MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER RESOURCES DIVISION

GUIDANCE

CONDUCTING A SUBWATERSHED-SCALE SOURCE SURVEY – REMOTE SENSING

This document provides recommendations and method suggestions for conducting watershed- or subwatershed-scale assessments by remote sensing for *E. coli* sources, as a supplement for Michigan's Statewide *E. coli* Total Maximum Daily Load (TMDL).

Other resources available on the Michigan Department of Environmental Quality's (MDEQ) *E. coli* TMDL Web site include:

- The MDEQ *E. coli* Pollution and Solution Mapping System
- Conducting a Subwatershed-Scale Source Survey - Field Inventories
- Locating Priority Areas for Septic System Investigations

Introduction

The MDEQ has provided an online interactive mapping system to help interested stakeholders locate *E. coli* sources. Additionally, the MiWaters Site Explorer can provide compliance information and access to public documents for National Pollutant Discharge Elimination System, groundwater, biosolids, and other permitting systems. These are all tools in the source assessment toolbox. Remote sensing is another tool to build knowledge of sources, best used in conjunction with the *E. coli* TMDL Mapping System, MiWaters Site Explorer, windshield surveys (driving the watershed and identifying issues), and monitoring water quality (*E. coli* and microbial source tracking techniques).

Remote sensing is the obtaining of information about a geographic topic, without physically touching the objects you are studying. In this case, remote sensing is a way of gathering information about *E. coli* nonpoint sources without actually driving a watershed. Remote sensing does require 'ground trothing,' which is the verification of conclusions made during remote sensing by visiting the site in person. A remote sensing project should supplement a driving windshield survey, because from aerial imagery you could spot issues that are far from the road or hidden by trees.

Remote sensing using aerial imagery is becoming easier, and better, continually with the accessibility and improvement of free software that allows anyone to scroll across aerial or satellite imagery of watersheds and even travel through time by looking at imagery across the years. Remote sensing for fecal bacteria sources requires knowledge of sources that can be identified from aerial and satellite imagery.

Method Recommendations:

1) Establish your search area: Your area of interest (political division or subwatershed) is your search area. Shapefiles of these areas are available by searching in the Michigan Center for Geographic Information Data Library (http://gis-michigan.opendata.arcgis.com/).

Selecting an entire subwatershed, rather than a middle or lower portion alone, is advised. The 12-digit hydrologic unit code scale is a manageable size (they average about 30-square miles), but this will depend on your available resources.

2) Establish your search pattern: You may wish to overlay a grid, such as legal descriptions (sections, quarters, and quarter quarters) over the imagery, and systematically examine each grid block. Free or online programs may not allow this. In that case, we recommend establishing a pattern, such as; examining a half-mile on the west side of a road, moving north until you have reached the boundary of the watershed, then move south along the same road and look at the half-mile to the east of the road.

3) Mark potential sources: In free software, you may be able to mark sources that require further investigation by 'dropping a pin' or 'marker' and record the latitude and longitude in a spreadsheet along with notes. In more expensive software you can create a point shapefile and add columns for latitude, longitude, and descriptive information.

4) Ground truthing: The MDEQ recommends conducting a full windshield/driving survey to confirm sites, determine livestock type, estimate their numbers, and note the conditions of the operations or farms.

5) Contact the appropriate agencies for help on addressing issues in an appropriate and responsible manner: For issues with livestock, please contact the MDEQ and Michigan Department of Agriculture and Rural Development. For septic system or illicit connection issues, please contact the local health department.

Things to look for with livestock:

- Loafing areas: Worn spots in pastures where animals spend a lot of time or may take dust baths (Figure 1).
- Feed piles: Small piles of feed, usually with bare earth surrounding them (Figure 1).
- Trails: Trails are usually dirt paths that an animal would use repeatedly, leading to food, shelter, or water. Trails leading to surface water may indicate that the livestock have direct restricted (fenced out of most areas, but allowed some access for drinking or crossing) or unrestricted access (no fencing) to surface water (Figure 1).
- Exercise areas: Usually circular trails from horses on picket lines or larger oval paths used as a race track (Figure 1).
- Feed silos: Neat looking metal barns with an attached silo may contain poultry or hogs (Figure 2). Large and well organized hog farms often have manure storage under the barns and the animals may never leave the barns; therefore, large hog farms may have a distinctive lack of trails, feed piles, etc. The manure from these systems may be spread locally or manifested (sold or given away).
- Barns: Not all barns will contain animals, but all livestock will need a barn, shed, or other building for shelter. Investigators should look for additional signs (such as those listed above), to reduce errors.
- Livestock stream crossing: Livestock with direct access to surface waters may be a source of *E. coli*. Clues to identifying this issue include trails that lead through rivers and wetlands, and pastures on one side of a water body with shelter or food on the other side (Figure 3).

