

DATE: February 20, 2023 WPDES Permit #0059315-04-0

TO: Jeff Jackson – Wastewater Specialist, Baldwin

FROM: Ian Anderson – CAFO Hydrogeologist Program Coordinator

SUBJECT: Emerald Sky Dairy – Groundwater Monitoring Review

**Background:**

The Emerald Sky Dairy (ESD) production area is located in Section 22, T30N R16W, Town of Emerald, St. Croix County. The WPDES permit for Emerald Sky Dairy (Permit #59315-04-0) has been expired since 2020. There have been concerns expressed by the public about groundwater issues in the area after a manure spill in 2017 and some regional well sampling indicating elevated nitrate. The St. Croix County Land Conservation Department has conducted water supply well sampling efforts before and after 2017 to help people understand the water quality of their wells. This memo describes the site-specific information used to make the recommendation that groundwater monitoring should not be required in the upcoming permit reissuance, including local well construction reports, published county-scale geologic maps, mapping and well sampling efforts conducted by St. Croix County.

**Geology/Hydrogeology:**

Bedrock in the Town of Emerald is primarily Ordovician dolomite of the Prairie du Chien group, with some pockets of St. Peter sandstone (LePain, 2006). The Prairie du Chien in St. Croix County is known to have numerous sinkholes and bedrock fractures. The county has a sinkhole mapping project to help identify and remediate sinkholes.

Depth to bedrock is somewhat variable in St. Croix County, but appears to be 30 meters (97.5 feet) or more for most of the town of Emerald, getting shallower to the west (Mudrey et al. 1987). Surficial deposits are mapped as River Falls diamicton (Kostka et al. 2004). This description is confirmed by onsite soil pits, which describe soils ranging from silty fine sand (SM) with trace gravel to sandy clay (CL). Notably, surface expressions of bedrock fractures and sinkholes are visible in aerial photos, despite the thickness of unconsolidated material.

Groundwater elevation at the ESD production area is between 1060 and 1080ft MSL, based on water table elevation maps produced by the Wisconsin Geologic and Natural History Survey (WGNHS, 1974, 1981). Both maps indicate groundwater flow is generally from northeast to southwest in the vicinity of the ESD production area, with a regional divide located roughly 3 miles to the east.

Well construction reports (WCRs) at the ESD production area list clay from the surface to 83ft or more, underlain by limestone, which is consistent with what is mapped. Other WCRs show similar geology, predominantly clay over limestone, although sand and gravel deposits are occasionally found. Bedrock appears to get shallower to the north and west of the ESD production area, consistent with what is mapped by Mudrey et al. (1987). Depth to static water level in WCRs at ESD is 150ft or more, which is consistent with the mapped water table elevations (~1060ft) when subtracted from land elevation (~1200ft).

**Groundwater Sampling Results:**

While there is not currently groundwater monitoring at the ESD production area or on their landspreading fields, there have been groundwater samples collected from private wells as part of the county sampling program.

St. Croix County collected three rounds of private well samples in 2016 as part of their drinking water program. Samples collected on 5/23/2016 are largely focused on the town of Emerald, which could potentially be affected by ESD production area or landspreading activities. Results from the 5/23/16 sampling event included 21 samples tested for nitrate and total coliform. Nitrate ( $\text{NO}_3^- + \text{NO}_2^-$ ) concentrations ranged from 0.5-9.7mg/L, with a mean of 4.1mg/L. These concentrations suggest some impact from human activities, but none exceed the enforcement standard of 10mg/L. Twenty of the samples tested absent for total coliform and one tested present. The total coliform positive well was retested for E. coli, which is standard protocol, and came back absent for E. coli.

St. Croix County has also collected samples from the Emerald Town Hall well (Wisconsin Unique Well Number UC686) monthly since January 2021. All of the samples (n=21) have been well over the enforcement standard for nitrate, with concentrations ranging from 22.1-64.5mg/L and a mean concentration of 41.9mg/L. Well UC686 has static water level below casing depth, which is not optimal well construction, leaving the well vulnerable to contamination.

### **Conclusions and Recommendations:**

While reports have confirmed an egregious manure spill occurred in 2017, mostly due to human error, I have not seen evidence that the spill has caused extensive groundwater quality problems.

As noted above, the county has mapped known sinkholes in the Town of Emerald and beyond. The presence of these sinkholes combined with the suboptimal well construction likely explain the water quality issues at the town hall well.

The site-specific geologic setting at ESD with roughly 80ft to bedrock, overlain by mostly clay with static water level at 150ft makes it difficult to assess the impacts of land use activities with groundwater monitoring. This particular setting in the Town of Emerald, with deeply buried bedrock fractures likely dominating the flow system is unlikely to yield useful monitoring results. As such, I do not recommend groundwater monitoring at Emerald Sky Dairy at this time.

I recommend that fields upgradient of the Town Hall be field surveyed for sinkholes. If sinkholes are located, they should be added to manure spreading restriction maps.

### **References:**

Preliminary Geologic Map of the Buried Bedrock Surface of St. Croix Cty, WI

LePain, D., 2006. WGNHS OFR 2006-04.

<https://wgnhs.wisc.edu/catalog/dataset/000870/resource/wofr200604/view/449c6eec-dfbe-42fe-9de3-68adb63c960a>

Bedrock Geology of Wisconsin, Northwest Sheet. Mudrey, M. et al., 1987.

<https://wgnhs.wisc.edu/catalog/publication/000406/resource/m094>

Preliminary Quaternary Geologic Map of St. Croix County, Wisconsin. Kostka, S.J., Hinke, H.J., Mickelson, D.M., Baker, R.W., 2004. WGNHGS WOFR 2004-22

<https://wgnhs.wisc.edu/catalog/publication/000855/resource/wofr200422>

Water-table map of St. Croix County, WI 1974. WGNHS IC32-plate01

<https://wgnhs.wisc.edu/catalog/publication/000282/resource/ic32plate01>

Generalized Water-Table Elevation Map of St. Croix County, Wisconsin. I.D. Lippelt, 1990. WGNHS Publication M113.

