650.1900 Introduction

The tools contained in Engineering Field Handbook (EFH), Chapter 19, have been reviewed for use in North Dakota. The applicable situations for use of each tool are described in this North Dakota Supplement to EFH, Chapter19.

650.1901 Use of stream and lake gages

A computer program for applying this tool is available through the engineers in the North Dakota State Office of NRCS. However, few rivers in North Dakota have the type of floodplain where this tool will be helpful. Contact the State Conservation Engineer for further information and/or assistance.

650.1902 Runoff volumes

Contact the State Conservation Engineer for further information and/or assistance.

650.1903 Supplemental data for remote sensing

This tool is extensively used in North Dakota in conjunction with the North Dakota mapping conventions. For the years that the slides are available in a given county, climatic data is entered into a computer program which computes wet, dry, and normal years for use with the procedure described in Part 650.1903. All the slides are examined for possible wet signatures. The slides of "normal" years, as determined by the evaluation procedure described in Part 650.1903, are examined and the number of normal years with wet signatures is determined as a percentage of the total number of normal years. National Oceanic and Atmospheric Administration (NOAA) weather stations are used since information is available for those sites on the internet (www.wcc.nrcs.usda.gov) and they have a long term record where precipitation and temperature information are also available. An individual evaluation may use a local cooperating rainfall gage operator's record, and compare it to the NOAA record if circumstances indicate that the meteorological distribution of rainfall would not accurately be captured by the NOAA station's record. This should be considered supplemental, and the NOAA station information should be included in the case file.

Further information on this procedure with an example is given in the student notebook for the National Employee Development Center (NEDC) course "Hydrology Tools for Wetland Determination".

650.1904 DRAINMOD

Contact the State Conservation Engineer for assistance with DRAINMOD.

650.1905 Scope and Effect Equations

(a) Encirclement

Every site evaluated should be considered for possible encirclement, or cutting off the water supply to a wetland that keeps it wet. Encirclement is accomplished by interrupting the flow of surface or subsurface water that is significant to the water budget of the wetland. A tile line or ditch can act as an underground diversion, or surface intakes or a ditch can intercept surface water and keep it from reaching the wetland. A tile placed adjacent to a wetland across the portion of the landscape that allows groundwater to reach the wetland to keep it wet is acting as an underground diversion. This often has enough impact to remove or noticeably impact a wetland. In cases where a subsurface drainage system may act as an underground diversion, the distance to keep drainage systems back from a wetland is three times the usual lateral effect distance in the direction(s) where the groundwater is expected to travel toward the wetland. Increasing the distance to three times the usual lateral effect distance will help to minimize the impact of the drain on the groundwater; however, surface water may also be a consideration.

(b) Instructions for using the ND_DRAIN_NASIS computer program to calculate lateral effect

The ND_DRAIN_NASIS computer program was developed by Terry Carlson (retired), Assistant State Conservation Engineer in Bismarck, North Dakota, with assistance from Sonia Jacobsen, Hydraulic Engineer in St. Paul, MN; Roy Boschee, Wetland Team Hydrologist in Rapid City, South Dakota; and Laurel Foreman, Hydraulic Engineer in Des Moines, Iowa. The current version is dated May 2004.

This program will calculate lateral effect using four different methods: 1) ellipse, 2) Hooghoudt, 3) van Schilfgaarde, and 4) Skaggs' drain in a semi-infinite medium. The help screens associated with the program explain a little more about each of the four methods. The program is to be used with provided files of soils information and drainable porosities. Layer thicknesses of a given soil may vary from county to county and all these options are in the soils database associated with the program. Lateral effect is determined in the soil in which the drainage system is installed.

Three different scenarios may require use of lateral effect computations. Note the three situations in Figures 1, 2, and 3 in Exhibit 1. In the instructions which follow, some differences are given for input parameters depending on the circumstances involved. For computing distances to stay away from wetlands with new tile (Figure 3), a variable time factor is used. This variable accounts for climatic differences that can affect the lateral effect distance. For instance, western North Dakota will have larger setbacks than eastern North Dakota due to the drier climate and less chance of replenishing rainfall. See Exhibit 2 for the map of the time factors to use in the van Schilfgaarde equation.

<u>Instructions:</u>

1. The **van Schilfgaarde** method is to be used in North Dakota as agreed to by hydrologists from the states of North Dakota, South Dakota, Minnesota, and Iowa. The other equations are to be used in special cases as directed by the State Conservation Engineer.

