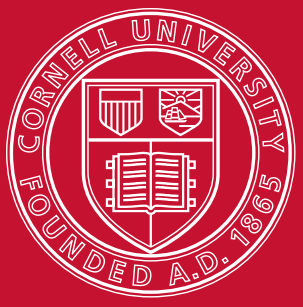

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Manure Management Guidelines for Limestone Bedrock/Karst Areas of Genesee County, New York: Practices for Risk Reduction

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Introduction

Drinking water well contamination issues related to manure management continue to occur in New York State, with three suspected occurrences in Genesee County over the last 10 years. Protection of groundwater resources may require additional measures beyond those provided in the 2004 guidance document, "Manure and groundwater: The case for protective measures and supporting guidelines" (Czymmek et al., 2003). In this document, we outline manure management practices for the karst area of Genesee County, New York. These risk reduction practices may also be effective in karst and other sensitive areas throughout New York State. While this guide is solely focused on agriculture, other activities and conditions in karst landscapes, including residential, commercial, industrial, and wildlife, also pose an elevated risk for groundwater contamination.

Background

"Karst" is the term used for areas associated with carbonate bedrock (limestone or dolomite), where cracks, fractures, and other solution channel irregularities are present. Karst conditions enhance these bedrock features over time through the action of flowing water to create sinkholes, depressions in the land surface, disappearing streams, etc., which provide a direct connection between surface water and ground water – these enhanced connections are known as "focused recharge". While the cracks and karst channels in the bedrock provide for high yielding wells, this type of landscape and geology, especially where the topsoil is thin, allows water to rapidly flow into (or out of) bedrock with little or no filtration. In such areas where ground water is under the influence of surface water, recharge waters influenced by residential, commercial, industrial, wildlife, or agricultural activities may also generate a contaminant risk to surface and ground water supplies. Available bedrock geology maps identify carbonate bedrock areas of New York State, but higher resolution maps of the boundaries as well as karst features in these bedrock units are needed to better manage and protect groundwater in these areas. Human activities in karst areas, including manure application, have a higher potential to contaminate groundwater as compared to most other hydrogeologic conditions found in New York State.

Karst and Karst Features

Within karst areas, it is also important to identify sinkholes and other karst features and their related contributing drainage area to optimize groundwater protection. While confirmation of karst features may ultimately require expert evaluation, in most cases, initial decisions to identify and treat sensitive locations will need to be made. A USGS publication evaluated existing information to provide a current map estimation of the general karst boundaries in Genesee County along with locations of possible and likely karst features (see Figure 1).