<https://wgnhs.wisc.edu/catalog/publication/000425/resource/m113>

**Attachments:**

- Figure 1 – Aerial Photo of Emerald Sky Dairy Production Area
- Figure 2 – Figure 1 -Topographic Map of Emerald Sky Dairy Production Area
- Figure 3a – Modified from Preliminary Geologic Map of the Buried Bedrock Surface of St. Croix Cty
- Figure 3b – Map Legend from Geologic Map of of the Buried Bedrock Surface of St. Croix County
- Figure 4 – Depth to Bedrock Map of Northwest Wisconsin
- Figure 5a – Quaternary Geologic Map of St. Croix County
- Figure 5b – Map Legend of Quaternary Geologic Map of St. Croix County
- Figure 6 – Water Table Map of St. Croix County, WI 1974
- Figure 7 – Map of Well Locations Sampled by St. Croix County in 2016.
- Figure 8 – Map of Nitrate Results from Wells Sampled by St. Croix County in Town of Emerald
- Figure 9 – Locations of Sinkholes in Town of Emerald, as mapped by St. Croix County
- Figure 10 – Inset of Sinkhole Map, zoomed in on area of Emerald Sky Dairy
- Figure 11 – Well Construction Report for Emerald Town Hall



Figure 2 – Aerial photo of Emerald Sky Dairy production area

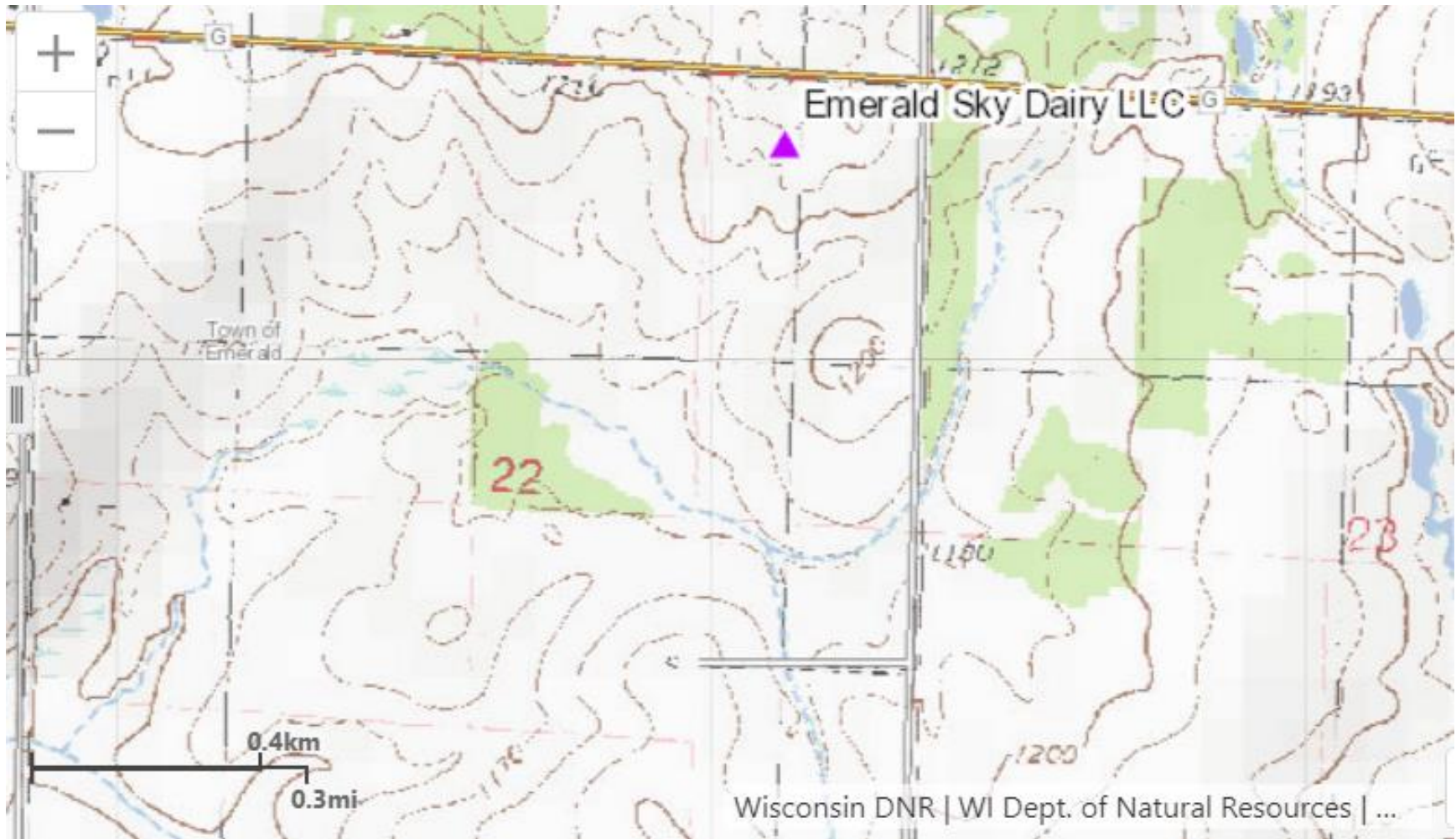


Figure 3 -Topographic Map of Emerald Sky Dairy production area

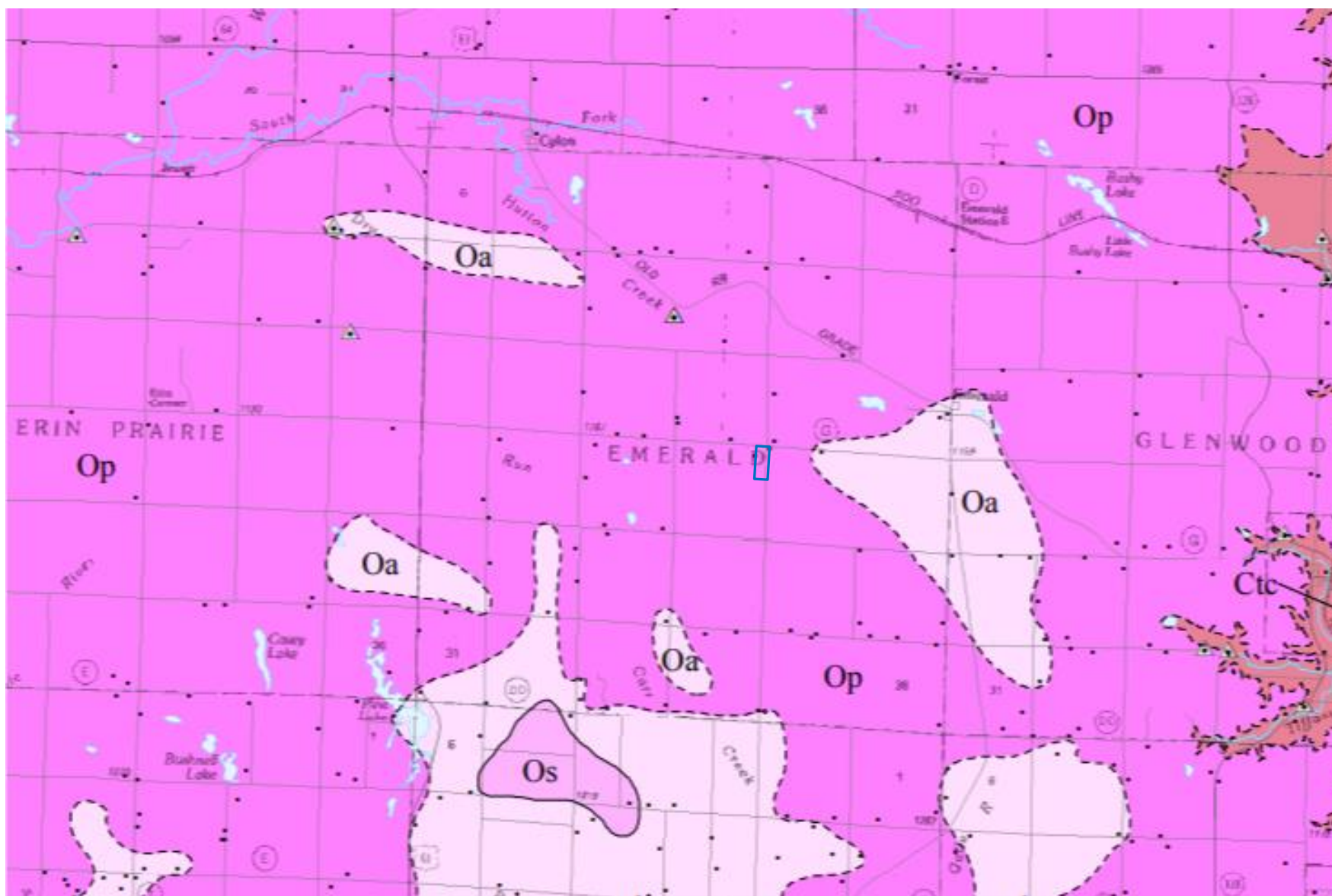


Figure 4a – Excerpt from Preliminary Geologic Map of the Buried Bedrock Surface of St. Croix Cty, WI LePain, D., 2006. WGNHS OFR 2006-04. Blue rectangle is approximate location of Emerald Sky Dairy production area.

## EXPLANATION

### SINNIPEE GROUP

Os

