HOMEWORK 2 - TRAFFICABILITY

Executive Summary

A building and associated parking lots are to be constructed on a poorly drained, Rains soil on a site in Aurora, North Carolina. The contractor for this project needs 30 working days of suitable conditions in order to complete his work. For this site, suitable conditions are present when the water table is at least 1.0 meter below the soil surface at all locations in the project area. Simulations were completed using Drainmod over the period 1976 to 2005. The goal of the simulations was to determine the appropriate drain tube spacing(*s*) and depth(*s*) to ensure suitable conditions would exist on the site during 90% of the years evaluated (*i.e. 10 year return interval*). Four drain tube depths were evaluated and detailed results of all evaluations are presented in Table 3 of this report. The evaluations indicated that maximum allowable spacings for drain tube depths of 120, 150 and 180 cm are 1050, 1650 and 1950 cm, respectively. A shallower drain tube depth of 90 cm was evaluated; however, evaluation results indicated that this depth was inadequate to achieve suitable conditions at any spacing.

Problem Statement

Drainage is needed to enable construction of a building and associated parking lots on a poorly drained site in Aurora, North Carolina.

Latitude = 3539

HI = 76

The soil is Rains sandy loam. The restrictive layer is 7 ft (*210 cm*) below the surface and the hydraulic conductivity is given below (*Table 1*).

Table 1. Soil lateral hydraulic conductivity data

Depth (cm)	*Lateral Hydraulic Conductivity (cm/hr)*
0-30	8
30-210	1
>210	0

A drainage canal (8 ft deep; 240 cm) is adjacent to the site and can be used as an outlet for subsurface drains. Surface drainage is relatively good with depression storage of 1.5 cm (max value). Construction work can be done if the water table is 1 m deep or deeper. This corresponds to a drained water-free pore space of 6.9 cm under drained to equilibrium conditions. Rainfall greater than 1.9 cm will delay construction for two days.

Methods

Rains soil data and Aurora weather data were used for this evaluation. Detailed soil and weather data utilized in this evaluation are included in Appendix 1 and 2. Other Drainmod input data used for this evaluation are included in Table 2.

Table 2. Drainmod input parameters for trafficability project.

Drainage system	Conventional
Soil profile depth	210 cm
Surface storage	1.5 cm max, 0.75 cm Kirkham
Effective drain radius	2.0 cm
Drainage coefficient	2.5 cm/day
Rainfall effect of workage	1.9 cm or more delays work for 2 days
Drained pore space for trafficability	6.9 cm
Weather data period	1976-2005, Aurora location
Hydraulic Conductivity	0-30 cm : 8 cm/hr
	30-210 cm : 1 cm/hr
	>210 cm : 0

Once all applicable data was entered into Drainmod, the system design page was used to systematically evaluate drain tube depth from 90 cm to 180 cm, in 30 cm increments, while drain tube spacing was evaluated from a minimum spacing of 2 m to a maximum of 30 m, using increments of 2 m. All depths were evaluated for all spacings. 10YRI (*10*

year recurrence interval) working days and average working days for each scenario are presented in Table 3. This data was used to create plots (*Figures 1 and 2*) for each drain depth scenario and to help determine the maximum drain tube spacing allowable for each depth, while maintaining suitable conditions with a 10YRI.

Once the initial evaluation data was evaluated to determine the approximate maximum drain tube spacing for each depth, the system design page was once again utilized to accurately determine the absolute maximum spacing allowable, to within 0.25 m. To complete this determination, the author selected the maximum drain tube spacing that created suitable conditions on the site, per drain tube depth evaluated, and then evaluated the effect of a drain tube spacing 1 m greater. If the resultant 10YRI working days were less than 30, the author subsequently decreased the drain tube spacing by 0.5 m, then evaluated the results. Conversely, if the 10YRI working days were greater than 30, the author subsequently increased the drain tube spacing by 0.5m, then evaluated the results. Lastly, the author increased or decreased the drain tube spacing in 0.25 m increments according to the same process until the appropriate maximum drain tube spacing was determined, to within 0.25 m.

Results

Drainmod evaluation results indicated that no effective drain tube spacing is available for an associated depth of 90 cm. Maximum drain tube spacings for associated depths of 120, 150 and 180 cm are 10.5, 16.5 and 19.5 m, respectively. Evaluation results indicate that any drain spacing less than or equal to the maximum listed above will create suitable conditions on this site with a 10YRI (*Table 3, Figures 1 and 2*).