2. If a map unit contains more than one named soil component, the component which results in the larger lateral effect is to be used as the representative soil. Therefore, each named soil component in the map unit shall be analyzed and the larger lateral effect shall be selected for that map unit. In developing the soils data base, no more than two named soils components were included in the map unit.

   The same rationale is applied if more than one map unit exists between the drain and the wetland. Each named soil component of each map unit shall be analyzed and the largest lateral effect shall be used.

3. If a soil is not listed in the computer program's database, options are available, listed here in order of the soil scientists' preference for their use. The first is the preferred option.
   a. Calculate the hydraulic conductivity, K, from the soil permeability data manually, or using one of the spreadsheets for this purpose. Use the drainable porosity for a similar soil. Proceed with calculations, noting what was done.
   b. Find a similar soil and use its permeability and drainable porosity information in DRAIN.
   c. Use the lateral effect distances calculated for a similar soil. This should be done in consultation with a soil scientist as the drainage features of a soil are what make it similar for this application, not texture alone.

4. If variations in soil properties cause wide variations in lateral effects for a given soil from county to county, work with

the soil scientists in the area to determine a set of "composite" soil properties for that soil. Then use this composite soil to calculate lateral effect. Wide variations should not occur on either state or county lines. Round all values of lateral effect within reason.

5. Use the number of days as whole integers in the van Schilfgaarde equation. The lateral effect distances may be rounded to provide more uniform values of lateral effect. As an example, one particular soil at a 4' depth produces Le=145 feet for T=12 days and Le = 152 feet for T=13 days. Both of these values could be rounded to 150 feet and thus would appear as the same value in two counties that may have different number of days to be used.

Input parameters for the van Schilfgaarde Equation:

Drainable Porosity, voids at 60 cm tension: This parameter is used to describe the fraction of the soil volume, water that can be removed by a subsurface drain. This is expressed as a dimensionless value. If a soil is chosen from the data list in the program, the drainable porosity will be entered by the program. It may be entered manually as well. The ND_DRAIN_NASIS program is accompanied by soils files that include the drainable porosity values.

Hydraulic Conductivity, K (above and below the drain in inches per hour): Hydraulic conductivity is reasonably approximated by use of permeability information. If a soil is chosen from the list offered by the program, the hydraulic conductivity will be calculated by the program after the various depth information parameters are entered. For each site, soils information will be obtained from field investigations and published soil surveys. The ND_DRAIN_NASIS program uses soils data which is quite specific for each soil in exact locations within each state. Consultation with a soil scientist is encouraged to be certain that the correct soil is chosen from the list. See Exhibit 3 for the county codes used in ND_DRAIN_NASIS when selecting soils information. The soils vary, especially in layer thickness, from one location to another. The permeabilities are given as a range for each soil, and the ND_DRAIN_NASIS program uses an average of the range given. Below the lowest depth given in the soils data, the drainage class is lowered by one to account for compaction from the soil above, less root channels, less weathering, and reduced earthworm activity. Again, an average value for the range given in the soils database will be used. This will have units of inches per hour in the soils database but is converted to feet per day for use with computations. ND_DRAIN_NASIS makes this conversion.

NOTE: The following sections discuss the variables h1, h2, h3, and h4. All of these values are measured from the hydric soil boundary line of the wetland in question.

Initial Water Level Height Over Barrier, h1 (ft): This is also known as the depth to the impermeable layer. This depth is needed to identify a "bottom" to the calculations, a point where the flow lines are turned horizontally and do not continue vertically. A soil layer that has a permeability of 1/10th or less of the soil layer above it can be considered relatively impermeable for this purpose. Use a depth of 10 feet if the impermeable layer has not been encountered above that point. At this point the compaction of the soil due to the weight of 10 feet of soil above it is reducing the permeability sufficiently to justify this depth. If the impermeable layer occurs above 10 feet, use that depth. Use units of feet. Physiographic regions within the state have water tables at depths less than 10 feet which may act as barriers. The soil is assumed to be saturated to the surface when time = zero.