**Platteville Formation**

Light brown to buff dolomite, thin- to medium-bedded. Up to 20 ft thick on hilltops in southwestern St. Croix County.

### ANCELL GROUP

Oa

**St. Peter Formation**

Yellow-brown, white to gray sandstone. Sandstone is friable to well cemented and fine- to coarse-grained. Thickness up to 130 ft in southern St. Croix County.

### PRAIRIE DU CHIEN GROUP

Op

**Shakopee and Oneota Formations, undifferentiated**

Light brown, gray-brown, and yellow dolomite, sandy dolomite, and dolomitic sandstone. Sharp lower contact with Trempealeau Group. Oneota Formation 20 to 40 ft thick in the eastern part of the county; Oneota Formation approximately 140 ft thick, and Shakopee Formation at least 45 ft thick, in the western part of the county. Locally silicified and commonly vuggy; larger solution cavities partially filled with brown unconsolidated sediment are common.

### TREMPEALEAU GROUP

Ct

**Jordan and St. Lawrence Formations, undifferentiated**

Brown-yellow to white sandstone, gray siltstone, and minor gray shale. Sandstone is friable to well cemented, very fine- to coarse-grained quartzose sandstone and siltstone. Gradational lower contact with Tunnel City Group and sharp upper contact with Prairie du Chien Group. St. Lawrence Formation (Lodi Member) approximately 30 ft thick, dolomitic siltstone and very fine-grained sandstone. Jordan Formation (Norwalk and Van Oser Members) 80 to 90 ft thick, fine- to coarse-grained sandstone. Finer grained sandstones are commonly micaceous.

