Lincoln Township
Kewaunee County, Wisconsin
Groundwater and Surface Water Protection Report and Recommendations

Adopted by the Lincoln Township Board of Supervisors

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On March 1, 2021

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On February 24, 2021

Lincoln Township, Kewaunee County, Wisconsin

Groundwater and Surface Water Protection Report and Recommendations, March 1, 2021

Introduction

In 2017 Lincoln Township completed the Supplement to the Comprehensive Plan (S2CP) as mandated by State Statute. In town government, the Comprehensive Plan along with its Supplement serves as the overarching document guiding town administrators because "local programs and actions impacting land use must be consistent with that local government's comprehensive plan". (2001 Brian Ohm, UW Extension "Key Points of Wisconsin's New Comprehensive and "Smart Growth" Law) The S2CP, by law, must allow for rigorous public input and scrutiny and must be adopted by Ordinance.

Protecting the Town's groundwater and surface water quality and quantity was raised at those public meetings as the top concern of residents. In response the S2CP outlined numerous goals and objectives, one of which was the development and adoption of a "Groundwater and Surface Water Protection Plan" that would, as indicated, protect our ground and surface waters into the future. By law it is the responsibility of the Plan Commission to deliver such a plan. By stitching together the research, field work, studies, and reports from the past 13 years, this document addresses those concerns.

Over the course of the last 16 years more than 14 scientific experts from the federal to the local level, from the agricultural to the academic communities, have conducted numerous studies to quantify the contamination, identify the contaminants, identify the source of the contamination and its access to our groundwater and then identify solutions to abate the contamination. These experts scientifically, meticulously, and objectively documented the Town's water quality, the underlying hydrogeology, waste management, population and agricultural trends. In addition, various individuals from the township have donated hundreds of hours of time on committees and work groups to help facilitate our understanding of Kewaunee County's ground and surface waters.

The Plan Commission has used this research along with the recommendations included in them to provide what we believe is an objective and accurate plan for Lincoln Township. Critics may argue that this report could be considered "one sided" as it overwhelmingly points to agriculture as the predominant source of the contamination. We would like to be clear that it is the previously mentioned scientists, researchers, and experts and not members of the Plan Commission who have concluded that the predominant land use in the town is agriculture, that the predominant geology is shallow soil over fractured bedrock, that the predominant waste production is agricultural, and the predominant contamination is from bovine manure. It's our obligation to the town residents to recognize and report the situation for what it is.

This report is science based and data driven. The report does not include news articles, TV reports, or personal opinion. It is worth noting that the science, much like our geology, is not stagnant. The experts are still working to understand our ever-evolving geology. As always, new technology and practices are being tested. Human populations are fluctuating and herd sizes are increasing. There are more recent efforts and studies being conducted that have yet to return measurable results to the scientific community. Town leadership should consider all new scientific findings and factors going into the future.

It is hoped that providing this information will give Lincoln Township residents a greater sense of ownership and instill heightened stewardship in two of their most precious resources that also add value to their properties and lives: our groundwater and surface waters.

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List of Acronyms Used in This Document

BLRPC	Bay Lakes Regional Plan Commission
BMP	Best Management Practices
CAFO	Confined Animal Feeding Operation
CP	Comprehensive Plan
DATCP	Department of Agriculture, Trade, and Consumer Protection
DNR	Department of Natural Resources
EDC	Endocrine Disrupting Compound
EPA	Environmental Protection Agency
GWPP	Ground Water Protection Plan
GW&SWR&R	Groundwater and Surface Water Report and Recommendations
KC	Kewaunee County
KC LWCD	Kewaunee County Land and Water Conservation Department
KCLWRMP	Kewaunee County Land and Water Resource Management Plan
LT	Lincoln Township
LWCD	Land and Water Conservation Department
LWRMP	Land and Water Resource Management Plan
N	Nitrogen
NRCS	Natural Resource Conservation Service
P	Phosphorus
S2CP	Supplement to the Comprehensive Plan
TMDL	Total Mean Daily Load
ToL	Town of Lincoln
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
UWGB	University of Wisconsin Green Bay
UWO	University of Wisconsin Oshkosh
UWSP	University of Wisconsin Stevens Point
UW-X	University of Wisconsin Extension
WDNR	Wisconsin Department of Natural Resources
WGNHS	Wisconsin Geological and Natural History Survey

The Groundwater Situation in Lincoln Township

The population of Lincoln Township has remained relatively stable over the past 50 years, having lost only about four percent of the township population over that time frame. The face of farming, on the other hand, has changed considerably. Small mom-and-pop family dairy farms, the mainstay of Lincoln Township's economy just 20 years ago, are all but history. They have been replaced by three large family-owned employee-operated dairy operations. With farm consolidation has come a very different type and scale of agriculture with subsequent impact on ground and surface waters.

According to nearly all sources, the two primary potential sources of groundwater and surface water contamination of concern are human waste from septic systems and animal waste from agricultural operations. While there are probably other minor sources of groundwater and surface water contamination in the township (chemical fertilizer runoff is moving to the fore), addressing these two sources has been established as the best and most reasonable approach to improving our essential groundwater and surface water resources in Lincoln Township. However, they are not equal sources of equal magnitude". This document will examine what is known about the sources of contamination, the issues around reducing them, and other potential and likely contaminants.

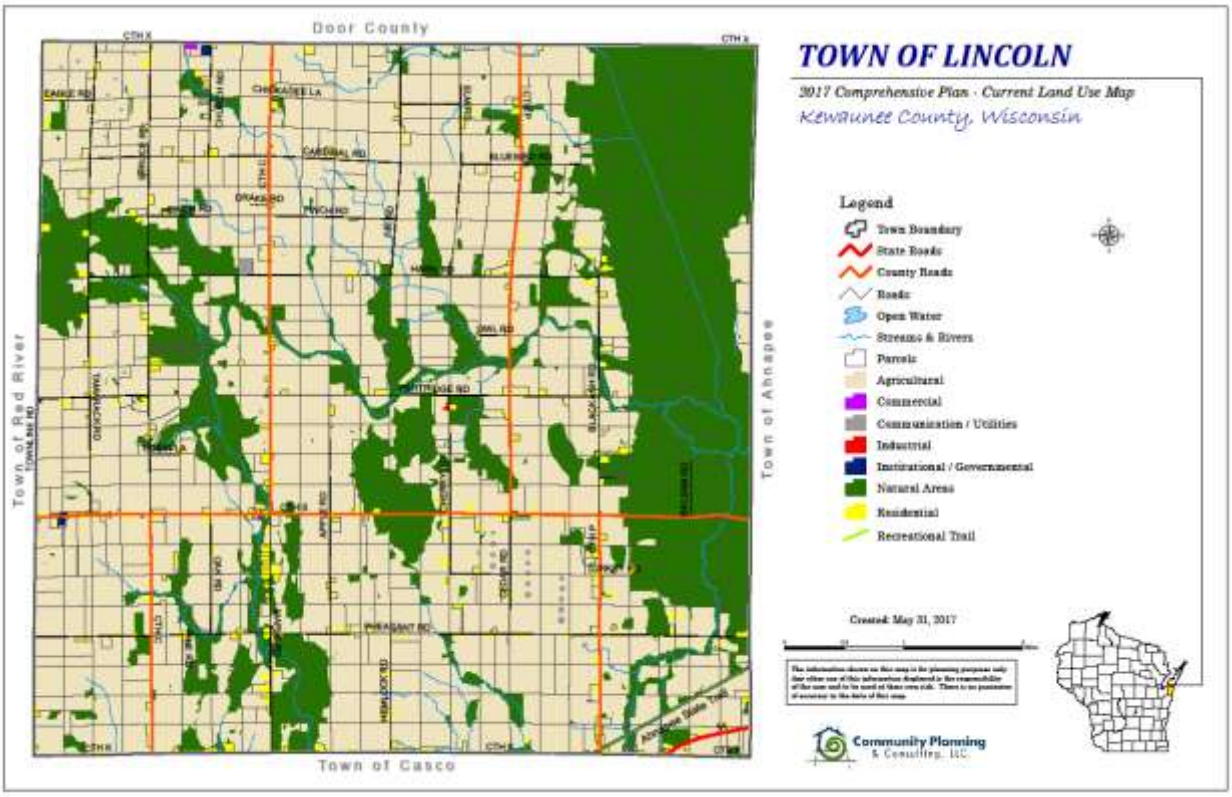
Lincoln Township Overview / Summary

Human

- Approximately 933 residents (January, 2020) All on private wells.
- As of December 31, 2020 there are 397 septic systems in Lincoln Township, 382 or 96% are code compliant with only 15 yet either to be inspected or non-compliant, based on numbers provided by Kewaunee County Land and Water Department.

Land use

- 75% tillable land zoned as A1 or A2 Agriculture
- 20% Forest and Wetlands
- 5% Residential and Commercial
- Below is the Lincoln Township's Current Land Use Map from the 2017 Comprehensive Plan



Agriculture

Based on numbers provided by Kewaunee County Land and Water Department for 2018, Lincoln Township hosts:

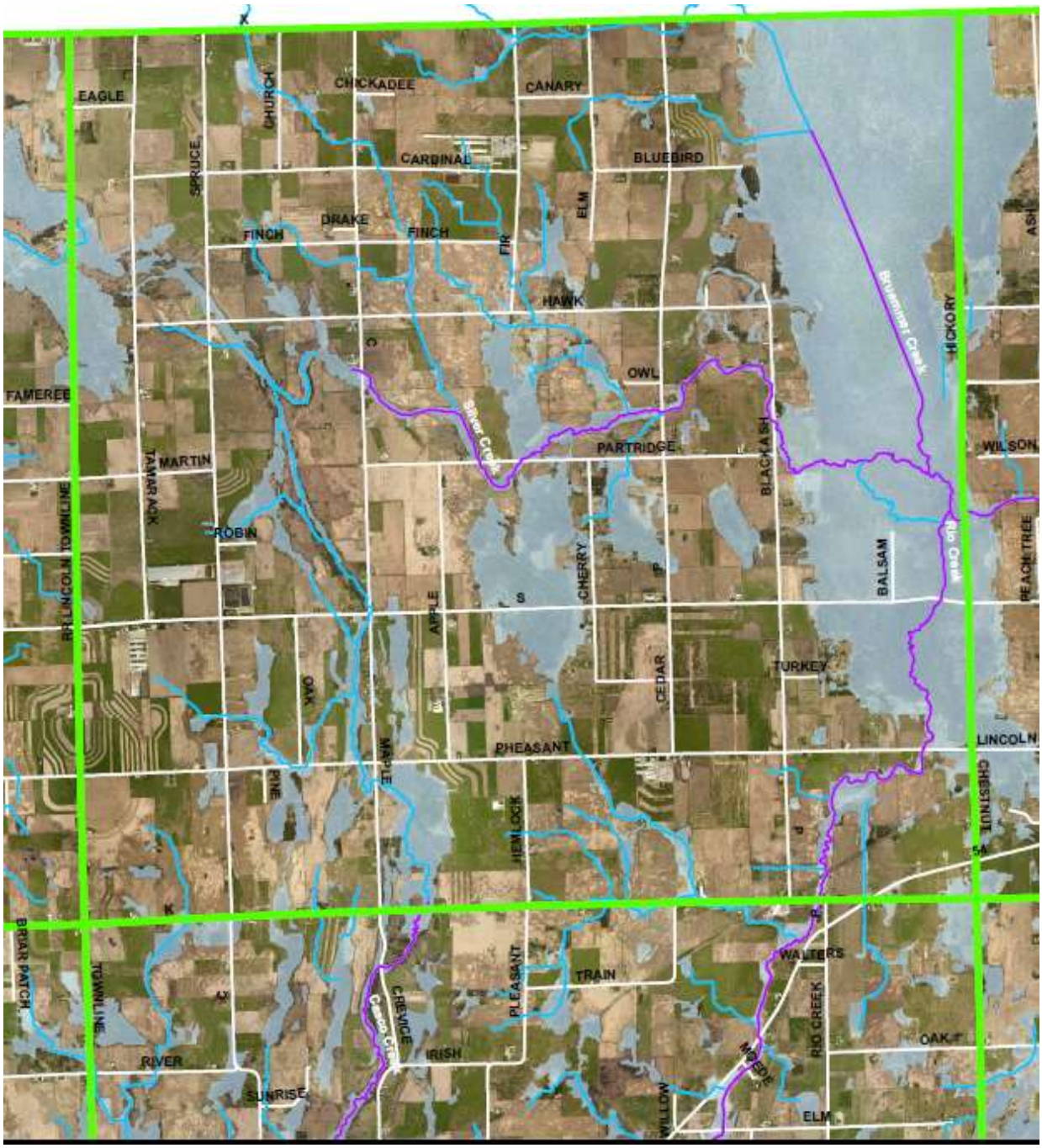
- Three Confined Animal Feeding Operations with WPDES permits.
- Two farms are considered “Large” farms (over 500 animals but under 1000 in confinement) but are not CAFOs.
- Approximately 13 other “family farms” with herd sizes ranging from 30 to 300 animals
- 19,312 cattle in Lincoln, 17,041 are on the three CAFOs (88%). (See LWCD spreadsheet on page 43)

Geological/Hydrogeological/Natural Resources

- “The Door Peninsula (on which Lincoln Township sits) rests on layers of dolomite rock first formed as sediment within the warm, shallow Silurian sea between 428 and 444 million years ago. Rain and snow-melt water erode the fractured and soluble bedrock made up primarily of calcium magnesium carbonate, forming enlarged fissures and other karst features. Characteristics of the bedrock are occasionally visible on the surface of the land as sinkholes, swallets, closed depressions, fracture traces, crevices, springs, seeps, and exposed dolomite pavement. These features, knows as ‘Swiss cheese bedrock’, can act as direct conduits to ground water sources.”

Reference: *Best Management Practices to Protect Groundwater at Hines Emerald Dragonfly Larval Sites in Door County, Wisconsin.*

- 75% of the tillable land in Lincoln is “sensitive” hydro-geologically speaking due to a variety of unsuitable conditions (see CP Sensitive Areas Map on page 47)
- Lincoln township hosts three major tributaries of Lake Michigan watershed (all on DNR Impaired Waters List)



Lincoln Township Wetlands and Creeks

- Eastern edge of Lincoln Township is home to the unique Black Ash Swamp, the State's largest hardwood swamp, home to endangered Hines Emerald Dragonfly, as well as several other endangered and rare species, from bald eagles to lady slipper orchids.
- The Glacial Lakes Conservancy, with the cooperation of Lincoln Township, sought to establish a landowner-initiated conservation easement on 420 acres on wooded land in the Black Ash Swamp. While Lincoln Township's Town Board voted unanimously to support this effort based on town residents' support, the Kewaunee County Board of Supervisors would not support the acquisition by GLC, and as of late 2020, GLC was subsequently unable to obtain DNR funding to preserve the land.

Public/Private Partnerships to Protect Residents & Ground and Surface Waters

Town of Lincoln residents have become increasingly involved with a number of local, state and federal agencies and researchers as CAFOs increased in size and water quality has been compromised. Below is a list of those partnerships developed in the attempt to find solutions for the residents of the town and surrounding region:

Researchers and Collaborators	Type	Affiliation
Kevin Masarik	Researcher	UW – Stevens Point Center for Watershed Science
Andrew Wallander	Conservationist (Retired)	Kewaunee County LWCD
Davina Bonness	Conservationist	Kewaunee County LWCD
Dr. Mark Borchardt	Microbiologist	USDA
Mike Parsen	Hydrogeologist	Wisconsin Geological and Natural History Survey
Dr. Ken Bradbury	Geologist	Director, Wisconsin Geological and Natural History Survey
Dr. Maureen Muldoon	Hydrogeologist	UW-Oshkosh, Wisconsin Geological and Natural History Survey
Kevin Erb	Program Director	UW-Extension
Dr. Krassimira Histrova	Professor, Researcher	Marquette University, Director of Marquette Global Water Center
Dr. John Luczaj	Professor, Researcher	UW- Green Bay
Dr. Kevin Fermanick	Professor, Researcher	UW-Green Bay
Dr. Angela Dantoin-Bauer	Professor, Researcher	UW-Green Bay
Kimberly Busse	Researcher	UW-Oshkosh

Organizations & Companies	Project	Timeframe
Stonehouse Technologies	Whole House Clean Water Pilot Project (terminated)	2016-2018
Algoma School District	Clean Water Kiosk for Residents	2015- current
Wisconsin DNR	5 DNR Workgroups, various matters	2012 – current
Wisconsin Department of Agriculture	Livestock Siting and Local Control over-ride	2014 -current
League of Conservation Voters	Revision of NR 151	2017
Wisconsin State Land and Water Conservation	Revision of NR151	2017
Kewaunee County Groundwater Taskforce	Solutions for Kewaunee County	2014-2015

Studies and Reports For and About Lincoln Township

Note: all studies and reports are available on the web and also archived by Lincoln Township. If the link provided does not work, type the title in the search engine and the report or study will come up. All of these are available in the public domain.

1 Northeast Wisconsin Karst Task Force Final Report

- On February 9, 2007, The Northeast Wisconsin Karst Task Force issued its Final Report. This workgroup was composed of a number of highly credentialed and extremely qualified professionals from across Wisconsin as well as representatives from the agricultural industry and farmers. While the Final Report made a number of recommendations especially apropos to Lincoln Township, probably the most significant recommendation was the establishment of soil depth to bedrock table (page 7 of the report) as an attenuation factor in mitigating groundwater contamination from anything applied to the soil at or near surface level (Table 1).
- The Final Report also made a series of recommendations in #5: Carbonate Aquifer Protection Strategies – Basic Recommendations (page 14 of the report). Note: These recommendations provide a good entry-level checklist for Lincoln Township and Kewaunee County. We believe that LWCD has either adopted or is implementing nearly all of them.

Table 1: Level of protection recommended based on vulnerability ranking and site specific criteria. Criteria are site specific, and multiple criteria may occur in the same agricultural field.

Level of protection required	Criteria	Relative vulnerability to contamination
1*	Less than 5 feet (60 inches) to carbonate bedrock, *and/or* closed depressions or any drainage areas that contribute water to sinkholes/bedrock openings	Extreme
2	5-15 feet to carbonate bedrock	High
3	>15-50 feet to carbonate bedrock	Significant
4	Greater than 50 feet to carbonate bedrock	Moderate

* Level 1 requires the most protection.

- Finally, the Final Report concludes with a series of recommendations in #6: Carbonate Aquifer Protection Strategies – Enhanced Strategies (page 15 of the report). Note: Lincoln Township should consider adopting the following recommendations in its final Groundwater Protection Plan:
    - Reduce water use in manure systems to create more solid manure;
    - Incorporate karst features and drainage tile mapping into local requirements for ATCP 51 (Livestock Siting);

Reference: *Northeast Wisconsin Karst Task Force Final Report* by Kevin Erb and Ron Stieglitz is available at https://cdn.shopify.com/s/files/1/0145/8808/4272/files/G3836.pdf

2 Well Testing: Beginning in 2004 and continuing to the present, Kewaunee County Land and Water Conservation Department has offered well testing to county residents. The purpose is twofold: to educate homeowners about the status of their wells while accumulating data on the wells and groundwater quality in the county. Testing is voluntary on the part of homeowners. However, "voluntary" testing has been criticized by some, suggesting that those who test are a self-selected pool, not a random sampling of wells. (The well testing and reports done by Drs. Muldoon and Borchardt addressed these criticisms.)