Final Water Level Height over Barrier, h2 (ft): After a period of time has elapsed, such as 14 days for the situations in Figures 1 and 2, the water table is assumed to be at a known point below the ground surface. By the hydrology criteria in the NFSAM for Figures 1 and 2, and by agreement for the situation in Figure 3, this is 1 foot for non-sandy soils. Thus the value entered in this line is the depth to the impermeable layer minus the 1 foot. In sandy soils in the situations described in Figures 1 and 2, this value is only 0.5 foot. Note that these water table depths, 6” or 12”, are as described in the National Food Security Act Manual (NFSAM) for hydrology, not soils.

Drain Height above the Barrier, h3 (ft): Measuring from the point chosen as the impermeable layer, determine the distance from the impermeable layer to the bottom of the drain. This will often be 10 feet minus the drain depth described below. The depth where an impermeable layer is said to exist is widely understood to be where the permeability of a soil is 10% or less of the soil layer above it. If this is not encountered at a depth shallower than 10 feet, it is assumed to exist at 10 feet because of the weight of the soil column in the top 10 feet, the lack of root channels, and lack of earthworm activity, all of which reduce permeability. If a water table exists that acts as a barrier, h3 is typically set at 0.1 feet.

Drain Depth below Groundline, h4 (ft): This is the depth from the average soil surface to the flow line of the tile, usually averaged for a single line

Effective Radius of Tile, Re (ft): A tile’s effective radius (re) is considerably smaller than the actual drain tube radius. This is due to the resistance to inflow due to a finite number of openings that allow water to enter the tile in an otherwise impervious wall. This parameter describes the proportion of the tile that actually allows water to enter the subsurface drainage system. In plastic drainage tubing, re is the approximate diameter of a tile which would be composed only of the holes cut into the plastic drainage tubing by which water enters the tile. For clay or concrete tile, this is an approximate diameter of a tile if it were somehow composed only of the cracks between the sections of tile where water enters the drainage system. A value of 12 inches is recommended for open drainage ditches. Compared to typical tile values (0.4-1.0 inch), this may seem large, yet it changes the lateral effect minimally.

The effective radius is to be determined from the table below which is derived from the DRAINMOD reference manual.

Table 2. Effective Radius of Drainage Tile

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

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

or a tile system. If field logs show the depth to the top of the tile, the thickness of the tile wall and the inside diameter of the tile will be added to the depth to obtain the flow line depth. This is given in units of feet. The drainage system may be clay, concrete, plastic tubing, or an open ditch. In an open ditch, this depth is measured to the typical free water surface, which may not be the ditch bottom.

Time to Remove Saturation, T (days): For the situations described in Figures 1 and 2, Exhibit 1, this is the 14 days as mandated in the NFSAM, Third Edition, which is effective at the time of this writing. For the situation in Figure 3, Exhibit

1, the user is to read the time in days (whole days - no fractions) from the map provided in Exhibit 2. For the situation in Figure 3, Exhibit 1, this is related to the water budget of the wetland and adjacent upland, and the local rainfall and evaporation patterns. The plant water use affects this too. This is the time period, on a long-term average, over which sufficient rainfall falls at a given geographic location to "recharge" the soil column above the tile. The tile must then again remove the free water from the soil immediately above it.

Surface Roughness: This parameter describes the small amount of moisture that may be held on the surface of the soil by the particles (not any depressional topography) and will need to move through the soil column rather than running off, being evaporated, or used by a plant. This must be small, since the drainage equations are not set up to handle ponded water (except Kirkham's equation). A value of 0.1 inch is used in North Dakota. This is consistent with a description on page 2-11 of the DRAINMOD reference manual for a surface that has been smoothed by weathering (wind and water in the Midwest). The user does not need to enter this value, it is built into the program.

References:

Natural Resources Conservation Service, Fort Worth, TX, Student Notebook for NEDC class, "Hydrology Tools for Wetland Determination"

Jacobsen, Sonia M. M. and R. Wayne Skaggs, "Lateral Effect: What's Known and Unknown", American Society of Agricultural Engineers (ASAE) paper 972034, 1997, 9 pages.

(c) Multiple soils

See Exhibit 3, Example Problem for Calculating Lateral Effect in Multiple Soils.

61650.1906 NRCS drainage guides

The North Dakota Drainage Guide does not contain information specific to the impact of drainage on wetlands. It was developed for optimal drainage of cropland. The basic information on how drainage works applies to both situations.

650.1907 Observation wells

Little data exists for observation wells in North Dakota. The "Reference Wetland Simulation" procedure developed by Dr. R. Wayne Skaggs has been used with a short observation well record. Contact the State Conservation Engineer for information. Information is also available on how to install monitoring wells.

