OPERATING INSTRUCTIONS FOR THE DRAIN PROGRAM

This drain program is the result of the combined efforts of South Dakota, North Dakota, Minnesota, and Iowa to achieve consistency between the states in the evaluation of scope and effect on wetland hydrology due to lateral effects of subsurface drainage features. The program allows the user to select between four methods in determining the lateral effects to wetland hydrology due to subsurface drainage features. **The user of this program is cautioned that these equations apply to saturated soil conditions only and are not intended for use in the evaluation of duration of ponding, removal of ponding by subsurface movement of water, or surface hydrology. Refer to the Engineering Field Handbook (EFH), Chapter 19, for methods to evaluate subsurface drainage features effects on ponding.**

The computer program has four methods to calculate the lateral effect of subsurface drainage on saturated soil conditions. The methods in the program are the Ellipse equation, Hooghoudt equation, van Schilfgaarde equation, and Skagg semi-infinite medium method. All four equations assume surface water has been removed and does not have to go through the subsurface drainage system.

The Ellipse equation as detailed in the National Engineering Handbook (NEH) 16, Drainage of Agricultural Land, and EFH 19, Hydrology Tools for Wetland Determination is a steady state equation and was developed for determining spacing of parallel drains. The Ellipse equation makes several assumptions: the soil is homogeneous and has an uniform hydraulic conductivity; rain is falling or irrigation water is applied and removed at a constant rate; an impermeable layer underlies the drain at some depth; and the drains are evenly spaced. The Ellipse equation has several limitations. These include: when the depth to the impermeable layer is large the equation is not valid; the equations should not be applied where the vertical hydraulic conductivity exceeds the horizontal hydraulic conductivity or where the soils are not homogenous; and the equation itself does not have a factor for time (assumed time used in the equation is 24 to 48 hours, but parameters used in the equation can be adjusted to account for other duration's).

The Hooghoudt equation is quite similar to the Ellipse except that the hydraulic conductivity is calculated separately for the layers above and below the drainage feature and the depth from the drain to the impermeable barrier is modified to an effective depth with the use of the of the effective radius of the drainage feature. The same assumptions and limitations of the Ellipse equation apply to Hooghoudt's equation.

The **van Schilfgaarde equation is the recommended equation** to use in determining the lateral effects of subsurface drainage features. The van Schilfgaarde equation uses an equivalent hydraulic conductivity for layered soils, a soil specific drainable porosity (percent voids at 60 cm tension), an independent variable for time is used, and the equation is a non-steady state equation. Limitations of van Schilfgaarde's equation are that it does not give reasonable solutions when the drain rests on the impermeable barrier and the equation uses equivalent depth instead of actual depth.

Skagg's semi-infinite medium method is a nonsteady state equation and uses the same assumptions and limitations as van Schilfgaarde's equation. The main limitation is it is only applicable for single drains.

Program Installation

Create a directory on the hard drive where you wish to install the program. Example: D:\DRAINEQ. Copy the PROGRAM.EXE file from the disk into this directory, then type PROGRAM.EXE. This will unzip the program files. Next, copy the state soil database from the diskette to the same directory as the program files. Example of soil database file SD.EXE. In the directory on your hard drive, type the soils database file name (example SD.EXE). This will unzip the database and prepare it for use in the program. **Note: The soils database was developed from the MUUF (Map Unit User File) database and may contain errors or outdated soils information.**

Program Operation

To run the program, get into the directory where the program files are stored (example D:\DRAINEQ) and type DRAIN.EXE. This will load the program files.

Select the soil to be evaluated by pressing the **F5** function key (or if soils information is known it may be directly entered into the appropriate cells). The message <u>Enter Soils Series (Min.2 Letters)</u> will appear. Type in a minimum of the first two letters of the soils name (example: TO). A list of soils will appear on the screen (using the example the first soil will be Tonka). By using the up or down arrow key select the soil to be evaluated. **Note: the soils listed have a Surface Texture, Survey Area, and S.I.R. Number column, make sure these columns identify the proper information for the soil to be evaluated.** After selecting the soil, press enter to return to the program and note that the information for Drainable Porosity, Voids at 60 CM Tension (f) has been filled in.

Next, enter the Drain Height Above Barrier (h3) in feet. This is the height from the barrier to the drain invert. Notice that the Hydraulic Conductivity Below Drain (Kb) has been calculated. **Note: h3 + h4 should equal the total depth from the ground line to the barrier. Also, it is recommended that this overall depth not exceed 10 feet.**

Next, enter the Drain Depth Below Ground line (h4) in feet. This is the depth from the ground surface to the drain invert. Notice that Hydraulic Conductivity Above Drain (Ka) has been calculated.

Next, enter the Final Water Level Height Over the Barrier (h2) in feet and the Initial Water Level Height Over Barrier (h1) also in feet (at wetland boundary). The final water level height over the barrier is typically 12 inches less than the initial water level height over barrier. **Note: The 12-inch difference is the height agreed to during the multi-state meeting and is a reflection of the change to the driving head.**

From the Climatic Factor Zones map select the zone where the wetland lies that corresponds to the table below to identify the days it takes to accumulate 1" of rain in May. Enter the days for the Time For Water Drawdown, h1 to h2, (Days).