Reference: Kewaunee County well test report summaries are available electronically from the KC Land and Water Conservation Department

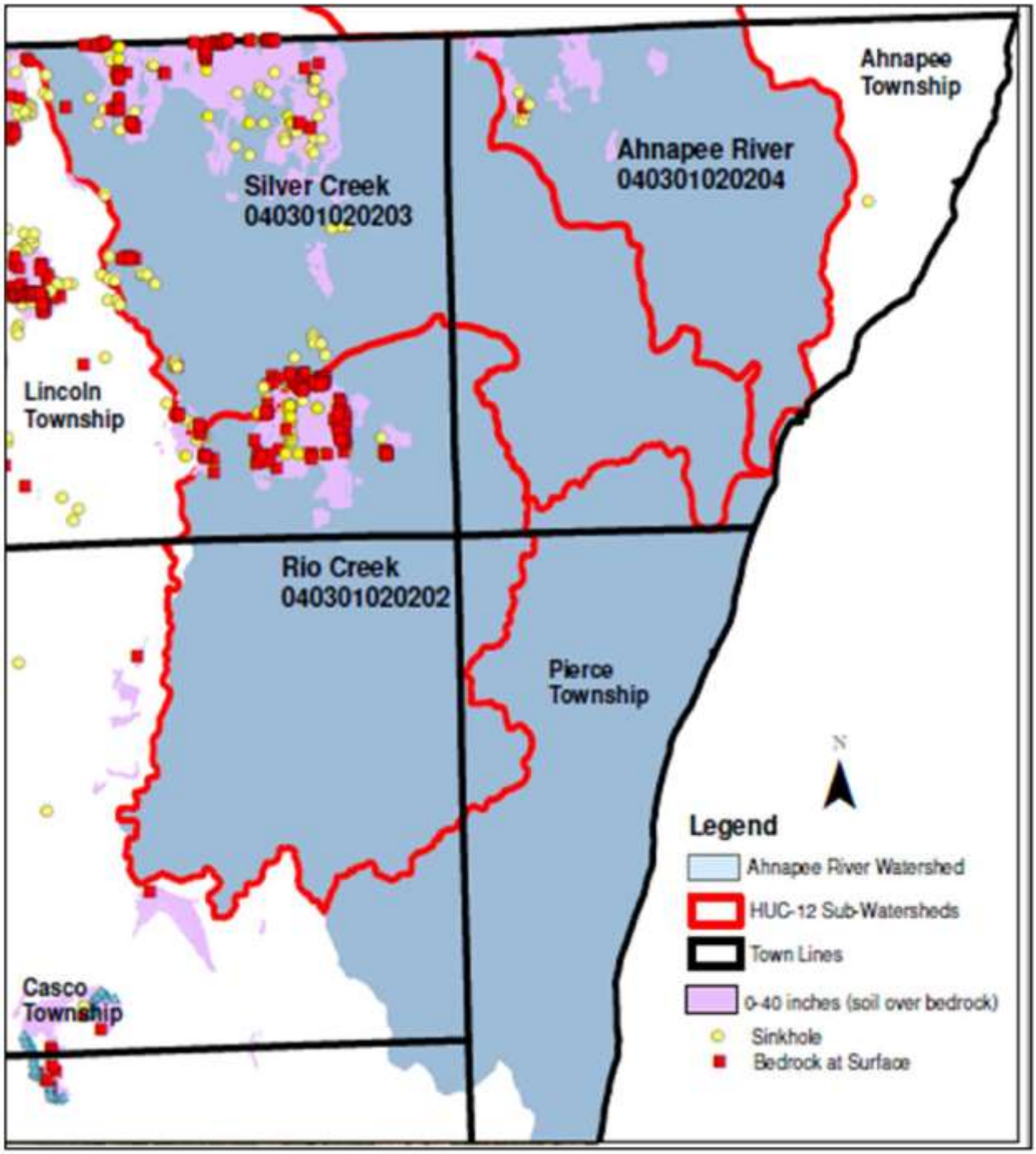
Jumping ahead to the *Ahnapee River Watershed 9-Key Element Plan*, Published by the Kewaunee County Land and Water Conservation Department in April, 2020, Davina Bonness called out the results for Lincoln Township in Table 5 of the report. Over the 15 years of well testing conducted by KC LWCD, Lincoln Township came in with a 33.2% excess nitrates or bacteria contamination rate for wells.

Table 5. Township Cumulative Well Testing Data (2004-2018)

Townships within selected HUC-12s	Total Number of Tested Wells	Total Unsafe Wells *Bacteria Present and/or Nitrates > 10 ppm*	
		Number	Percent
Ahnapee	85	22	25.9%
Casco & Village of Casco	191	50	26.2%
Lincoln	208	69	33.2%
Kewaunee County	**1369**	**413**	**30.17%**

On nitrates, the report states: "Nitrate-nitrogen is the most widespread groundwater contaminant in Wisconsin and because of its mobility through soils and groundwater, **is generally considered to be a good indicator of groundwater susceptibility and land-use impacts** (emphasis added). Background or natural levels of nitrate-nitrogen in groundwater are generally less than 1mg/l (milligrams per liter) or 1 ppm (parts per million). Concentrations above 1mg/l indicates influence by one or more of the following sources: nitrogen fertilizers, manure or other bio-solids (both application to land surface or leakage from storage), land applications of septage, or septic system drain fields."

The report also states: "Fracture traces, sinkholes, and other direct conduits commonly found in karst settings can provide surface water and any associated nutrients or pathogens direct pathways to groundwater. LWCD has done an extensive job in identifying these karst features **(Map 3: Documented Karst Features)**." Again, Lincoln Township is highlighted but not by choice.



Map 3: HUC 12 Documented Karst Features

Reference: *Ahnapee River Watershed 9-Key Element Plan* is available from the KC Land & Water Conservation Department electronically on request.

3 Well Water in Karst Regions of Northeast Wisconsin Contains Estrogenic Factors, Nitrate, and Bacteria by Dr. Angela Dantoin-Bauer, was the first formal study of non-natural contaminants found in ten randomly chosen wells sampled in each of four counties, including Kewaunee County and Lincoln Township (2012). The wells were chosen based on the following criteria:

- They were cased into the Silurian aquifer;
- They were shallow in depth;
- Historical sampling data for bacteria and nitrate existed;
- The well owners agreed to participate in the study;
- And the wells were located in areas with suspected or known sources of agricultural contamination.

The report states: "Eight wells from each county were designated 'susceptible' to contamination based on past high levels of contamination, while two wells from each county were deemed 'control' wells based on low levels of past contamination." Testing was done by UW-Oshkosh Halsey Science Center's Environmental Microbiology Laboratory.

The sampling, conducted between 2008 and 2009, found the highest levels of endocrine disrupting compounds (EDCs) in Kewaunee County in a well in northern Lincoln Township, an area with known shallow depth to bedrock. The report states: "Results from the study indicate that groundwater contamination with EDCs, bacteria and nitrate is a common problem in karst areas of northeast Wisconsin. EDC contamination was greatest during the months of August and November." The study did not identify the source of the groundwater contamination, only its existence, although the authors of the study speculated that the source was bovine, given the land use and population.

Reference: Assessing Levels of Endocrine Disrupting Chemicals in Groundwater Associated with Karst Areas in Northeast Wisconsin by Dr. Angela Dantoin-Bauer et al is available at: https://www.wri.wisc.edu/wp-content/uploads/FinalWR08R004.pdf or typed in the title of the research paper.

4 Investigating Inter-annual Variability of Well Water Quality in Lincoln Township by Davina Bonness and Kevin Masarik (2014) was a year-long study of ten wells commissioned and funded by Lincoln Township, co-funded with a $2500 grant by the Lakeshore Natural Resources Partnership and cost-shared by Kewaunee County Land & Water Department.

The wells chosen were of various depths and construction. All wells were "code compliant." To standardize the study, all sampling was done by Davina Bonness and all testing was done by UW-Stevens Point. Contrary to conventional wisdom, the results indicate that the depth of the well had no bearing on whether it could be contaminated. Conclusions include:[1]

[1] The bolded and/or underlined text that follow indicates emphasis added.

- **Groundwater contamination is traveling freely horizontally as well as vertically in the underlying dolomitic bedrock in Lincoln Township.**
- **Drilling a new or deeper well is no guarantee of safe water.**

Table 1: Land-use within half-mile radius of selected wells

Well ID	Non-cropland (acres)	Non-cropland (%)	Total Cropland (acres)	Cropland (%)	Cropland with a Nutrient Management Plan (acres)	Cropland with a Nutrient Management Plan (%)	Fertilizer nitrogen (lbs/acre of cropland/yr)	Manure Nitrogen (lbs/acre of cropland/yr)	Total agricultural nitrogen (lbs/acre of cropland/yr)	Total nitrogen from agricultural sources (lbs)	# of septic systems	Nitrogen from septic systems (lbs)
1	134	27	368	73	295	80	31	27	58	21,432	6	150
2	314	63	188	37	178	95	31	28	59	11,073	7	175
3	181	36	321	64	321	100	26	39	65	20,881	11	275
4	117	23	385	77	385	100	16	63	78	30,130	7	175
5	132	26	370	74	370	100	13	70	83	30,684	1	25
6	107	21	395	79	395	100	29	51	79	31,383	6	150
7	127	25	375	75	185	49	26	44	69	25,916	9	225
8	293	58	209	42	191	91	13	33	47	9,762	14	350
9	45	9	457	91	337	74	38	54	92	41,943	11	275
10	134	27	368	73	368	100	33	51	83	30,706	14	350
Average	**158**	**32**	**344**	**68**	**303**	**89**	**25**	**46**	**71**	**25,391**	**8.6**	**215**

- Table 1 (Land-use within one half-mile radius of selected wells) indicates that, on average, **less than one percent of the nitrogen contribution originated from septic sources, with the balance of the nitrate coming from surrounding croplands**.
- However, the authors later state: **"Assuming that all of the septic systems N (nitrogen) and 5,075 lbs. N (or 20% of total N inputs) will end up in groundwater, we estimate that 96% of nitrate in groundwater around these wells is from agricultural sources while 4% is attributable to septic systems."**
- In addition, the authors stated that, with "89% of the cropland under Nutrient Management Plans, we conclude that elevated nitrates are a result of acceptable agricultural management practices and not the result of gross mismanagement or negligence."
- Further, **"if the goal is long-term reduction of nitrates in groundwater, then (farmers) need to reduce nitrogen inputs beyond the current source, rate, and timing (of) risk management strategies outlined in existing nutrient management plans**."

"Nitrate, because of its mobility through soils and groundwater, is generally considered to be a good indicator or groundwater susceptibility and land use impacts." – Kevin Masarik and Davina Bonness

Reference: *Investigating Inter-annual Variability of Well Water Quality in Lincoln Township* by Davina Bonness and Kevin Masarik (2014) is available from the KC Land & Water Conservation Department electronically on request.

5 Monitoring of Non-point Source Pollutants in the Ahnapee River Watershed, by Kimberly M. Busse, January 2014. Under supervision of Ms. Busse, a team of students sampled 20 sites in the Ahnapee Watershed on the Ahnapee River, Silver Creek and Rio Creek for E.coli bacteria and total phosphorus. Field samples were tested by UW-Oshkosh Environmental Research and Innovation Center. While the bulk of the 20 sampling sites were in Ahnapee Township, two sampling sites were in Lincoln Township on Rio Creek (sites #16 and #17) and three sampling sites were in Lincoln Township on Silver Creek (sites #18, #19 and #20).

Figure 1: *E. coli* and total phosphorus concentrations at each of the 20 open water sites throughout the Ahnapee River Watershed and Crescent Beach.

Sampling resulted in[2] **a correlation between rainfall events and storm water runoff containing E.coli and phosphorus, which indicated an agricultural land source** (known as non-point source pollution) particularly in the Silver Creek and Rio Creek watersheds. The statements in the site assessments from site #18 at Black Ash Road, site #19 at County Road P, and site #20 at Partridge Road, all intersecting Silver Creek, are telling of the findings: "This site appears to be heavily impacted by agriculture but has a large vegetative buffering area." A further conclusion at site #20 is "The apparent sources of contamination at this site that impacted *E. coli* concentrations was total phosphorus. **The only parameter affecting total phosphorus concentrations at this site that was statistically valid was rainfall**. With the agricultural impact at this site it is no surprise the phosphorus levels are elevated and have an impact on *E. coli*

[2] The bolded and/or underlined text that follow indicates emphasis added.

concentrations. Since there is a large amount of mowed lawn and bare dirt, nutrients like phosphorus may be running directly into the creek especially after rain."

Reference: *Monitoring of Non-point Source Pollutants in the Ahnapee River Watershed*, by Kimberly M. Busse, January 2014 is available from Lincoln Township electronically on request.

6 Kewaunee County Public Health and Groundwater Protection Ordinance was adopted on September 23, 2014 by the Kewaunee County Board of Supervisors after overwhelming support in a public referendum. The Ordinance does the following:

- Restricts the application of wastes, manure, septage or agricultural wastewater on land with 20 feet or less to bedrock from January 1st until April 15th unless exempted in writing by Land and Water;
- Restricts the application of wastes, manure, septage or agricultural wastewater on land with 20 feet or less to bedrock when the soil is frozen, snow covered, or saturated; when snow is actively melting such that water is flowing off the field; or precipitation capable of producing runoff is forecasted within 24 hours of application;
- Restricts application of wastes, manure, septage, or agricultural wastewater to direct conduits to groundwater, or allowed to drain to direct conduits to groundwater; and
- Restricts temporary stockpiling of wastes, manure, or septage on land with 20 feet or less to bedrock from January 1st until April 15th unless exempted in writing by Land and Water.

Lincoln Township should be particularly interested in the following sentence from the **Declaration of Policy and Findings** section of the Ordinance, Section 1(4)(f): **"Based on available data and past implementation experience in Kewaunee County, current generally accepted nonpoint source pollution abatement best management practices do not adequately protect the County's groundwater resources from contamination with excessive nutrients, microbial pathogens, and pharmaceuticals present in waste applied to the land."**

Reference: The *Kewaunee County Public Health and Groundwater Protection Ordinance* can be found on the Kewaunee County website at https://www.kewauneeco.org/i/f/files/Ordinances/Chapter%2030.pdf

7 Safe Drinking Water Act Petition to the Environmental Protection Agency: In October of 2014, Kewaunee County residents and concerned environmental groups took legal action in the form of a petition requesting that the EPA use its emergency powers under the SDWA, 42 U.S.C. § 300i, to identify and abate the source(s) of drinking water contamination. The petition stated "The contamination in Kewaunee County warrants emergency action under the Safe Drinking Water Act, 42 U.S.C. § 300i. Prompt and decisive emergency action from EPA under the SDWA is needed in Kewaunee County, Wisconsin."

The Petition made the claims that:

a. Contaminants are present in, and likely to continue to enter, an underground source of drinking water in Kewaunee County.
b. Nitrate and bacteria contamination of Kewaunee County's drinking water is causing an imminent and substantial endangerment to public health
c. Appropriate state and local authorities have not acted to protect the health of persons affected by groundwater contamination in Kewaunee County.

The Petition states: "Despite developing an understanding of the cause and extent of the bacteria and nitrate groundwater contamination within its borders, Kewaunee County has not been able to protect public health from threats of nitrate and bacteria pollution because it lacks sufficient authority and resources to do so. Importantly, state law limits local units of government such as Kewaunee County from taking decisive action to address pollution"

Believing that the petitioners had proven their case, the EPA started action with the DNR in an attempt to address the concerns raised by the petitioners. The resulting action was the creation of the DNR/Kewaunee County Collaboration Workgroups which in turn were the catalysts for revisions on NR151 and ATCP 50 and changes in the DNR Well Compensation Program. Additionally, new actions were taken by the Land and Water Conservation Department and USDA/NRCS to incentify the use of cover crops, revise Nutrient Management plans and require manure haulers to carry Nutrient Management maps in vehicles. One Workgroup focused on determining the sensitive areas and adjusting application rates for manure in those areas. In Lincoln Township, the work done in this Workgroup and the lack of detailed maps delineating depth to bedrock and water tables prompted the town to commission its own Ground Water Mapping Project with the Wisconsin Geological and Natural History Survey specifically including a Sensitive Areas Map.

Reference**:** The EPA Petition can be found at:
https://midwestadvocates.org/assets/resources/Safe%20Drinking%20Water%20Act%20Petition/2014-10-22_Kewaunee_SDWA_Petition_to_EPA.pdf

Updated information on the EPA Petition case can be found at:
https://midwestadvocates.org/search?q=EPA%20petition

8 DNR Workgroup Final Report 2016

Given the unique hydrogeology in certain regions of the state, in particular the karst geology in northeast Wisconsin, the Wisconsin Department of Natural Resources (DNR) and a number of local, state and federal partners convened a Groundwater Workgroup to assess issues regarding land spreading and contamination of groundwater and drinking water wells.

The workgroup was established in response to concerns over contaminated drinking water wells in Kewaunee and Door counties, as well as a formal request from environmental groups and concerned citizens made to the U.S. Environmental Protection Agency (EPA), under the Safe Water Drinking Act, to investigate and address contaminated wells in Kewaunee County.

The charge of the workgroup was to develop recommendations to reduce risk to groundwater quality and public health in Kewaunee County, with the idea that many of the recommendations could also be applied across Wisconsin.

Five workgroups were established with Lincoln Township residents involved in all five workgroups:

- Short Term Solutions
- Compliance
- Best Management Practices / Sensitive Areas (contrary to the report, this workgroup never reached consensus on their recommendations)
- Communications
- Alternative Practices (still meeting to finalize fact sheets)

Many changes to existing processes and policies at both the state and county levels were made as a direct result of these Workgroups. Changes made and studies initiated included reduced income thresholds for the State's Well Compensation Program, new Silurian Dolomite Standards in NR151[3], comprehensive well testing by the USDA to identify contamination level and source[4], and the DNR ending the practice of permitting land spreading of human septage in Kewaunee County.

Reference: *The Groundwater Collaboration Workgroup Final Report* can be found on the Kewaunee County website at https://www.kewauneeco.org/i/f/files/Public%20Health/Groundwater%20Collaboration%20Workgroup%20FINAL%20REPORT%206-16.pdf

On July 1, 2018, Wisconsin adopted standards and prohibitions specific to Silurian Dolomite bedrock, defined as "the area in Wisconsin where the bedrock consists of Silurian Dolomite with a depth of bedrock of 20 feet or less," which includes Kewanee County.

On September 18, 2018, Kewaunee County locally adopted the Wisconsin Department of Natural Resources' NR151 Agricultural Performance Standards and Prohibitions as Chapter 39. The "Agricultural Performance Standards" Ordinance, which includes the recently adopted Silurian Dolomite rules that address land application of manure on 20 feet or less to bedrock, allows Kewaunee County to enforce the standards and prohibitions.

Reference: https://www.kewauneeco.org/departments/land-water-conservation/nr151-state-agricultural-performance-standards/

KC Chapter 39: https://www.kewauneeco.org/i/f/files/Ordinances/Chapter%2039.pdf

[3] See https://www.kewauneeco.org/departments/land-water-conservation/nr151-state-agricultural-performance-standards/

[4] See page 23 of this document for the first Borchardt report (#10) for initial findings and pages 32 and 33 of this document for the final Borchardt report (#13).

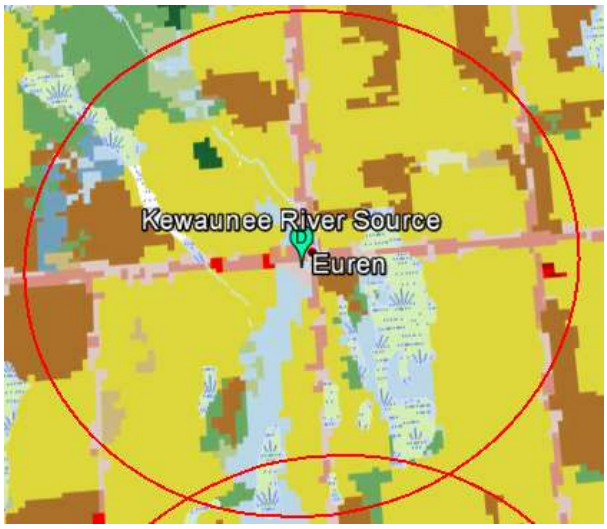
9 Kewaunee County: Using Research to Help Determine Contaminants and Risks to Human Health, by Dr. Krassimira Histova, Marquette University, September 2015. Water samples analyzed by Marquette Engineering, Pace Laboratories, and University of Illinois Champaign Urbana.

