at the landfill. The tipping fee at the landfill is the sole means of revenue collected.

It is estimated that the remaining life of this landfill is 14 years (2019). When the landfill is closed the Winneshiek County Area Solid Waste Agency is required to monitor and maintain the site for the following 30 years. The items that will be monitored include methane gas production, settlement, groundwater, storm water runoff, leachate, fencing, vegetation, building maintenance, and erosion. Closure and post-closure costs at this site are included in the tipping fee that the current landfill customers are paying. Closure and post-closure costs at this site are currently estimated at $5,600,000.

The property owned by the county for this site is approximately 200 acres. The landfill foot print, the area that actually contains sold waste, is approximately 83 acres.

The Department of Natural Resources regulates landfills through the solid waste program. Landfills are tracked from the initial site selection (in this case by Nishna in 1974), through approval of the engineer's site plans, construction of base works, day-to-day operations, final closure, and the 30 year post-closure monitoring and maintenance.

The DNR's Solid Waste Section gives initial site approval, approves plans, and monitors reports that the landfill operators and responsible officials are required to submit. The reports include water monitoring, gas monitoring, and engineer inspections.

The DNR's Field Office located in Manchester inspects the site on a periodic basis for compliance with the solid waste regulations and to offer operator assistance. The Field Office also maintains a working relationship with the landfill personnel so they are aware that assistance from the DNR is available. The Field Office also works closely with the Solid Waste Section to insure that any concerns noted in any of the reports are properly addressed.

Groundwater Monitoring

Bob Libra, State Geologist, Iowa DNR-Geological Survey

Groundwater monitoring is required at all Municipal Solid Waste Landfills. Monitoring wells are placed and designed based on the "hydrogeologic investigation" that was done for each landfill. A range of parameters are measured depending upon well position and site history. In 2004, a review of annual monitoring reports from landfills was conducted by the DNR-Solid Waste and Geological Survey staff. At that time, there were 14 monitoring wells in use at the Winneshiek landfill. Wells monitor both the "top of the water table" within the unconsolidated deposits, and groundwater from the underlying bedrock. Two locations on Trout River are also monitored, as the stream passes close to the landfill and loses water into the Galena Limestone downstream to the north. While some monitoring wells have detected indications of landfill leachate in the shallow geologic materials, concentrations have not been significantly above background, and no upward trends were visually identified in the monitoring data. The review included a recommendation for better monitoring of the deeper zones, given the relatively vulnerable nature of the underlying aquifers. Stream sampling has shown minor contamination in Trout River. The landfill operates a leachate control/recirculation system which is likely helping to limit leachate movement.

A Trout Stream at a Landfill

Bill Kalishek, Biologist, Iowa DNR-Fisheries

Trout River is a small coldwater stream that originates 2 miles south of the Winneshiek County landfill. As the stream flows north toward its confluence with the Upper Iowa River it is adjacent to the east edge of the landfill site. Downstream of the landfill Trout River is a losing stream and goes completely dry in one segment during most summers. This stream has been stocked with four-inch fingerling brook trout yearly since 2000. Brook trout are the trout that are native to Iowa and the trout species that is the most intolerant of warm water temperatures and pollution. These trout have survived and flourished in the section of Trout River on the landfill property. Recent fishery surveys have shown good numbers of brook trout present with fish up to 14 inches in length. In the case of the Winneshiek County Landfill, a managed brook trout stream and a landfill are compatible uses for the same piece of property.

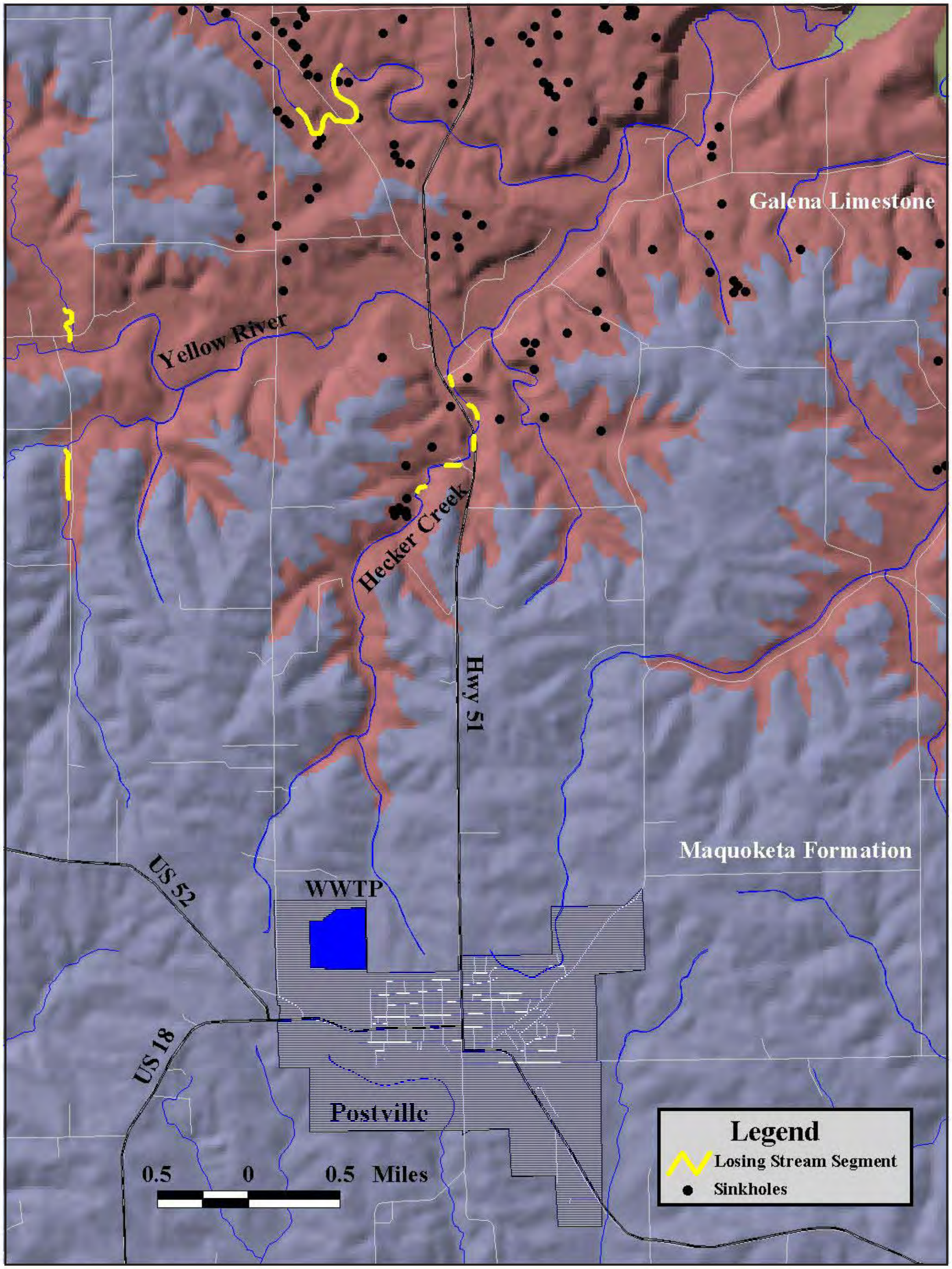


Figure 6-1. Geologic map of the Hecker Creek – Postville area.

STOP 6.

Hecker Creek – Losing Streams

Geologic Setting

Hecker Creek is a tributary of the Yellow River. The creek heads near Postville and joins the Yellow about 5 miles north, just a short distance downstream from this stop. The uppermost part of the watershed is underlain by bedrock of the relatively slowly permeable Maquoketa Formation, and a relatively thick cover of glacial deposits. As the stream flows north, its valley cuts into the underlying karstic Galena Limestone. Where the stream runs over the fractured Galena bedrock, it "loses water" into the rock. During relatively dry conditions, the entire flow disappears into the rock. At this stop we will visit one of the places the stream typically sinks. Figure 6-1 shows the Hecker Creek – Postville area.

Losing Streams in Iowa
Bob Libra, State Geologist, Iowa DNR-Geological Survey

Losing streams like Hecker Creek are not uncommon in northeast Iowa and other parts of the state that are underlain by shallow permeable bedrock. Some streams lose water into their underlying sand and gravel deposits, even when no shallow rock or karst is involved. Losing streams are complex to characterize, as the losing aspect may vary seasonally, and the locations where water goes into the ground often changes through the year with flow conditions. Efforts to map losing stream reaches, sinkholes, and springs are underway in northeast Iowa, including detailed geologic mapping to further our ability to predict where such features are most likely to occur.

The Yellow River in this area provides a larger example of a losing stream. Like Hecker Creek, the Yellow River heads on the slowly permeable Maquoketa Formation, and as its valley cuts into the karstic Galena Limestone, the river loses water into the rock. In the drier parts of most years, the Yellow River has no flow as it crosses the Galena Limestone (see Figure 3), although it is fed by an 80-square-mile watershed. Further downstream, the valley cuts into the Decorah Shale "floor" below the Galena. Where this occurs, numerous springs discharge groundwater into the Yellow River, and its flow from that point on downstream is typically perennial.

Losing streams are defined by Iowa Code:

"Losing streams" means streams which lose 30 percent or more of their flow during the seven-day, ten-year low stream flow periods to cracks and crevices of rock formations, sand and gravel deposits, or sinkholes in the streambed.

An additional part of the Code addresses losing streams this way:

The Escherichia coli (E. coli) content of water which enters a sinkhole or losing stream segment, regardless of the water body's designated use, shall not exceed a Geometric Mean value of 126 organisms/100 ml or a sample maximum value of 235 organisms/

100 ml. No new wastewater discharges will be allowed on watercourses which directly or indirectly enter sinkholes or losing stream segments.

Iowa streams, whether losing or not, commonly exceed these bacteria levels. At present, new discharges to losing streams are not allowed, regardless of the level of treatment.

Streams that lose water to fractured rocks and sinkholes are typically considered greater environmental and public health threats than those that lose water to sand and gravel aquifers, in that the lost surface drainage moves much faster and farther in fractured rock, and can appear in hard-to-predict places. The fractured rock situations also offers little or no filtration of contaminants. Testing in the Hecker Creek area provides an example of the complexity of karst systems.