- *Manure Storage: Lagoons have a tendency to be rectangular, but prefabricated storage structures that are above ground are usually round. Manure storage could also simply be piles of solids (Figure 4).*

Things to look for with Septic Systems:

Finding potential signs of septic system failures using remote sensing is much more difficult than livestock issues. Often only obvious issues can be seen from the ground or aerial imagery. Color infrared imagery, in particular, has been used to locate failing septic systems in several studies. Infrared cameras visually records subtle differences in temperature or color and can detect ground failure, seasonal failures, and seasonal stress, as well as illicit connections (Roper, 2008). More discussion on using spatial data, other than aerial imagery (such as soils data), can be found in the MDEQ online guidance document titled, "Locating Priority Areas for Septic System Investigations" found on our Statewide *E. coli* TMDL Web site (www.michigan.gov/waterquality and follow the link to "TMDLs").

It should be noted that just because you cannot see the problems using a windshield survey or remote sensing, it does not mean the problems are not there. Things to look for with residential areas:

- Small lot size or too many trees to allow for a septic system in an unsewered area (Figure 5). This may indicate a potential problem worth investigating.

- Signs of septic system failure, such as bare or muddy areas in lawns indicating a surface failure (wastewater on the ground surface) or green stripes signaling issues with the septic system field (Figure 6).

- Systems that may not meet code requirements; such as systems that are located too close to surface water (Figure 7).

- Areas with impermeable soils or saturated soils. One sewage treatment option that was once more common in Michigan is the septic system surface lagoons, replacing adsorption fields, in areas that have impermeable soils (Figure 8). New systems with surface lagoons are not typically allowed by local code in most areas of Michigan, but some older ones are still in operation. These lagoons are generally shallow and circular and can be 60 to 100 feet (or more) in diameter. Many issues exist with these systems that made them an undesirable option, including: overflow during wet weather, human health issues with contact, and failure due to animal burrowing and root intrusion.

Figure 1. Examples of trails (1), loafing areas and feed piles (2), and animals (3) in pastures along with the outbuildings all indicate the continued presence of livestock.

The oval tracks in this image are indicative of a horse living here, likely with other livestock. Horse farms, even with only one horse, sometimes have racetracks.

This farm has active pasture used by an unknown number of animals. Can you see the livestock in this picture? Bare earth indicates areas where animals loaf and have trampled or over-grazed. These animals may have direct access to the stream on the right side of the image, but it looks fenced off. Pasture runoff could be an issue depending upon the topography.

Trails, animals and feed piles are visible in this aerial view, but might be hard to see from the road.

This hobby horse farm was missed in a driving inventory of the watershed, likely because it has very few animals and is far from the road. In 'leaf on' conditions, the pasture may have been hidden. The stream at this monitored road crossing has high *E. coli*. Older imagery (bottom) indicates a circular trail likely created by a horse on a line. In newer imagery (above), you can see several animals at the same site.

From the number of feed piles (2), evidence of over-grazing (bare soils), and trails (1), this farm probably has a lot of animals. This farm has 40 acres of pasture, and is adjacent to the headwaters of a small stream.

Figure 2. Feed silos (1) and barns (2) at a hog facility. Manure is stored beneath the barns.

Figure 3. This cattle herd (1) must cross this river (2) to reach their covered shelter. There is no fencing to keep them from walking directly in the water (left image). Later imagery (right) shows that one pasture is now row crops, and a barrier (3) would now prevent the cattle from walking up or down the stream. This is a definite improvement, but they still must walk through the water.

Figure 4. Aerial image of a large farm with pastures and manure storage.

