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Drain Spacing Tool

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www.egr.msu.edu/bae/water/drainage/drain-spacing-tool

1. Overview of the Drain Spacing Tool

The Drain Spacing Tool estimates the optimum spacing of 4-inch lateral drain pipes that maximizes economic return on investment. For soils that would benefit from subsurface (tile) drainage, use this tool to estimate the optimum drain spacing for any rotation of corn and soybean (Figure 1). The tool has a geographical user interface that allows navigating to a specific field in the Midwest USA. Once at the specific field, enter a few simple inputs. Then, the tool uses site-specific soil and weather data to estimate the optimum drain spacing. An advanced input setting is also available for entering custom soil and economic inputs for a tailored analysis.

2. Why is the tool needed?

Choosing a drain spacing that is too narrow, increases the cost of the drainage system, reduces profit, and leads to higher nitrate loss (Kladivko et al., 2004; Skaggs, 2017). On the other hand, choosing a drain spacing that is too wide, increases yield variability across the field and removes less total water that may cause yield loss from not enough drainage (Figure 2). The Drain Spacing Tool estimates the optimum drain spacing that removes enough water to maximize economic return on investment (Golden Rule of Drainage), and it helps avoid over-design and under-design of drainage systems.

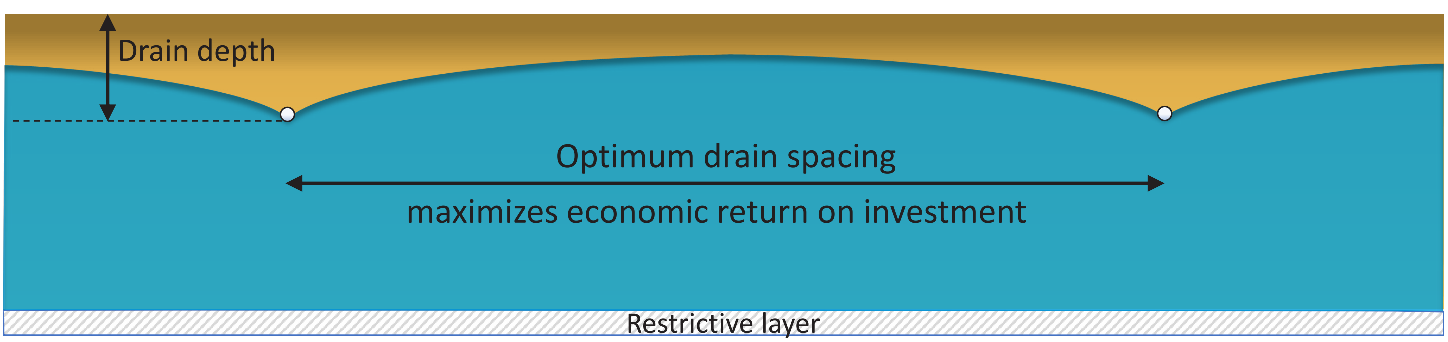

Figure 1- An example of the soil and water-table profile with a subsurface drainage system.