Figure 3b – Map Legend excerpted from WGNHS Open-File Report 2006-04, providing explanation of map symbology and general description of geologic units

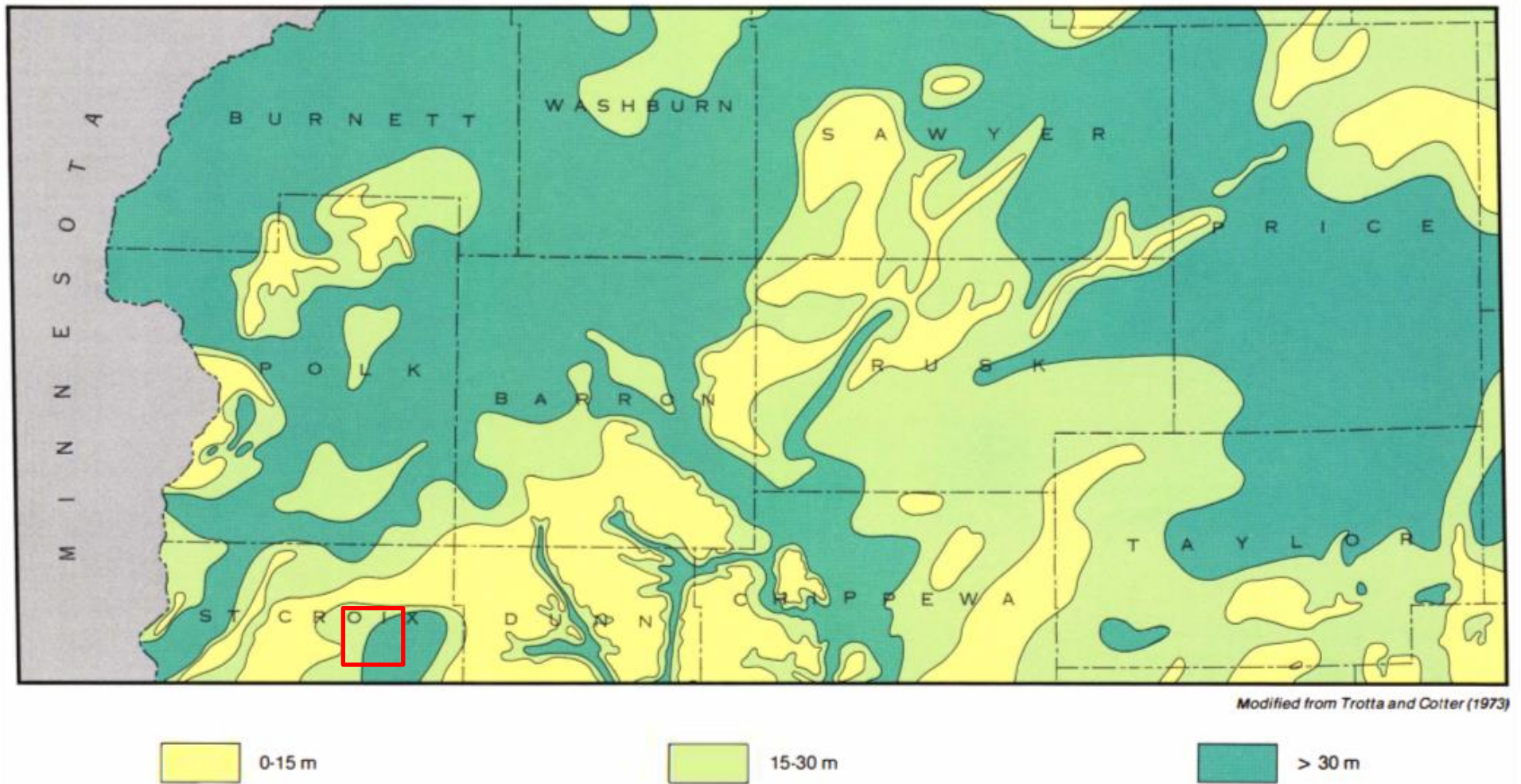


Figure 4 – Excerpt from Bedrock Geology of Wisconsin, Northwest Sheet, Depth to bedrock Inset. Mudrey, M. et al., 1987. Red Box is approximate location of Town of Emerald.