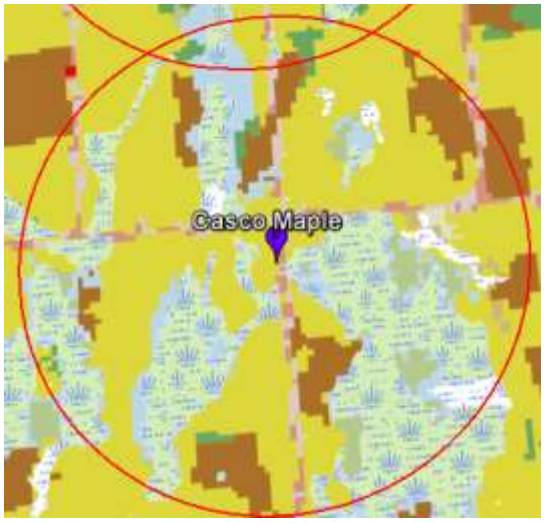
Research Questions (quoted directly from the report):

1. What is the level of nutrients and fecal pollution in Kewaunee County surface waters?
2. Are hormones and Pharmaceuticals Personal Care Products (PPCPs) present?
3. Are Antibiotic Resistance Genes (ARGs), coding for resistance to clinical antibiotics, present in Kewaunee County surface waters and sediment?
4. If present, does proximity to CAFO operations impact ARG levels?
5. Does seasonal manure application impact the dissemination of ARGs in Kewaunee County?

Findings from the 20 sites samples and analyzed (quoted directly from the report):

- E.coli and coliforms are present above EPA standards for recreational standards in Kewaunee County Rivers.
- Nitrate is above drinking water standards at multiple sites.
- Nitrogen positively correlates with percent of agricultural land use.
- E.coli correlates with agricultural land use.
- The presence of hormones (estrone) and pharmaceuticals (fluoxetine), which are a threat for chronic exposure to aquatic life and humans.
- Multidrug resistant and pathogenic bacteria are residing within river sediment
- Antibiotic Resistant Genes are present in Kewaunee County surface waters and sediment (sediment is an indicator of long-term contamination).
- Highest numbers were found in October; October copy numbers represent year-long accumulation after seasonal manure accumulation.
- Farming practices in Kewaunee County impact Antibiotic Resistant Genes on a seasonal scale.





Left map: Cty. Rd S and Maple Rd. **Right map: Pheasant Rd. and Maple Rd.**

- The chemical and biological assessment confirms impairment of Kewaunee County surface water and poses concerns for fishing, recreation, and drinking water wells on local residents.

Reference: ***Kewaunee County: Using Research to Help Determine Contaminants and Risks to Human Health***, by Dr. Krassimira Histova, Marquette University, September, 2015, can be acquired by contacting Do. Histova through https://www.marquette.edu/biology/directory/hristova.php

10 Assessing Groundwater Quality in Kewaunee County, Wisconsin, a public presentation by Dr. Maureen Muldoon and Dr. Mark Borchardt in June, 2017.

Part one of a two part study laid out the objectives and preliminary findings for the Borchardt/Muldoon team's well water testing research in Kewaunee County.[5]

Objectives of the two part study:

1) Estimate the county-wide contamination rate for indicator bacteria and nitrate as related to depth of bedrock;

2) Characterize seasonal variation in recharge and groundwater quality;

3) Determine sources of fecal contamination in private wells using viruses and fecal markers capable of distinguishing septic system versus bovine fecal material;

[5] See pages 32 and 33 for the final results and conclusion of the Borchardt study (#13).

4) Install an automated sampling system on one or more wells to determine the timing of peak transport for pathogens and indicator bacteria and identify those time periods/recharge conditions that lead to the highest pathogen loads;

5) Compare water-quality data from samples collected during this study to existing waterquality data for Kewaunee County;

6) Compare private well contamination rate of bovine manure-specific microbes with the risk predictions for surface water runoff from the Runoff Risk Advisory Tool.

Preliminary Summary:

- Depth to bedrock and contamination
    - Depth to bedrock is one of the most important factors related to private well contamination in Kewaunee County.
    - Wells located in the two shallowest depth-to bedrock categories used in the present study (less than 5 feet and 5 to 20 feet) had the highest contamination rates of coliform bacteria, E. coli, or nitrate-N greater than 10 mg/L.. **Statistical modeling reported elsewhere suggests the depth to bedrock must be greater than 50 feet for the risk of well contamination to be similar to the Wisconsin statewide averages for coliforms, E. coli, and nitrate.**[6]
    - About 2% of private wells in Kewaunee County are located where the depth to bedrock is less than 5 feet. While it might be encouraging (that) there are fewer wells considered highly vulnerable to contamination, the data show contamination vulnerability extends to much deeper depths to bedrock than originally thought (e.g., wells with 5 to 20 feet depth to bedrock are more likely to be contaminated than wells with bedrock depths greater than 20 feet).
    - The fecal wastes in private wells in Kewaunee County stemmed from both human and bovine sources. Septic systems and cattle manure are the two largest fecal sources on the 44 Kewaunee County rural landscape. Statistical modeling shows significant quantitative relationships between **septic system density** and well contamination with human fecal microbes, and similarly, quantitative relationships between **agricultural activities** and well contamination with bovine manure microbes.
- Tool for predicting private well contamination: The Runoff Risk Advisory Tool managed by the University of Wisconsin – Madison Department of Soil Science predicts when runoff to surface waters will occur. The proportion of private well sampled positive for

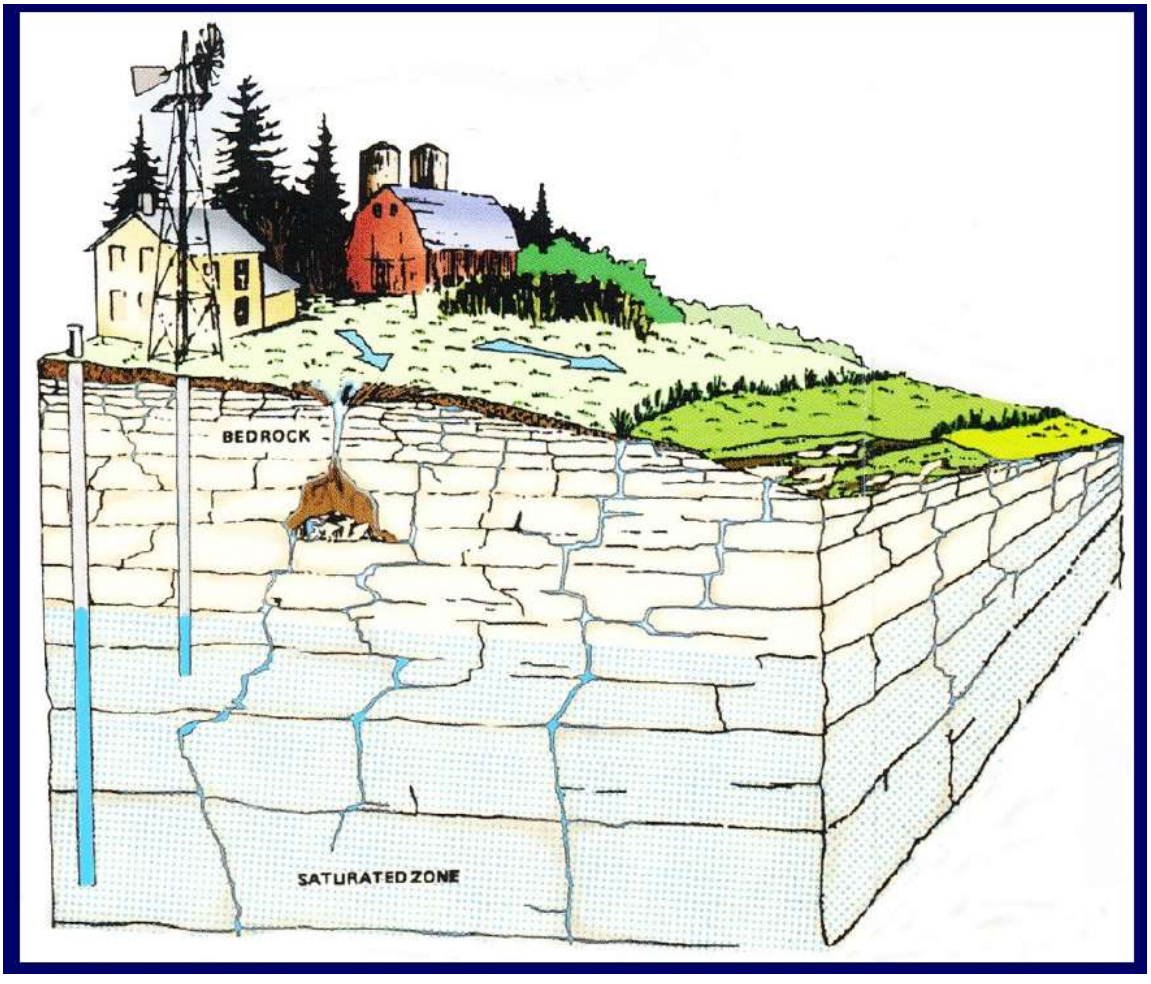
[6] The bolded and/or underlined text that follow indicates emphasis added.

bovine manure was associated with the runoff risk level predicted by the tool, particularly when risk was characterized for the 7 day period prior to well water sample collection.

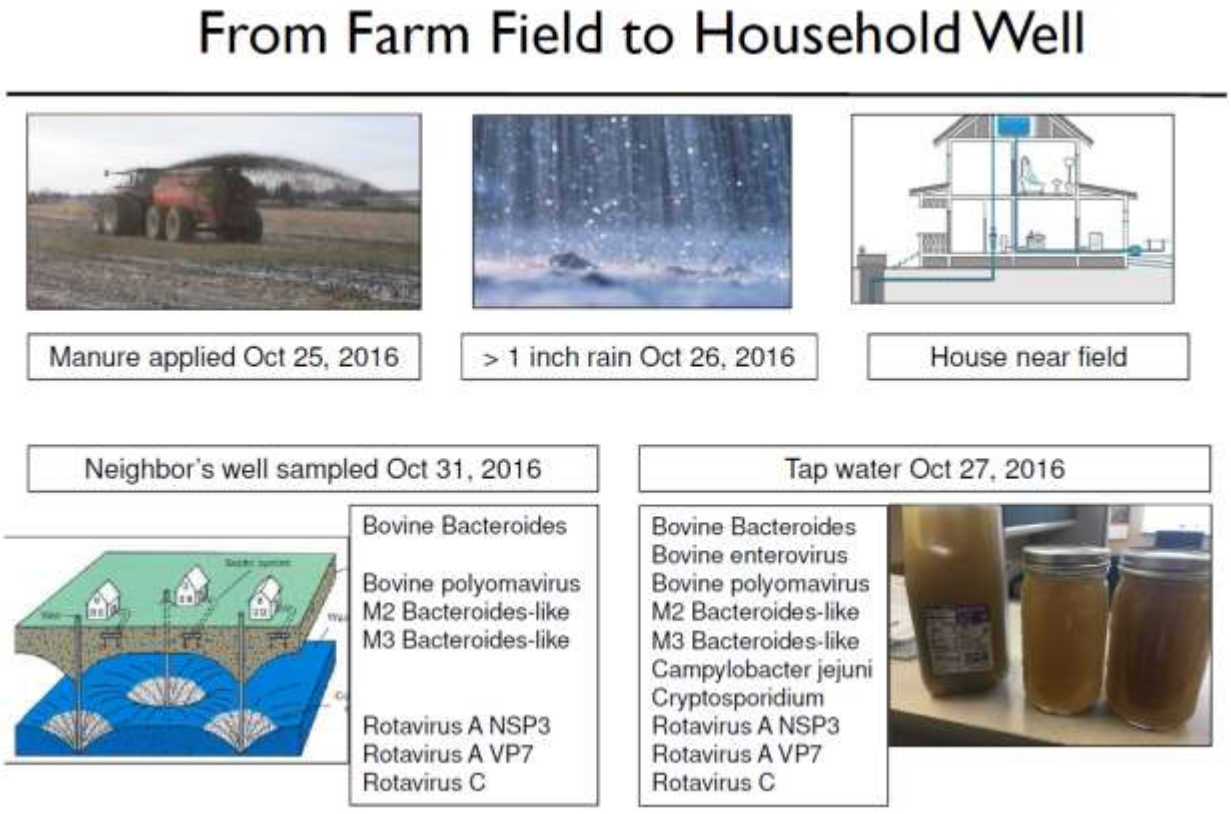
Dr. Muldoon laid out the critical issues that we face with karst geology relative to groundwater contamination in Kewaunee County (quoted directly from the presentation):

Flow Characteristics of Silurian Dolomite Aquifer:

- Dense and ubiquitous fracture network
  - Little surface runoff
  - Water easily infiltrates to subsurface
- Recharge
  - Exceedingly rapid
  - Carries surface contaminates to the water table
- Flow within the aquifer occurs primarily along bedding plane fractures
- Flow rates vary from 10s to 100s of feet/day



Above from Door County Soil and Water brochure: *Protect the Water You Drink*



Editorial clarification:

One of Dr. Borchardt's slides from his 2017 presentation of his preliminary findings showed this scoreboard of bacterial contamination from people versus cattle:

The Plan Commission believes it is necessary to take the time to clarify the misinterpretations of this data in the public arena. An interpretation of the values on the scoreboard alone without first understanding and taking into consideration the magnitude of contamination from each source has resulted in an incorrect conclusion that has continued to be falsely repeated. Focusing on this scoreboard alone has led to the erroneous conclusion that "septics are half the problem, and cows are half the problem." That is categorically, scientifically, and mathematically untrue.

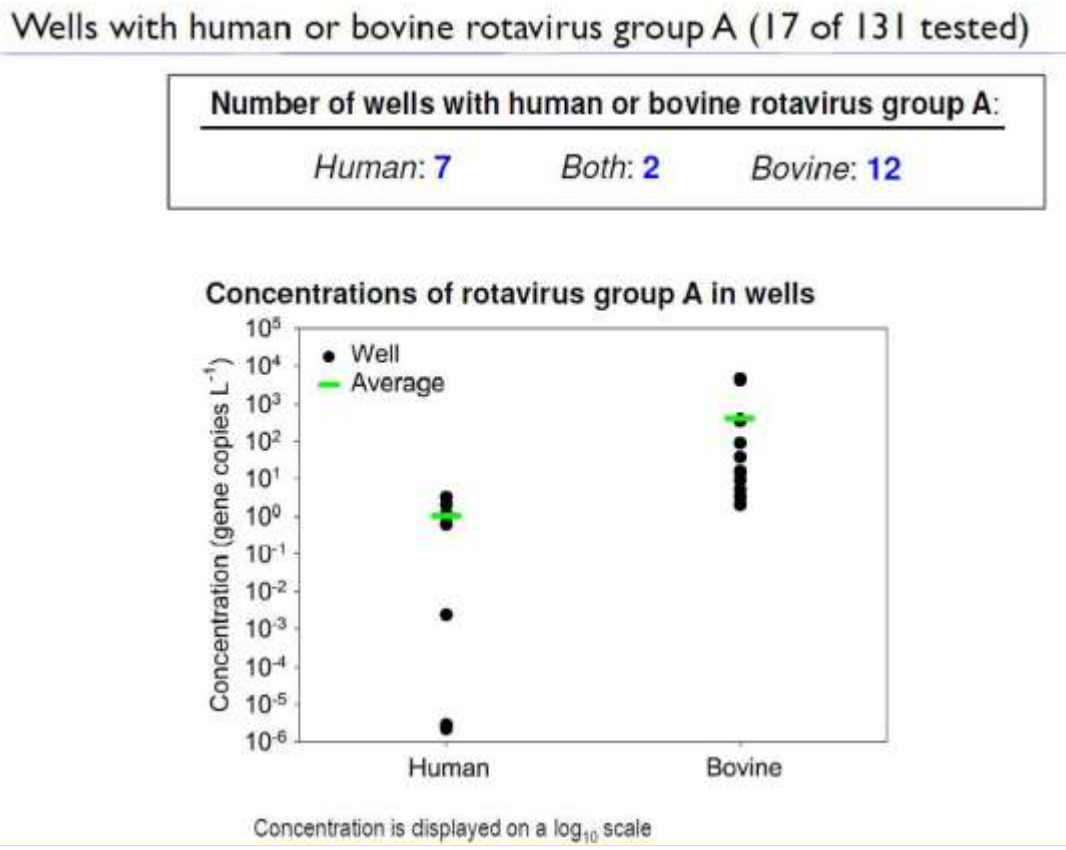
In order to properly understand and analyze the "scoreboard" graphic we must examine the underlying data used to create it and apply mathematical principles to properly show the impact.

We must examine not just the number of times a bovine or human genome was detected, but also how large was the concentration of that genome. The data show the concentration of bacteria in the bovine samples was as much as 49,818 gene copies of bacteria/liter, while the highest concentration of bacteria in the human samples was 1,050 gene copies/liter.

Simply put, the bovine samples have a much higher concentration of bacteria, and therefore have a much greater chance of contaminating the groundwater than the human samples. Using only the numbers of "hits" from a source is misleading. Instead we must consider the much greater impact that the concentration of bovine contamination will have on the groundwater.

Even if every one of the 33 human samples contained the maximum 1,050 copies per liter (which they do not), this would not equal one sample of the 49,818 copies per liter in the bovine samples.

A more in-depth look at Dr. Borchardt's data reveals something quite different from the simple scoreboard above. Another of Dr. Borchardt's presentation slides depicts the following:



As stated, the simple count of “hits” does not accurately represent the data without an understanding of the “relative size” or “quantity” of each hit. The slide above shows a representative sample of wells tested and amounts of human and bovine concentrations of rotavirus. Just looking at the graph, we see that in most cases the number of bovine rotavirus exceeds the amount of human rotavirus. However those numbers in and of themselves do not provide the whole picture of the scale of the contaminants found.

It’s critical to note that the Y-axis of the graph above is a “log scale”, frequently used by scientists and mathematicians to display extremely large or extremely small numbers or quantities. To properly calculate the true magnitude of the amount of the bovine rotavirus versus the human rotavirus the Log 10 factor must be applied. It is only then that we can arrive at the actual numbers.

Therefore, to make all of this easier to understand we asked a mathematician to properly apply the “log 10” factor and display the data (in the graphic below) in a manner that helps citizens better visualize the relative magnitude of the actual amounts of bovine and human contaminants that were found:

In this graphic, each individual “hit” is displayed by its quantity or concentration. Bovine is in **BROWN** and human in **GREEN** in the lower right hand corner. The larger the square, the larger the quantity or concentration in that sample. Due to the fact that some quantities are

extremely small, three human “hits” in the lower right do not even show up on the graphic because the quantities are too small.

We believe that this graphic properly shows the amount of bovine contamination overwhelmingly exceeds that of human contamination in the wells tested by Borchardt and Muldoon in 2015-2016 and fully debunks the fallacy that human and bovine contaminates are a 45/55 split,. This assessment is also born out in Borchardt’s final report wherein he concluded that “septic system variables were not significant”. (see page 33 of this report).

Reference: From the presentation *Assessing Groundwater Quality in Kewaunee County, Wisconsin* by Dr. Mark Borchardt and Dr. Maureen Muldoon The PowerPoint presentation can be obtained electronically from Lincoln Township. The full report can be downloaded from https://www.wri.wisc.edu/wp-content/uploads/Final-Report-Kewaunee-County-Groundwater-Quality-DNR-Project-227.pdf

End of editorial clarification

11 Town of Lincoln 2017 Supplement to the Comprehensive Plan

Some of the working points of the Supplement to the Comprehensive Plan and their status include:

Develop a comprehensive ground and surface water protection plan including but not necessarily limited to:

- Coordinate with the Kewaunee County Land Water Conservation Department and WDNR to implement agricultural and residential best management practices to reduce nonpoint source water pollution.
    - **Status: Ongoing with…**
    - **Resulting actions:** See
        - The DNR Best Management Plan Workgroup recommendations;
        - The KC Land & Water Resource Management Plan 2020-2029;
        - The new NR 151 requirements;
        - The new Silurian standards;
        - KC Chapter 39, essentially NR 151 enforced by KC LWCD
    - All of these were the result of our efforts with the DNR, KC LWCD, DATCP, Natural Resources Board, the meeting of a group of private Lincoln Township citizens and Governor Tony Evers, DATCP Secretary Brad Pfaff, and DNR Secretary Cole Preston; citizen involvement with the Speaker’s Task Force on Groundwater, and township residents’ awareness and speaking out on the Groundwater situation and issues in Lincoln Township.