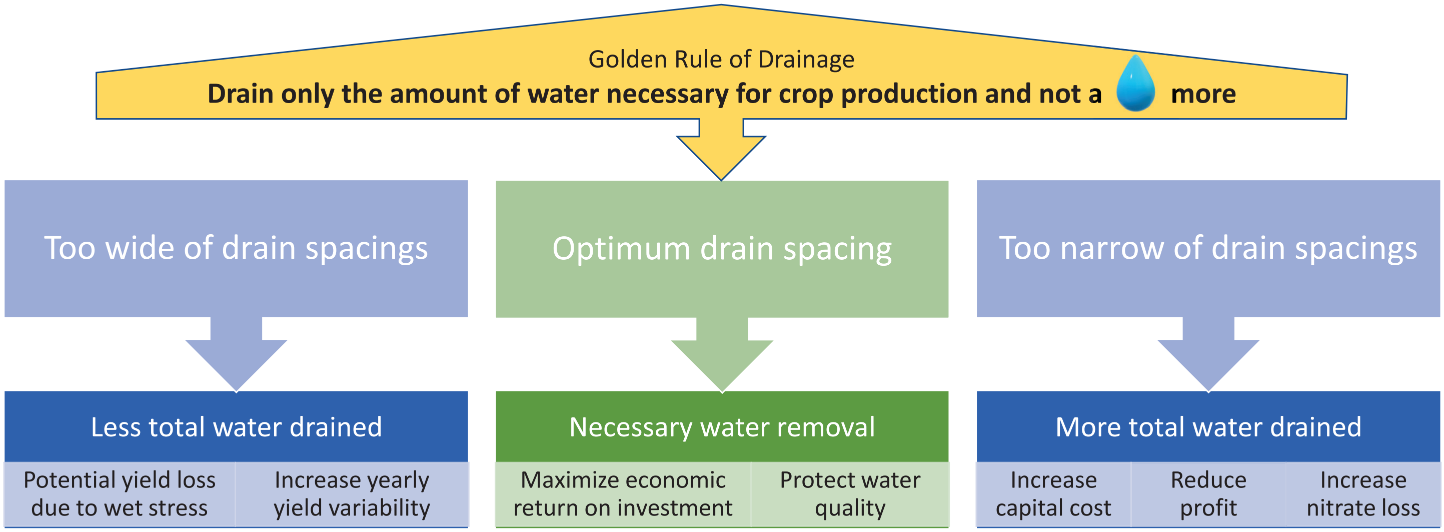

Figure 2- Summary of the potential outcomes for a too wide or too narrow drain spacings at a constant drain depth.

3. How does the tool work?

The tool relies on equations to estimate the optimum drain spacing and the long-term average annual drainage discharge. This section briefly describes these two equations. For more information, see the User Manual of the Drain Spacing Tool (www.egr.msu.edu/bae/water/drainage/drain-spacing-tool).

3.1. Estimation of the optimum drain spacing

The tool uses an equation developed by Ghane et al. (2021) to estimate the optimum drain spacing. That equation was developed based on computer modeling work for three drain depths and five soils at four locations planted. Figure 3 shows an example calculation for the Lansing, Michigan, location that was used to develop the equation. In this example, the maximum annual return on investment occurred at a 56-ft optimum drain spacing. Similar calculations were performed for Albany, New York; Urbana, Illinois; and Waseca, Minnesota.

To estimate the optimum drain spacing, the tool uses site-specific data. Some of the data are manually entered in the tool by the user (for user inputs, see Section 6). Soil and weather data (1990–2019) are automatically imported into the tool from the gSSURGO database (Soil Survey Staff, 2020) and the PRISM Climate Group database (PRISM Climate Group, 2020), respectively. The advanced inputs of the tool allow entering custom soil and economic inputs for a tailored analysis.

The tools's economic analysis consideres annual corn production income, annual conr production cost, and annual drainage system cost.

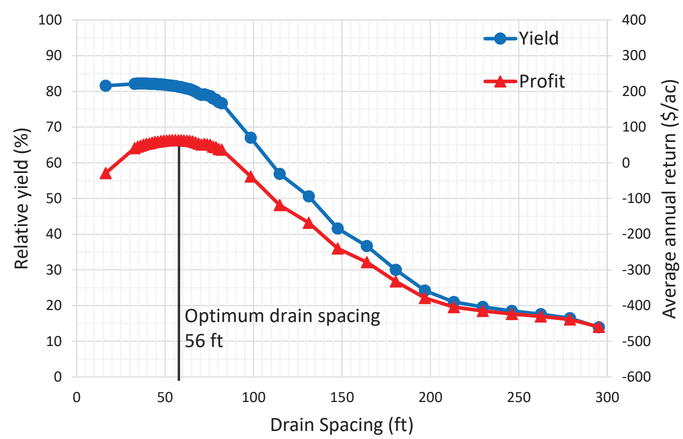

Figure 3- Relationship between drain spacing and 30-year average annual return on investment (1990–2019) for a Drummer silty clay loam soil in Lansing, Michigan. The peak of the profit line is the 56-ft optimum drain spacing for drains installed at 2.5-ft depth.