Table 3. Working days allowed by evaluated drain tube depths and spacings

	Drain Tube Depth (*cm*) and Working Days							
	90		120		150		180	
Spacing (c*m*)	10YRI	Ave.	10YRI	Ave.	10YRI	Ave.	10YRI	Ave.
200	0.0	3.3	48.8	51.9	48.8	51.9	48.8	51.9
400	0.0	1.8	48.7	51.7	48.8	51.9	48.8	51.9
600	0.0	1.3	47.5	51.1	48.8	51.9	48.8	51.9
800	0.0	0.9	43.8	48.9	48.8	51.8	48.8	51.9
1000	0.0	0.6	34.9	43.8	48.6	51.7	48.8	51.9
1200	0.0	0.6	21.2	37.4	47.1	51.1	48.8	51.8
1400	0.0	0.5	11.8	30.0	43.4	48.9	47.4	51.5
1600	0.0	0.3	5.6	23.4	34.1	45.1	46.8	50.1
1800	0.0	0.2	0.3	17.5	20.8	39.4	39.3	47.8
2000	0.0	0.2	0.0	12.2	10.1	32.5	26.7	43.9
2200	0.0	0.1	0.0	8.1	3.2	26.3	12.8	37.8
2400	0.0	0.1	0.0	4.8	0.0	20.5	5.0	30.8
2600	0.0	0.1	0.0	2.5	0.0	16.0	0.2	25.1
2800	0.0	0.1	0.0	1.3	0.0	11.9	0.0	20.0
3000	0.0	0.1	0.0	0.6	0.0	7.5	0.0	15.9