- Identify those areas where susceptibility to groundwater contamination is highest…
  - **Completed.**

  …and develop plans to ensure that land use within these areas occurs in a manner consistent with protecting groundwater.
  - **Resulting actions:** See…
    - The Sensitive Areas Map,
    - The Agricultural Transition Map,
    - The WGNHS Maps especially the Groundwater Contaminant Susceptibility Map
    - And the Catchment and Closed Depressions Map.
  - **TO DO YET: Develop guidelines for residential and commercial development in "sensitive" areas. Or do this case by case basis?**

- Work with WGNHS, KCLWCD, local universities and WDNR to conduct a comprehensive groundwater assessment study to determine impacts/solutions to regional groundwater quality and quantity issues.
  - **Completed—see all the above.**

- Adopt a groundwater protection ordinance(s) or a groundwater protection overlay district within the zoning ordinance.
  - The Plan Commission assembled a body of evidence to support going forward with either an ordinance or an overlay including this document and the maps that the Town commissioned along with all of the studies that that the Town commissioned and were a part of; **therefore partially completed.**
  - **Status on an overlay district:** The Plan Commission was advised by Bay Lakes Regional Plan Commission that an overlay district is not the way to proceed.
  - **Status on a GW Protection Ordinance:** The Plan Commission was advised that BLRPC has no experience in writing such an ordinance. Regardless, the Plan Commission should consider Zoning Ordinance language as appropriate as the need arises.

- Add language to existing Town ordinances to strengthen protection of groundwater quality/quantity (especially with respect to high volume groundwater withdrawal of any kind).
  - There has been a lack of scientific evidence that would elevate this to a priority concern. The Town Board and Plan Commission are encouraged to watch studies being done in the Central Sands region where the issue of high capacity wells causing surface water draw down is a high priority.
  - **Status: Tabled.**

- Work with Kewaunee County (Land Information Office?) or BLRPC to create a regional map indicating areas susceptible to environmental contamination (based on soil type, depth to bedrock, slope, water table, recharge, etc.

- **Completed;**
    - Sensitive Areas Map, Ag Trans Map, WGNHS Groundwater Contaminant Susceptibility Map for Lincoln Township;
    - LWRMP 2020-2029 for Kewaunee County
    - SnapMaps 20 https://snapmaps19.snapplus.wisc.edu/
  - Note: a "regional map" is technically outside of our scope / territory / ability to work / area of influence; **therefore completed** if we consider 2020-2029 and SnapMaps 20

- Consider developing an information & education strategy aimed at providing residents with the tools to protect their potable water supply.
  - **Completed: See:**
    - What can homeowners do? page 60
    - Kewaunee County Department of Public Health-Environmental Health website
      - Note: while some of this information is valuable, other information is outdated or irrelevant so read this web site and information with a critical eye. **Relevant links can be found in "Resources at the end of this document."**

- Encourage or require the installation of groundwater test and observation wells to measure transmissivity and storitivity for proposed development.
  - **Status: Not done yet;**
  - Lincoln Township should consider seeking a grant for groundwater monitoring wells at up to 5 locations in the town which would represent a variety of susceptible groundwater areas.
- All of the following maps were completed for the Supplement to the Comprehensive Plan and also exist in this report:
    - Current Land Use Map See page 8
    - Environmental Corridors Map See page 59
    - Sensitive Areas Map See page 47
    - Future Land Use/Ag Transition Map See page 50

Reference: The complete Supplement to the Comprehensive Plan can be found on the Lincoln Township website at https://lincolnkewauneewi.com/2017/11/04/final-town-of-lincoln-comprehensive-plan-chapters-1-6-available/

12 Hydrogeological Characterization of the Town of Lincoln, Kewaunee County, Wisconsin, Wisconsin Geological and Natural History Survey, 2017. The groundwater mapping project of the township was funded by the town with a $20,000 grant from the Kewaunee County Land Information Office. At the time that this mapping project was done, it was one of only a handful done in all of Wisconsin. Besides WGNHS and Lincoln Township, assistance was provided by:

- Kewaunee County Land and Water Conservation Department,
- Wisconsin Department of Natural Resources,
- Kewaunee County Land Information Office,
- University of Wisconsin-Stevens Point,
- University of Wisconsin-Extension,
- United States Geological Survey,
- USDA-Natural Resources Conservation Service,
- Madison Gas & Electric,
- Wisconsin Public Service,
- And the cooperation from the farming community in Lincoln Township.

The final report included information and maps on the following:

- Site Map—Overview of Lincoln Township
- Depth to bedrock,
- Input datasets for depth-to-bedrock map,
- Water-table elevation,
- Depth to water table,
- Groundwater recharge,
- Groundwater contaminant susceptibility, and
- Catchments and closed depressions.

Of particular value in the report are the sections for each map titled:

- What is a XXX map?
- What does this map show?
- How was this map constructed?
- Why is this map important?
- How should this map be used? and
- Limitations of this map.

The town and county can use the new maps and report for making informed land-use management decisions.

Reference: the full report *Hydrogeological Characterization of the Town of Lincoln, Kewaunee County, Wisconsin*, Wisconsin Geological and Natural History Survey, 2017 can be found on the Lincoln Township website at https://wgnhs.wisc.edu/catalog/publication/000952

13 Borchardt and Muldoon studies: Risk Factors Associated with Private Well Contamination in Kewaunee County, Wisconsin, Dr. Mark Borchardt and Dr. Maureen Muldoon, UW-Oshkosh, 2019. This is the final analysis of the data collected in 2015-2016 and detailed in the ***Assessing Groundwater Quality in Kewaunee County, Wisconsin*** (quoted directly from the slides cited):

Research objectives: (slide #3)

- Identify county-wide contamination rates for nitrate and indicator bacteria related to depth-to-bedrock
- Determine source of fecal contamination using virus and fecal markers
- Identify risk factors for private well contamination using statistical models

Well construction and siting risk factors investigated (slide #29)

- Well age
- Well depth
- Casing depth
- Length of casing into bedrock
- Length of casing below water table
- Open interval length
- Depth to groundwater at time of well construction
- Depth to bedrock
- Elevation at site
- Soil drainage at site

Conclusions:

- Risk factors for high nitrate detection—fall and summer sampling (slide #22)
    - Important factors:
        - Distance to nearest agricultural field
        - Distance to nearest manure lagoon
        - Distance to nearest cropped field
        - Area of cropped fields (acres) within 750 feet of well
        - Area of cropped fields (acres) within 1500 feet of well
        - Depth to bedrock
    - Unimportant factors:
        - **Septic system variables were not significant** (emphasis added)

- Risk factors for coliform bacteria detection—fall and summer sampling (slide #24)
    - Important factors:
        - Distance to nearest manure lagoon
        - Distance to nearest agricultural field
        - Area agricultural fields (acres) within 750 feet of well
        - Distance to nearest cropped field
        - Area of cropped fields (acres) within 750 feet of well
        - Depth to bedrock
    - Unimportant factors:
        - **Septic system variables were not significant** (emphasis added)

- Summary: (slide #33): Risk factors for well contamination are:
    - Septic system density
    - Agricultural land use

- Manure storage
- Groundwater recharge
- Depth to groundwater
- Precipitation
- **Well construction is not very important** (emphasis added)

Reference: The full PowerPoint presentation, *Risk Factors Associated with Private Well Contamination in Kewaunee County, Wisconsin,* Dr. Mark Borchardt and Dr. Maureen Muldoon, UW-Oshkosh, 2019, can be requested electronically from Lincoln Township.

14 Kewaunee County's Land & Water's Resource Management Plan Update 2020-2029

While Lincoln Township is not the primary focus of this excellent 148-page overview of Kewaunee County land and water resources, our township does weigh heavily in many of the recommendations that come out of the Management Plan due to the township's geology and groundwater issues. Some points highlighted in the report that cover Lincoln Township include:

- The Ahnapee River Watershed is dominated by agriculture (71%) and wetlands (17%) and is ranked high for nonpoint sources affecting streams and groundwater. The Ahnapee River was placed on the impaired waters list for total phosphorus in 2014.
- Silver Creek, which outlets into Lake Michigan, has fair to poor quality water. In 2018, Silver Creek was added to the impaired waters listing for total phosphorus.
- Rio Creek has very poor quality water, but has not yet been designated for total phosphorus.[7]
- **Both creeks experience impacts from farmland erosion and other nonpoint sources throughout the watershed** (WDNR 1995)**.**
- **Surface water and groundwater are often directly connected in karst geology.**
- Karst features, including fracture traces and sinkholes often become direct conduits for transporting unfiltered groundwater contaminants, such as sediments, chlorides, nitrates, bacteria and other microorganisms to local drinking water aquifers.
- The 2007 Northeast Wisconsin Karst Task Force Final Report identified soils with less than 5 feet to carbonate bedrock, and/or **closed depressions** or any drainage areas that contribute to sinkholes/bedrock openings as "extreme" relative vulnerability contamination; 5-15 feet to carbonate bedrock as "high"; and 15-50 (feet) as "significant".
- **When overlaying the nitrate data and unsafe well locations (from the LWCD 2004 to 2018 well testing program) with the depth to bedrock layers, the impact or unsafe wells often correlate to areas with shallow soils**.
- Previous groundwater research by Muldoon & Bradbury (2010) indicates contamination in the Silurian dolomite aquifer is often an indication of depth of the overlying glacial materials (or soil). Generally, thicker soil provides greater protection and increases the

[7] The bolded and/or underlined text that follow indicates emphasis added.

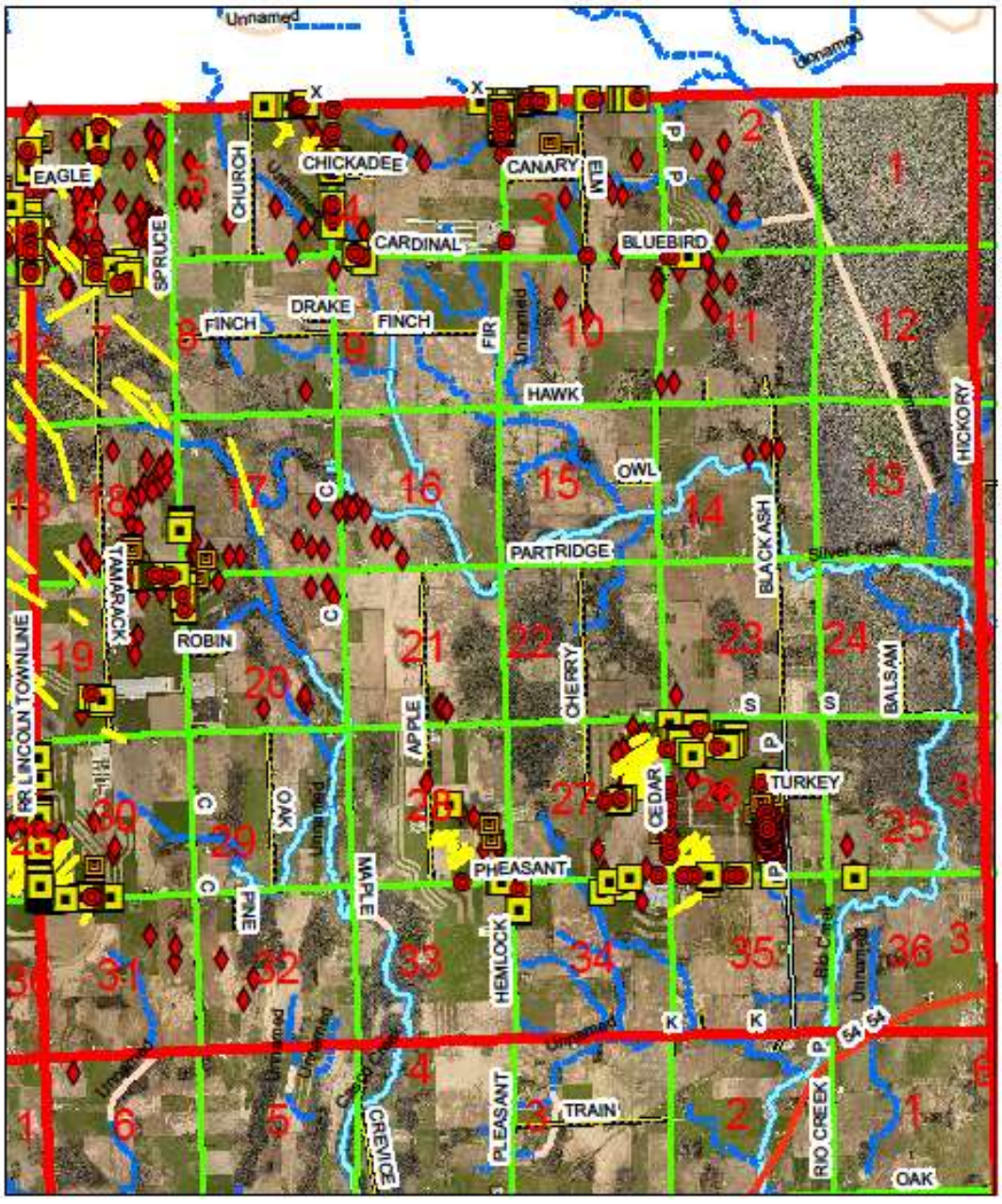
filtration of contaminants before entering the aquifer which is what we see in the voluntary testing results.

- **Commonly noticed issues in cropland fields (during walkovers by LWCD staff) are farming too close to stream corridors, eroding grassed waterways, un-vegetated concentrated flow channels, and sheet/wind erosion.** (emphasis added) Manure management concerns noticed include direct runoff from feedlots and stored manure into waters of the state, process wastewater or leachate discharge, unlimited access of livestock to waters of the state, overflow manure storages, and unconfined manure in Water Quality Management Areas (for all of Kewaunee County, not just Lincoln Township).
- A local priority while conducting NR151 walkovers is to map karst features found on the landscape. Since 2010**, LWDC staff has identified more than 800 new karst features, including sinkholes, bedrock at the surface, karst ledges, fracture traces, and closed depressions (for all of Kewaunee County, not just Lincoln Township.)** (photo credit: Mick Sagrillo, 2020)
- LWCD is updating the **Lincoln Township Karst Map** (see the next page) as information about new karst features and verification of stone piles become available from farmers.

Reference: *Kewaunee County's Land & Water's Resource Management Plan Update 2020-2029* is available from the Kewaunee County Land & Water Conservation Department

The web link below to the DN**R's SnapMaps 20** shows the most up to date karst features including sink holes, bedrock at the surface, karst ledges, and all other geologic fractures and impediments that are required to be reported to LWCD and the DNR.
https://snapmaps19.snapplus.wisc.edu/

KARST MAP
LINCOLN TOWNSHIP
JANUARY 25, 2021



Legend

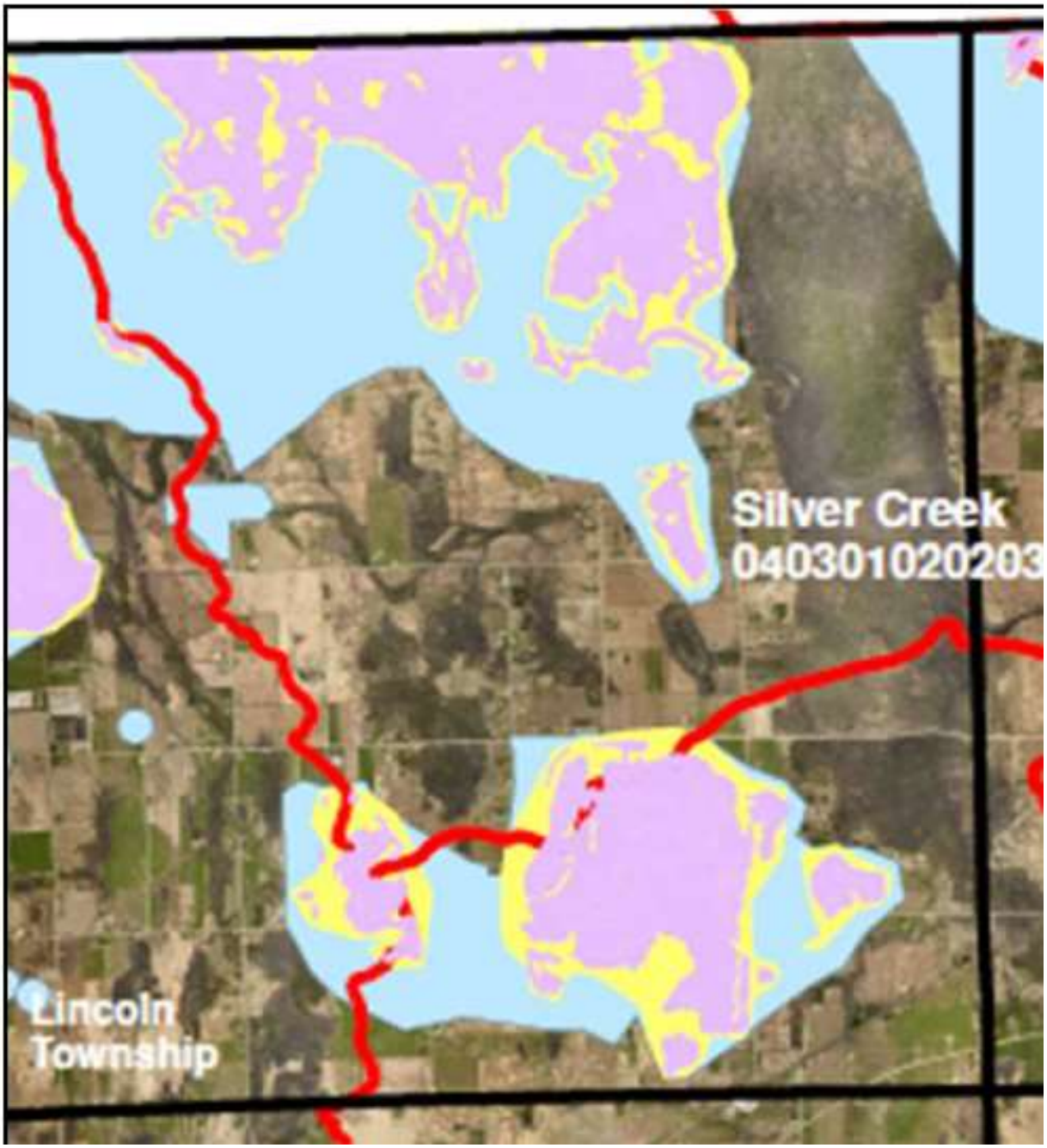
- Karst Features
- Exposed Bedrock
- GPS Sinkhole
- Fracture Traces
- Navigable Stream
- Intermittent Stream
- Section

Kewaunee County
Land & Water Conservation Department

March 1, 2021

15 Ahnapee River Watershed 9-Key Element Plan, KCLWCD April 2020

- All crop producers and livestock producers that mechanically apply manure directly or through contract or other agreement to cropland or pasture areas must meet the Silurian Bedrock Performance Standards specified in NR151.075
- Table 8 identifies the approximate acres impacted by NR 151.075 with soil depths less than 40 inches to bedrock **(identified in pink on Map 9),** 40 inches to 5 feet **(yellow)** and 5 feet to 20 feet **(blue).**



Map 9, NR 151 Silurian Dolomite Standards: Depth to Bedrock, Lincoln Township

Table 8: HUC-12 - Bedrock Depths Acres & Percentages

HUC-12 Sub-Watersheds	Total Acres in HUC-12	Bedrock at 0-40 inches (pink)		Bedrock at 40 inches to 5 feet (yellow)		Bedrock at 5 feet to 20 feet (blue)		Total Bedrock at 0-20 feet	
		Acres	%	Acres	%	Acres	%	Acres	%
Silver Creek	17,923	1,913	10.7	741	4.1	3,744	20.9	6,398	35.7
Rio Creek	15,941	804	5.0	444	2.8	890	5.6	2,138	13.4
Ahnapee River	8,376	280	3.3	170	2.0	1,158	13.8	1,608	19.2
Totals:	**42,240**	**2,997**	**7.1**	**1,355**	**3.2**	**5,792**	**13.7**	**10,144**	**24.0**

- From the table above:
  - Silver Creek sub-watershed contains the highest amount of shallow soils over bedrock, mostly located in Lincoln Township at 35% or approximately 6000 acres.
  - Overall, 24% of the acres in the Ahnapee River watershed have soils less than 20 feet to bedrock and therefore have newly associated Silurian Dolomite manure spreading restrictions.[8]
- **"Tile drains in fields can act as a conduit for nutrient transport to streams if not managed properly."**
- "An average of 0.9 lbs. of phosphorus/acre/year and 240 lbs. of sediment/acre/year was found to be leaving via tile drainage on a UW-Discovery Farm study in Kewaunee County."
- "The UW-Discovery Farm study compared surface phosphorus loss to tile phosphorus loss **and found that the tile drainage was 34% of the total phosphorus lost."**
- **"Treating tile drainage at the outlet and better management of nutrient/manure applications of fields can reduce the amount of phosphorus reaching rivers and streams."**

[8] The bolded and/or underlined text that follow indicates emphasis added.