Zone 1 - 11 Days	**Zone 5 - 15 Days**
Zone 2 - 12 Days	**Zone 6 - 16 Days**
Zone 3 - 13 Days	**Zone 7 - 17 Days**
Zone 4 - 14 Days	

The Effective Radius of Drain (ft) (Re) is only needed if Hooghoudt's Equation is used to calculate the lateral effect of the subsurface drain. To use this method select the Re from the attached table for the corresponding size of the drain.

Press F4 to perform the calculations. From the screen choose the method of calculation by typing the highlighted letter for the corresponding method. **Note: the preferred method to use is van Schilfgaarde method.**

Other keys available to the program are: F1, for help on input items; F2, allows the user to learn more about the development of the program and disclaimers; and, F3 which allows the printing of the programs output.

Other Program Notes

This program is being released as a "Beta" version and results generated by it should be used with caution. Potential errors may occur as a result of inaccurate soils information within the database or changes in soil map units. Soils information can be directly entered into the program if known.

When using the Ellipse or Hooghoudt equation, if the Initial Water Level Height Over Barrier (h1) is greater than two times the Drain Depth Below Ground line (h4) these equations are not valid and the program will not calculate a value using these methods.

The climatic data map is to be used only for drainage systems located outside of the wetland. To use these equations for evaluation of scope and effect for systems within a wetland, 14 days will be the only time factor used.

The attached hydric soils list should be consulted prior to use of this program. These soils are potentially saturated due to the influence of groundwater. Prior to placement of a drainage system adjacent to these soils a site visit may be required to assure that the drainage system does not cut off a source of groundwater to the wetland.

Also included with the program files is a program for climate simulation (files PROBABLE.EXE and SIMULATE.EXE). This program was added with the thought that this program may be applicable for irrigation scheduling as well as wetland scope and effect determinations.

Effective Radius (Re)

For use with Hooghoudt's Equation

Tile Diameter	Re, inches	Re, feet
4"	0.20	0.0167
5"	0.41	0.034
6"	0.58	0.048
8"	0.96	0.080 (extrapolated)
10"	1.33	0.111 (extrapolated)
12" and larger	1.70	0.142 (extrapolated and limit set)
Ditch, any size	12	1.0 (chosen by practical experience)
Drain tube*	1.177n	1.177n

*surrounded by a gravel envelope with a square cross section of length 2n on each side

Possible Groundwater (Discharge) Hydric Soils

Albaton (IA0120)
Albaton, Depressional (IA0271)
Albaton, Dry (IA0107)
Arlo, Poorly Drained (SD0349)
Arlo, Very Poorly Drained (SD0579)
Arveson (MN0050)
Badus (SD0157)
Baltic (SD0173)
Baltic, Flooded (SD0317)
Bigwinder, High PPT (WY1408)
#*Blake (IA0172)
Borup (MN0051)
Borup, Saline (MN0144)
Calco (IA0075)
Canisteo (MN0059)
Castlewood (SD0478)
*Chaska, Channeled (MN0768)
*Clamo, Frequently Flooded (SD0313)
*Clamo, Gravelly Substratum (SD0327)
*Clamo, Loamy Substratum (SD0389)
*Clamo, Poorly Drained (SD0542)
Colo (IA0071)
Colvin (ND0002)
Colvin, Overblown, Saline (ND0348)
Colvin, Saline (ND0181)
Colvin, Wet (ND0001)
Dogiecreek (SD0430)
Durrstein (SD0024)
Egas (SD0026)
Egas, Poorly Drained (SD0590)
Elpam (SD0239)
Fedora (SD0028)
Flom (MN0069)
Forney (IA0121)
Fossum (MN0102)
Fossum, Gravelly Substratum (MN0644)
Fossum, Ponded (MN0424)
Gannett (NE0035)
Glenross (SD0014)
Harps, Moderately Coarse Substratum (IA0157)
Harriet (ND0064)
Hegne (MN0053)
Herdcamp (SD0489)
Hidewood (MN0013)
Higgins (SD0192)
Holmquist (SD0492)
James (SD0125)
James, Very Poorly Drained (SD0486)
Lallie (ND0053)
Lallie, Saline (ND0196)
*Lamo, Wet (NE0140)
*Lamoure (SD0176)
*Lamoure, Saline (SD0419)
*Lawet (NE0052)
Loup (NE0058)
Lowe (SD0455)
Ludden (ND0032)
Ludden, Ponded (ND0333)
Ludden, Saline (ND0301)
Ludden, Wet (ND0447)
Luton (IA0127)
*Marshbrook (SD0315)
Marysland (MN0103)
Marysland, Flooded (MN0588)
Minnewaukan, Flooded (ND0144)
Minnewaukan, Nonflooded (ND0167)
Norway (SD0547)
Norway, Frequently Flooded (SD0548)
Oldham (SD0174)
Oldham, Wet (SD0563)
Orwet (NE0073)
Owego (IA0122)
Owego, Calcareous, Overwash (IA0290)
Playmoor (SD0170)
Rauville (SD0177)
Rauville, Ponded (SD0437)
Rauville, Ponded (SD0598)
Regan (ND0125)
Ryan (ND0077)
Sage (SD0345)
*Salmo (SD0042)
#*Sarpy, Frequently Flooded (MO0118)
Southam (ND0248)
Stirum (ND0149)
Stirum, Ponded (ND0232)
Trosky (MN0185)
Vallers (MN0055)
Vallers, Saline (MN0147)
Whitewood (SD0045)
*Whitewood, Nonflooded (SD0392)

Some phases of this soil are not frequently flooded for long duration
* Some soil Interpretation records representing phases of this series are not hydric