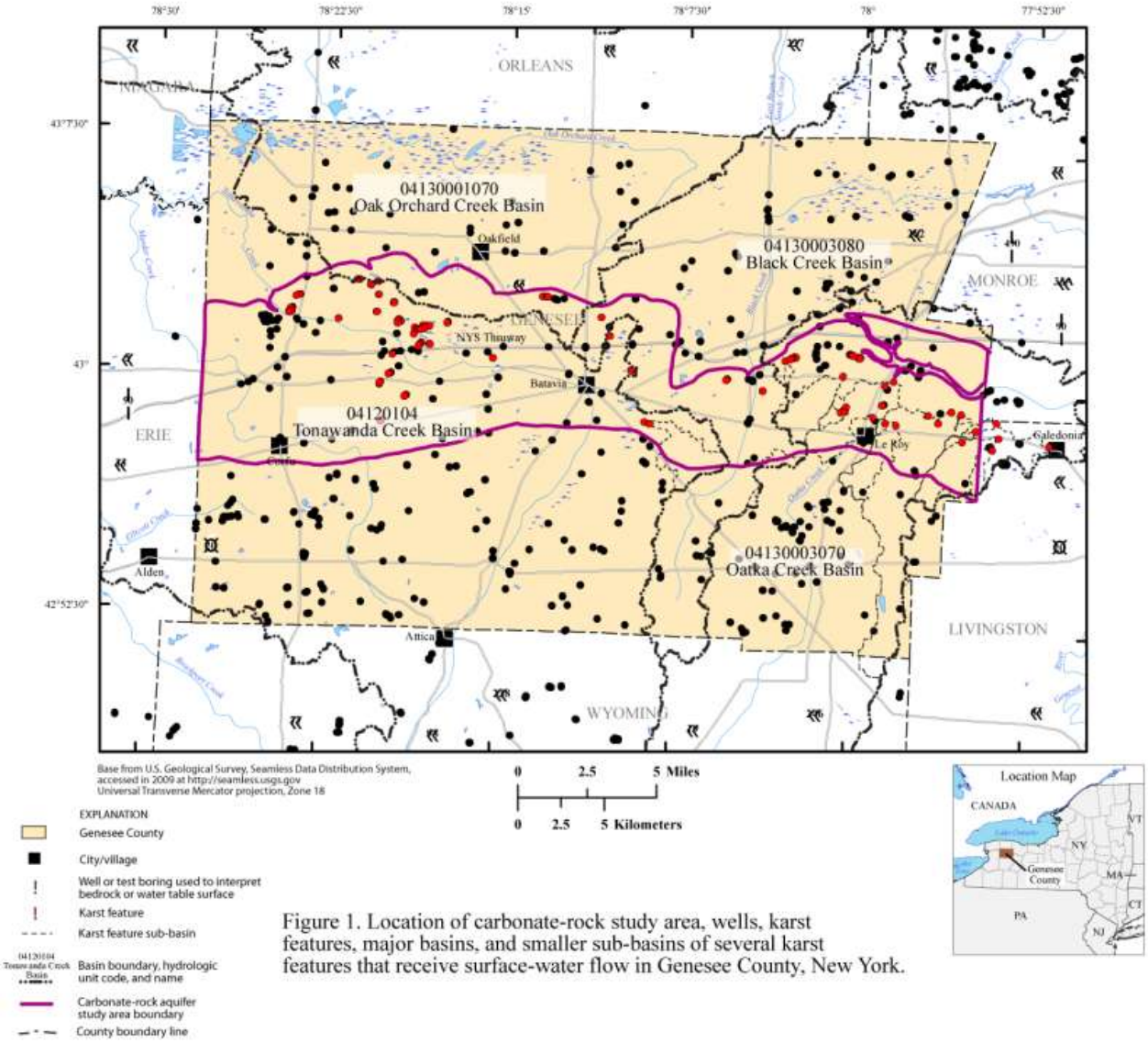

Figure 1. Location of carbonate-rock study area, wells, karst features, major basins, and smaller sub-basins of several karst features that receive surface-water flow in Genesee County, New York.

Figure 1. Location of carbonate-rock study area, wells, karst features, major basins, and smaller sub-basins of several karst features that receive surface-water flow in Genesee County, New York (Source: Reddy and Kappel, 2010; reprinted with permission). Note, the "karst area" of Genesee County is outlined in red.

Areas of Increased Risk

Based on observations from experiences in Genesee County, it appears that manure applied to soils 40 inches or less in thickness directly over some types of permeable limestone are most vulnerable to contaminating groundwater (although well water quality problems relating to manure elsewhere in New York State have also been observed in coarse sandy soils and in other types of fractured bedrock formations where rapid infiltration to groundwater can occur). The USGS publication and location of shallow soils is a starting point for identifying features that need field verification, but the predominant and minor mapped soil types in these areas need to be determined while also watching for smaller, unmapped patches of soil ("inclusions") that are shallow over karst.

In the case of manure application, risk is significantly higher when manure is: (1) liquid (generally <12% solids); and/or (2) freshly applied outside the normal growing season to wet, frozen, and/or bare soils; and/or (3) applied to snowpack with a high moisture content or that is about to melt; and/or (4) when significant rainfall is anticipated. Manure applied to the soil surface or on top of snowpack in advance of rain or snowmelt presents a significant risk concern (Reddy and Kappel, 2010), especially when the manure is not mixed with the soil through incorporation. In karst areas, any soil and water condition that generates flowing water on the surface can potentially impact groundwater by moving into bedrock pathways. Therefore, during wet weather, especially in late winter and early spring when most groundwater recharge occurs, the soil moisture/snow condition and weather forecast (http://forecast.weather.gov often includes predicted rainfall amounts) should be evaluated before manure is applied. Daily temperatures above 40°F can cause snowmelt and rapid infiltration when underlying soil is not frozen. Seven-thousand gallons of liquid manure/acre is approximately equal to a 0.25 inch rainfall, and when combined with wet soils, additional rain or snowmelt, and permeable bedrock, could be enough to trigger runoff or movement of pollutants.

In addition, past contamination of drinking-water wells from any source should alert planners and farmers to use extra caution when spreading manure, especially when applying liquid manure on unfamiliar fields in karst areas. Farmers are advised to make inquiries about field

history and to apply liquid manure with extra care while gaining experience with a newly acquired site or returning to a site that has not had manure in some time.