3.2. Estimation of the long-term average annual drainage discharge

The tool uses an equation to estimate the long-term average annual drainage discharge based on the same modeling data described in Section 3.1. Estimating the drainage discharge requires three values including the long-term average annual precipitation, drain depth, and drain spacing. The tool uses the manual user-entered design drain depth (figures 4 and 5), and the drain spacing and annual precipitation are estimated internally by the tool.

4. How do you improve your bottom line using the tool?

The Drain Spacing Tool estimates the optimum drain spacing that provides the best corn yield at the lowest drainage system cost (Figure 3). This tool allows entering economic inputs (corn price, drainage system cost, and other inputs) for tailoring the tool to custom economic conditions. This tool helps avoid spacings that are narrower than necessary, thereby preventing an unnecessary increase in drainage system cost.

5. How does the tool protect water quality?

In this section, two water-quality benefits of the tool are described.

5.1. Avoiding too narrow of drain spacings

The tool improves water quality by helping the user avoid choosing too narrow of drain spacings that would otherwise increase nitrate loss. When drain spacing is narrower than necessary, more water is drained, and thereby nitrate loss increases (Kladivko et al., 2004; Skaggs, 2017). As a water-quality guide, avoid choosing a drain spacing smaller than the one the tool estimates.

5.2. Reducing nitrate load with shallow drains

Reducing drainage discharge is the primary method of reducing nitrate load from a subsurface-drained field (Ross et al., 2016), and shallow drains reduce drainage discharge (Craft et al., 2018). Therefore, shallow drains reduce nitrate load by reducing drainage discharge.

When designing a drainage system, make an informed decision about drain depth by estimating the nitrate load reduction of shallow drains compared to deep drains. First, use the Drain Spacing Tool to estimate the average annual drainage discharge of shallow and deep drains. Then, use the Shallow Drains Tool to calculate the average annual nitrate load reduction of shallow drains compared to deep drains. To learn more about shallow drains, see the Extension bulletin by Ghane (2022). To use the Shallow Drains Tool, visit www.egr.msu.edu/bae/water/drainage/tools

6. Steps for using the tool

For easy use, the tool has a basic version with default settings. To use the basic version of the tool, follow the steps below (figures 4 and 5). Users are encouraged to use the advanced input setting for tailoring the tool to custom soil and economic conditions. Detailed description of the advanced inputs and outputs are in the User Manual at: www.egr.msu.edu/bae/water/drainage/drain-spacing-tool