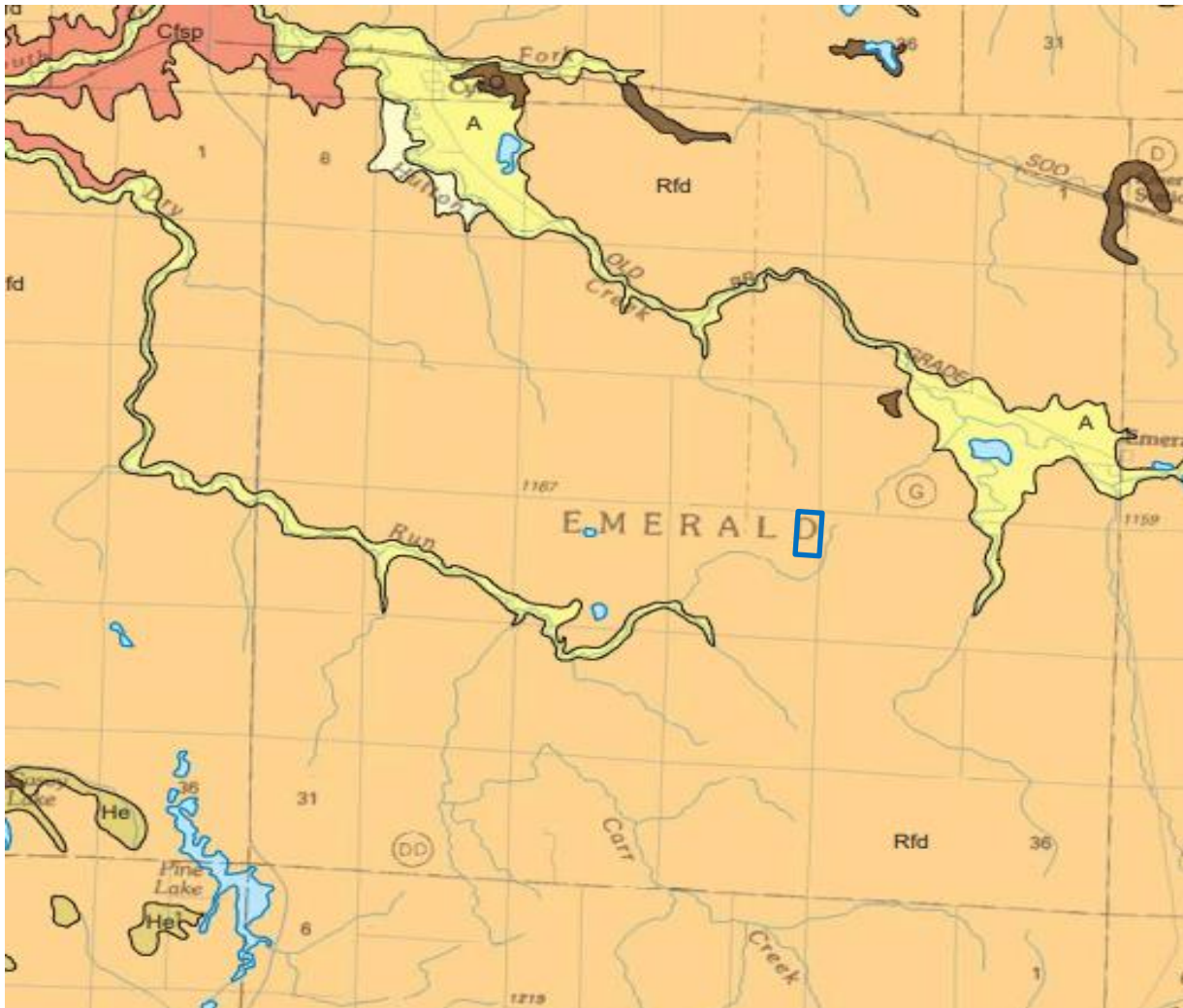


Figure 5a –Excerpt from Preliminary Quaternary Geologic Map of St. Croix County, Wisconsin. Kostka, S. et al., 2004. WGNHS WOFR 2004-22. Blue rectangle is approximate location of Emerald Sky Dairy production area.

## RIVER FALLS FORMATION

- Rfd** **River Falls diamicton** Reddish-brown, unsorted or poorly sorted, non-stratified, slightly-cohesive, variable in grain-size distribution, lacks significant amount of silt and clay; commonly contains areas of bedded sand and gravel; often overlain by less than one meter of loess, same appearance and grain-size distribution as Copper Falls Formation but lacks glacial landforms and hummocky topography, has a generally rolling surface topography with few kettles, deposits of variable thickness on hill tops, local shallow bedrock exists.
- Rfs** **River Falls sand and gravel in outwash deposits** Sorted and bedded deposits of sand and gravel; often overlain by less than one meter of loess; dominant lithologies are red-brown sandstones and mafic rocks derived from the Lake Superior basin.
- A** **Postglacial sand and silt** Commonly a mixture of sand, silt and clay with various amounts of organic matter; found mostly along edges of modern streams and rivers as flood plain and low fluvial terraces; boundaries between this unit and postglacial organic sediment have been drawn arbitrarily in many places.
- Cfsp**  
**Cfspp**  
**Cfsh**  
**Cfsb** **Copper Falls sand and gravel in outwash deposits** Sorted and bedded deposits of sand and gravel; often overlain by less than one meter of loess; dominant lithologies are red-brown sandstones and mafic rocks derived from the Lake Superior basin, includes river terraces of Pleistocene age. **Cfsp**: less than 20 percent of original stream bed interrupted by depressions formed by melting ice blocks, (kettles). Unit **Cfspp**: more than 20 but less than 50 percent collapsed surface. Unit **Cfsh**: more than 50 percent collapsed surface. Unit **Cfsb**: steep hill slopes in areas of deeply dissected drainage.

Figure 5b –Map Legend excerpted from WGNHS WOFR 2004-22 providing map symbology and brief explanation of units.