The Genesee County karst boundary lines in the USGS publication represent an area where all surface activities increase the risk of groundwater contamination and planners and farmers must exercise caution when spreading manure in this area. According to NYS DEC, AEM planners who provide services in Genesee County, NY, must use the guidelines noted here and in the "What you should do" section below to: (1) determine if a particular field is in, or straddles the karst boundary; (2) evaluate or confirm that field conditions include karst features (i.e., sinkholes, swallets, depressions, the shallow soils listed below, rock outcrops, and/or shallow bedrock); (3) assess whether the field appears to be in the drainage area of those karst feature(s); and (4) update the CNMP to meet the manure application guidelines listed below.

What You Should Do According to NYSDEC

The following pilot manure application guidelines are developed for the karst area of Genesee County as delineated in the USGS publication as well as an area of shallow soils immediately north of the karst boundary in northeastern Genesee County (*specifically, north of the karst area, east of Route 237, south of Route 262, and west of the Genesee/Monroe County line*). The pilot guidelines may be used in other karst areas where fields have a history of or are likely to cause or contribute to groundwater contamination.

A. The following manure application setbacks are required:

1) Without exception, all water wells within the karst area described above require a manure application setback of 100 feet. Wells with a past history of problems may require greater setback distances to be implemented based on best professional judgment of the AEM planner. For properties where well location is uncertain, the application setback should be initiated from the adjacent property boundary or apparent lot boundary associated with a residence. The establishment of long term perennial vegetation in well setback areas is encouraged, but not required.

2) Sinkholes and swallets must be protected with a vegetated buffer 30 feet wide and a manure application setback of 100 feet at all times.

B. Any liquid manure less than 12% solids applied from January 1 through April 15 of each year must be incorporated the same calendar day as it is applied in fields with:

1) Surface depressions (either mapped or observed by a AEM planner) that contain shallow soils (Aurora, Benson, Newstead, Rubbleland, or Wassaic), rock outcrops, and/or shallow bedrock; and/or
2) Any other area mapped with Aurora, Benson, Newstead, Rubbleland or Wassaic soil types; and/or
3) Contributing drainage areas to karst features (i.e., sinkholes, swallets, depressions, the shallow soils listed above, rock outcrops, and/or shallow bedrock).

In addition, all activities need to be consistent with other CNMP requirements when a farm is operating with a CNMP, such as RUSLE2, the N and P Indices, Cornell Nutrient Guidelines, etc. AEM planners should be mindful of the tillage aspects of manure incorporation and how tillage and/or manure application may impact other CNMP compliance issues relating to the amount of residue needed for erosion control, nutrient balances, and risk indices. The CNMP should be updated accordingly.

Applications to an old or firn (re-frozen or crystallized) snow pack should be avoided if the depth of this snowpack is greater than 10 inches due to risk of runoff when snowmelt occurs. The crystalline nature and high water content of aged snow limits the benefit of incorporation and adds substantially to the amount of water available for recharge upon melting. Aerator incorporation or other light tillage of manure is acceptable if the manure is applied before the tillage operation, and if the implement provides reasonable mixing of the manure and soil.

Manure applications during other times of the year and any solid manure applications should be conducted with care and must follow the provisions of the CNMP when there is one. Carefully managing the level of manure in storages and field applications throughout the year as well as

choosing low risk fields for any applications that are necessary in late winter/early spring will further reduce risk. Additional information is available in the 2005 guidance document "Supplemental manure spreading guidelines to reduce water contamination risk during adverse weather conditions" (Czymmek et al., 2005).

GIS Map Resources to Assist in Identifying Karst Landscapes and Features

Depressions:

- USGS 7.5 Minute Topographic Maps – 1:24,000 scale Digital Raster Graphics: http://cugir.mannlib.cornell.edu/datatheme.jsp?id=92
- Orthoimagery from NYS GIS Clearinghouse: www.nysgis.state.ny.us/gateway/mg/

Sinkholes and Swallets:

- USGS 7.5 Minute Topographic Maps – 1:24,000 Digital Raster Graphics: http://cugir.mannlib.cornell.edu/datatheme.jsp?id=92
- SSURGO soil data: http://soildatamart.nrcs.usda.gov/
    - For web-based viewing, the Web Soil Survey: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm
- Shapefile of karst features (point features) associated with the USGS publication.

Shallow Soils:

- SSURGO soil data: http://soildatamart.nrcs.usda.gov/.
    - Web Soil Survey: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm.
    - Refer to this guidance document and "Manure and Groundwater: The case for protective measures and supporting guidelines" for the list of shallow soils.
- Shapefile of shallow SSURGO soils for Genesee County (Aurora, Benson, Newstead, Rubbleland or Wassiac associated with this guideline document.