Part of Map 16: Known Tile Lines in Rio Creek HUC-12

- "Target Audience: Focused attention will be on agricultural land owners and operators **since the main source of pollutant loading in the watershed is from agricultural land**." "**Non-operator agricultural landowners are an important subset of this group as they are usually not focused on and are less likely to participate in conservation programs."**
- "Legacy phosphorus in a soil occurs when phosphorus in soils builds up much more rapidly than the decline due to crop uptake. In stream channels, legacy phosphorus can result from sediment deposition of particulate phosphorus, sorption of dissolved phosphorus into riverbed sediments or suspended sediments, or by incorporation into the water column." "Legacy instream sediment may need to be evaluated as a significant source of phosphorus." (See the findings from Heidelberg University's National Center for Water Quality Research on page 66.)
- Water Quality Monitoring Process Evaluation (the following items need to be evaluated and documented)
    - "The presence and extent of drain tiles in the watershed area in relation to monitoring locations."
    - "Do these drainage systems contribute significant phosphorus and sediment loads to receiving streams?"

Reference: The *Ahnapee River Watershed 9-Key Element Plan, KCLWCD April, 2020,* is available electronically from the KC LWCD.

16 DNR Total Maximum Daily Load (TMDL) Study of the Ahnapee River watershed (and Silver Creek as it feeds the Ahnapee watershed) for phosphorus is ongoing. The impact to the Ahnapee River watershed is unknown at this point in the study. We will continue to monitor the study as it proceeds.
Reference: https://dnr.wisconsin.gov/topic/TMDLs/NELakeshore.html

17 DNR Special Well Casing Depth Areas

The DNR has designated three areas in Lincoln Township as requiring special well casement depths which are in excess of the State's specification. The designation is controlled by the DNR and is triggered by contamination events. In these cases the contaminant was identified as livestock and or bacteria.

- All parcels in sections 1 to 6—Extension of Door County Special Casing Depth Area due to bacteria; 140' of casing required.
- A parcel in section 17—Special Area of Well Compensation Eligibility due to livestock waste / Bovine Bacteroides; 160' of cement grouted casing.
- A parcel in section 19—Special Area of Well Compensation Eligibility due to livestock waste / Bovine Bacteroides; 200' of cement grouted casing.

Reference: https://dnr.wi.gov/topic/wells/documents/SpCsgDpthAreaLst.pdf

CONNECTING THE DOTS

With all of these studies at hand and all of this documentation in mind, the current situation in Lincoln Township (and by extension, other parts of Kewaunee County with karst geology and shallow soils) can be summarized as follows.

- According to every scientist and specialist that Lincoln Township has consulted with or that has made a presentation to us, we have been told that groundwater and surface water are hydro-geologically connected. You cannot separate groundwater from surface water or surface water from groundwater. What you do to one will invariably impact the other.

- 100% of Lincoln Township residents rely on groundwater for their drinking water, cooking, bathing, and other potable water uses unless they have opted to purchase their water from an outside supplier. Some residents have had various water purification devices installed in their homes at their own expense, usually only for drinking and cooking water.

- Lincoln Township is not served by a public sewer system so all occupied buildings in the township have, by law, a private septic system.

- Septic systems are required for homes that do not have sewer to properly treat and disperse wastewater from their homes. Septic systems, when properly sited, designed, constructed and maintained, pose a minimal threat to drinking water source.

- On September 11, 2018, 29 members of the Local Advisory Committee for the Land and Water Resource Management Plan ranked various issues to be addressed in the final plan. Ranked relatively high by this particular group included:
    - Septic systems;
    - Bringing all septic systems up to code;
    - Increase septic system compliance;
    - Inventory and properly abandon wells in cropland, ditches, and no longer used; and,
    - Lawn fertilizer

1. Kewaunee County Land & Water Conservation Department annually releases a Sanitary Systems Updated Report for the previous year. Below is the latest report.

Note: Lincoln Township has the highest compliance rate (along with Red River Township) **of any township in Kewaunee County.**

Note: The State of Wisconsin and Kewaunee County requires all septic systems, regardless of how old, to be pumped and maintained at least once every three years.

SANITARY SYSTEMS IN KEWAUNEE COUNTY SINCE 1985 AS OF 2/31/2020

Source: Kewaunee County Zoning Department 2020 Annual Report

TOWNSHIP	TOTAL # OF ALL SYSTEMS	TOTAL # OF INSPECTED & COMPLIANT SYSTEMS	TOTAL # OF NOT INSPECTED SYSTEMS	COMPLIANT PERCENTAGES	TOTAL # OF SYSTEMS THAT ARE NOT IN USE-NOT INSPECTED
AHNAPEE	442	404	38	91%	7
CARLTON	479	441	38	92%	10
CASCO	498	464	34	93%	12
FRANKLIN	443	398	45	90%	12
LINCOLN	397	382	15	96%	5
LUXEMBURG	584	544	40	93%	6
MONTPELIER	562	504	58	90%	8
PIERCE	423	403	20	95%	6
RED RIVER	477	458	19	96%	7
WEST KEWAUNEE	557	516	41	93%	13
VILLAGE OF CASCO	6	6	0	100%	0
VILLAGE OF LUXEMBURG	4	4	0	100%	0
CITY OF ALGOMA	10	9	1	83%	0
CITY OF KEWAUNEE	34	26	8	76%	0
TOTAL	4916	4559	457	93%	86

Please Note: The county-wide numbers above also include 157 "Not In Use" septic systems. Of the 157 "Not In Use" systems, 86 are not inspected systems and 71 are inspected and compliant systems. Therefore, we have 271 "Not Inspected" systems that are currently being used and 4488 inspected systems that are currently being used.

Source: KC Land & Water Conservation Department, January 2021)

2. As stated earlier, Lincoln Township is home to three CAFOs each with over 1000 dairy cattle, two small dairy operations, both with over 500 cattle, and 11 smaller farms hosting from 30 to 300 cattle. These farms represent only those operations that submit a manure management plan to the Land and Water Conservation Department for the purpose of complying with Wisconsin's Farmland Preservation Program. There are several other farms with various small herds that are not included in the following table:

Farms in Lincoln Township	2020 Total Dairy & Beef Cattle and Calves (1-1-2021)				
(Not all-inclusive)	Dairy/Dry	Heifers 800 to 1200 lbs	Beef	Calves/YS to 800 lbs	TOTAL
Dantoin, Pat (Springdale Dairy)	120	0	0	0	120
Eisenman, Brent & Dixie	0	0	0	300	300
Fenendael, Lonnie/Shane (EL-NA Farms) (WPDES)	1750	450	0	950	3150
Jandrin, Jason	65	30	0	20	115
Kinnard, David & Randy (Kinnard Highland)	328	165	20	60	573
Kinnard, Jeff & Sharon	55	0	0	0	55
Kinnard, Rod & Lee (Kinnard Farms Inc) (WPDES)	7661	0	0	120	7781
LeCaptain, Cletus & Chris	30	18	0	7	55
Monfils, Arlin	0	0	20	0	20
Nowak, Andrew	0	0	30	0	30
Pagel, John & Don Niles (Dairy Dreams) (WPDES)	3250	838	0	2022	6110
Pinchart, Nick	0	0	15	15	30
Srnka, Scott (Srnka Farms)	370	135	0	90	595
Strnad, Tim & James (Valley High Dairy)	54	31	0	37	122
Wallace, Paul	90	70	0	25	185
Zellner, Joe	0	13	58	0	71
Total Dairy Cattle					19312
3 CAFOs =					17041
(Source: KC Land & Water Conservation Department, October, 2020/Lincoln Town, January, 2021)					

- Lincoln Township has a very high ratio of cattle (19,312 as of 2021) to residents (933 as of 2020).

3. The Kewaunee County Land and Water Conservation Department Resource Management Plan for 2020-2029 documents nitrate and phosphate pollutant loading on the land from various sources including septics, cropland, pastureland, feedlots, and various miscellaneous sources as can be seen below:

Pollutant Loading in Kewaunee County From Septics Systems versus Cropland from LWRMP 2020-2029

Table 24. 9-Key Element Plan – Current Total Load by Land-Use (with BMP)

Sources	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lbs./year	lbs./year	lbs./year	tons/year
Urban	1693.85	261.21	6669.12	38.69
Cropland	138453.62	36869.61	267418.24	5338.27
Pastureland	45455.92	4317.62	146217.71	378.51
Forest	2958.24	1576.8	7245.32	93.93
Feedlots	16982.44	2915.32	21699.78	0.00
Septic	435.24	170.47	1777.21	0.00
Gully	116.88	96.42	233.75	73.05
Streambank	0.00	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00	0.00
Totals:	**206,096.18**	**46,207.45**	**451,261.12**	**5,922.44**

Source: WDNR Communication, 2018

Kewaunee County 2020-2029 Land & Water Resource Management Plan Excerpted from page 99

Selecting out the highlighted sections of the above table:

Selections from Table 24: 9-Key Element Plan						
Total Pollutant Load by Land Use (with BMP)						
		N load	% of		P load	% of
		lbs./year	total		lbs./year	total
Cropland		138453.62	67.2%		36869.61	79.8%
Feedlots		16982.44	8.2%		2915.32	6.3%
Septic		435.24	0.2%		170.47	0.40%
Total		206096.18			46207.45	
for all of Kewaunee County						
Source: WDNR Communication, 2018						

Focusing on septic systems only versus liquid manure and agricultural wastewater spread on crop fields[9], **67.2% of the nitrogen pollutant load on the land comes from cropland whereas only 0.2% of the nitrogen pollutant load comes from septic systems**. This nitrogen pollutant load from crop lands clearly impacts groundwater at a significantly higher percentage than septics. The high level of nitrates in our groundwater has been documented, starting with the 2007 the Karst Task Force Report and revalidated in subsequent studies by Dr. Mark Borchardt, Dr. Maureen Muldoon, Davina Bonness and Kevin Masarik, the DNR Final Workgroup Reports, and the Kewaunee County Land & Water Resource Management Plan. Nitrogen from agricultural sources is the primary nitrogen load on groundwater as documented by Dr. Maureen Muldoon and Dr. Mark Borchardt in *Assessing Groundwater Quality in Kewaunee County, Wisconsin (2017):* In Kewaunee County, "**dairy farming and associated crop production comprise the primary land use** and manure is commonly applied to crop land prior to spring planting and again in fall after crops have been harvested."

Again, focusing on septic systems only versus liquid manure and agricultural wastewater spread on crop fields, **79.8% of the phosphorus load on the land comes from cropland whereas only 0.4% of the phosphorus load comes from septic systems**. The phosphorus load will most likely impact surface waters as documented by Kimberly Busse's study on Non-Point Source Pollutants in the Ahnapee River Watershed, particularly Silver Creek in Lincoln Township.

- As documented above, the highest inputs of nitrogen, phosphorus, and bacteria pollution on the town's lands come from agricultural sources, not human sources. This reinforces the data from the Bonness and Masarik well study in Lincoln Township in Table 1 on page 10 of this report. It is confirmed from all of this documentation that with a 96% septic compliance rate, **septic systems are not a primary source of groundwater contamination in Lincoln Township.**

- Furthermore, the Land and Water Conservation Department Ahnapee River Watershed 9-Key Element Plan, page 53 states: **"…the main source of pollutant loading in the watershed is from agricultural land".**

Septic systems are barely mentioned in both the Ahnapee River Watershed 9-Key Element Plan and the LWCD Resource Management Plan 2020-2029. Given the fact that Lincoln Township has a 96% septic compliance rate and Kewaunee County has an overall septic compliance rate of 93%, it should be no surprise as to why this is so. **Except possibly very site specific, septic systems are not a consequential cause of groundwater contamination in Lincoln Township.**

- That said, Dr. Mark Borchardt, in a meeting with the Lincoln Township Board of Supervisors and Plan Commission on July 17, 2019, **strongly advised against clustered housing development with our type of shallow soils over karst bedrock**. Dr. Borchardt stated that

[9] The bolded and underlined text that follow indicates emphasis added.

housing development and septic systems in this type of geology are better distributed over the landscape. Dr. Borchardt said that if he were to build a house in Lincoln Township, "it would be in the middle of a 40-acre parcel". This is the very type of rural residential development that is advised against by land use planners, including the consultant that Lincoln Township hired to help us with our Comprehensive Plan.

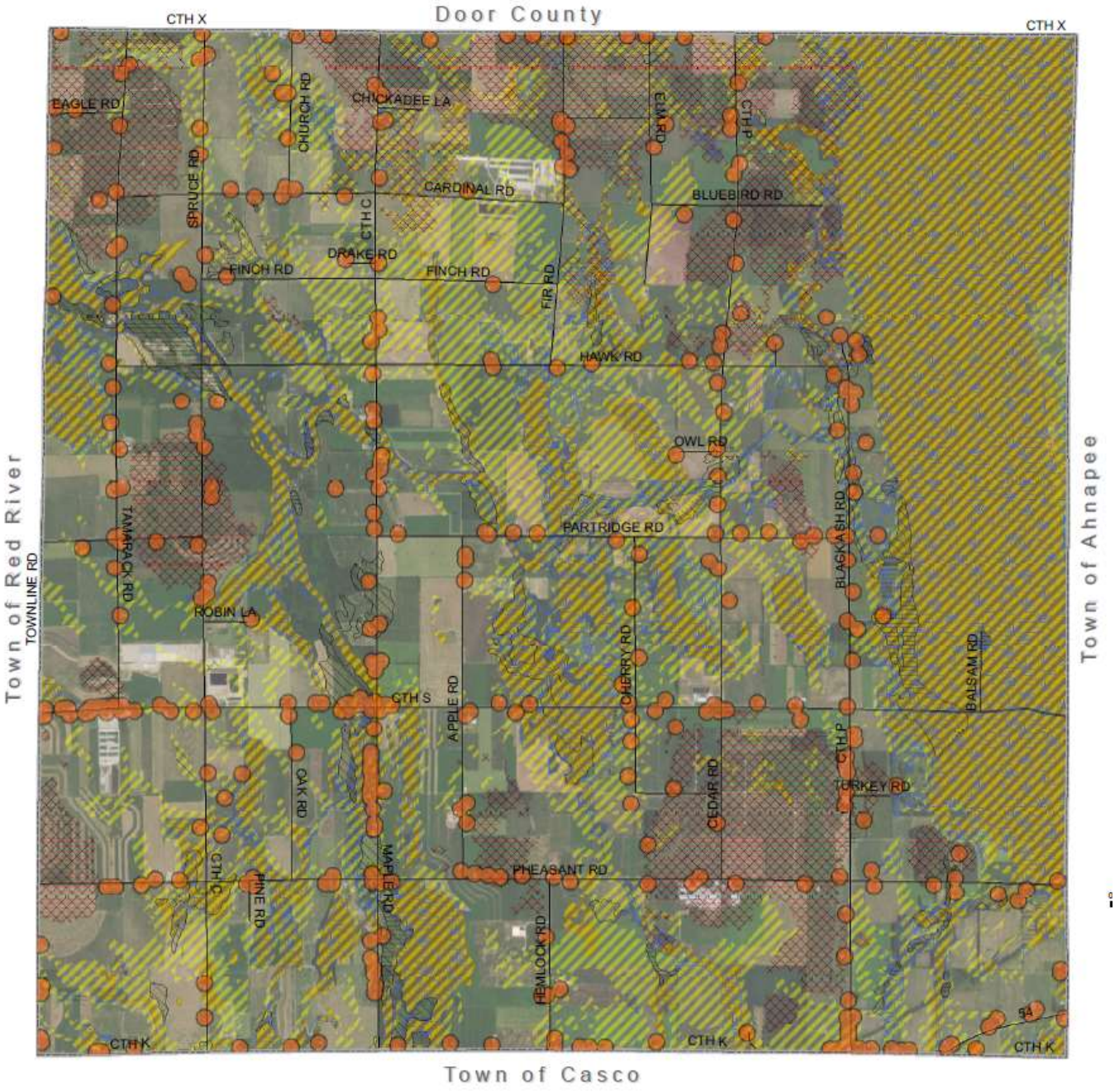
Lincoln Township developed a Sensitive Areas Map in our 2017 Comprehensive Plan with the aid if the DNR, the Kewaunee County Land Information Office, and the Land & Water Conservation Department. Dr. Mark Borchardt's comment on the map: "It's the best GIS data I've seen in the state."

4. The result of many of these inputs into our Comprehensive Plan Sensitive Areas Map we wished to have was reluctance on the part of our comprehensive plan consultant to actually create the Sensitive Areas map. The consultant was reluctant because he stated that the map would look like a "Jackson Pollock painting", far too complicated to be able to reliably interpret on a small scale for planning processes.