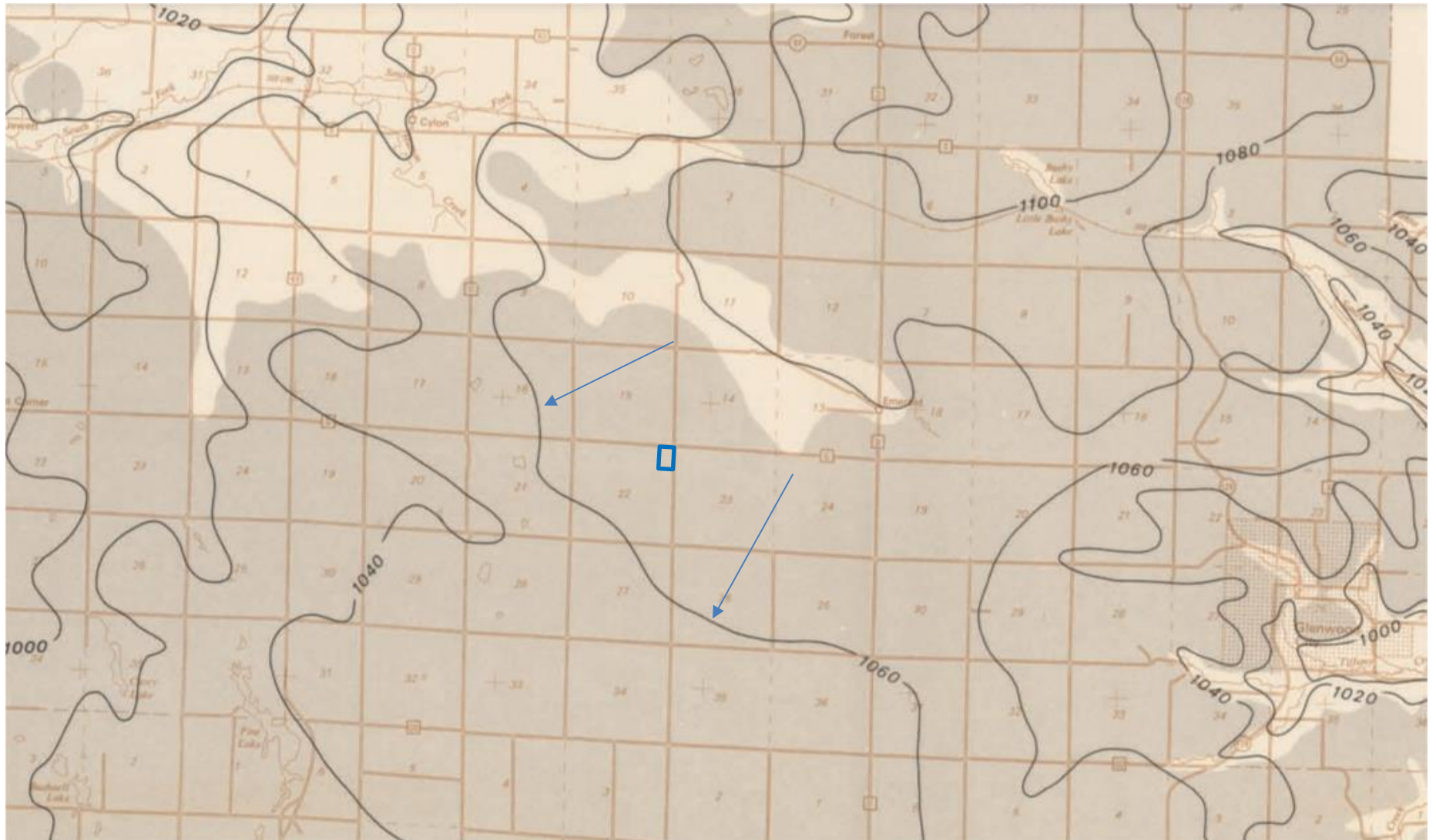


Figure 6 – Excerpt from Water table Map of St. Croix County, WI 1974. WGNHS IC32-plate01. Blue rectangle is approximate location of Emerald Sky Dairy production area. Blue arrows were added to illustrate regional groundwater flow.

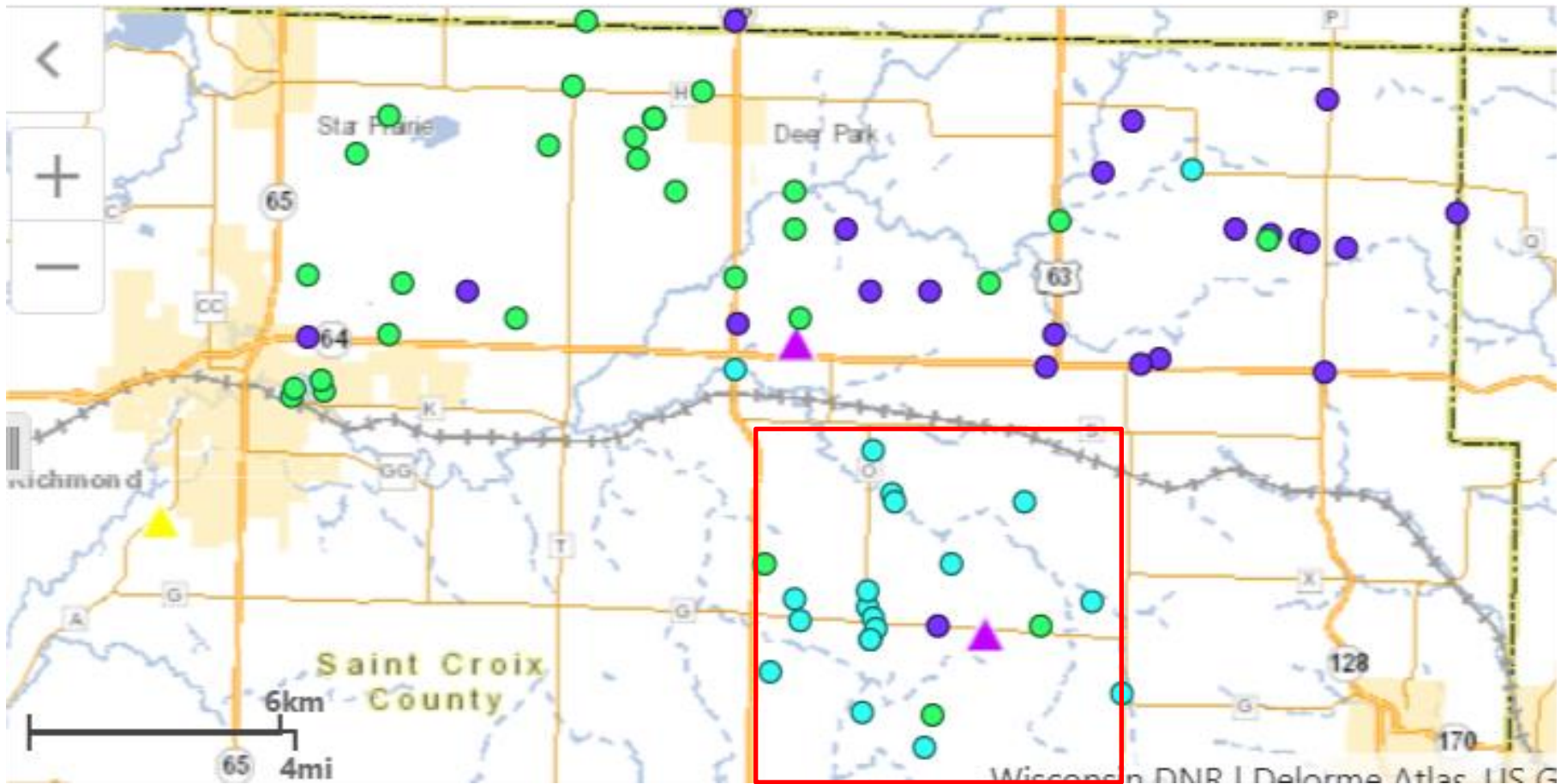


Figure 7 – Locations of wells sampled by St. Croix County in vicinity of ESD in 2016, color coded by sampling date. Light blue circles are samples from May 23, 2016 sampling event, with numerous samples in the Town of Emerald, outlined in red.