Dye traces in the Hecker Creek area

Paul Berland, Regional Watershed Coordinator, Northeast Iowa RC&D

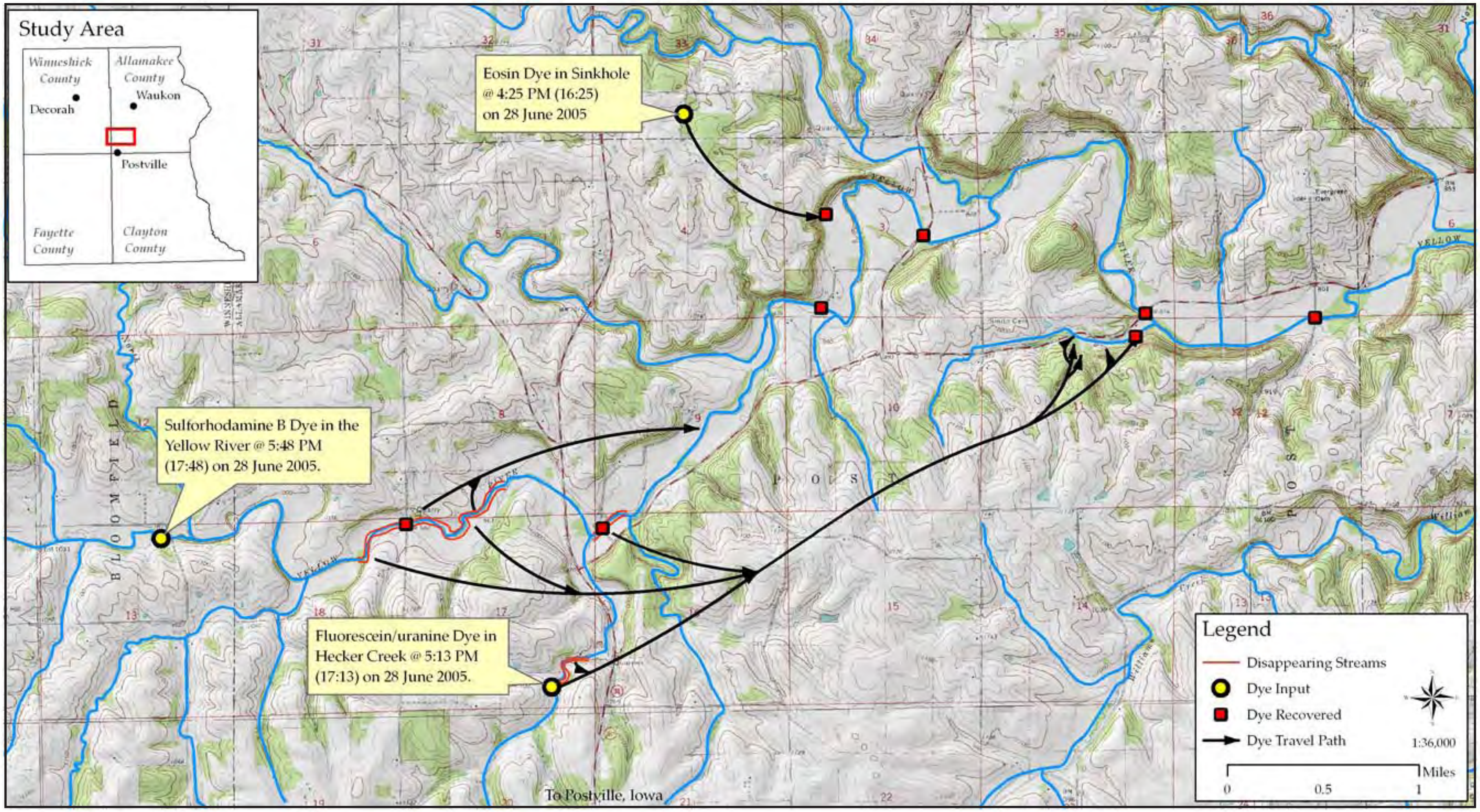
Northeast Iowa RC&D, through a grant from the Altria Group, conducted a series of dye traces along the Yellow River north of Postville during the summer of 2005, to gain an understanding of the dynamic surface water-groundwater interactions and travel paths in this part of the watershed. Northeast Iowa RC&D contracted Dr. Calvin Alexander, Professor of Geology at the University of Minnesota, to assist with the dye traces and analysis of the results. In order to map the watershed, three different color dyes were input into one of three distinct locations: 1) above this stream sink in Hecker Creek; 2) in the Yellow River upstream of where Hecker meets the Yellow River, and 3) into a sinkhole located in section 33 of Ludlow Township in Allamakee County, on the north side of the Yellow River (see Figure 6-2).

Direct water sampling and activated charcoal packets were used to determine which of the dyes were present in various streams, drilled wells, and springs following dye injection. Results of the study showed a connection between the three source waters and two different springs (see Figure 6-2). These are shown on a map in this section. Dye that went into the sinkhole in Ludlow Township resurged at Livingood Spring approximately 14 hours after input and dye from Hecker Creek resurged at the Stonehouse Springs approximately 19 hours after input. A portion of the dye poured into the Yellow River sank underground and also resurged at Stonehouse Springs. As evidenced by the study, surface water in karst landscapes can disappear underground through sinkholes and stream sinks, and readily mix with groundwater aquifers before reappearing from springs miles away. The dynamic surface to groundwater interactions in karst areas makes karst aquifers highly susceptible to contamination.

Water Quality Considerations

Rick Langel, Geologist, Iowa DNR-Geological Survey-Water Monitoring
Mike Wade, Environmental Specialist, Iowa DNR-Manchester Field Office

Hecker Creek receives wastewater discharged from the Postville/AgriProcessors treatment plant, along with nonpoint source runoff from its watershed. Discharges from the plant occur during discrete time periods. During dry conditions, Hecker Creek has little or no natural flow from the watershed. If the Postville plant discharges under such conditions, the water in the creek is essentially all wastewater. During wetter periods, discharges from the plant mix with



Map Created by: Adam Kiel, Northeast Iowa RC&D

Figure 6-2. Yellow River Watershed dye tracing results.

runoff from the watershed, and the resulting water quality is a blend of wastewater and runoff from nonpoint sources. This range of conditions causes quite variable water quality in the creek. After we have looked at more of the Yellow River watershed, we will discuss the results of water quality monitoring at a number of its "subwatersheds," including Hecker Creek, to examine how point and nonpoint sources of various contaminants impact stream quality. In general, monthly monitoring since 2004 shows that Hecker Creek stands out in terms of total phosphorus and nitrogen concentrations, relative to other Yellow River subwatersheds. It is also clearly higher in its chloride concentrations, which relates to the salt used by AgriProcessors in the kosher process. Concentrations of the indicator bacteria *E. coli* are higher in Hecker Creek than most, but not all, of the other subwatersheds. Improvements in some measures of water quality are expected as the new Postville-Agriprocessors treatment system comes online.

STOP 7.

Postville Industrial Wastewater Treatment Plant – Wastewater and Water Quality

Geologic Setting

Postville straddles the drainage divide between the Yellow and Turkey rivers. We are at the highest elevation we will reach on the field trip. This, in combination with the regional dip, or slope, of the rock units, means we are at the "stratigraphically" highest point on the trip as well. Postville is underlain by 40 to 100 feet of unconsolidated glacial materials which rest on the Maquoketa Formation. The karst-forming Galena Limestone is nowhere to be seen, and in fact lies about 200 feet below us. Between Postville and the Yellow River (by our last stop), Hecker Creek cuts downward towards the upward-sloping Galena Limestone (Figure 6-1). Where the two meet, the creek begins to lose water.

Wastewater Discharge and the Postville Plant

Joe Sanfilippo, Supervisor, Iowa DNR-Manchester Field Office

Iowa has a little over 1500 facilities covered under individual "National Pollutant Discharge Elimination System" (NPDES) permits. Of those about 800 are municipal facilities, 365 are industrial facilities, 280 are semi-public facilities (such as mobile home parks), and there are about 80 other miscellaneous facilities with permits (water treatment plants, land application facilities, and industrial stormwater). In addition, there are three stormwater general permits that cover a total of more than 6000 active sites, and one general permit for over 400 rock and sand-and-gravel mining operations. At this stop we will visit one of the newer wastewater plants in the state.

The Postville Industrial Wastewater Treatment Plant was constructed in 2005 to serve the wastewater treatment needs of a meat packing plant located adjacent to the treatment plant. The new mechanical plant replaces an outdated and inadequate 4-cell lagoon treatment system. The new plant was built at a total project cost of $10,800,000. AgriProcessors, the meat packing plant, has invested $4,200,000 in funding for the project. The other $6,600,000 was funded through the City of Postville by loans and grants. The new plant was designed by Bolton & Menk of Ames, Iowa. Greg Sindt served as chief engineer.

The plant is designed to receive raw wastewater at a flow of 1,024,000 gal/day, with a CBOD concentration of 2,166 mg/l, and a CBOD mass load of 18,500 lbs/day. The plant must also meet the *E. coli* limit of 400 cfu/100 ml because the discharge from the plant is to a stream with a losing segment. A losing segment indicates that significant stream flow is lost to groundwater. The plant will process the wastewater to meet permit limits of 30 mg/L CBOD concentration and 218 lbs/day CBOD mass. Treated water will be discharged to Hecker Creek which is a tributary to the Yellow River. AgriProcessors is a kosher meat processor which results in a slightly different wastewater load coming to the wastewater plant as compared to the type of flow that would be seen from a similar, but non-kosher plant. Basically, salt is used in the process which results in a high total dissolved solids and chloride concentration for the plant to treat.

The Department of Natural Resources regulates this facility through the National Pollution Discharge Elimination System (NPDES) permitting and inspection process. Plans for the plant, beginning with site location separation distances were submitted to the department and separation distances were verified in the field. The final plans were reviewed and approved by DNR engineers prior to construction. The plant will be monitored by AgriProcessors, who will operate the plant and submit periodic reports to the department. The plant will also be monitored by the DNR's Field Office in Manchester which will conduct periodic inspections of the plant, monitor the receiving streams (Hecker Creek and Yellow River) and respond to concerns from the public.