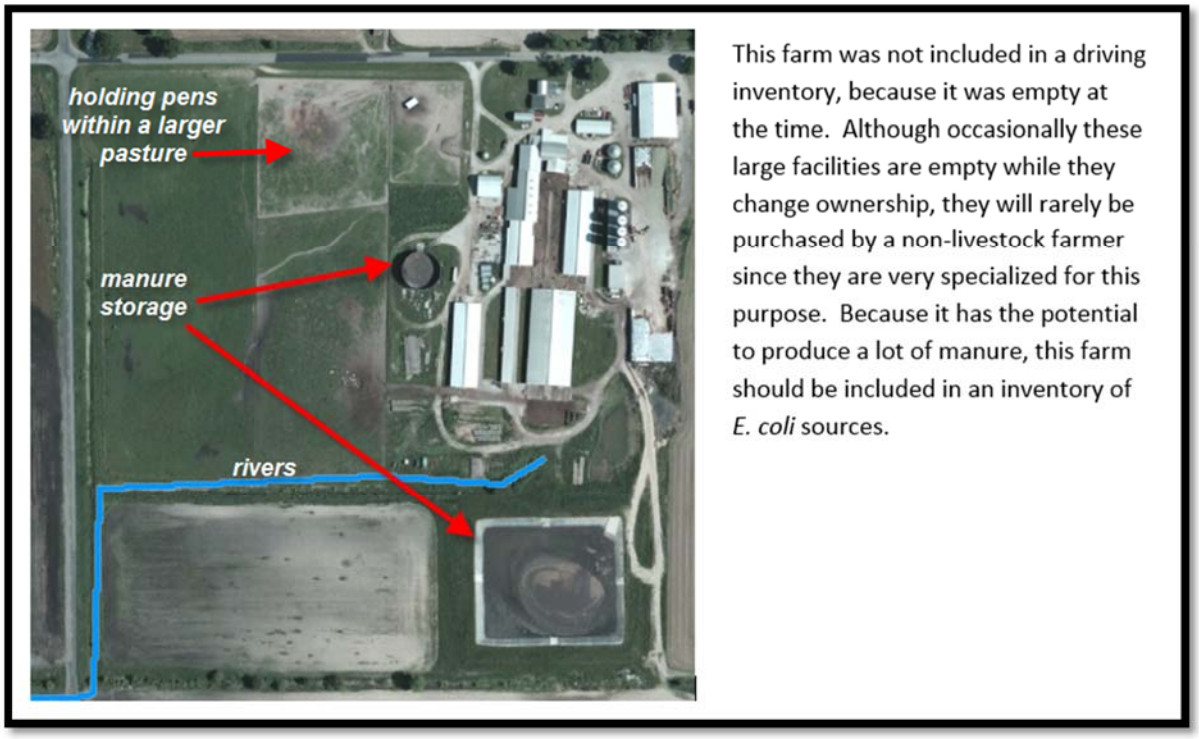

Figure 5. Homes on small lots (in this case ¼ acre), in the absence of sanitary sewers are an indication of a potential issue.

Figure 6. Green stripes in this well-watered lawn may indicate that this septic field is not operating properly and the grass is receiving extra nutrients from the graywater that should be percolating downward. In a dry time of the year, this may be more prominent, and is referred to as 'seasonal stress.'

Figure 7. Left Image: At the bottom of this image is a surface lagoon (evaporation system) for sewage treatment (1); these are sometimes used where soils are not suitable for a typical septic adsorption field. Near the middle of the image is a manure storage lagoon/pit (2). The tree line (across the middle of the image) is a stream. Right Image: Another surface lagoon (3) that was too close to surface water and had other issues (newer imagery shows that is has been replaced). These systems are only allowed in a few areas of Michigan, and have many large setback requirements from homes and surface water.

Figure 8. These surface septic system lagoons are in a county that no longer allows new construction of these systems. Old ones may still be in use, and repair permits might still be issued (consult with your local health code).

Figure 9. The soils in this area are so suitable for ponds (impermeable) that nearly everyone has one, some of which may have been part of a septic system either currently or in the past. Such soils are not generally ideal for adsorption fields. Multiple septic system failures and illicit connections were found in this area.

REFERENCE

Roper, W. E. (2008). Color Infrared Survey for Identification of Failing Onsite Treatment Systems, George Mason University.