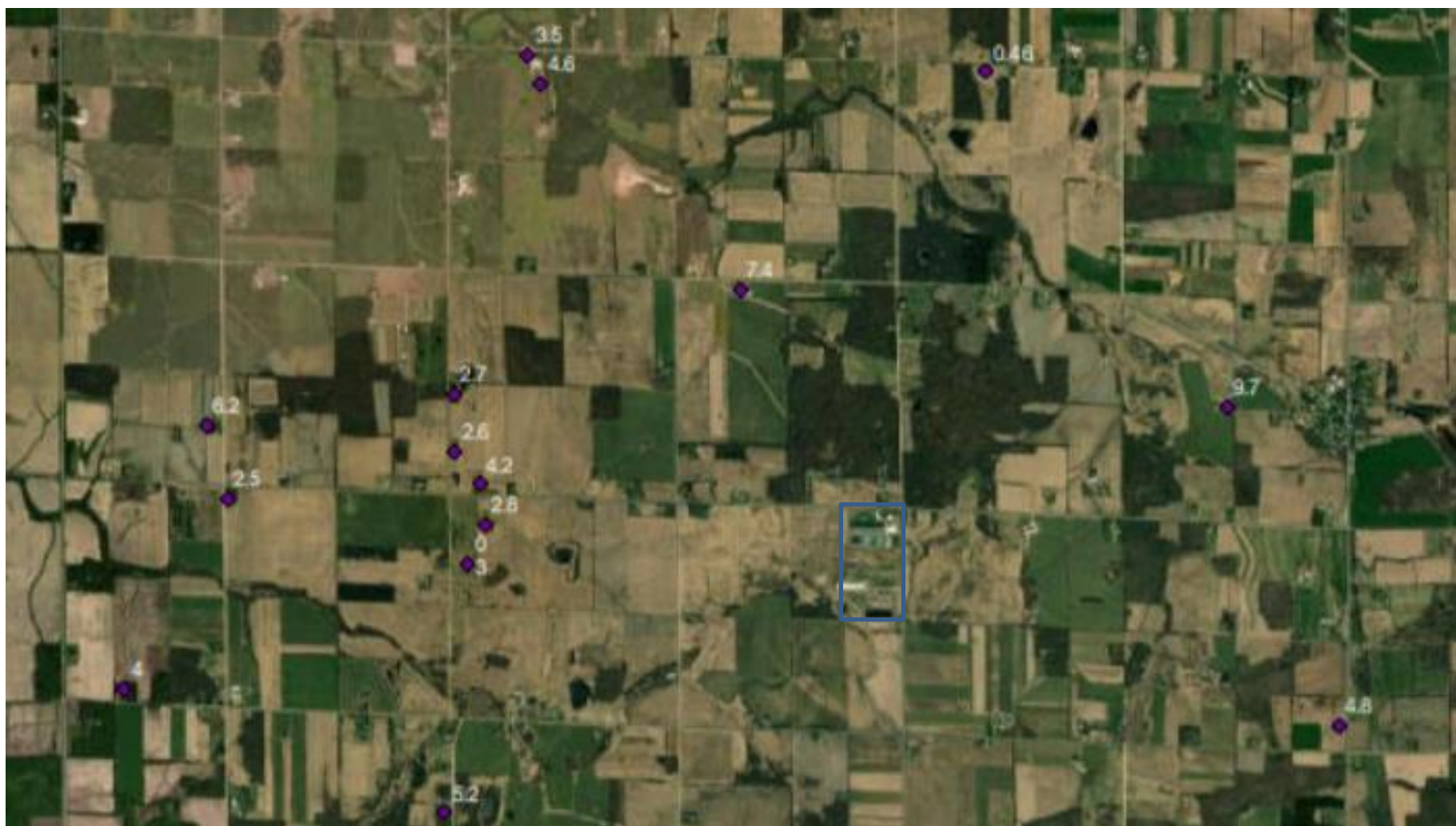


Figure 8 – Aerial photo with locations and results of May 23, 2016 sampling event. Results are nitrate ( $\text{NO}_2^- + \text{NO}_3^-$ ) concentrations in mg/L. ESD Production area is outlined in blue.



Figure 9 – Locations of sinkholes in the Town of Emerald, as mapped by St. Croix County.