STOP 8.

Glenwood Cave – Caves In Iowa

Mike Bounk, Geologist, Iowa DNR-Geological Survey
Bob Libra, State Geologist, Iowa DNR-Geological Survey

Glenwood Cave developed near the base of the Galena Limestone, about three miles northwest of the Winneshiek landfill. The mapped extent of the cave is shown in Figure 8-1. The cave has been known at least since the late 1890s, when Professor H. W. Shiel, of Luther College, reportedly explored the cave and described its length at 2,400 feet with a stream "navigable" for 1,400 feet. The cave was apparently in "business" during the summers from 1931-1935. Tours were offered by boat and cost 25 cents per person. The boats, which held a guide and two passengers, were poled by the guide. Illumination was by flashlight. Spook Cave, east of Monona in Clayton County, is still in the underground boat-ride business.

During wet weather, the amount of groundwater discharging from the cave was enough to make former residents of the area build a bridge over the discharge channel. During dry weather, the cave entrance leads downward about 10 feet to the water level. This wet passage can be followed for about 1600 feet to a T intersection with a stream that flows from left to right. The cave "sumps" (is completely water-filled) about 30 feet to the right of the "T." It is believed to resurge at a spring located in the next valley to the north, on the west side of the road. To the left of the T, the passage continues for about 1100 feet, where the stream comes out of a narrow, impassable slot. A short distance before this, there is a "flowstone" climb to an upper level. Total passage length for this cave is about 1 mile. This makes it one of Iowa's longer mapped caves. However, it pales in comparison to Coldwater Cave, in northern Winneshiek County where over 16 miles of passage have been mapped.

Caves – particularly those with streams and those that are completely water-filled – are important parts of the karst groundwater system. They act as drains for the carbonate aquifers, efficiently transmitting water to spring outlets, much as tile lines drain the soil below an agricultural field and deliver water to the tile outlet. Caves and smaller conduits can have significant influence on groundwater over large areas. They are fed by "tributaries" much like a surface stream, only the tributaries to caves are in all three dimensions.

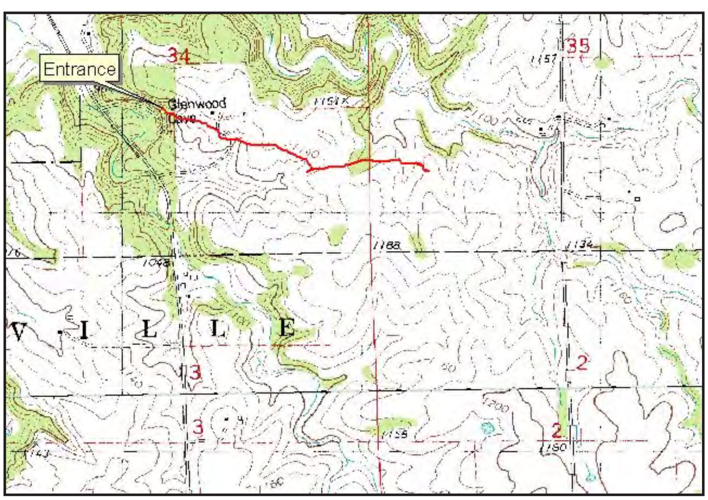


Figure 8-1. Mapped extent (in red) of Glenwood Cave.

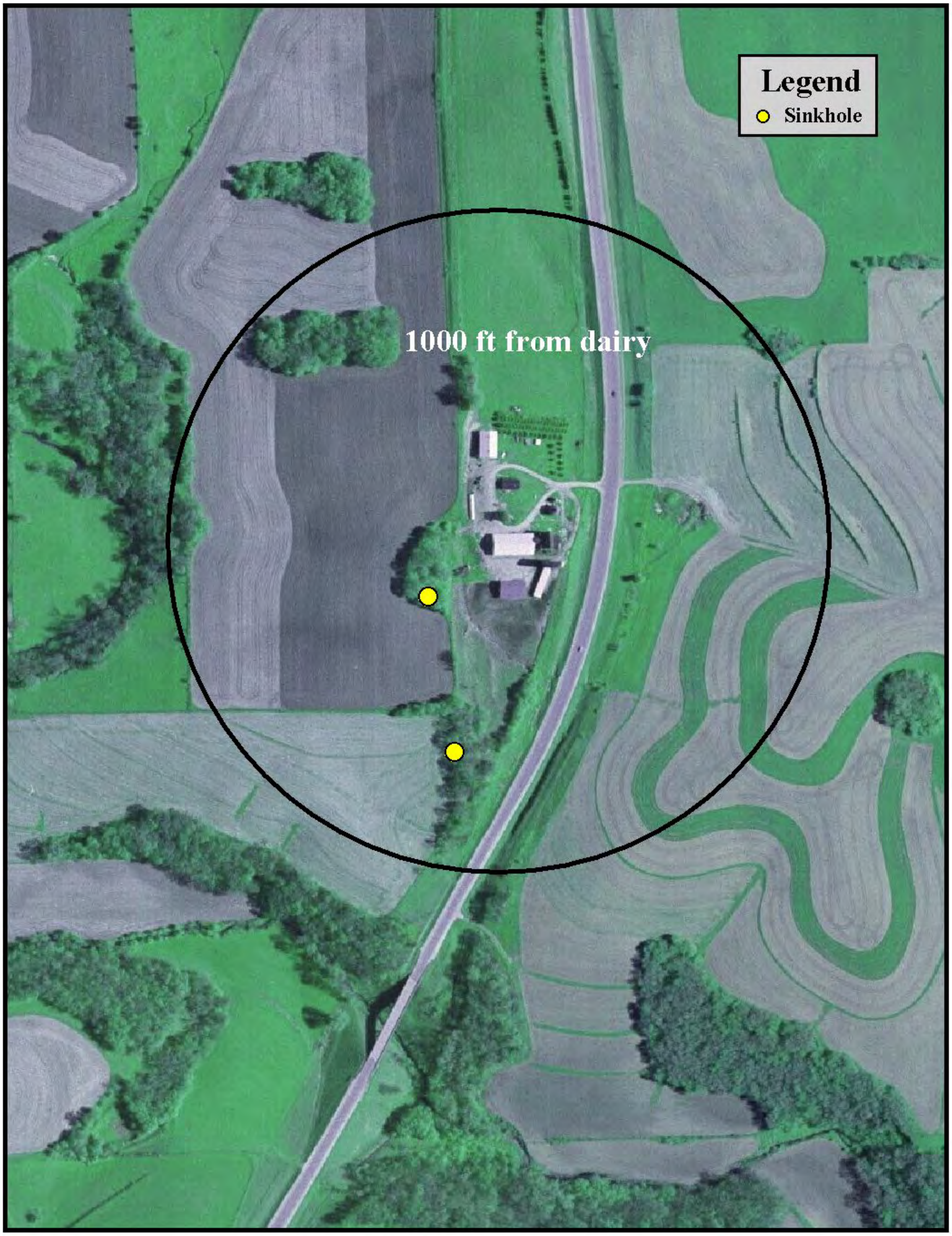


Figure 9-1. Color infrared photo of the Enyart Farm showing sinkholes.

STOP 9.

Enyart Farm – AFOs in Karst Part 1

Geologic Setting

The Enyart farm is located within the outcrop belt of the Galena Limestone, just north of the Yellow River, and just to the south of Ludlow Township (Figure 9-1). Ludlow Township has the distinction for having the most mapped sinkholes of any township in Iowa: the county soil survey shows more than 1000 sinkholes in the 36-square-miles of the township, or about one mapped sinkhole every 20 acres. The sinkholes here aren't all mapped; in places the soil survey stopped trying to map individual sinkholes and created a soil mapping unit that is described as containing "sinkholes too numerous to map."

Senate File 2293, the latest major livestock bill, banned confinement structures within 1000 feet of "known" sinkholes. DNR uses soil-survey mapped sinkholes as "known" sinkholes. Figure 9-2 shows these for Allamakee County. Much of the soil mapping was carried out 20 or more years ago. DNR's Geological Survey, the Northeast Iowa RC&D, and other partners are mapping sinkholes in the area to improve and update our knowledge of their locations and characteristics.

In Ludlow Township and adjacent areas, over 75% of the land is within 1000 feet of known sinkholes, as shown by Figure 9-3. At the Enyart Farm, sinkholes are present within 200 feet of the farm's AFO structures. Fortunately, the dairy operation does not drain to the nearby sinkholes.

Enyart Farm Dairy Operation

LuAnn Rolling, NRCS District Conservationist
Brian Enyart, Farm Operator
Chad Kehrli, Environmental Specialist, Iowa DNR-Manchester Field Office

Brian Enyart is a beginning farmer. He purchased the land, facilities, and livestock from his father. The operation includes a 90-head dairy herd. To improve manure handling, Brian added an 8-foot deep, 90-foot circular tank. The tank gives him about 5 months of manure storage, and eliminates the need for daily scraping, hauling, and applying of manure. As the tank is within 1000 feet of known sinkholes, the operation needed a variance from DNR to construct the tank. The variance was granted based on the fact the tank and barn areas don't drain to the nearby sinkholes, and that the addition of the structure was likely to improve environmental protection (about 12 variances for sinkhole or stream separation distances have been granted in northeast Iowa). However, the presence of nearby sinks and shallow Galena Limestone places the operation in "karst terrain" and therefore the tank was built to the upgraded concrete standards put in place by DNR at the direction of SF 2293. The total cost of the tank was about $47,400, or a little over $500/animal. NRCS staff oversaw construction of the tank, and Brian received 50% cost share from the Environmental Quality Incentive Program (EQIP), plus an additional 25% as he qualified as a 'beginning farmer." As a requirement of receiving USDA assistance the NRCS wrote a "Comprehensive Nutrient Management Plan," which the producer is required to follow. Part of this plan included DNR rules requiring setback distances for manure application around sinkholes.