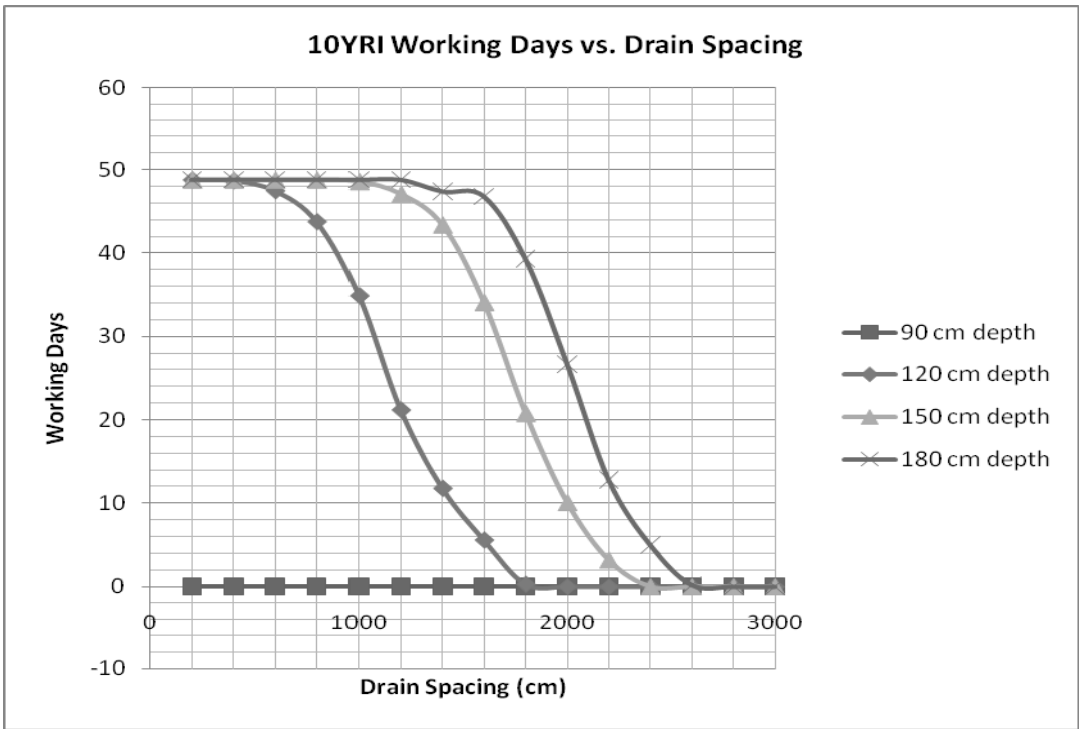

Figure 1. 10YRI working days versus drain tube spacing and depth

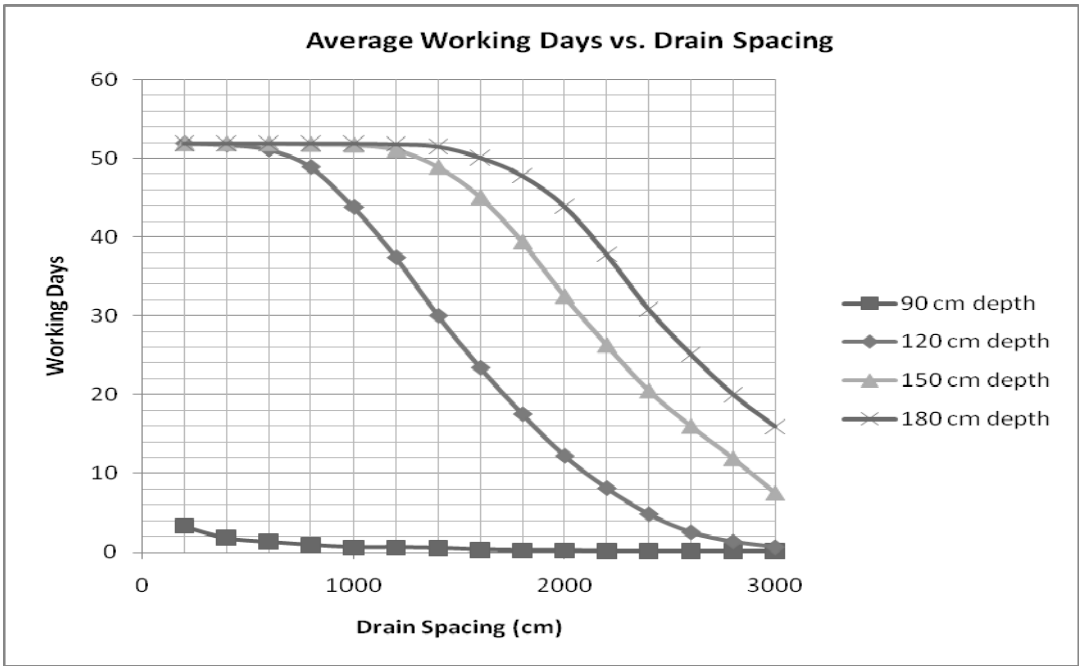

Figure 2. Average working days versus drain tube spacing and depth

Discussion

Drain tube depths and spacings evaluated for this project clearly illustrate that increased drain tube installation depth will allow a corresponding increase in drain tube spacing for this particular soil, and within the depth parameters evaluated. This relationship is due to the increased hydraulic head created by increasing drain tube depth in relation to the minimum water table depth allowable for suitable conditions on this site. Increases in drain tube depth or decreases in drain tube spacing will act to increase the hydraulic head in the system, thereby increasing the drainage capability of the drain tube system. These relationships are true for all scenarios evaluated except for a drain tube depth of 90 cm. Since this drain tube depth is less than the required water table depth for suitable conditions and the ET demand is low during February and March, it is essentially useless for meeting the drainage needs for this project.

Conclusions

Based on the lecture in module 4, the author is assuming that drain tube installation depth will not affect installation cost. If this cost assumption holds true for this particular project, it is clear that a drain tube installation at a depth of 180 cm (*6 ft*) and a spacing of 1950 cm will provide the required drainage at the lowest cost. Another assumption required for this statement is that a drain tube depth greater than 180 cm would be inappropriate due to installation costs, high water levels in receiving canal, or some other reason. If drain tube depths in the range of 120 cm to 180 cm were found to be important in installation cost calculation, these conclusions would have to be revised accordingly. Regardless of cost, drain tube installations with depths much less than 120 cm will not

adequately drain this site for the intended use.