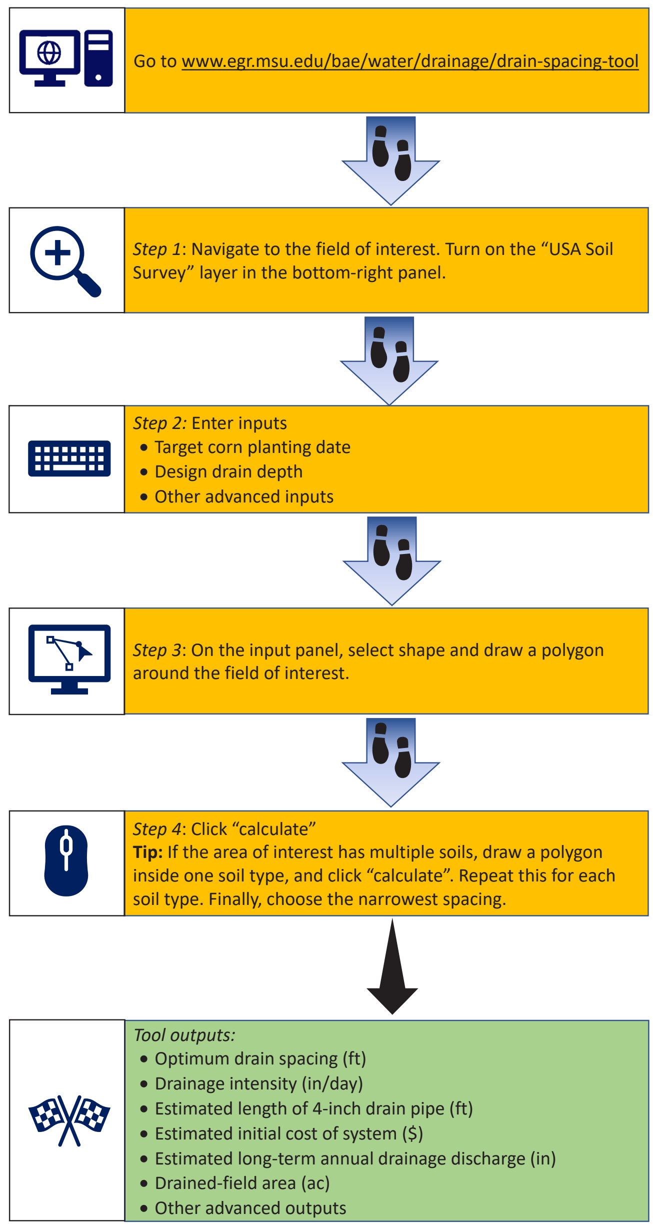

Figure 4- Summary of the steps for using the tool.