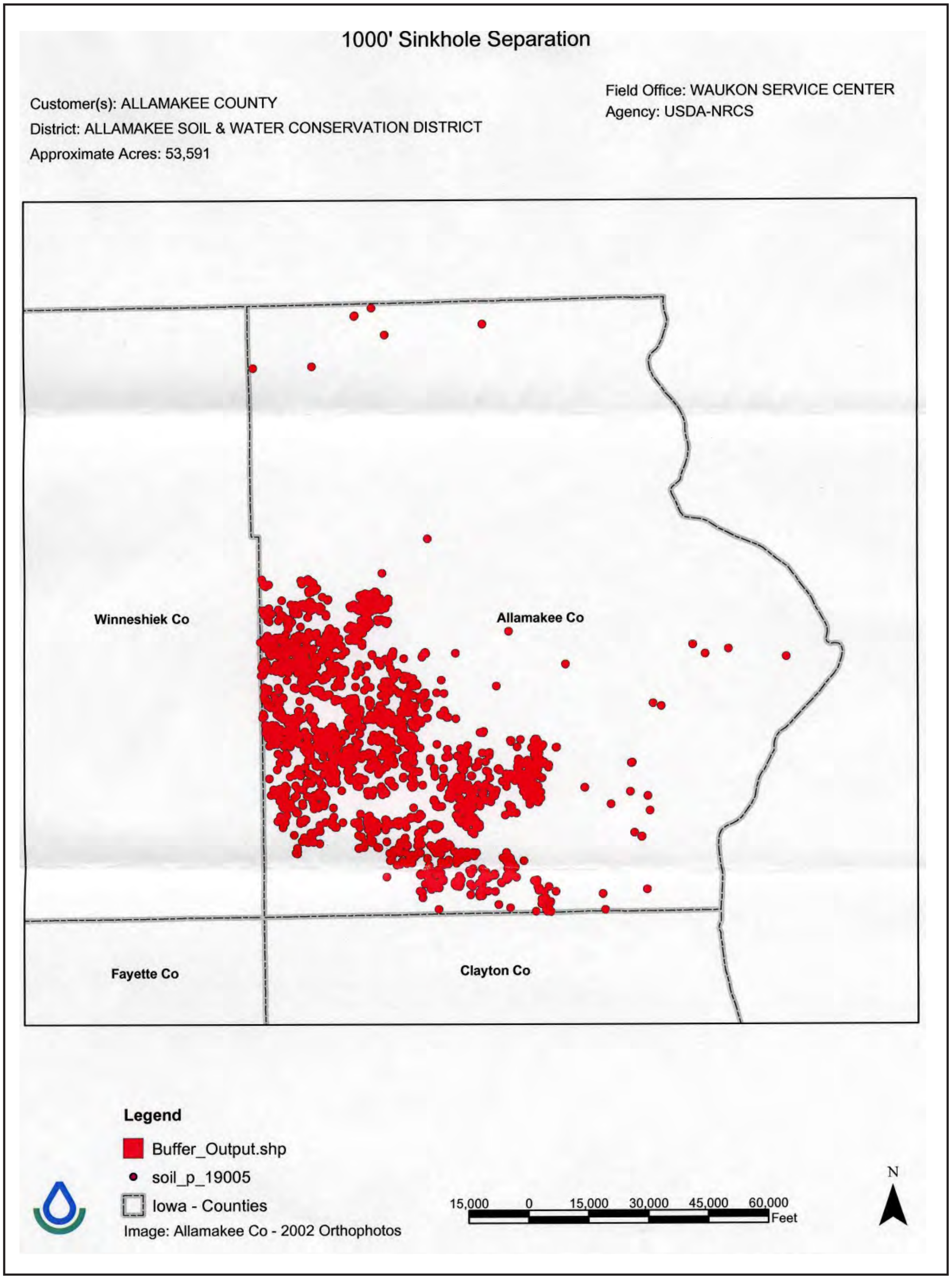


Figure 9-2. Soil Survey sinkholes in Allamakee County.

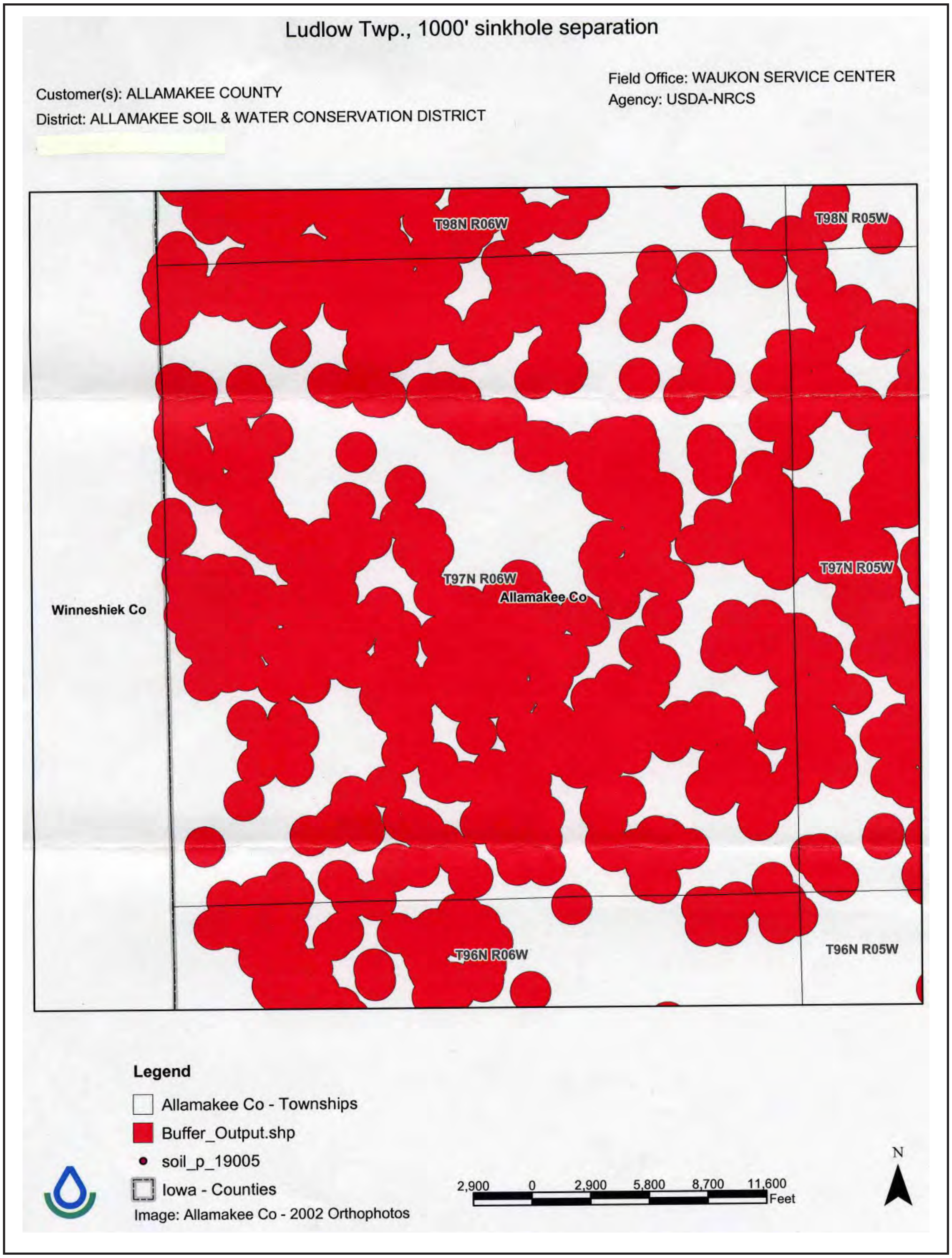


Figure 9-3. Over 75% of the land in Ludlow Township is within 1000 feet of known sinkholes.

STOP 10.

Forestry Planting – Alternative Land Use

Geologic Setting

From Stop 9 we have traveled about 5 miles due east, downstream through the Yellow River Valley. Stop 10 overlooks the valley, which has cut through the Galena Limestone and into the underlying St. Peter Sandstone. As this occurs, groundwater from seeps and springs in the Galena flows into the Yellow River. In this reach, it is again a "typical" gaining stream. Here, uphill from the valley, the Galena rocks are the uppermost bedrock, and sinkholes and shallow limestone characterize the landscape.

Forestry Alternatives
Bruce Blair, District Forester, Iowa DNR-Forestry

The property we are visiting is owned by Leigh Keehner, of Farmersburg, Iowa. The site highlights a 75.2 acre direct seeding under a CRP/CP3A tree planting contract. The site was planted in the fall of 1996. A total of 1125 bushels of walnut (15 bushels/acre) + 75 bushels of white oak (1 bushel/acre) + 75 bushels of green ash (1 bushel/acre) + 35 bushels of bur oak (1/2 bushel/acre) were sewn. First, the site was disked following corn harvest. The seed was broadcast using a fertilizer cart. The site was disked a second time to incorporate the seed. In the spring, Pendulum® 3.3 EC herbicide was applied at a rate of 3 quarts/acre. A second application of herbicide was applied in the fall of 1997. No other major management has been done to the site since then. The walnut, ash and bur oak seed all germinated well. Typically, we would have applied red oak seed instead of bur oak and white oak, but there was no red oak seed crop that year.

The wood products industry in Northeast Iowa is booming. The region's climate and great soils combine to produce some of the highest quality fine hardwoods in the world. Buyers travel from all over to Northeast Iowa because we are viewed as growing some of the best quality black walnut anywhere. In a recent timber harvest in Delaware County, a 2.5 acre stand of red oak, white oak and black walnut sold for $29,200. The 140-year-old trees were quite large, but were otherwise of typical quality for the area. The stand went virtually unmanaged from the time squirrels planted the seeds. The stand averaged $83.43 of net return <u>per acre per year</u> with very small input costs including no property taxes.

The water quality benefits from timber production are obvious when compared with row crop production. Storm runoff is minimal with most of the rain being intercepted by the forest canopy and absorbed in the soil. Pollution from pesticides and nutrients is a tiny fraction of that from row crop production. Woodlands also provide clean air, wildlife habitat, carbon storage and recreation. Timber production in Northeast Iowa is a terrific conservation alternative. Policy makers and natural resource agencies should promote timber production on our most highly erodible farm ground.