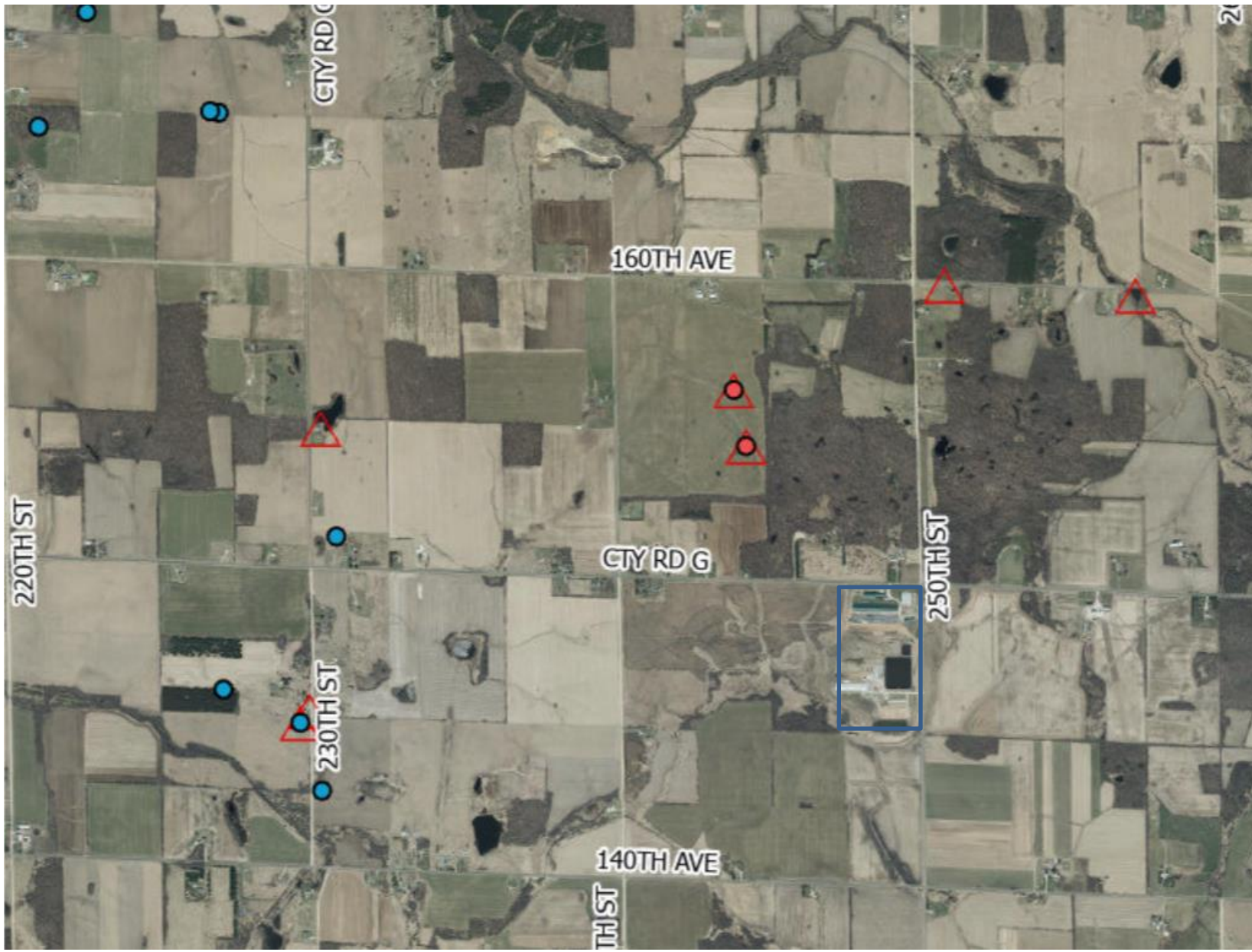


Figure 10 – Inset of mapped sinkhole locations shown in Figure 10, zoomed in on area near Emerald Sky Dairy (outlined in blue).

WISCONSIN UNIQUE WELL NUMBER <b>Source: WELL CONSTRUCTION</b>			<b>UC686</b>		State of Wi-Private Water Systems-DG/2 Department Of Natural Resources, Box 7921 Madison, WI 53707		Form 3300-77A (Rev 02/02)bw	
Property Owner <b>EMERALD TOWNHALL</b>			Telephone Number -		-		Depth <b>240 FT</b>	
Mailing Address <b>CO RD G</b>			City <b>EMERALD</b>		State <b>WI</b>		Zip Code <b>54012</b>	
County of Well Location <b>56 ST. CROIX</b>			Co Well Permit No <b>W</b>		Well Completion Date <b>09/05/2007</b>		1. Well Location T=Town C=City V=Village T of <b>EMERALD</b> Fire#	
Well Constructor <b>MARTELL STEVE PUMPS &amp; WELDRG INC</b>			License #		Facility ID (Public)		Street Address or Road Name and Number <b>CO RD G</b>	
Address <b>PO BOX 28</b>			City <b>SOMERSET</b>		State <b>WI</b>		Zip Code <b>54025</b>	
Date Of Approval			Specific Capacity <b>.3</b> gpm/ft		Gov't Lot or <b>SE</b> 1/4 of <b>SW</b> 1/4 of Section <b>15</b> T <b>30</b> N R <b>16</b> W		Block #	
High Capacity Well? <b>N</b>			Property? <b>N</b>		Reason for replaced or reconstructed Well?		2. Well Type <b>1</b> (See item 12 below) 1=New 2=Replacement 3=Reconstruction <b>45 4.7354 N</b> <b>92 18.6847 W</b>	
Well Serves # of homes and or <b>P</b> (eg: barn, restaurant, church, school, industry, etc.)			High Capacity Well? <b>N</b>		Property? <b>N</b>		1 = Drilled 2 = Driven Point 3 = Jetted 4 = Other	
5. Drillhole Dimensions and Construction Method			Lower Open Bedrock		Geol. Code		Geol. Descrip.	
From To Upper Enlarged Drillhole			Dia.(in.) (ft)		From (ft)		To (ft)	
10 0 surface 105			X -- 1. Rotary - Mud Circulation		_C_ CLAY		0 102	
6 105 240			-- 2. Rotary - Air		_L_ LIMEROCK		102 240	
			-- 3. Rotary - Air and Foam					
			-- 4. Drill-Through Casing Hammer					
			-- 5. Reverse Rotary					
			-- 6. Cable-tool Bit in. dia					
			-- 7. Temp. Outer Casing in. dia. depth ft. Removed?					
			Other					
6. Casing Liner Screen Material, Weight, Specification			From To		9. Static Water Level		11. Well Is:	
Dia. (in.) Manufacturer & Method of Assembly			(ft.) (ft.)		150 feet B ground surface		12 in. A Grade	
6 18.99#/FT. ASTMA53 NEW PRIME PE CHINA			surface 105		A=Above B=Below		A=Above B=Below	
10. Pump Test			From To		Developed? Y		Disinfected? Y	
Dia.(in.) Screen type, material & slot size			From To		Pumping level 180 ft. below surface		Capped? Y	
DRILL MUD & CUTTINGS			Surface 105		Pumping at 10 GPM 1 Hrs			
7. Grout or Other Sealing Material			# Sacks		12. Did you notify the owner of the need to permanently abandon and fill all unused wells on this property?		If no, explain	
Method From To			(ft.) (ft.)		13. Initials of Well Constructor or Supervisory Driller		Date Signed	
Kind of Sealing Material			Cement		SF		09/28/2007	
DRILL MUD & CUTTINGS			Surface 105		Initials of Drill Rig Operator (Mandatory unless same as above)		Date Signed	
					CT			

Figure 11 – Well Construction Report for the Emerald Town Hall. Highlighted are the depth of casing and static water level. Having well casing shallower than static water level can potentially affect water quality.