Higher Resolution Karst Area Boundary for Genesee County:

- Shapefile of carbonate-rock study area (polygon features) associated with the USGS publication.

Lower Resolution Bedrock Geology for all of New York State:

- NYS Museum Bedrock Geology Data–1:250,000 scale: www.nysm.nysed.gov/gis/#bedr.

Glossary of Karst Terms

Adapted from: Field, M.S. 1999. A lexicon of cave and karst terminology with special reference to environmental karst hydrology: USEPA, National Center for Environmental Assessment, EPA/600/R-99/006, 201 p. and the digital version by Karst Waters Institute.

Aquifer

A formation (bedrock or soil), or part of a formation that contains sufficient saturated, permeable material to yield significant quantities of water to wells and springs.

Contributing drainage area

That portion of land-surface area from which measurable accumulated runoff water flows to a receiving surface or ground waterbody of interest.

Joint

A break or paper-thin fracture in the bedrock occurring either singly, or more frequently in a set or system, but not attended by a visible movement parallel to the surface of the joint. A joint is where water may initially seep and slowly dissolve carbonate rock to begin to create solution channels and initiate karst.

Karst

A terrain, generally underlain by limestone or dolomite, in which the topography is formed chiefly by the dissolving of rock, and which may be characterized by sinkholes, losing (sinking) streams, closed depressions, subterranean drainage, and caves (Monroe, W.H.,

1970, A glossary of karst terminology: US Geological Survey, Water-Supply Paper 1899, 26 p).

Karst aquifer

A body of soluble rock that conducts water principally via a connected network of tributary conduits, formed by the dissolution (slow dissolving) of the rock, which drain a groundwater basin and may discharge to a spring. The conduits may be partly or completely water filled and the volume and nature of flow in karst varies throughout the year.

Karst topography

A landscape characterized by the presence of sinkholes, caves, springs, and losing streams created by groundwater solution of sedimentary rock such as limestone.

Sinkhole

Any closed depression in soil or bedrock formed by the erosion and transport of earth material from below the land surface, which is illustrated by a closed topographic contour on a map and drains to the subsurface. Types of sinkholes formed in soluble rock include dissolution sinkhole or doline (gently sloping depression that is wider than it is deep), karst window (sinkhole exposing an underground stream), vertical shaft (depressions in bedrock much deeper than it is wide and roughly circular in plan), grike (depression in bedrock much deeper than wide and crudely shaped like a lens (lenticular in plan).

Sinking (losing) stream

Any stream that disappears underground, typically over a longitudinal section of a stream channel or directly into a swallet.

Spring

Any natural discharge of water from rock or soil onto the surface of the land or into a body of surface water.

Surface depression

A closed, bowl-shaped feature in the land surface that does not drain to a stream or to any other surface feature.

Swallet (swallow hole)

A place where water disappears or sinks underground. A swallet generally implies nearly instantaneous water loss into an opening of a sinkhole or karst valley.

Topography

The general configuration of the land surface or any part of the earth's surface, including its relief and the position of its natural and man-made features. Maps of the topography commonly represent the shape of the surface with contour lines of constant elevation. Sinkholes and surface depressions are represented by contours that form a closed loop, and may be marked with a series of tick marks on the interior or downslope side.

Acknowledgements

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References

- Czymmek, KJ, LD Geohring, QM Ketterings, P Wright, and A Eaton (2005). Supplemental manure spreading guidelines to reduce water contamination risk during adverse weather conditions. What's Cropping Up? 15(3): 1-3. Downloadable at: http://nmsp.cals.cornell.edu/publications/files/WinterSpreadingGuidelines.pdf.

- Czymmek, KJ, H van Es, and L Geohring (2004). Manure and groundwater: The case for protective measures and supporting guidelines. Northeast Dairy Producers Conference Proceedings. Downloadable at: http://nmsp.cals.cornell.edu/publications/files/Groundwater.pdf.

- Field, MS (1999). A lexicon of cave and karst terminology with special reference to environmental karst hydrology: USEPA, National Center for Environmental Assessment, EPA/600/R-99/006, 201 p. and the digital version by Karst Waters Institute.

- Reddy, JE, and WM Kappel (2010). Hydrogeologic and geospatial data for the assessment of focused recharge to the carbonate-rock aquifer in Genesee County, New York. U.S. Geological Survey Scientific Investigations. Downloadable at: http://pubs.usgs.gov/sim/3132/.