Pasture based dairies
James Ranum, Grassland Conservationist, NRCS

A pasture based dairy will have around one acre of intensively managed pasture per cow. They may have another half acre of hay where they take one or two cuttings, then graze. They may purchase their stored feed, creating a market for other producers. These well managed pastures will be a dense sward which practically eliminates soil erosion and greatly reduces surface runoff. On a 10% slope, a 3-inch rain in 90 minutes will only have 10% runoff vs. 50% to 60% for cropland or overgrazed pastures. The reduced runoff decreases the chance of nutrients and pesticides reaching sinkholes. Another water quality advantage is the reduced amount of fertilizers and pesticides applied to the land. A 100-cow dairy would have 100 acres of pasture receiving 0 to 100 lbs/acre of nitrogen and minimal phosphorus compared to row crop that would be heavily fertilized. Pesticides are only spot applied as needed, as opposed to broadcast applications for cropland. Another advantage can be the reduced amount of manure storage needed. Seasonal systems can have the cows on pasture from seven to twelve months spreading their own manure. Cropland can be converted to long-term pasture for less than $100 per acre making this system the most cost effective method of erosion control.

The local community receives considerable economic benefits from dairies, and new operations should be a priority. Grass-based systems are a viable entry avenue for beginning farmers. 200 acres could support a 100-cow dairy. Low costs and labor efficiency are the keys to success. An efficient milking parlor is essential and should be considered as a cost shareable practice in the same manner as a manure storage structure.

STOP 11.

Thompson-Reisinger Farm – AFOs in Karst Part 2

Geologic Setting

The Thompson-Reisinger Farm is located in the outcrop belt of the Prairie du Chien dolomite. These carbonate rocks form an important statewide aquifer. Wells as far southwest as the Des Moines area are drilled into the Prairie du Chien and the underlying Jordan Sandstone, where these rocks lie more than 1500 feet below the surface. The Prairie du Chien typically exhibits solutionally enlarged openings, but rarely sinkholes. As the geologic map in your guidebook shows (Figure 3), the number of Prairie du Chien sinkholes mapped by the county soil survey are miniscule compared to those mapped on the Galena Limestone. However subsurface voids do occur in the Prairie du Chien , even though there are no sinkholes to help indicate their presence. At the Thompson-Reisinger farm, unanticipated voids were found to be present and affected the manure upgrades the operators were planning.

Thompson-Reisinger Farm Dairy Operations

LuAnn Rolling, NRCS District Conservationist
Pat Reisinger/Bob Thompson, Farm Operators

Pat Reisinger is a beginning farmer. He purchased the facilities and livestock from his father-in-law, Bob Thompson. The farm includes a 160-head dairy. The operators were working with NRCS to add a manure storage tank. They added a 12-foot-deep, 120-foot circular tank. The tank gives the operation about 6 months of manure storage and eliminates the need for daily scraping, hauling, and applying of manure. As there are no "known" soil survey sinkholes within 1000 feet, a variance from rule was not needed at this site. However, the presence of shallow fractured Prairie du Chien rocks did place the site in karst and required the tank to be built to the upgraded concrete standards put in place by DNR at the direction of SF 2293. The total cost of the tank was \$82,000, or about \$500/animal. NRCS staff oversaw construction of the tank and Pat received 50% cost share from the Environmental Quality Incentive Program (EQIP). As a requirement of receiving USDA assistance the NRCS wrote a "Comprehensive Nutrient Management Plan," which the producer is required to follow.

During excavation for the tank a small cave system was discovered below the planned tank location, raising questions as to whether the tank could be built there. The caves, which can be entered by crawling, were investigated by staff from the DNR's Geological Survey. After discussions with NRCS Engineers, DNR geologists and field office staff, and others, the decision was made to move the tank uphill, where the potential for a thicker "roof" over the voids would be greatest; roof in this case being both thicker rock and a thicker soil zone over that rock. In addition the design was modified such that less excavation would be needed, again adding to the separation between the tank and any voids. It was felt that this approach, adding a greater cover of rock and soil over any voids, in combination with the structural stability provided by the upgraded concrete standards, would be sufficient to protect the integrity of the tank, the environment, and the investment made by the operators and EQIP.

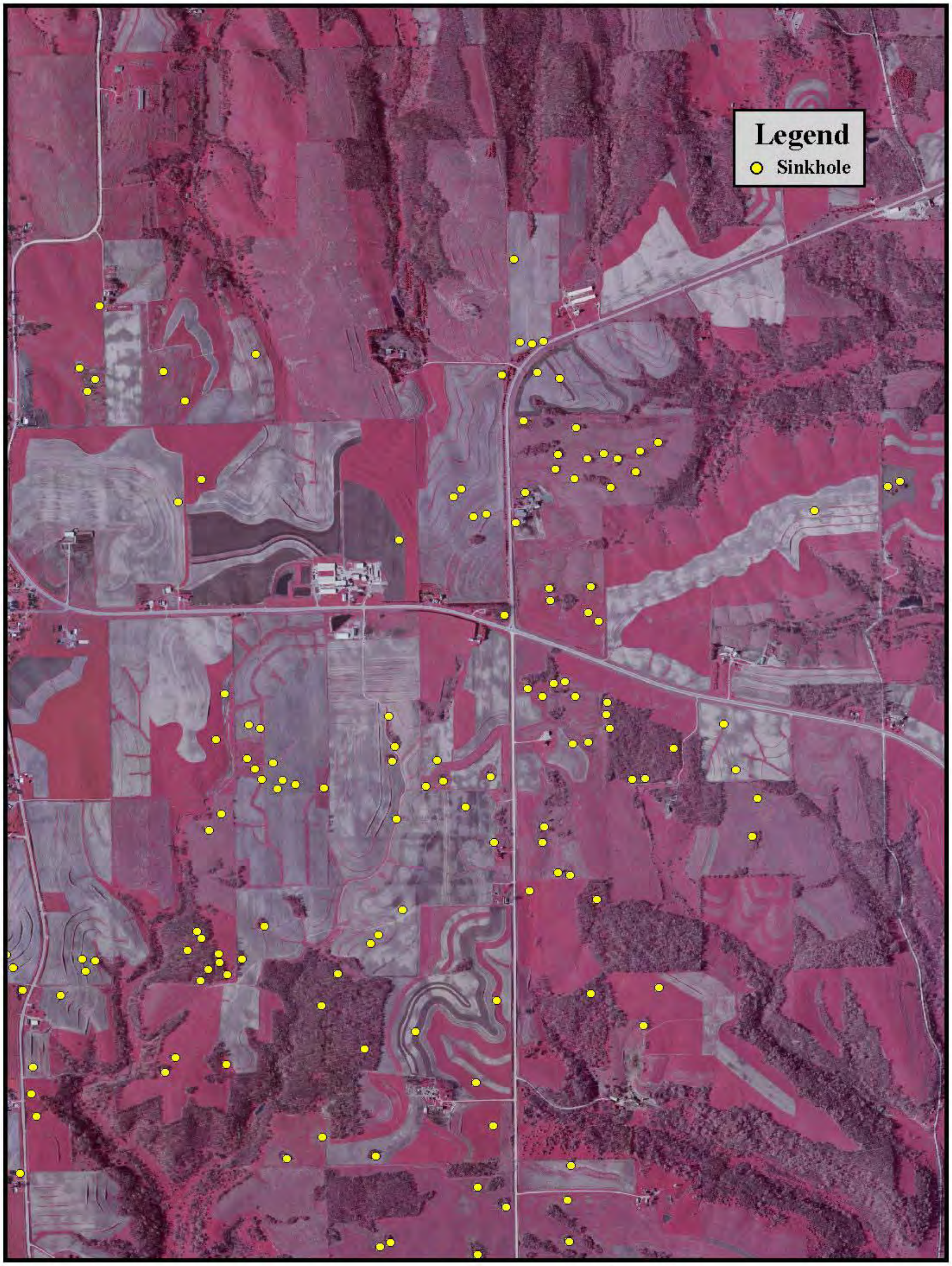


Figure 12-1. Color infrared photo of the Rossville area showing sinkholes.

STOP 12.

Rossville County Park – Stepping Inside a Sinkhole

Geologic Setting

Rossville County Park is located on the drainage divide between the Yellow River to the south and Paint Creek to the north. State Highway 76 follows the divide southeast to the Mississippi River, a distance of roughly 10 miles. The valleys of Paint Creek and the Yellow River are cut through the Galena Limestone and into the St. Peter Sandstone and older rocks. But on the divide, Galena Limestone is present much of the way to the Mississippi River, and sinkholes are very common in the Rossville area (see Figure 12-1). We will view and enter a prominent sinkhole in the wooded part of the park, and see several depressions in the ground where sinkholes appear to be forming…or re-forming.

Sinkhole Development

Bob Libra, State Geologist, Iowa DNR-Geological Survey

Percolating soil water is typically acidic and therefore can dissolve carbonate rocks such as limestone. When near surface fractures and cracks are dissolved into larger voids, the overlying glacial soils may no longer have the strength to bridge the void, and will slowly begin to slump downward. The process of dissolving out voids takes thousands to tens of thousands of years. The failure of surface soils over the void is a much shorter process. It can occur over months to years, or it can occur instantaneously. Figure 12-2 is a schematic depiction of sinkhole formation. Saturated glacial soils will collapse into voids more readily than dry soils. They can flow and ooze into relatively small openings. For this reason, seepage from earthen structures such as lagoons and farm ponds may accelerate collapse, as the seepage keeps the underlying soils permanently saturated. This was the unfortunate case of the Garnavillo sewage lagoon in Clayton County in the early 1980s.

The Garnavillo lagoon system was built as a passive three-cell system, a design easy for the small community to maintain and operate. The cell shown was built into a hillside, with the floor of the lagoon cut to within 5 feet of the Galena Limestone. As the lagoon system was approaching completion, stormwater was directed into this cell to test the seal of the liner, filling the cell to roughly a 1-2 foot depth. This occurred on a Friday afternoon. By Monday morning, a sinkhole had formed and the lagoon was dry (Figures 12-3 and 12-4). Over the coming months a line of small depressions formed in the cell. Ultimately, this cell and a second were abandoned. The third cell, which overlies a thicker cover of glacial materials, was converted to an aerated system. This was a less simple design than the city had planned on, but it was a retrofit that would work.