Exhibit 1. Possible Situations To Determine Lateral Effect

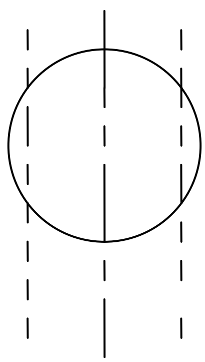


Figure 1. Single tile line or ditch passes through wetland and is unlikely to affect the hydrology of the entire basin in a normal 14 days.

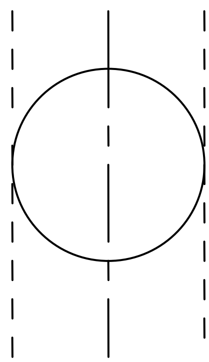


Figure 2. Single tile or ditch passes through wetland where it may affect the hydrology of the entire site within 14 days.

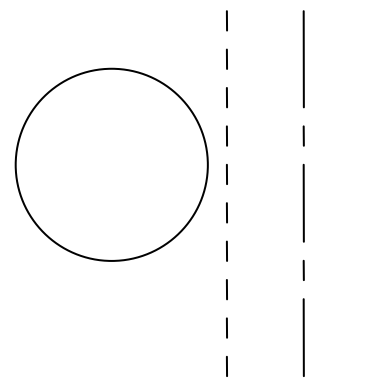
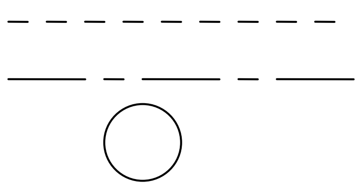


Figure 3. Tile or ditch will be installed adjacent to the wetland but want to avoid impacting the hydrology of the wetland within the time from Exhibit 2.

Legend:



Extent of lateral effect of drain

Centerline of drain (tile or ditch)