However, that was exactly the Plan Commission's objective. Lincoln Township occupies an extremely complicated area of real estate in Northeast Wisconsin, an area heavily sprinkled with:

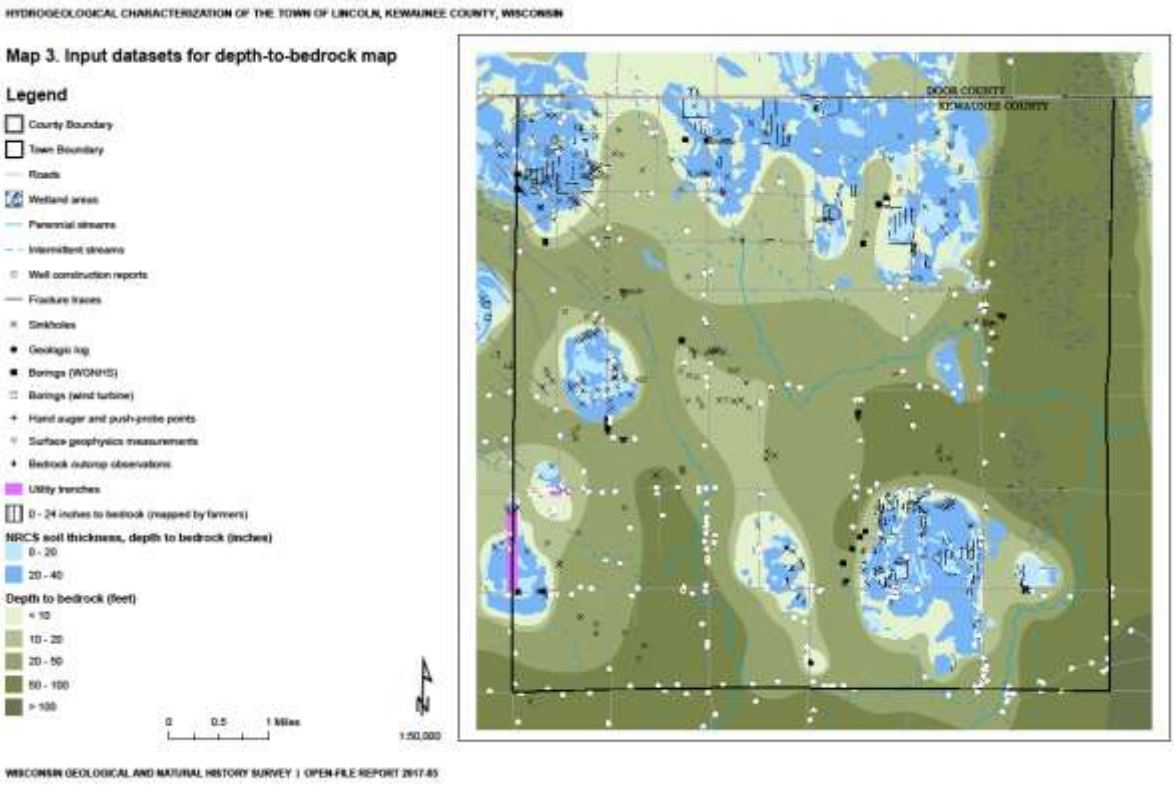
- DNR wetlands
- Sand subsoils
- Highly permeable soils
- Soils with low attenuation potential
- Shallow karst potential soils
- Less than 5 feet to bedrock
- Water table within 3 feet, and
- Hydric soils

As a result, somewhere around 75% to 80% of Lincoln Township is deemed "Sensitive Areas" by DNR definitions. This does not mean that this 75+% of Lincoln Township is unsuitable for agriculture, residential, or commercial ventures. It does mean, however, that 75+% of Lincoln Township lands are inappropriate for the spreading of liquid manure, agricultural wastewater, municipal waste, and whey in the manner in which they have been applied in the past. It also means that the Town Board and the Plan Commission need to proceed cautiously when granting building permits or rezoning requests, and to fully inform residents and land owners of the issues that they will face as they develop their properties as well as the issues that exist with undeveloped properties due to existing land uses, regardless of what they are or what is proposed.

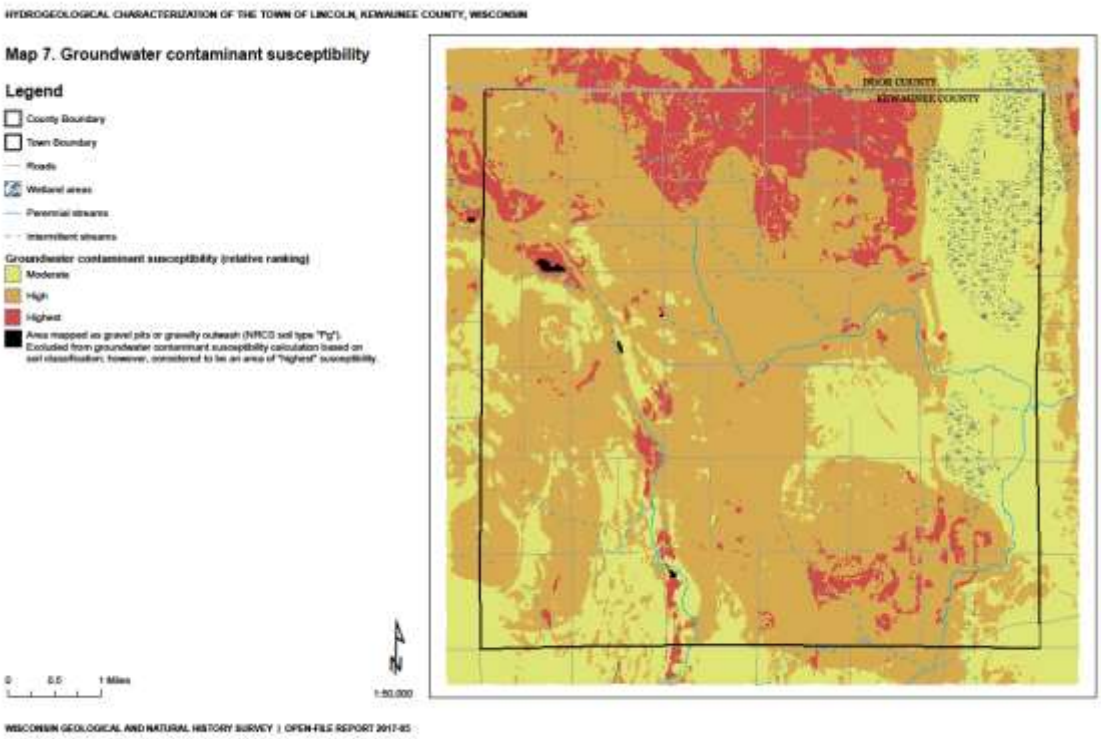


Town of Lincoln Sensitive Areas Map

5. Combined with the Wisconsin Geological and Natural History Survey Depth to **Bedrock Map (Map 3)**



6. and **Groundwater Contaminant Susceptibility Map (Map 7)**



7. Dr. Borchardt's observations of the risk factors for nitrate and bacteria in our groundwater at his July 19th, 2019 presentation to the town specifically noting that **"septic system variables were all not significant:**

Risk Factors for High Nitrate Detection - Fall and Summer Sampling

High nitrate: exceeds health standard; $N\text{-}NO_3^-$ > 10 ppm

Important factors

- Distance to nearest agricultural field
- Distance to nearest manure lagoon
- Distance to nearest cropped field
- Area of cropped fields (acres) within 750 feet of well
- Area of cropped fields (acres) within 1500 feet of well
- Depth to bedrock

Unimportant factors

- Septic system variables were all not significant

Risk Factors for Coliform Bacteria Detection
Fall and Summer Sampling

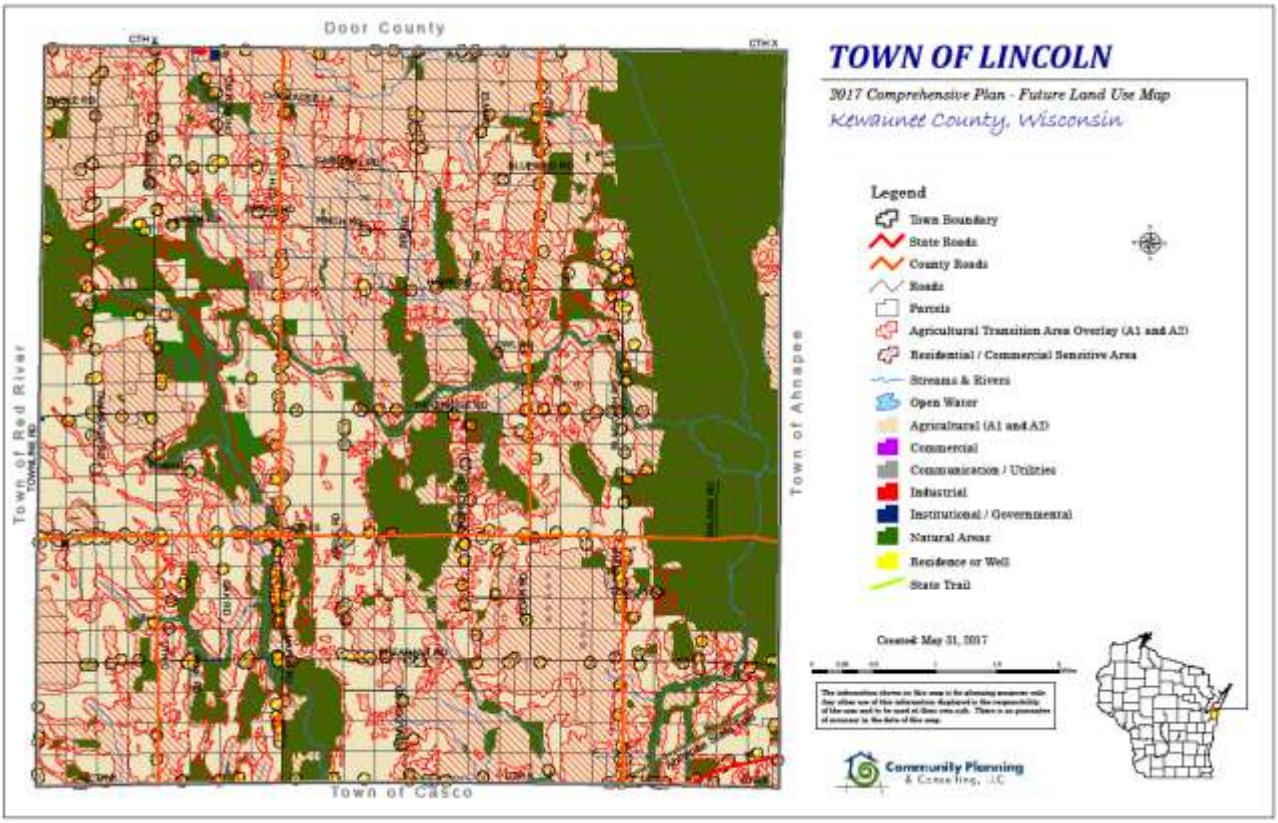
Important factors

- Distance to nearest manure lagoon
- Distance to nearest agricultural field
- Area agricultural fields (acres) within 750 feet of well
- Distance to nearest cropped field
- Area of cropped fields (acres) within 750 feet of well
- Depth to bedrock

Unimportant factors

- Septic system variables were all not significant

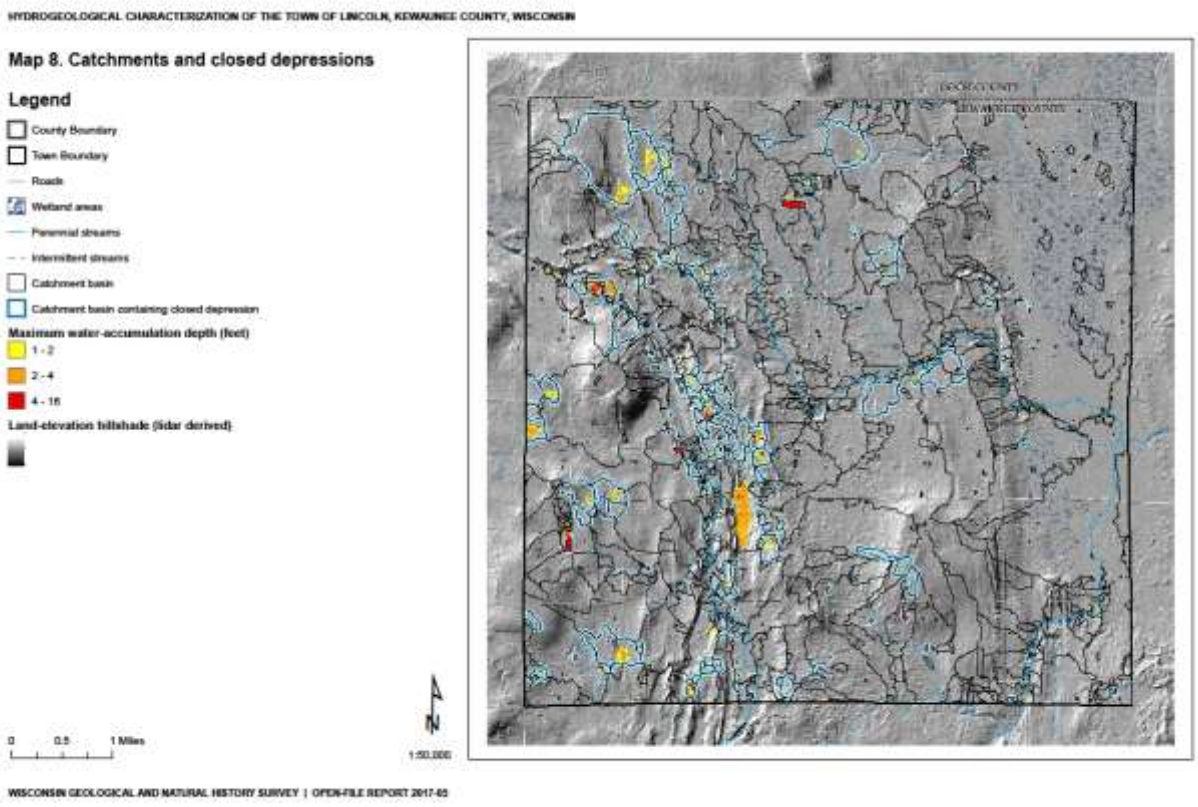
8. Lincoln Township has developed an **Agricultural Transition Map in our Comprehensive Plan**



- Lincoln Township **is not opposed to agriculture**. It would be irresponsible to ignore the fact that **not all agricultural business models or practices are appropriate in all locations in Lincoln Township.**

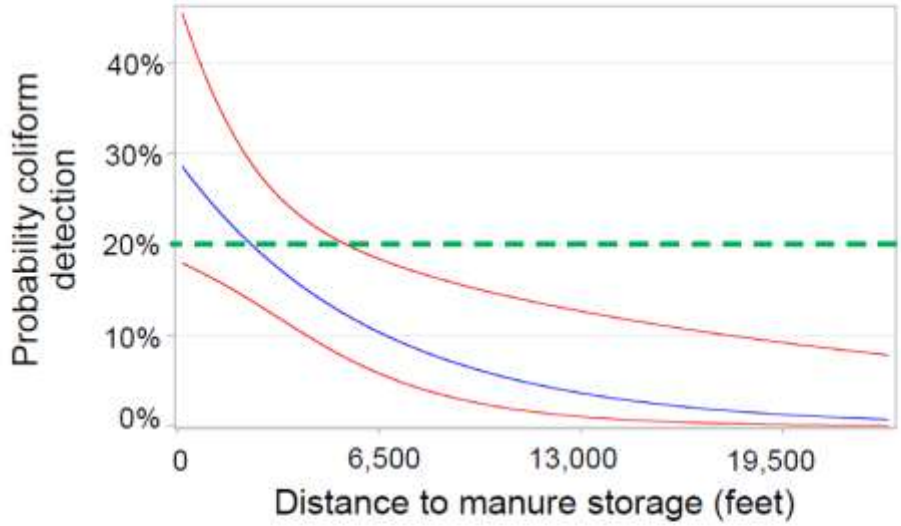
9. Dr. Borchardt (USDA), Dr. Muldoon (UW-O), Kevin Masarik (UW-SP), Davina Bonness (LWCD), and many others have all told us repeatedly what the issue in Lincoln Township is: **Our groundwater problems are primarily caused by liquid manure being applied on karst bedrock with soil depths under 50 feet to bedrock.**

- One criteria not taken into consideration in the above Ag Transition Map dataset is the **Catchment and Closed Depressions Map (Map 8)**, part of the town's Groundwater Mapping Project. Including such additional information would have just been too complicated even for the highly skilled cartographer we employed. However, that doesn't mean that the information on closed depressions is of no value. Instead, such information should be considered on a very site specific basis as it relates to land use in the near immediate area of a well, say within one-half to one mile, as well as <u>any</u> land use within that radius. Such land use was taken into consideration by Bonness and Masarik in their study for the report ***Investigating Inter-annual Variability of Well Water Quality in Lincoln Township.*** See Table 1 on page 9 of this document.



10. Dr. Borchardt also found that a minimum distance of three miles from a manure pit is required to obtain zero probability of bacterial contamination (Borchardt, Lincoln Township presentation, July 19, 2019). From Dr. Borchardt's presentation:

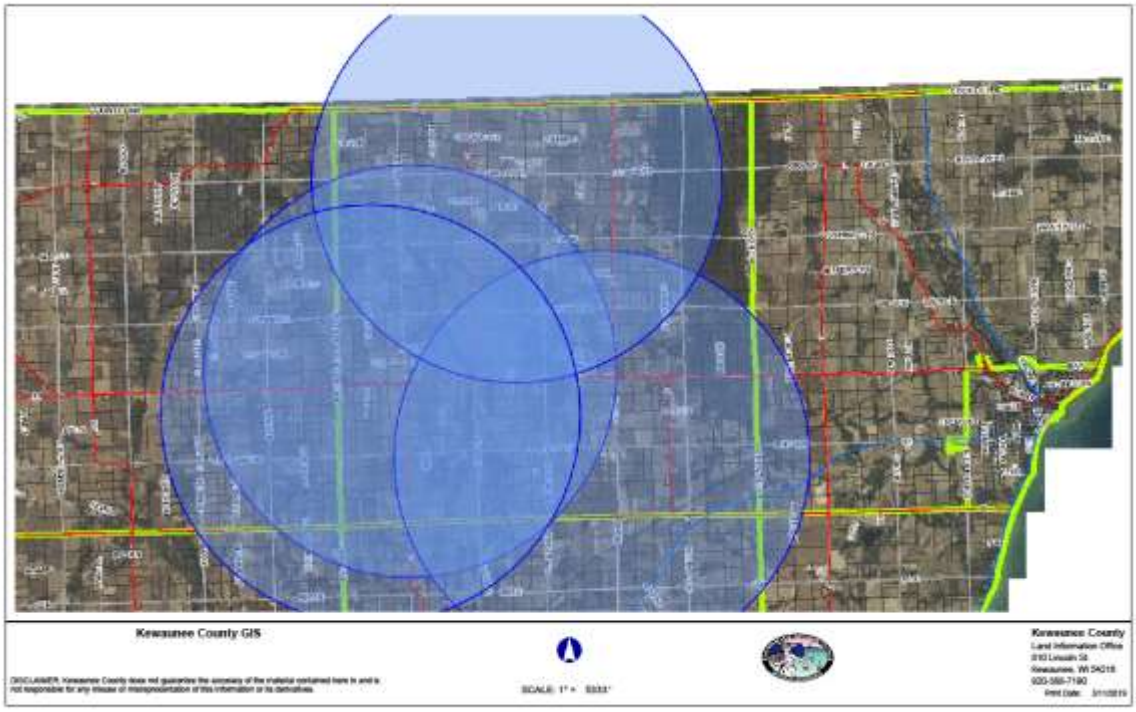
Wells located farther from manure storage are less likely to be contaminated with coliform bacteria



Model accounts for the effects of:
Distance to nearest agricultural field
Area of cropped fields within 750 feet of well
Depth to bedrock

Probability of detection
95% confidence interval
State average (~20%)

11. The map below shows a 3-mile radius from the four CAFO manure pits in Lincoln



- Given the 3-mile cautionary radius recommended by Dr. Borchardt**, no well in Lincoln Township is currently in a safe zone from bacterial contamination from a CAFO wastewater lagoon.**

SUMMARY, CONCLUSIONS and LESSONS LEARNED

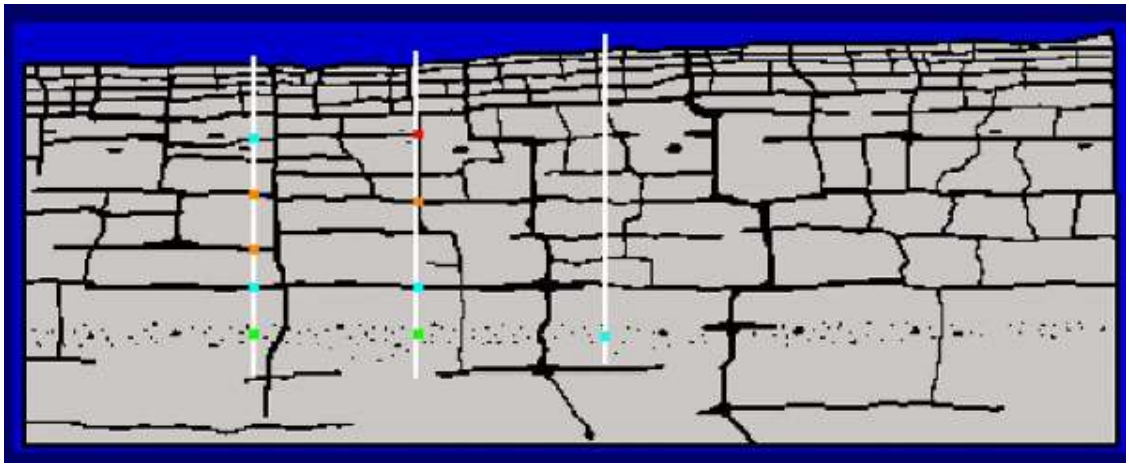
After all of the miles walked and all of the water samples collected and analyzed and all of the studies completed, the data show:

SEPTIC SYSTEMS VERSUS LIQUID MANURE[10]

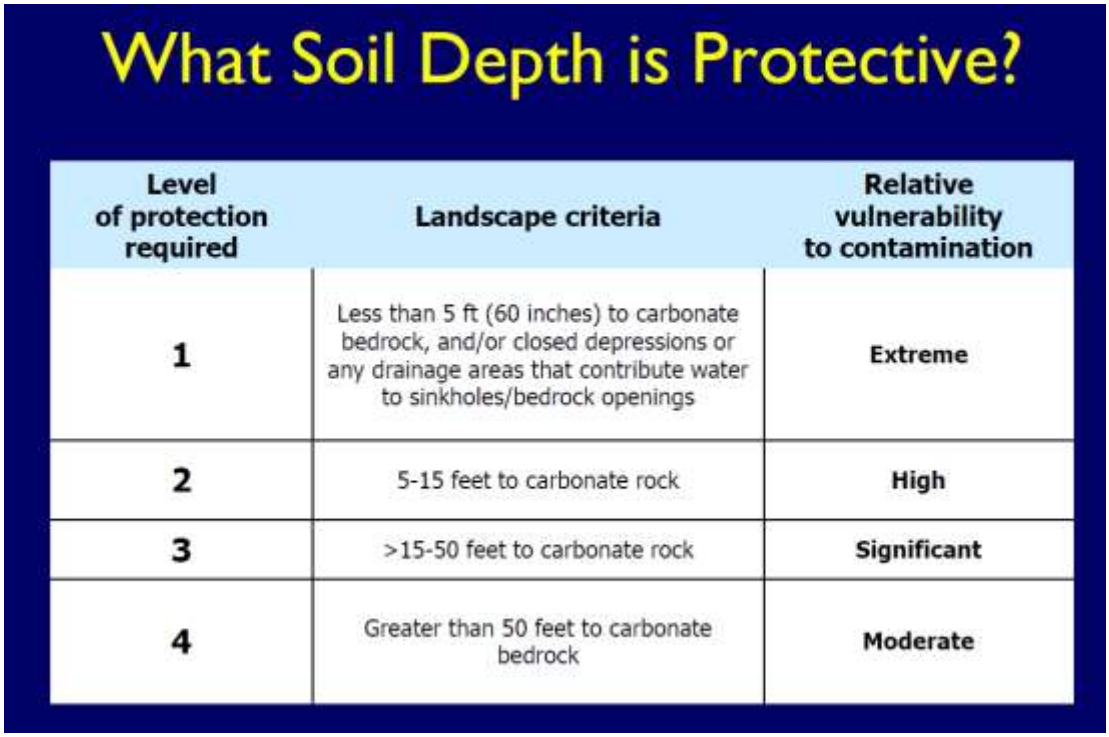
- **"Both Silver Creek and Rio creek experience impacts from farmland erosion and other nonpoint sources throughout the watershed (WDNR 1995)."** (KCLWRMP 2020-2029)
- **Surface water and groundwater are often directly connected in karst geology.** (Muldoon, Parsen, Borchardt, Bonness)
- Karst features are ever changing and seem to be increasing in number and severity in Lincoln Township, posing an increasing threat to our groundwater resources.
- "Since 2010**, LWDC staff has identified more than 800 new karst features, including sinkholes, bedrock at the surface, karst ledges, fracture traces, and closed depressions**." (KCLWRMP 2020-2029)
- **"When overlaying the nitrate data and unsafe well locations (from the LWCD 2004 to 2018 well testing program) with the depth to bedrock layers, the impact or unsafe wells often correlate to areas with shallow soils**." (KCLWRMP 2020-2029)
- The Land and Water Conservation Department Ahnapee River Watershed 9-Key Element Plan, page 53 states: **"…the main source of pollutant loading in the watershed is from agricultural land".**
- **"Commonly noticed issues in cropland fields (during walkovers by LWCD staff) are farming too close to stream corridors, eroding grassed waterways, un-vegetated concentrated flow channels, and sheet/wind erosion."** (KCLWRMP 2020-2029)
- From the LWRMP 2020-2029, "…**67.2% of the nitrogen pollutant load on the land comes from cropland whereas only 0.2% of the nitrogen pollutant load comes from septic systems… and 79.8% of the phosphorus pollutant load on the land comes from cropland whereas only 0.4% of the phosphorus pollutant load comes from septic systems**."
- From Borchardt: **"Septic system variables were not all significant risk factors for high nitrate detection."** And **"Septic system variables were not all significant risk factors for high coliform bacteria detection."**
- Given the fact that Lincoln Township has a 96% septic compliance rate and Kewaunee County has an overall septic compliance rate of 93% (end of 2020 statistics), it should be no surprise as to why this is so. **Except possibly for very site specific situations, septic systems are not a consequential cause of groundwater contamination in Lincoln Township.**

[10] The bolded and/or underlined text that follow indicates emphasis added.

- With all the research and studies that have been conducted, the uncertainty has been cleared up about where the majority of our groundwater and surface water contamination is emanating from. It should be obvious from all of this documentation that with a 96% septic compliance rate, **septic systems are not a primary source of groundwater contamination in Lincoln Township.**
- Dr. Borchardt (USDA), Dr. Muldoon (UWO), Kevin Masarik (UWSP), Davina Bonness (LWCD), and many others have all told us repeatedly what the issue in Lincoln Township is: **Our groundwater problems are primarily caused by** (too much) **liquid manure and agricultural wastewater being applied on karst bedrock with soil depths under 50 feet to bedrock.**
- From Dr. Maureen Muldoon's presentation *"Hydrogeology of Wisconsin Karst Landscapes: What's a Protective Soil Cover?"* November 15, 2016:
    - Flow Characteristics of Eastern Dolomite Aquifer
        - Dense and ubiquitous fractured network
            - Little surface runoff
            - Water easily infiltrates to subsurface
        - Recharge
            - Exceedingly rapid
            - Carries surface contaminants to water table
        - Flow within the aquifer occurs primarily along bedding plane fractures
            - Little to no attenuation of contaminants within the aquifer
        - Flow rates vary from 10s to 100s of ft/day



Slide 51:



- In addition to the above designations, somewhere between 75% and 80% of Lincoln Township is also deemed "Sensitive Areas" by DNR definitions. This does not mean that this 75+% of Lincoln Township is unsuitable for agriculture, residential, or commercial ventures. It does mean, however, that 75+% of Lincoln Township lands are inappropriate for the spreading of liquid manure and agricultural waste water at the rate allowed prior to the adoption of NR151 / KC Chapter 39 in 2018. It also means that the Town Board and the Plan Commission need to proceed cautiously when granting Conditional Use Permit or rezoning requests, and to fully inform residents and land owners of the issues that they will face as they develop their properties as well as the issues that exist with undeveloped properties due to existing land uses, regardless of what they are or what is proposed.
- Lincoln Township is not opposed to agriculture. **We have come to realize that not all agriculture, nor all residential development, is appropriate in all locations in Lincoln Township. We have gone to where the data have led us.**
- For example, Lincoln Township needs to proceed cautiously when considering cluster development as recommended by most comprehensive planning consultants because there are large areas of the township where the geology cannot support this type of pressure on the groundwater resources.

TILE LINES[11]

- Tile lines are recognized as a serious surface water problem and subsequently a serious groundwater problem.
- **From *Ahnapee River Watershed 9-Key Element Plan, KCLWCD April 2020:***
    - **"Tile drains in fields can act as a conduit for nutrient transport to streams if not managed properly."**
    - "An average of 0.9 lbs. of phosphorus/acre/year and 240 lbs. of sediment/acre/year was found to be leaving via tile drainage on a UW-Discovery Farm study in Kewaunee County." (Cooley, et al, 2010) (Note: per conversation with Eric Cooley on 2-1-2021, sedimentation loss was confirmed for the older cement and clay tiles.)
    - "The UW-Discovery Farm study compared surface phosphorus loss to tile phosphorus loss and found that the tile drainage was 34% of the total phosphorus lost." (Cooley, et al, 2010)
    - **"Treating tile drainage at the outlet and better management of nutrient/manure applications of fields can reduce the amount of phosphorus reaching rivers and streams."**
    - "Additional options for treating tile drainage at the outlet include constructing a treatment wetland, saturated buffers, phosphorus removal structures, and installation of water control structures to stop the flow of drainage water during poor conditions."
- **No tile line should ever be terminated into a surface water or a DNR-designated wetland, or drainage ditch that leads directly to a surface water or creek.**

(Photo by Mick Sagrillo)

[11] The bolded and/or underlined text that follow indicates emphasis added.

WHAT WE CAN DO TO PROTECT AND IMPROVE LINCOLN TOWNSHIP'S GROUNDWATER AND SURFACE WATERS

So what does all this data mean for our groundwater and surface water problems and perhaps, more importantly, what does it mean to you? In this section, we have distilled 16 years of research, studies and science down to:

- Five key take-aways;
- What do we want our future conditions to be?; and finally,
- What can we do as a community to meet our desired future conditions?

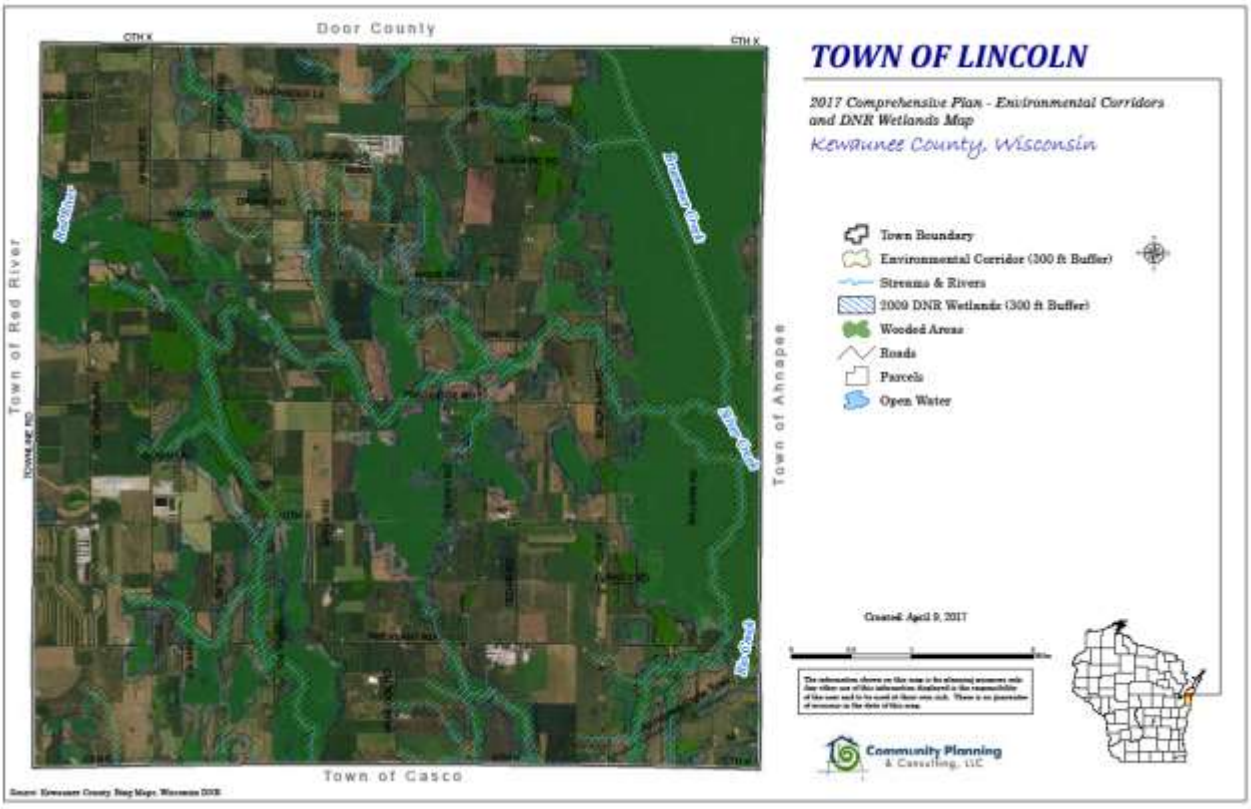
FIVE KEY TAKE-AWAYS

1. As indicated in previous studies, 67% of the nitrate contamination in Kewaunee County is coming from ag fields; 0.2% is coming from septics. Contamination is primarily coming from agricultural land use and not from residential septic systems.
2. Our geology is what it is. We are stuck with shallow soils on top of fractured bedrock. This makes 75+% of Lincoln Township not conducive to the spreading of liquid manure or agricultural wastewater at the level allowed prior to 2019, or clustered residential or commercial development.
3. The current setbacks and buffers to surface waters and karst features are not sufficient.
4. What we do on the land impacts our surface and ground water. We must live and farm in Lincoln Township with extra-ordinary attention to groundwater and surface water mitigation practices and care.
5. We are a community. While we have a right to clean groundwater, we also have the responsibility to not contaminate our ground and surface waters. These efforts require all of us to do the right thing without being mandated or paid to do so.

Desired future conditions for Lincoln Township

- All wells that provide drinking water will be bacteria (total coliform and e-coli) free/absent.
- All wells that provide drinking water will have nitrate levels less that the state standard of 10 ppm.
- All wells that provide drinking water will be free of microbes and viruses.
- Wetlands shall be preserved.
- There will be zero manure spills.
- Sedimentation runoff from farm fields shall be eliminated.
- The transport of nitrogen, phosphorus and sedimentation to surface waters from tile lines shall be eliminated.

- Buffers and setbacks: increase cultivation and spreading setbacks from Silver Creek, Rio Creek, and streams flowing to the Ahnapee River. Increase buffers and setbacks for all environmental corridors and DNR wetlands.



Lincoln Township Environmental Corridors and DNR Wetlands Map

- All tributaries (Silver Creek, Rio Creek, and Casco Creek) are removed from the DNR/EPA Impaired Waterways List, including for phosphorus.
- Move to more sustainable development and agriculture in Lincoln Township through matching land use, development, and agricultural practices with groundwater and surface water susceptibility.

What can be done to achieve our Desired Future Conditions?

It's important to note that because of the legislation passed at the State and County levels since the adoption of the Supplement to the Comprehensive Plan, and because of the attention farmers are giving to nutrient management plans and manure spreading, and because of the possible improving results of well testing, **the Plan Commission is not, at this time, recommending the adoption of a Groundwater Protection Ordinance.** Instead, we are making the following recommendations for each stakeholder group in the Township to undertake. Based on the data reviewed, we firmly believe that these recommendations, if followed, will help achieve the stated Desired Future Conditions.

What can homeowners and/or landowners do to protect our groundwater and surface waters? (Action Items)

1. Use the town's Susceptibility Map, Closed Depression Map and Sensitive Areas Map to identify your property's risk to groundwater and surface water.
2. Test your well annually, preferably when well testing is offered by the Land and Water Conservation Department. As part of LWCD's well testing effort, everyone benefits with the additional shared data points.
3. Make sure that your well has a vermin proof well cap.
4. If you are in need of a new well, consider exceeding state well construction standards including casing, grouting, well depth, and casing down to water source to possibly improve well water quality.
5. Greatly reduce the use of fertilizers and chemicals in closed depressions. Better yet, eliminate their use entirely in these areas, as closed depressions eventually drain into our groundwater.
6. Build berms to direct water away from sinkholes, fractures, wells, and closed depressions on your property which feed our groundwater.
7. Avoid using fertilizers or pesticides near sinkholes, fractures, wells, ditches, or closed depressions.
8. Minimize the use of lawn chemicals and fertilizers, **especially when rain is predicted over the next week.**
9. Direct downspouts to your lawn or rain barrel and away from pavement, asphalt or blacktop.
10. Have your septic system pumped and inspected every three years as required by Wisconsin law.
11. Properly dispose of household and hazardous waste, antifreeze, motor oil, leftover pesticides and fertilizers with Kewaunee County's periodic Clean Sweep Program. NEVER dump these items on your driveway or in a ditch or stone pile. And NEVER flush these items down your drains or toilet and into your septic system. Save them for the Kewaunee County Clean Sweep Program.
12. Prescription drugs can be disposed of anonymously 24/7 at the Kewaunee County Sheriff's Department Safety Building. NEVER flush them into your septic system, compost them, or dispose of them into the environment.
13. If you have an abandoned well on your property, contact the DNR to have the well properly decommissioned and registered as such.
14. According to Wisconsin, Kewaunee County, and Lincoln Township ordinances, burn barrels may only be used to burn unrecyclable paper and cardboard, natural fibers, clean, untreated wood and similar materials. Burning anything other than these items is an ordinance violation as it causes, among other things, groundwater contamination. (https://dnr.wisconsin.gov/topic/OpenBurning/BeforeYouBurn.html)

What can landowners (including those who rent out their land) do to protect our groundwater and surface waters? (Action Items)

In addition to the above:

1. The goal is to reduce the impact of agriculture on moderate, high, or highly susceptible lands. Therefore work closely with LWCD and NRCS and their programs.
2. Increase your buffers between wetlands, streams, or sinkholes and cultivated fields.
3. Increase buffers to known sinkholes to 75 feet or more.
4. Clean out any sinkhole that was historically used as a dump site. Establish a buffer around the sinkhole.
5. Protect exposed bedrock.
6. Greatly reduce the use of fertilizers and chemicals in closed depressions. Better yet, eliminate their use entirely in these areas, as closed depressions eventually drain into our groundwater.
7. Educate yourself as to what conservation programs your land or sections of your land may qualify for. For information, see: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/
8. If your land is adjacent to a tributary, stream, or creek, consider planting cover crop annually to protect from soil erosion and nutrient runoff over winter.
9. If your land is adjacent to a tributary, stream, or creek, consider no-till planting to protect your soil from erosion and nutrient runoff.
10. If your land is in a high or moderate risk area, karst, or groundwater attenuation area based on the Susceptibility Map, Closed Depressions Map, or Sensitive Areas Map, consider not allowing liquid manure applications in the fall after crop harvest as there are not crops on the land for nutrient uptake.
11. Require cover crops on land that is highly susceptible to groundwater contamination; encourage cover crops on other lands.
12. Properly dispose of all unwanted pharmaceuticals and hazardous wastes.