In the more typical setting in the countryside, when a sinkhole forms, it becomes the new low spot on the ground. Runoff will flow downhill into the sinkhole, and typically cause headward erosion and the establishment of a drainage way leading to the sink. Eventually the sinkhole may form its own watershed. Other sinkholes form in streams beds and are referred to more commonly as stream sinks or just as a losing stream point. These sinkholes come with their own watershed.

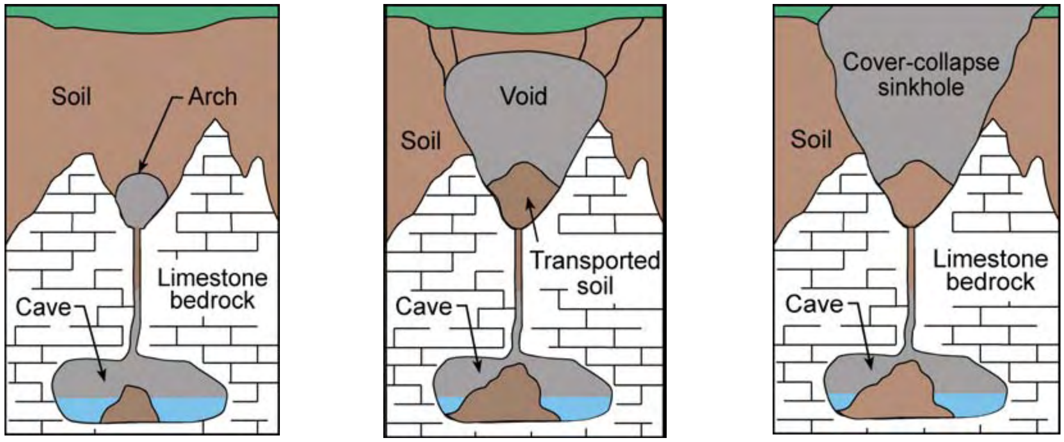


Figure 12-2. Diagram showing steps in sinkhole formation.

Since sinkholes take surface drainage, they receive inputs of sediment as well. Often, they will become "plugged" with sediment, and have no obvious opening. However, since they will continue to receive drainage, they will often plug and unplug repeatedly. This can happen on timescales of months, years, or decades. Sinkholes have been known to "form" and expose decades-old farm equipment that was dumped in a former sinkhole, at that location, in the past.

Along with sediment, sinkholes may receive runoff containing relatively high levels of herbicides, phosphorus, bacteria, ammonia nitrogen, and organic matter. This water is delivered into the groundwater system with little or no filtration, and may travel quickly through the fractured and karsted rocks. The water may impact wells or recharge the coldwater streams found in the valleys below.

As suggested above, sinkholes are far too convenient locations for waste disposal. Trash, old equipment, white goods, cars, and pesticide cans have been disposed of in sinkholes in the past. While this practice is no longer as common as it used to be, some dumping still occurs. The Groundwater Protection Act of 1987 provided funds for a number of sinkhole cleanups. As you can imagine, removing large quantities of trash and old equipment, mixed with sediment and rock, is not an easy or inexpensive task.

Figure 12-3. City of Garnavillo lagoon after sinkhole failure.

Figure 12-4. Close-up of sinkhole at city of Garnavillo lagoon.

Figure 13-1. Monitoring locations and subwatersheds in the Yellow River Basin.

STOP 13.

Lower Yellow River – Watersheds and Water Quality

Geologic Setting

We are now most of the way down the Yellow River watershed. The Mississippi River is about 7 miles east as the crow flies. The Yellow River headwaters are 25 miles to the west, and about 500 feet higher in elevation. Here the valley has cut through the Galena Limestone and St. Peter Sandstone, and into the Prairie du Chien Dolomite. Groundwater from springs and seeps continues to discharge to the river, increasing its flow.

Watershed Efforts

Paul Berland, Regional Watershed Coordinator, Northeast Iowa RC&D

The Yellow River Watershed (YRW) encompasses approximately 154,500 acres in Allamakee, Clayton and Winneshiek counties in extreme Northeast Iowa. The YRW contains 59.8 miles of surface water designated as High Quality Resource waters, 27.9 miles designated for Coldwater Aquatic Life (BCW), and 21.9 miles designated for Primary Body Contact. The YRW also encompasses Effigy Mounds National Monument, portions of the Yellow River State Forest, and drains into the Upper Mississippi National Wildlife Refuge. The Yellow River itself is the largest coldwater trout stream in Iowa. Despite its beauty and importance, several segments in the YRW are listed as impaired due to low aquatic life or elevated levels of bacteria.

In response to these impairments, the YRW Project at Northeast Iowa RC&D is leading watershed protection efforts in the YRW. The YRW Project Alliance is a collaboration of federal, state and local agencies, organizations and individuals dedicated to protecting and improving water quality and watershed health. At the forefront of the protection efforts is weekly water monitoring of 12 sites throughout the watershed, including 9 tributaries of the Yellow River and 3 sites on the Yellow River itself. The monitoring is funded through the Iowa DNR and conducted by the Allamakee County Soil and Water Conservation District (SWCD), the Winneshiek County SWCD and the Northeast Iowa RC&D staff. Water quality data obtained through the monitoring effort are used to identify impairments and to monitor water quality improvements. Once priority subwatersheds are identified, Geographic Information Systems (GIS) technology is being utilized to target particular land areas within the subwatersheds for specific watershed protection programs to address impairment sources. The local Natural Resources Conservation Service (NRCS), Farm Service Agency (FSA), and SWCD offices, as well as the Iowa DNR are assisting with the implementation of the watershed protection programs. Other partners working with the YRW Project to improve water quality in the YRW include; Iowa Department of Agriculture and Land Stewardship, U.S. Fish and Wildlife Service, National Park Service, U.S. Forest Service, U.S. Geological Survey, Pheasants Forever, Northeast Iowa Citizens for Clean Water, U.S. Environmental Protection Agency, Altria Group and the McKnight Foundation.

Water Quality Monitoring on the Yellow River Watershed

Rick Langel, Geologist, Iowa DNR-Geological Survey, Water Monitoring

In 2002, segments of the Yellow River were listed on the State of Iowa's 303(d) list of impaired waters. A cooperative project involving the U.S. National Park Service, U.S. Department of Agriculture, Iowa Department of Natural Resources, University of Iowa Hygienic Lab (UHL), U.S. Geological Survey-Water Resources Division, and the Allamakee County Soil & Water Conservation District was started to provide baseline water quality data for the Yellow River watershed. Twelve sample locations in the Yellow River watershed were selected for water-quality monitoring and have been sampled since May 20, 2004. Figure 13-1 shows the monitored subwatersheds. Summarized below are monitoring results for nitrate-nitrogen, total phosphate-P, the bacteria *E. coli*, and chloride. Data from other northeast Iowa streams for that time period are also shown for comparison.

Nitrate+nitrite-N

Nitrate+nitrite-N is an inorganic form of nitrogen in Iowa's streams and groundwater. Nitrogen is a necessary nutrient for plant growth. Excess nitrogen in surface waters, however, can contribute to nutrient enrichment, increasing aquatic plant growth and changing the types of plants and animals that live in a stream. The maximum allowable level of nitrate-N in drinking water is 10 mg/L. Sources of nitrogen include cultivated soils, human and animal wastes, decomposing plants, and fertilizers. Most nitrate is "leached" from soils by infiltrating soil waters. Figure 13-2 shows nitrate+nitrite-N concentrations for the Yellow River area.

Nitrate+nitrite-N concentrations ranged from <0.05 mg/L to 17 mg/L in the Yellow River watershed. Many streams in the watershed had higher nitrate+nitrite–N concentrations in the late spring/early summer, a trend that is similar to streams statewide. As summer progressed, nitrate+nitrite-N concentrations declined and were often lowest during late summer and winter periods. In general, watersheds with higher percentages of row crops had higher median nitrate-N concentrations. Median concentrations were around 7 mg/L for most tributaries, but were less than 5 mg/L for the Lower Yellow River.

Total Phosphate-P

Total phosphate-P is a measure of all dissolved and particulate forms of phosphate in water. Phosphorus is a necessary nutrient for plant growth and generally is limiting in the freshwater environment. Too much phosphorus in surface waters, however, can contribute to nutrient enrichment, increasing aquatic plant growth, and changing the types of plants and animals that live in a stream. Sources of phosphorus include certain soils and bedrock, human and animal wastes, decomposing plants, and runoff from fertilized lawns and cropland. Figure 13-3 shows total phosphate-P for the watershed sites.

Total phosphate-P concentrations ranged from <0.02 mg/L to 5.1 mg/L in the Yellow River watershed. Median concentrations clustered around 0.1 mg/L. With the exception of the Hecker Creek site, the total phosphate-P concentrations throughout the watershed were similar to those reported from other northeast Iowa streams. In general, watersheds with higher percentages of row crops had higher median total phosphate-P concentrations.