Wetland Boundary

Exhibit 2. Map for Determining Time Factor in van Schilfgaarde Equation

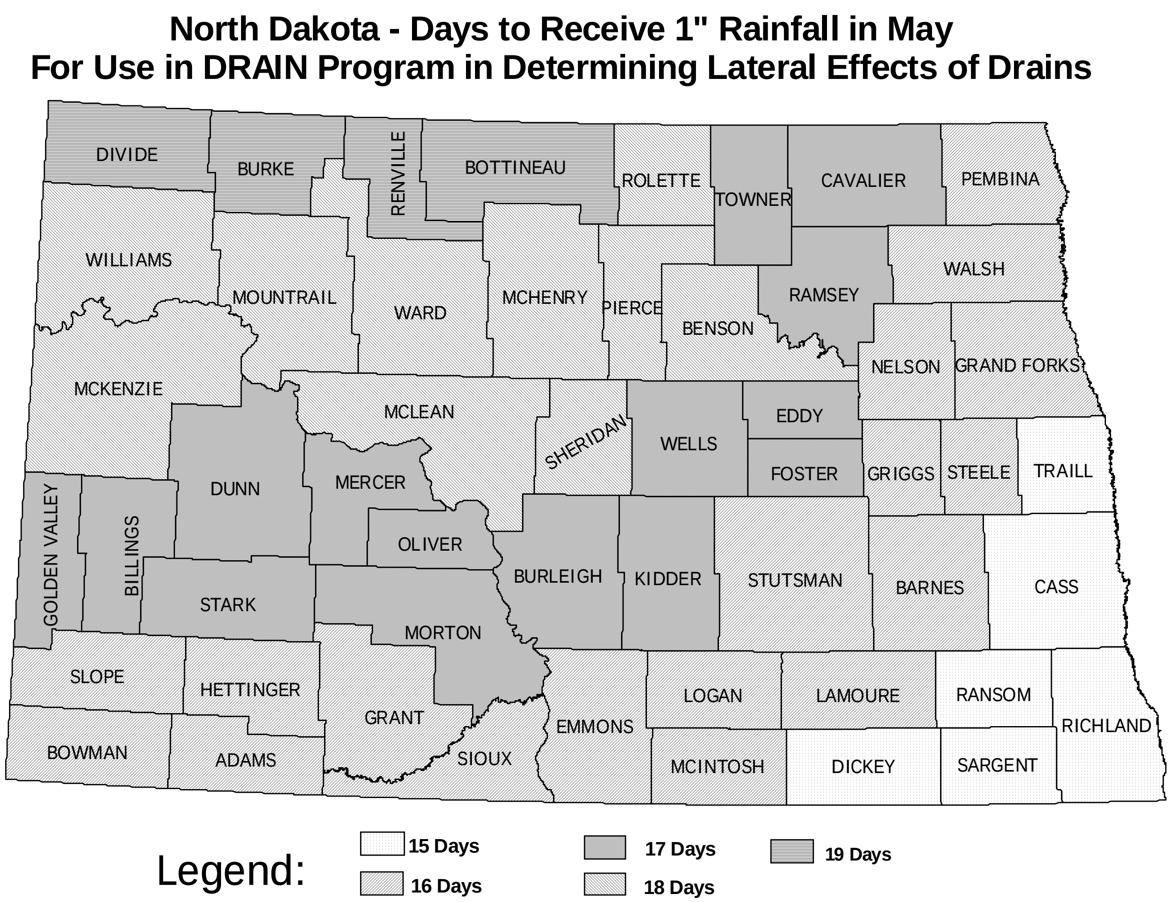


Exhibit 3. Example Problem for Calculating Lateral Effect in Multiple Soils

Question: A delineation of Hamerly-Tonka soils in Ransom County contains a small wetland that meets wetland criteria. The wetland is in the center of the map unit approximately 35 feet from the edge of the delineation. The remainder of the map unit does not meet wetland criteria. The adjoining delineation is Barnes-Svea (map unit 154), where 6” plastic drainage tubing will be installed 4’ deep measured from the hydric soil boundary line. The effective boundary layer can be assumed to be at a depth of 10 feet below the hydric soil boundary line. What is the lateral effect distance to stay away from the wetland boundary?

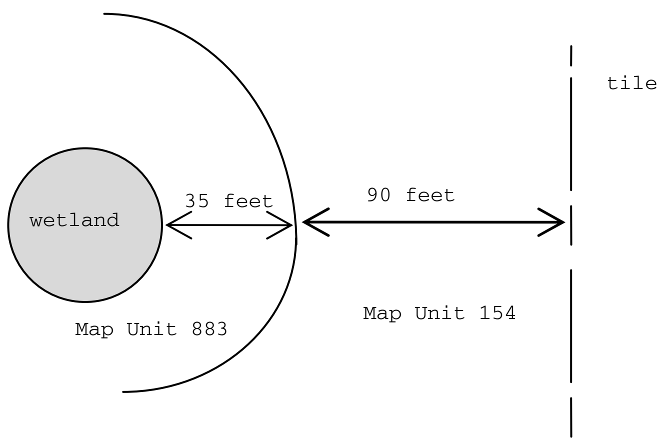
Answer: For Ransom County, t = 15 days from Figure 1. Using the ND_DRAIN_NASIS computer program, the lateral effect for a 6” drainage tubing installed 4’ deep is calculated for Map Units 883 (Hamerly-Tonka) and 154 (Barnes-Svea).

Le = 97 feet in Hamerly soil (round to 100 feet)
Le = 130 feet in Tonka soil
Le = 103 feet in Barnes soil (round to 100 feet)
Le = 120 feet in Svea soil

For Map Unit 883 (Hamerly-Tonka), use 130 feet as the lateral effect distance.
For Map Unit 154 (Barnes-Svea), use 120 feet as the lateral effect distance.

If the two lateral effect distances are within 10% of each other, as these are, an average can be used without further computations. However, if the soils’ lateral effect distances differ by more than 10%, the lateral effect is determined by pro-rating the “drawing power” of the tile.

For this example, use (130 + 120)/2 = 125 feet as lateral effect distance.



Example: If the difference in the two distances had been greater than 10%, say 130 feet in Map Unit 883 and 100 feet in Map Unit 154:

Distance in soil for Map Unit 883 = 35 feet = 27% of the “drawing power” of the tile is used in that map unit with a lateral effect 130 feet : 35/130*100 = 27%

100% - 27% = 73% of the "drawing power" of the tile is to be in Map Unit 154.

$$0.73 = \frac{\text{Distance in soil}}{\text{Lateral Effect}} = \frac{x}{100 \text{ feet}} \qquad x = 73 \text{ feet}$$

The drainage tile needs to be a total of **108 feet** (round to 110 feet) from the wetland boundary (35 feet in Map Unit 883 plus 73 feet in Map Unit 154).