What can the farming community accomplish? (Action Items)

1. The goal is to reduce the impact of agriculture on moderate, high, or highly susceptible lands. Therefore work closely with LWCD and NRCS and their programs.
2. Identify high-risk fields for groundwater and surface water contamination. These areas include closed depressions, fields with karst features, and shallow soils over bedrock. Consider retiring these fields from liquid manure and chemical applications.
3. Increase buffers to known sinkholes to 75 feet or more.
4. Clean out any sinkhole that was historically used as a dump site. Establish a buffer around the sinkhole.
5. Protect exposed bedrock.
6. Greatly reduce the use of fertilizers and chemicals in closed depressions. Better yet, eliminate their use entirely in these areas, as closed depressions eventually drain into our groundwater.
7. Reduce manure spreading, especially liquid manure, in closed depressions, particularly depressions that have shallower soils to bedrock.
8. Comply with NR 151 Silurian Dolomite Standards to reduce liquid manure applications on saturated soils.
9. Comply with the Manure Runoff Advisory System. **When it's RED, do not spread—before, during, or after.**
   http://www.manureadvisorysystem.wi.gov/runoffrisk/index
10. Tile lines are a conduit for nutrient and sediment loss resulting in contamination of surface waters and groundwater.
    - Treating tile drainage at the outlet and better management of nutrient/manure applications of fields can reduce the amount of nitrogen and phosphorus reaching rivers and streams.
    - Additional options for treating tile drainage at the outlet include (From the LWCD 9-Key Element Plan):
      - Constructing a treatment wetland,
      - Saturated buffers,
      - Phosphorus removal structures, and
      - Installation of water control structures (drainage water management and water table management) to stop the flow of drainage water during poor conditions.
    - Consider "end of pipe" treatment or constructed wetlands to manage tile line effluent, which, according to *Suitability of Using "End of Pipe" Systems to Treat Farm Tile Drainage Water* (Fleming, et al, 2004), includes: (this and other tile line references are available in Tile Line Resources at the end of this document)
      - Pathogens
      - **Nitrogen**

    - Phosphorus
    - Raw manure, milk wastes, and sewage
  - N**o tile line should ever be terminated into surface waters or DNR-designated wetlands.**
  - All existing tile lines should be reconfigured to terminate into laterals at least 25-feet from surface waters or DNR-designated wetlands.
  - Document where all field tile lines are and which ones need to be removed. All tile outlets into surface waters and DNR-designated wetlands must be marked on NMPs.
  - From Peninsula Pride Farms brochure, *Water Quality—A Dual Approach*:
    - **"Improve tile drainage management and installation of tile drainage treatment systems".**
- Buffers and setbacks: increase spreading setbacks from Silver Creek, Rio Creek, and streams flowing to the Ahnapee River.
  - Increase buffers and setbacks for all environmental corridors and DNR wetlands.
  - Better protect wetlands: increase setbacks for both cultivation and fertilization.
- Reduce nitrate applications.
  - See Kevin Erb: Manure 101 (11-11-02)
    - **The Manure Paradox**
      - Crops use N:P:K in a 3:1:2 ratio
        Dairy manure is a 1:1:2 ratio (available)
      - Meet the crop's N need = excess P
      - Meet the crop's P need = buy N fertilizer
- Get the water out of manure.
  - Reduce water use in manure systems to create more solid manure.
  - Consider composting manure.
- Identify the best locations for cover crops to protect high risk fields, fields adjacent to surface waters, wetlands, and in closed depressions. Are the proper fields being cover cropped?
  - Use SnapMaps 20 as a resource
    https://snapmaps19.snapplus.wisc.edu/
- Commit to a best management plan for protecting groundwater and surface waters in Lincoln Township.
- Properly dispose of all unwanted pharmaceuticals and hazardous wastes.
- In addition to the above, Peninsula Pride Farms suggest the following in their brochure *Water Quality—A Dual Approach: Surface Water: How will we measure our impact?*
  - *Track phosphorus and soil loss from conservation practices.*
  - *Improve tile drainage management and installation of tile drainage treatment systems.*
  - *Evaluate the difference in a field with and without a conservation practice.*
- Peninsula Pride Farms encourages the adoption and use of:
  - Cover crops

    - Harvestable buffers
    - Split nitrogen applications
    - See Peninsula Pride Farms January 13, 2021, press release which calculates water quality improvements due to cover crops and other conservation practices at https://peninsulapridefarmsinc.org/2021/01/12/analysis-peninsula-pride-farms-reduces-risk-to-water-quality/
- Even if not a Peninsula Pride Farm member, seriously consider adopting and implementing these and other conservation practices.

What Can Lincoln Township Do to Prevent Groundwater and Surface Water Contamination?

Rezoning and Conditional Use Permit CUP goals:

- Review all rezoning and conditional use permits with consideration towards their potential impacts on groundwater and surface waters. Advise rezoning applicants accordingly and develop and include conditions in conditional use permits as appropriate to protect groundwater and surface waters. (Supplement to the Comprehensive Plan or S2CP)
- During site plan reviews, consider the impact of the proposed construction on groundwater and surface waters and provide guidance accordingly. With each applicant, review so that they understand their situation:
    - Groundwater susceptibility map (map 7, page 48)
    - Catchment and closed depressions map (map 8, page 51)
    - Sensitive Areas Map (per the S2CP, page 47)
    - Consider riparian buffers and wetland setbacks as a condition of approval for all future land use permits (S2CP)
    - Karst Map (page 36)
- Assure that all conditional use permits and building permits take into consideration the location of sink holes and other karst features. Sink holes and karst features need to be appropriately buffered whether on agriculture land, residential properties, or commercial development. (S2CP)
- Proceed cautiously when considering cluster development as recommended by most comprehensive planning consultants due to the fact that there are large areas of Lincoln Township where our geology cannot support this type of pressure on the groundwater resources.
    - Housing development with their septic systems are better distributed over the landscape than clustered together in karst geology and over shallow soils. (Borchardt).
    - Make recommendations for residential and commercial development in mapped "sensitive" areas, areas of groundwater contaminant susceptibility, and closed depressions. (S2CP)
- The Plan Commission and Town Board need to consider what development is allowed in and along the Town's environmental corridors (Environmental Corridors and DNR Wetlands Map, page 59).
    - As much as possible, encourage cover crops and discourage intensive agriculture adjacent to environmental corridors. (S2CP)
    - Create buffers as much as possible.
- Encourage the planting and establishment of fencerows, windbreaks, shelterbelts, grassed waterways, buffers, natural vegetation areas, and similar land uses that provide

high-quality groundwater recharge. “Conservation buffers are a visual demonstration of your commitment to land stewardship.” (S2CP) See: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=nrcs143023568

- Heidelberg University’s National Center for Water Quality Research (NCWQR) has been monitoring tributaries leading into the Ohio River and Lake Erie for phosphorus and nitrates since 1974. They discovered a conservation practice, no-till agriculture, that turned out to be responsible for pollution runoff during high rainfall events and subsequent Lake Erie algal blooms. See *Increased Soluble Phosphorus Loads to Lake Erie: Unintended Consequences of Conservation Practices?* at https://acsess.onlinelibrary.wiley.com/doi/full/10.2134/jeq2016.07.0248 This seems to be a similar problem unveiled by Kim Busse, UW-O in her study *Monitoring of Non-point Source Pollutants in the Ahnapee River Watershed* that we see in at Crescent Beach in Lake Michigan. It would be worth Lincoln Township’s while to encourage Dr. Busse to collaborate with other researchers and perhaps NCWQR for further testing, studies, and recommendations as to how to alleviate this problem. See https://ncwqr.org/monitoring/ UWGB is mentioned as a university developing a model based on NCWQR’s, so there might be opportunities for collaboration here as well. (S2CP)
- Lincoln Township is not opposed to agriculture. **The science is telling us that not all agricultural practices, nor all residential development, are appropriate in all locations in Lincoln Township. We have gone to where the data have led us.** (Ag Transition Map, page 50).
- From 75% to 80% of Lincoln Township is deemed “Sensitive Areas” by DNR definitions. This does not mean that this 75+% of Lincoln Township is unsuitable for agriculture, residential, or commercial ventures. It does mean, however, that 75+% of Lincoln Township lands must be farmed or developed taking this into account. It also means that the Town Board and the Plan Commission need to proceed cautiously when granting conditional use permits or rezoning requests, and to fully inform residents and land owners of the issues that they will face as they develop their properties as well as the issues that exist with undeveloped properties due to existing land uses, regardless of what they are or what is proposed. (Sensitive Areas Map, page 47).
- Check in with Eric Cooley, Discovery Farms, UW-Extension, regarding on-going research on nutrient loss with plastic tile lines.
- Invite appropriate researchers or evaluators to monitor effluent from tile lines that empty into Silver Creek and town ditches and right of ways for nitrogen and phosphorus. Make the resulting study available to town residents.
- Work with LWCD, NRCS, and Discovery Farms to determine what to do with existing tile lines, especially those that terminate into streams and surface waters. (S2CP)
- Reconsider how to address tile lines in the township.

- Continue partnering with and funding the LWCD and UWSP on the bi-annual Lincoln Township's well testing research. (S2CP)
    - Request that the KC Conservationist update the town every other year on the well testing project results.
- Find and document ALL abandoned wells that need decommissioning.
    - Work with LWCD to create a database of all wells that need to be proper abandonment.
    - Research the establishment of a Lincoln Township fund to pay for proper abandonment of wells in the township.
    - Research the establishment of Lincoln Township abandoned well deputies with volunteers.
- Advocate for scientific testing by LWCD or the DNR to measure the effectiveness of new state standards and agricultural practices on groundwater and surface water quality.
    - LWCD is seeking a grant to test 600 wells in the 0 to 20-foot to bedrock area of the Kewaunee County.
    - 260 of those wells will be the same wells tested by Drs. Borchardt and Muldoon and will be used to scientifically ascertain any changes since their 2015-2016 tests.
- Research Incorporating karst feature and drainage tile mapping into local requirements for ATCP 51 (Livestock Siting). (S2CP)
- Investigate the possibility of updating the Sensitive Areas Map with LWCD karst features.
- Invite LWCD annually to Lincoln Township to do a presentation on: (S2CP)
    - What are the well test results?
    - Where are the cover crops in Lincoln Township?
    - Where have buffers been increased? Where do they need to be increased?
    - Where is the need for tile line reduction or redesign?
- Work closely with LWCD; someone from Lincoln Township should attend LWCD monthly meetings.
- Continue to research the need and feasibility of groundwater protection ordinance language and adopt GWPO language if and when appropriate. (S2CP)
- Post the Groundwater and Surface Water Protection Report and Recommendations on the Lincoln Township web site along with a page of "tools to protect Lincoln Township's groundwater and surface waters" and all references cited in the GW&SWPR&R. (S2CP)
- Display maps depicting groundwater and surface water resources and threats at the town hall and provide access to residents. (S2CP)

What does the future look like for Lincoln Township?

Recent Developments

In addition to the more than 16 years of research and efforts previously mentioned, the following are some recent initiatives being undertaken by Federal, State, and local agencies and farmer-led watershed groups intended to protect groundwater and surface waters from contamination. It is too early to know the extent of their effectiveness but it is important to document their existence and keep an eye on their progress.

- The Agricultural Performance Standards—KC Chapter 39
    - The revised NR 151 (particularly rule enforcement in Kewaunee County)
    - The new Silurian Dolomite Standards
- The use of cover crops on highly susceptible fields
- Low disturbance manure injecting
- Side dressing manure on growing crops
- NRCS focusing the ag community on soil health education
- Recommendations from the Speaker's Taskforce
- DNR SNAP 20 web map
- DATCP project measuring depth to bedrock using LIDAR technology

The Plan Commission recommends that these efforts be closely monitored to determine if they have provided **measurable scientific results** that rise to the level of other empirical data included in this report.

What Does The Future Hold?

It is without question that the geology of Lincoln Township is uniquely vulnerable to groundwater contamination and state-wide regulations were not sufficient to prevent it. Because of this, the citizens of Lincoln Township have suffered with some of the highest groundwater contamination in the state. They have endured 16 years of studies and taskforces, testing and trials needed to document the sources of the contamination and develop solutions.

Are we through the worst of it? Are we on the path to protecting our ground and surface water for ourselves and future generations? It is too early to tell. Scientists do believe a "zero contamination rate" goal is achievable but **only** if we are vigilant. In addition to the very specific actions recommended in this report, we encourage homeowners, landowners and the farming community to continue to do **whatever it takes** to protect our very vulnerable water supply **regardless of state or county regulations** and **regardless of available financial incentives**. This is our community, our water, our future. It's up to **all of us** to assure the sustainability of Lincoln Township's groundwater and surface water for ourselves and future generations.

Resources—Kewaunee County Policies Supporting Groundwater and Surface Waters Include:

See https://www.kewauneeco.org/government/page/ordinances/ to download any of the following ordinances.

- Chapter 13: Illegal Burning Ordinance
- Chapter 15: Sanitary Ordinance (for Private Onsite Wastewater Treatment Systems)
- Chapter 16: Shoreline Zoning Ordinance
- Chapter 17: Non-metallic Mining Reclamation Ordinance
- Chapter 18: Animal Waste Storage Facility Ordinance
- Chapter 19: Floodplain Zoning Ordinance
- Chapter 28: Private Water Systems/Well and Drillhole Abandonment
- Chapter 30: Public Health and Groundwater Protection Ordinance
- Chapter 37: Agricultural Waste and Process Wastewater Irrigation Ordinance
- Chapter 39: Agricultural Performance Standards Ordinance (NR151)
- Annual household well testing program
- Occasional hazardous waste collection program
- Prescription drug disposal at the Sheriff's Department Safety Building

Resources—Kewaunee County Public Health Department

- Kewaunee County Department of Public Health Environmental Health Groundwater Information https://www.kewauneeco.org/departments/public-health/environmental-health/groundwater-information/
- Centers for Disease Control and Prevention—Treatment of Well Water https://www.cdc.gov/healthywater/drinking/private/wells/treatment.html
- WI DNR—Information for Homeowners with Private Wells https://dnr.wisconsin.gov/topic/Wells/homeowners.html
- WI DNR—Water Quality and Contamination in Private Wells https://dnr.wisconsin.gov/topic/DrinkingWater/contaminants.html
- EPA—Private Drinking Water Wells https://www.epa.gov/privatewells
- WI DNR Well Compensation Grant https://dnr.wisconsin.gov/aid/WellCompensation.html
- USDA Household Water Well System Grants https://www.rd.usda.gov/programs-services/rural-decentralized-water-systems-grant
- Household Water Well Program Loan Fact Sheet https://www.kewauneeco.org/i/f/files/Public%20Health/Household%20Water%20Well%20Program.pdf

References – Bibliography

The following studies are cited in this document by number. They can be sourced by the web links included in the citation or by searching the internet by typing in the name of the study and the author. Or they can be obtained by contacting the agency referenced. The numbers below refer to the study in the document.

Studies

1. *Northeast Wisconsin Karst Task Force Final Report* by Kevin Erb and Ron Stieglitz is available at:
   https://cdn.shopify.com/s/files/1/0145/8808/4272/files/G3836.pdf

2. Kewaunee County well test report summaries are available electronically from the Kewaunee County Land and Water Conservation Department.

3. *Assessing Levels of Endocrine Disrupting Chemicals in Groundwater Associated with Karst Areas in Northeast Wisconsin* by Dr. Angela Dantoin-Bauer et al is available at:
   https://www.wri.wisc.edu/wp-content/uploads/FinalWR08R004.pdf

4. *Investigating Inter-annual Variability of Well Water Quality in Lincoln Township* by Davina Bonness and Kevin Masarik (2014) is available from the Kewaunee County Land & Water Conservation Department electronically on request.
   The PowerPoint presentation is available at:
   https://www.uwsp.edu/cnr-ap/watershed/Documents/lincoln_ppt.pdf

5. *Monitoring of Non-point Source Pollutants in the Ahnapee River Watershed*, by Kimberly M. Busse, Environmental Research and Innovation Center, University of Wisconsin-Oshkosh, January 2014, is available from Lincoln Township electronically on request.

6. The *Kewaunee County Public Health and Groundwater Protection Ordinance* is available on the Kewaunee County website at:
   https://www.kewauneeco.org/i/f/files/Ordinances/Chapter%2030.pdf

7. *The Environmental Protection Agency Petition on behalf of the Citizens of Kewaunee County can be found on the Midwest Environmental Advocates website at:*
   https://midwestadvocates.org/assets/resources/Safe%20Drinking%20Water%20Act%20Petition/2014-10-22_Kewaunee_SDWA_Petition_to_EPA.pdf

   Updated information on the EPA Petition case can be found at:
   https://midwestadvocates.org/search?q=EPA%20petition

8. *The Groundwater Collaboration Workgroup Final Report* can be found on the Kewaunee County website at:
   https://www.kewauneeco.org/i/f/files/Public%20Health/Groundwater%20Collaboration%20Workgroup%20FINAL%20REPORT%206-16.pdf

   NR151 State Agricultural Performance Standards:
   https://www.kewauneeco.org/departments/land-water-conservation/nr151-state-agricultural-performance-standards/

   Kewaunee County Agricultural Performance Standards, Chapter 39:
   https://www.kewauneeco.org/i/f/files/Ordinances/Chapter%2039.pdf

9. *Kewaunee County: Using Research to Help Determine Contaminants and Risks to Human Health*, by Dr. Krassimira Histova, Marquette University, September, 2015, can be acquired by contacting Do. Histova through:
   https://www.marquette.edu/biology/directory/hristova.php

10. The presentation *Assessing Groundwater Quality in Kewaunee County, Wisconsin* by Dr. Mark Borchardt and Dr. Maureen Muldoon, 2017, can be obtained electronically from Lincoln Township.

    The full report can be downloaded from:
    https://www.wri.wisc.edu/wp-content/uploads/Final-Report-Kewaunee-County-Groundwater-Quality-DNR-Project-227.pdf

11. The complete Lincoln Township Supplement to the Comprehensive Plan can be found on the Lincoln Township website at:
    https://lincolnkewauneewi.com/2017/11/04/final-town-of-lincoln-comprehensive-plan-chapters-1-6-available/

12. *Hydrogeological Characterization of the Town of Lincoln, Kewaunee County, Wisconsin*, Wisconsin Geological and Natural History Survey, 2017, the full report, can be found on the Lincoln Township website at:
    https://wgnhs.wisc.edu/catalog/publication/000952

13. *Risk Factors Associated with Private Well Contamination in Kewaunee County, Wisconsin,* Dr. Mark Borchardt and Dr. Maureen Muldoon, UW-Oshkosh, 2019. The presentation can be requested electronically from Lincoln Township.

14. *Kewaunee County's Land & Water's Resource Management Plan Update 2020-2029* is available from the Kewaunee County Land & Water Conservation Department

15. *The Ahnapee River Watershed 9-Key Element Plan, KCLWCD April, 2020,* is available electronically from the KC LWCD.

16. The DNR's Northeast Lakeshore Total Mean Daily Load website can be found at: https://dnr.wisconsin.gov/topic/TMDLs/NELakeshore.html

17. DNR Bureau of Drinking Water and Groundwater Special Well Casing Depth Areas can be found at: https://dnr.wi.gov/topic/wells/documents/SpCsgDpthAreaLst.pdf

Other References

Unless otherwise noted in the document, all of the Lincoln Township or Town of Lincoln maps are available from Lincoln Township electronically. Inquire with the town clerk.

- Page 8: *Best Management Practices to Protect Groundwater at Hines Emerald Dragonfly Larval Sites in Door County, Wisconsin,* Final Report February 1, 2013; Cooperative Agreement Between the USF&WS and The Ridges Sanctuary https://www.fws.gov/midwest/endangered/insects/hed/pdf/HEDBMPFinalReportFeb2013.pdf

- Page 35: *Town of Lincoln Karst Map* is available from the Kewaunee County Land and Water Conservation Department.

- *Increased Soluble Phosphorus Loads to Lake Erie: Unintended Consequences of Conservation Practices?* Helen P Jarvie, et al, Journal of Environmental Quality, January 1, 2017; https://acsess.onlinelibrary.wiley.com/doi/full/10.2134/jeq2016.07.0248

- All references cited in the 2017 Supplement to the Comprehensive Plan, Chapter 6 Appendix (pages 8-10) are hereby adopted by reference.

Tile Line Resources

- *Suitability of Using "End of Pipe" Systems to Treat Farm Tile Drainage Water,* Fleming, et al, 2004, is available at: https://www.ridgetownc.com/research/documents/fleming_end_of_pipe_final_Oct82004.pdf

- *Ten Ways to Reduce Nitrate Loads From Drained Croplands in the Midwest,* Frankenberger et al, University of Illinois Extension, 2016; is available at: http://draindrop.cropsci.illinois.edu/wp-content/uploads/2016/09/Ten-Ways-to-Reduce-Nitrate-Loads_IL-Extension-_2016.pdf
  or
  https://northcentralwater.org/files/2018/03/Ten-Ways-to-Reduce-Nitrate-Loads_IL-Extension-_2016.pdf

- *Ten Ways to Reduce Nitrate Loads From Drained Croplands in the Midwest* PowerPoint presentation Laura Christianson, University of Illinois, 2017, is available at: https://erc.cals.wisc.edu/ten-ways/#/home or http://neiwpcc.org/nationalnpsold/documents/presentations/Jane%20Frankenberger_Session3.pdf