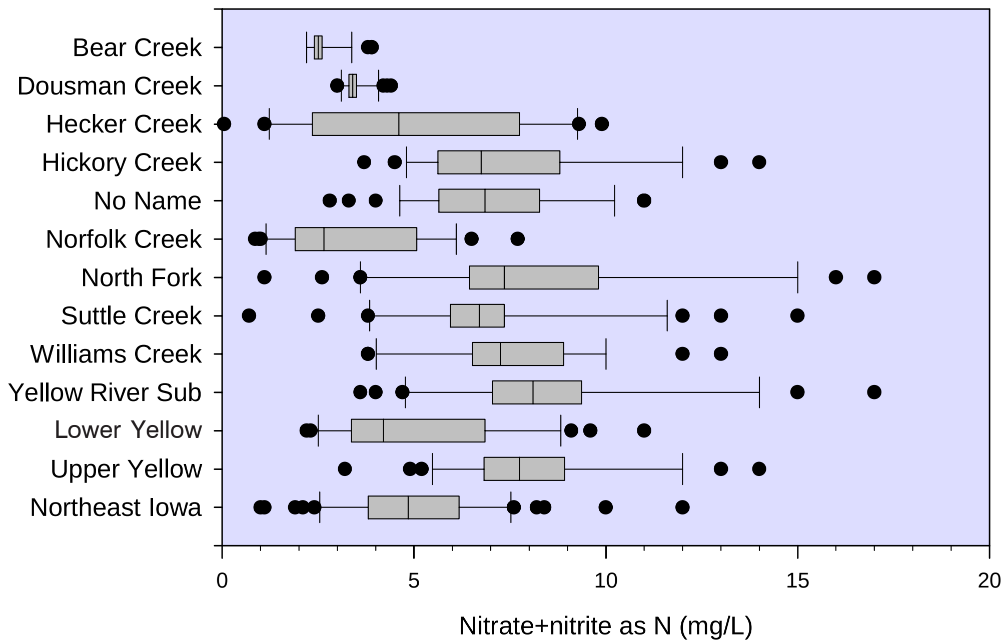


Figure 13-2. Nitrate+nitrite-N concentrations for theYellow River and northeast Iowa streams.

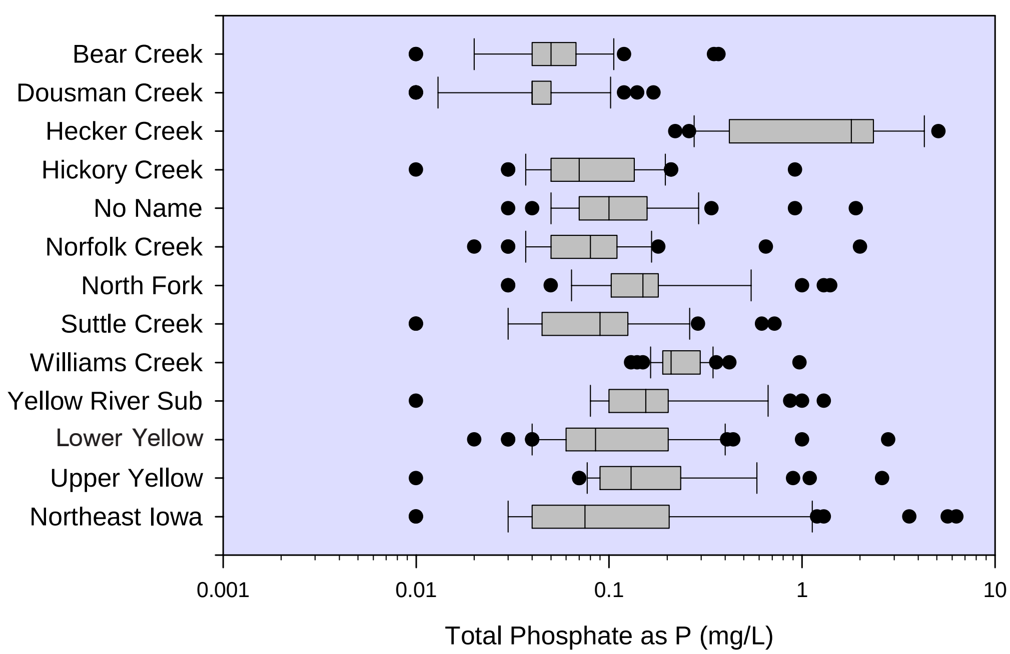


Figure 13-3. Total Phosphate-P concentrations for the Yellow River and northeast Iowa streams.

However, several high total phosphate-P results at the Hecker Creek and Upper Yellow sites were associated with discharges from the Postville-Agri Processors industrial lagoon.

E. coli Bacteria

Escherichia coli (*E. coli*) bacteria are a type of coliform bacteria present in the gastrointestinal tract of warm-blooded animals. *Escherichia coli* is called an “indicator bacteria,” meaning they do not cause illness, but their presence suggests that disease-causing organisms (pathogens) may be present. As the number of indicator bacteria rises in water, so does the likelihood that pathogens are present. The most frequent sources of pathogens are sewage overflows, malfunctioning septic systems, animal waste, polluted storm water runoff, and boating wastes. The presence of *E. coli* bacteria suggests that a pathway exists for a relatively fresh source of human or animal waste to enter the stream. Figure 13-4 shows *E. coli* concentrations for the watershed sites.

The *E. coli* concentrations ranged from <10 to 360,000 colony forming units (CFU)/100 mL. If all the streams in the watershed were classified as “swimmable,” all the streams would exceed the State of Iowa’s one-time maximum *E. coli* standard (235 CFU/100 mL). Many of the monitored sites in the Yellow had median concentrations exceeding this level. High *E. coli* results at the North Fork and Yellow River Subwatershed sites occurred on the days that also had high rainfall and high ammonia-N concentrations, which may indicate that these problems were caused by manure entering the streams. These watersheds, and Hecker Creek, had the highest median *E. coli* levels.

Chloride

Chloride is a component of salt, and can be used as an indicator of human or animal waste inputs to a stream. Potential sources of chloride to a stream include direct input from livestock, septic system inputs, and/or discharge from municipal and industrial wastewater facilities. During winter months, elevated chloride levels in streams may occur as a result of road salt runoff to nearby streams. Figure 13-5 shows chloride concentrations for the monitored sites.

Chloride ranged from 4.9 to 1,900 mg/L in the Yellow River watershed. Chloride data from other water monitoring stations showed median chloride levels typically below 25 mg/L across northeast Iowa. Two sites in the Yellow River watershed, Hecker Creek and the Upper Yellow River, had chloride values that routinely exceeded 25 mg/L. For both sites, high chloride values were associated with discharges from the Postville-Agri Processors industrial lagoon.

In summary, nonpoint and point sources of contamination both deliver contamination to the Yellow River. The large industrial point source impacting Hecker Creek has clear effects in terms of total phosphate-P and chloride concentrations. Hecker Creek does not stand out as high in terms of its nitrate+nitrite-N concentrations. However, the wastewater discharge contributes other forms of nitrogen to Hecker Creek, and the creek is high in terms of total nitrogen levels. Median concentrations of the indicator bacteria *E. coli* are above the “swimmable” criteria for most of the monitored sites, indicating that widespread bacterial sources exist throughout the watershed.

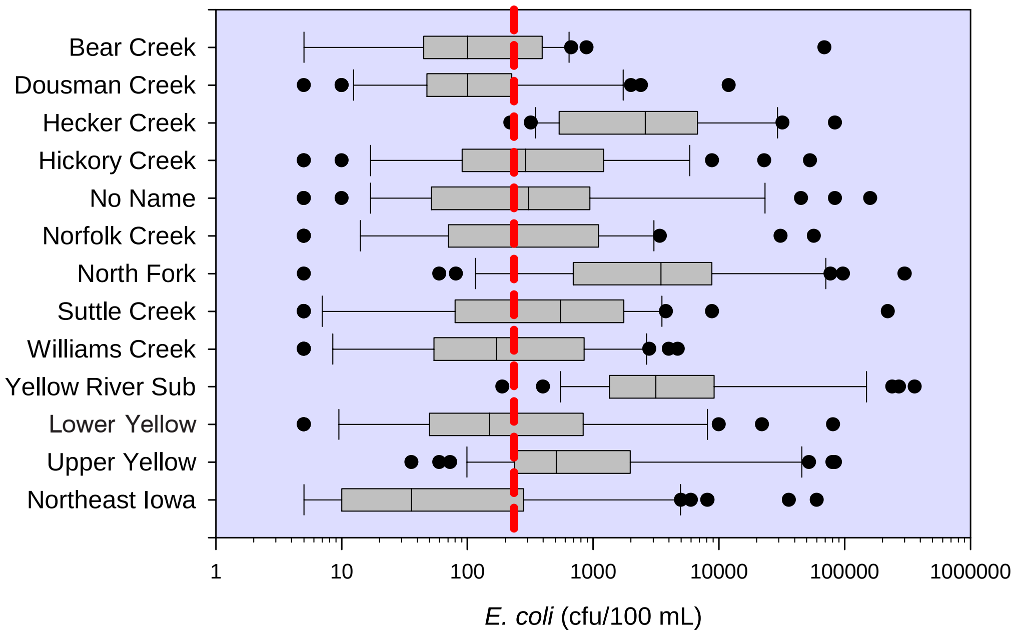


Figure 13-4. *E. coli* concentrations for the Yellow River and northeast Iowa streams. Dashed red line shows Iowa's one-time maximum *E. coli* standard.

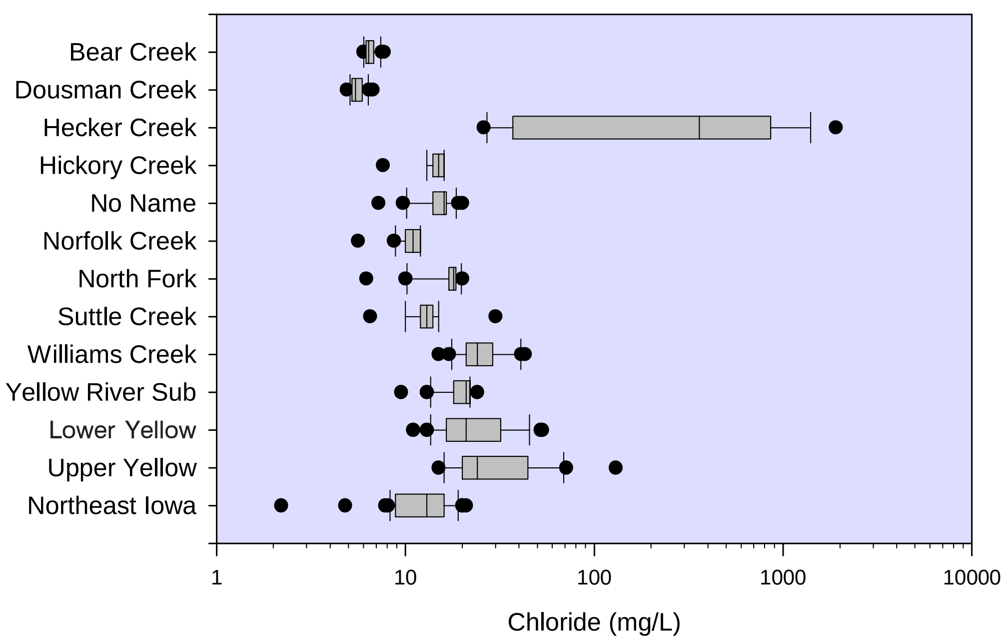


Figure 13-5. Chloride concentrations for the Yellow River and northeast Iowa streams.