Appendices

APPENDIX 1: DRAINMOD INPUT FILES

```
                                                                DHPTRF.GEN
*** Job Title ***
CONVENTIONAL DRAINAGE, NO YIELD, RAINS SOIL
AURORA, NORTH CAROLINA WEATHER DATA
*** Printout and Input Control ***
 3 100 C:\Drainmod\outputs

*** Climate ***
310375 C:\Drainmod\weather\aurora19732005.RAI

310375 C:\Drainmod\weather\aurora19732005.TEM

1976  1 2005 12 3539  76 0
 2.01 2.32 2.10 1.72 1.23 1.00  .86  .82  .92 1.05 1.22 1.44
*** Drainage System Design ***
 1
    180.00      28.52   1950.00       1.50       2.50       0.70      12.68      50.00
            0    0.000000E+00    0.000000E+00
            0    0.000000E+00    0.000000E+00    0.000000E+00
            0    0.000000E+00    0.000000E+00    0.000000E+00    0.000000E+00
    200.00        .50       .00
 1120 1120 1120 1120 1120 1120 1120 1120 1120 1120 1120 1120
*** Soils ***
    210.00       2.00
  30. 8.00210.0 1.00 0.00 0.00   0.  .00   0.  .00
99      .00
*** Trafficability ***
 2 1 331 817                6.90       1.90       2.0
12321232 820                 3.9        1.2       2.0
*** Crop ***
      .170
 410 818        30.00
 410 818
11
 1 1  3.00 416  3.00 5 4  4.00 517 15.00 6 1 25.00 620 30.00 718 30.00 820 20.00
 924 10.00 925  3.001231  3.00
*** Wastewater Irrigation ***
 0    1 1  10   1  6
 0 0       0 0       0 0       0 0
   7.00000   1.00000  .40  .40  .40  .40  .40  .40  .40  .40  .40  .40  .40  .40
WET *** Wetlands Information ***
 0
   1 365
 30.0  14
COM *** Combo Drainage Weir Settings ***
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
 0  0  0    .0
FPE *** Fixed Monthly PET ***
   1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00
MRA *** Monthly Ranking ***
 0
FAC *** Daily PET Factors ***
 0
OVR *** Contributing Area Flow ***
 0        .000

STM *** Soil Temperature ***
      ZA      ZB     TKA     TKB      TB    TLAG   TSNOW   TMELT    CDEG    CICE
   0.000   0.000    .000   0.000     0.0     0.0      .0     0.0     0.0      .0
Initial Soil Temperature
 1
    .0    0.00
Initial snow depth(m) & density(kg/m3)
      .00    100.00
Freezing characteristic curve
 1
    .0     .000
                                                                Page 1
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APPENDIX 2: DRAINMOD RANK FILES

DHPTRF.RNK

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-----------------------------------------------------
*              DRAINMOD version 5.1                 *
* Copyright 1980-04 North Carolina State University *
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CONVENTIONAL DRAINAGE, NO YIELD, RAINS SOIL
AURORA, NORTH CAROLINA WEATHER DATA
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----------RUN STATISTICS ---------- time: 2/ 1/2010 @ 16:44
input file: C:\Personal\NCSU Grad School\Drainmod\Module 4\H
parameters: free drainage and yields not calculated
drain spacing = 1950. cm drain depth = 180.0 cm

RANK	WORK DAYS	YEAR	SEW	YEAR	DRY DAYS	YEAR	IRRIG.	YEAR
1	59.0	1981	232.1	1984	93.0	1980	0.00	1976
2	57.9	1992	24.5	1976	85.0	2002	0.00	1977
3	57.1	1976	5.1	2003	69.0	1985	0.00	1978
4	56.0	1999	2.8	1981	68.0	1999	0.00	1979
5	55.4	1988	0.7	2005	67.0	1987	0.00	1980
6	55.2	1980	0.3	1978	66.0	1991	0.00	1981
7	55.0	1990	0.0	1977	65.0	1977	0.00	1982
8	53.6	2001	0.0	1979	65.0	1994	0.00	1983
9	52.2	1997	0.0	1980	64.0	1986	0.00	1984
10	51.0	1986	0.0	1982	63.0	1992	0.00	1985
11	50.6	1991	0.0	1983	63.0	2004	0.00	1986
12	50.0	2002	0.0	1985	52.0	1995	0.00	1987
13	49.9	2003	0.0	1986	52.0	2001	0.00	1988
14	49.2	2005	0.0	1987	48.0	1988	0.00	1989
15	49.1	2004	0.0	1988	47.0	1997	0.00	1990
16	48.4	1993	0.0	1989	44.0	1990	0.00	1991
17	47.4	1977	0.0	1990	42.0	1976	0.00	1992
18	47.0	1989	0.0	1991	42.0	1982	0.00	1993
19	46.2	1984	0.0	1992	41.0	1996	0.00	1994
20	44.0	1996	0.0	1993	39.0	1993	0.00	1995
21	42.7	1987	0.0	1994	38.0	2000	0.00	1996
22	42.5	2000	0.0	1995	37.0	1981	0.00	1997
23	39.8	1978	0.0	1996	37.0	1984	0.00	1998
24	39.7	1985	0.0	1997	37.0	2005	0.00	1999
25	31.8	1994	0.0	1998	36.0	1989	0.00	2000
26	31.1	1995	0.0	1999	34.0	1983	0.00	2001
27	30.7	1982	0.0	2000	29.0	1979	0.00	2002
28	28.7	1979	0.0	2001	20.0	1978	0.00	2003
29	22.0	1998	0.0	2002	18.0	2003	0.00	2004
30	10.0	1983	0.0	2004	17.0	1998	0.00	2005
AVERAGE	45.1		8.8		49.3		0.00	

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