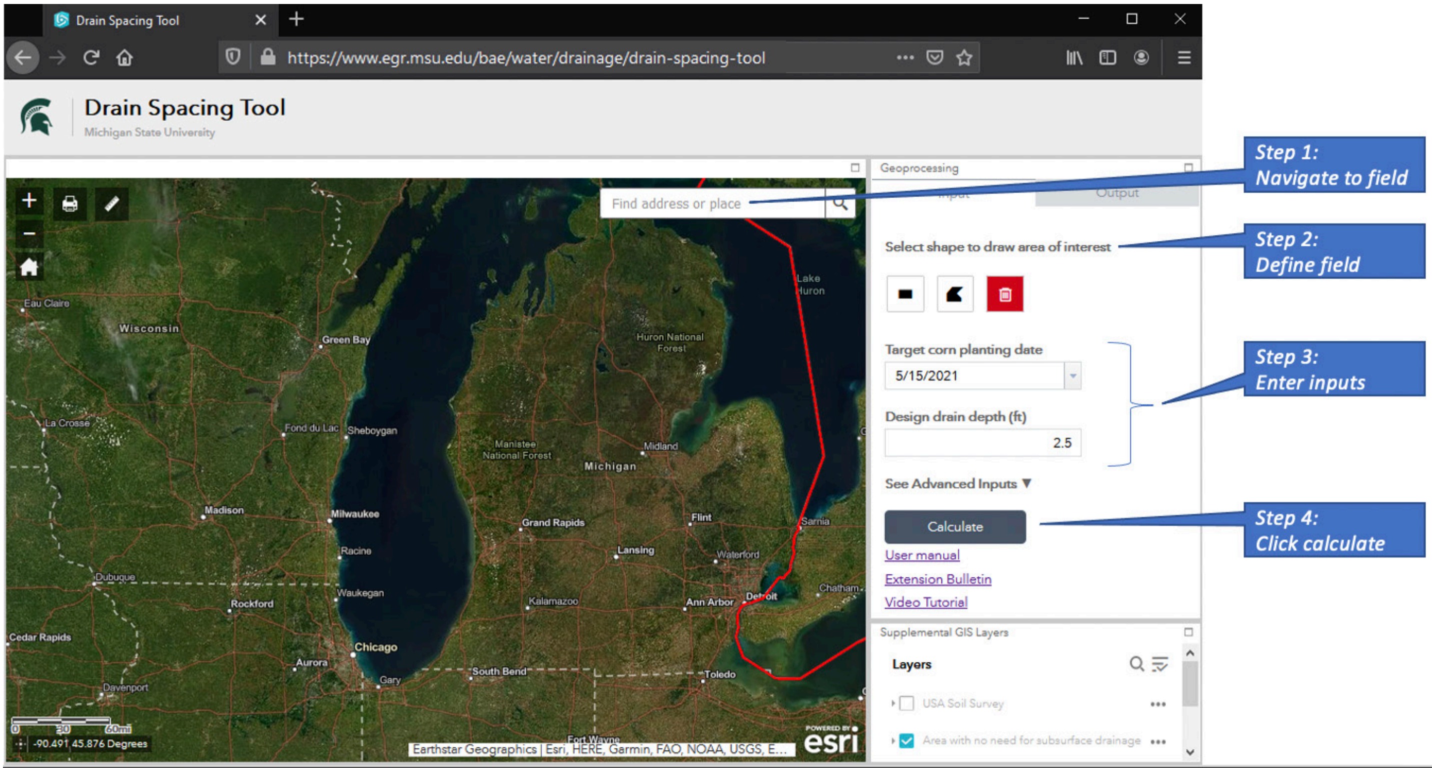

Figure 5- The user interface of the Drain Spacing Tool. Steps are shown for using the basic version of the tool to determine the optimum drain spacing. The user can select "See Advanced Inputs" for tailoring the tool to custom soil and economic conditions.

The tool displays a shaded geographical layer for soils that may not need subsurface drainage based on their soil drainage class (excessively drained, somewhat excessively drained, and well drained) (Figure 6). For soils that fall outside of that shaded layer, there may be a need for subsurface (tile) drainage. For these soils, use the tool to estimate the optimum drain spacing based on local conditions for any rotation of corn and soybean.

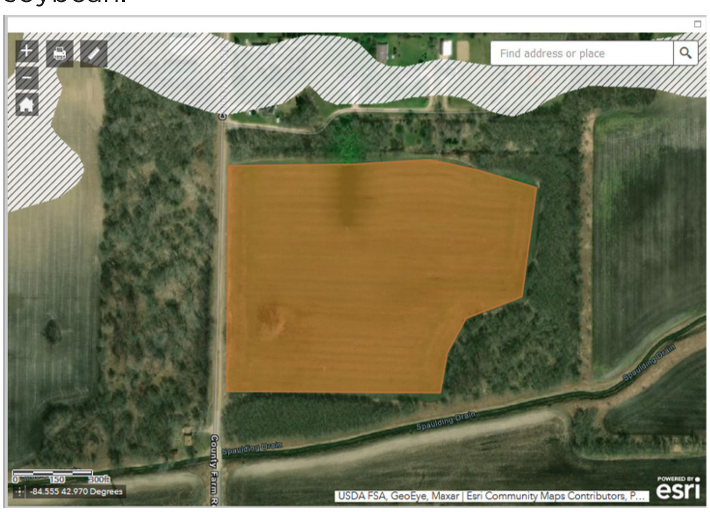

Figure 6- A screenshot of the user interface that shows a polygon drawn around the field of interest. The black and white striped area on the top is an example of the areas that may not need subsurface drainage based on their soil drainage class.

7. Conclusions and recommendations

Avoiding too narrow of a spacing provides a water-quality benefit by reducing nitrate loss. The tool encourages adoption of shallow drains by showing its potential to reduce nitrate load compared to deep drains.

The tool is not intended for coarse-textured soils with saturated hydraulic conductivities greater than about 1 inches per hour. For those soils, the tool overestimates the optimum drain spacing. Check the saturated hydraulic conductivity in the advanced outputs.

The tool relies on NRCS soil data to estimate the optimum drain spacing. For best results, verify the site's soil properties and use the advanced input setting for tailoring the tool to custom soil conditions. Use the tool's estimate of the optimum drain spacing as a guide for drainage design instead of a rigid design criterion. As a guide, choose a drain spacing within about 5 ft of the tool's estimate.

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Expert reviewed

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