Yellow River Fishery

Bill Kalishek, Fisheries Biologist, Iowa DNR Fisheries

The Yellow River is Iowa's largest coldwater trout stream. At this point the river has a 204-square-mile surface drainage that extends west almost to the towns of Ossian and Decorah. Most Iowa trout streams have surface drainages that do not exceed 40 square miles. In addition to the large surface drainage there are 2953 documented sinkholes and 277 individual springs that contribute to the Yellow River. Many of the sites that we have visited in the last two days are within this watershed and contribute directly to the quality of the water at this location. The Yellow River is impacted by one industrial and two municipal waste treatment plants, a myriad of private septic systems, and the nonpoint runoff from predominantly agricultural landuse; the scope of the challenge to maintain suitable water quality for trout survival can seem huge.

The Yellow River drainage has nine major tributary streams. Four of these tributaries are coldwater trout streams. Historically the majority of the main stem of the Yellow River supported a warmwater fishery dominated by smallmouth bass. But over the last two decades over 25 miles of the Yellow River have water temperatures that have become cold enough to support trout populations. Fish populations in the Yellow River are very diverse, consisting of 39 different species. The Yellow River trout populations are maintained by annual four-inch fingerling stockings of 50,000 rainbow trout and 50,000 brown trout. All of the stocked brown trout fingerlings originate from adults captured in the wild; the rainbow trout are offspring of domestic hatchery brood stock.

STOP 14.

Effigy Mounds – Northeast Iowa and the Mississippi River

Geologic Setting

At Effigy Mounds, the Yellow River flows into the Mississippi River. The water carries the sediment, nutrients, and chemicals from nonpoint source runoff and infiltration, and point-source discharges, from its 240-square-mile watershed. The Mississippi and Yellow River valleys are cut through the Prairie du Chien Dolomite and into the upper parts of the Jordan Sandstone. The Jordan-Prairie du Chien interval is typically called the Jordan Aquifer. This widespread, productive aquifer supplies wells as far away as central Iowa, where it lies over 1,500 feet below the surface. Only here in the northeast corner of the state are these rocks exposed at the surface.

Effigy Mounds owes its status as a National Monument primarily to its archeological resources, in particular the burial mounds constructed by the Eastern Woodland Indians. While these archeological treasures are beyond the scope of our trip and guidebook, their presence here tells us that humans have lived along, fished in, and treasured the Mississippi River for thousands of years.

The Driftless Area National Wildlife Refuge
Cathy Henry, U.S. Fish and Wildlife Service

The karst geology of the Paleozoic Plateau in Iowa, along with varying slope aspects, rock outcrops and springs, creates many unique habitats. One of these habitats is algific talus slopes, also known as cold air slopes. Algific slopes are home to a host of state and federal threatened and endangered species, as well as other endemic and rare species.

In the summer, air is drawn down through sinkholes, flows over frozen groundwater and exits from vents onto certain slopes, usually north facing. These cold air vents are usually covered by a loose talus (rock) layer. Temperature ranges from freezing to about 55 degrees Fahrenheit throughout the summer. This air flow provides a climate similar to what was prevalent in glacial eras and creates a habitat that a specific community of plants and animals need to survive. Some of the plants and animals are relicts from glacial eras. The plant community contains species that normally grow much farther north.

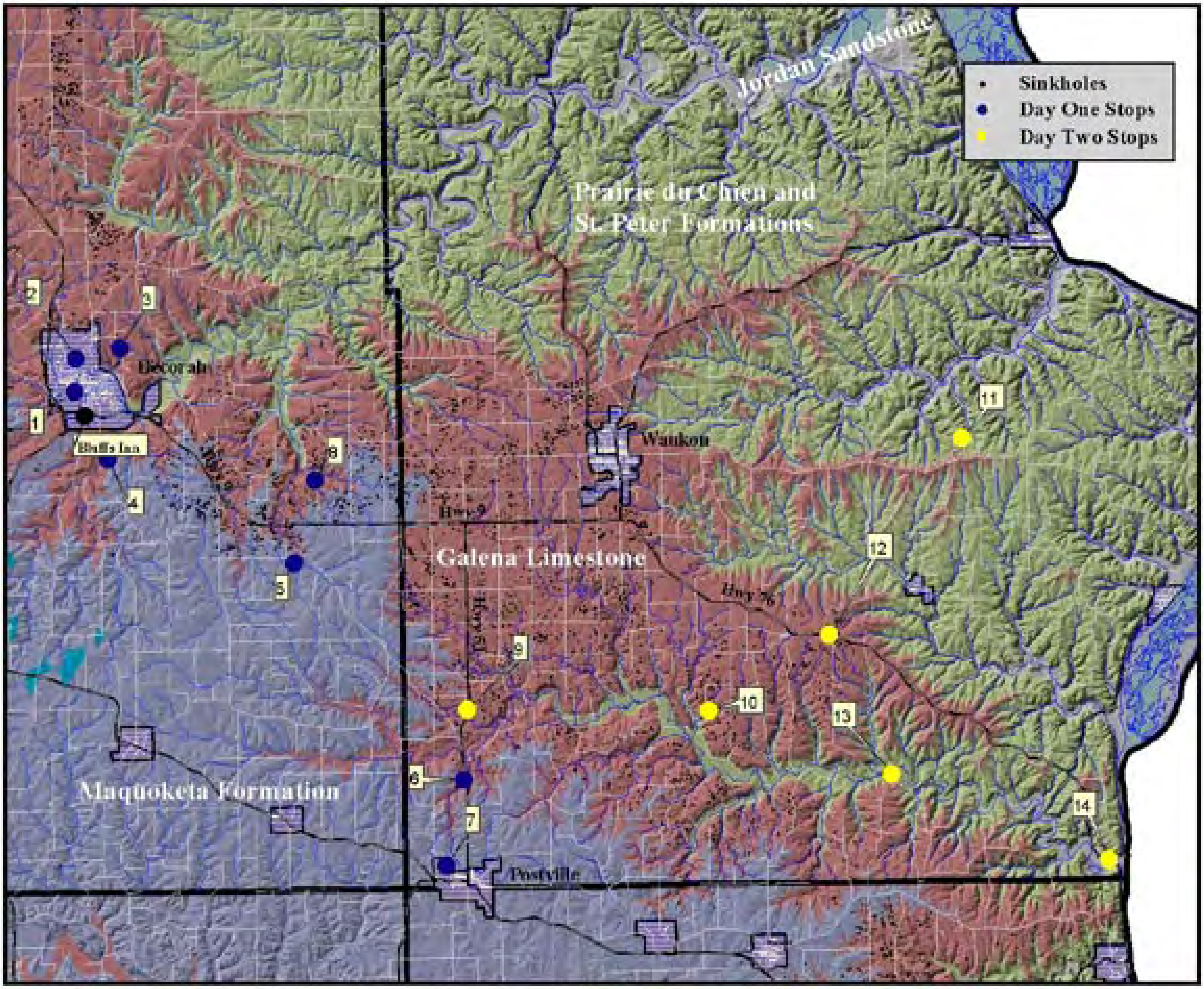
Algific talus slopes are sensitive to disturbance and activities that might disrupt air flow, such as the filling in of sinkholes. The Driftless Area National Wildlife Refuge was established in 1989 to permanently protect habitat for the federally threatened Northern monkshood and endangered Iowa Pleistocene snail. The Refuge currently covers 781 acres in 9 separate units. Additional acquisition throughout the four-state driftless area is planned.

Water Quality and Mississippi River Recreation
Scott Gritters, Fisheries Biologist, Iowa DNR Fisheries

Every inch of ground you have traversed for this trip drains into the Mississippi River. Every waterway, tile, spring, sinkhole, pasture, gaining stream, losing stream, industrial complex, cement road, septic, storm drain, toilet flush, forest, and row crop drains through here. For Iowans, the Mississippi River is where our association with the water quality stops. However, the issues you have been discussing ultimately impact our downstream neighbors all the way to the Gulf of Mexico.

Iowans are blessed to have this mighty water source on our border. The Mississippi River supports a massive tourism industry and offers unequaled recreation opportunities. More than 3 million people visit the Mississippi River each year making it the most visited refuge in the country. It is also a world-class fish and wildlife area harboring 306 species of birds and 119 species of fish. Fishing, hunting and other river-based recreation along our border is BIG BUSINESS. As with any business, continued investments are needed to keep it vital. Of paramount importance are investments in water quality improvements, discussed during this trip.

The challenges that influence river health are complex and include invasive species, navigational impacts, habitat alteration, and island loss to name a few. However, the single biggest challenge we face as river managers is sedimentation. On average, Iowa tributary streams deliver dump truck loads of sediment to the Mississippi River every few minutes. This clogs the lifeblood of the mighty river. Backwater areas vital to fish and wildlife production are silting in at a rate of ½ to 1 inch per year, and over the past 60-plus years, the impoundment backwater depth has been reduced three to six feet. All backwaters have been degraded, limiting their ability to produce fish and wildlife, and many have already been completely lost. Losing areas to sedimentation has ecological as well as financial implications. We are trying to correct some problems with programs such as the Environmental Management Program. To date, 16 large-scale ecosystem rehabilitation projects totaling nearly $37 million have been implemented or are on the verge of construction in Pools 9 through 11. These programs, plus a strong emphasis to keep Iowa’s soil on Iowa’s land is what is needed for the Mississippi River’s, and Iowa’s financial and ecological health.



Generalized geologic map of northeast Iowa showing field conference stops.

Iowa Department of Natural Resources
Geological Survey
109 Trowbridge Hall
Iowa City, Iowa 52242-1319
(319) 335-1575