Appendix 4a: Low Floor Elevation Guidance.

Overview of Lowest Floor Issue

There seems to be two reasons for establishing a minimum lowest floor elevation in the vicinity of a pond – to prevent flooding of the structure by surface water and to prevent seepage or damage from uplift pressures that could result from a rise in the water table elevation. The first reason (direct flooding) can easily be established with knowledge of the maximum flood elevation of a pond (or the 100-year elevation, if this is used) and ground surface topography. The second reason (a rise in the water table due to increased pond elevations) is not so straight forward. This second area is the subject of this memo.

When a formerly dry pond becomes wet (or when a wet pond's water elevation increases) due to a storm event, downward seepage of the ponded water begins. The rate of seepage through the bottom of the pond is dependent upon:

1) The elevation of the water surface above the pond bottom
2) The soil type at the bottom of the pond (i.e. the pond bottom's thickness and permeability)
3) The type of soil underneath the pond (e.g., clay, silt, sand, gravel)
4) The degree of saturation of the soils beneath the pond
5) The depth to the water table

In general, higher seepage through the bottom of the pond will occur when the water surface elevation is high, the pond's bottom sediments are thin and/or sandy, the soils underneath the pond are permeable (such as sand or gravel), the soils underneath the pond have a high moisture content (i.e, they are at field capacity or higher), and the water table is well below the bottom of the pond (i.e. the soils are freely draining).

Higher seepage rates through the bottom of the pond will cause the water table elevation to rise by creating a "mounding condition" below the pond. How high and how widespread the water table mound becomes are contributing factors to whether or not basements will be affected. *However, the single most important factor that will determine if seepage from a pond will cause wet basement problems is the depth to the water table, below the basement.*

The magnitude and extent of the groundwater mounding conditions is also contingent upon the aquifer's transmissivity (aquifer permeability multiplied by aquifer thickness), the specific yield of the aquifer materials, and the duration of the high water levels in the pond. In general, thicker aquifers with higher permeability will experience less mounding than thinner aquifers of lower permeability. Perched aquifers (i.e. groundwater zones less than about 10 feet that overlie extensive clay layers) typically experience the greatest amount of mounding.

Overview of Variance Evaluation Method

All of the combinations of settings, pond configurations, aquifer parameters, and distances from ponds cannot be anticipated before hand in coming up with a method to quickly evaluate whether or not a variance to the minimum floor elevation ordinance should be considered. However, by making some generalities, the most commonly encountered situations can be evaluated. This is the approach taken here.

A groundwater flow model of a "typical" pond and aquifer setting was developed. Aquifer parameters and pond elevations were varied and the resulting water table mounding conditions were simulated. The following conditions were evaluated:

1. Pond elevation increases of 2 feet, 4 feet, and 6 feet above normal or dry conditions

2. Depth to the water table (before flooding) of 3 feet (to represent conditions of 3 feet or less) and 10 feet (to represent conditions where the depth to the water table is greater than 3 feet). The purpose of simulating these two conditions is that with shallow water tables, the rate of infiltration is substantially reduced as the groundwater mound rises into the pond. For deeper aquifer conditions, the pond bottom is always above the water table and the depth to the water table has no bearing on the seepage rate.

3. Three aquifer conditions: clay or perched aquifers (transmissivities of 7 ft^2/day and specific yield values of 0.1); silt aquifers (transmissivity of 70 ft^2/day and specific yield values of 0.2) and sand and gravel aquifers (transmissivities of 2000 ft^2/day and specific yield values of 0.2).

4. Pond bottom sediment thickness of 1 feet and bottom sediment hydraulic conductivity of 1 ft/day.

5. Instantaneous occurrence of a flood condition in the pond, which lasts for 25 days, followed by instantaneous reduction to normal conditions. The purpose of

using this condition is that the effects of aquifer storage (specific yield) are taken into account. A duration of 25 days was selected as being a reasonable time period of flood conditions.

6. Increases in the water table elevation were recorded at several distances between 5 feet and 200 feet from the pond. The maximum rise during the modeled period was selected for plotting.

The U.S. Geological Survey's groundwater modeling code, MODFLOW, was used for this analysis.

How to Determine if a Variance is Warranted

In order to determine if a proposed lowest floor elevation is acceptable, the following need to be known:

1. Depth to the water table and an estimation of the water table's seasonally high elevation.
2. Type of aquifer materials – e.g., clay, silt, sand, gravel
3. Information as to whether or not the water table is perched or is part of a deeper, thicker aquifer system.
4. An estimate of the flood elevation of the pond.
5. The distance of the proposed floor to the pond.

Depth to the water table and the type of aquifer material needs to be determined through the installation of soil borings. The other information should be estimated from other sources.

Once this information is obtained, the minimum depth to the water table from the bottom of the proposed floor slab can be determined from one of six plots, attached to this memorandum. Which of the six plots to use depends on the depth of the water table with respect to the pond's bottom and the type of aquifer material (e.g., clay, silt, sand, gravel). The following steps should be used:

1. Determine the closest distance of the proposed floor to the pond (if the pond size increases during flooding, the distance should be from the flooded perimeter of the pond to the proposed floor).

2. Using Plot 1, determine the minimum permissible depth to the water table for the specified distance from the pond. If the actual depth to the water table (see discussion below for determining this) is greater than the value on Plot 1, no further evaluation is necessary – the floor is sufficiently high with respect to the water table that the water table will not reach the bottom of the slab, regardless of the soil type or transmissivity. If the depth to the water table is less than the value from Plot 1, further evaluation is necessary.

3. If the soil type of the aquifer, below the water table, is mostly clay OR if the aquifer is perched (a continuous clay layer is less than 5 feet below the water table), Plot 2 must be used. The appropriate pond level increase (2, 4, or 6 feet) for flood conditions must be used in Plot 2 to find the minimum permissible depth to the water table. If the depth to the water table from Plot 2 is less than the actual depth to the water table, the proposed floor elevation is too low and must be raised to equal the value from Plot 2.

4. If the soil type of the aquifer is mostly silt AND the pond bottom is 3 feet or less above the water table, Plot 3 should be used.

5. If the soil type of the aquifer is mostly sand or gravel AND the pond bottom is 3 feet or less above the water table, Plot 4 should be used.

6. If the soil type of the aquifer is mostly silt AND the pond bottom is 3 feet or more above the water table, Plot 5 should be used.

7. If the soil type of the aquifer is mostly sand or gravel AND the pond bottom is 3 feet or more above the water table, Plot 5 should be used.

The values from the plots are guidelines, based on typical conditions. If the plots indicate the proposed floor elevation is too low, additional analyses and data collection could be pursued by the applicant. These additional analyses could include additional soil borings, long-term monitoring of piezometers, or more sophisticated modeling.

Determining Depth to the Water Table

If a variance to a lowest floor elevation ordinance is to be considered, the depth to the water table at the location in question must be known. Without this knowledge, there cannot be a technical basis for approving a variance. Furthermore, the applicant should demonstrate that the measured water-table elevation is both representative of conditions over the entire floor area and is representative of values typical for seasonally high conditions (e.g. spring conditions). A suggested requirement for collecting this information is the following:

1) A minimum of two soil borings shall be installed at or near the perimeter of the lowest floor. At least one of these borings shall be where the floor is closest to the nearest pond.

2) Soil borings shall extend to a depth of at least 7 feet below the water table. The borings shall be left open for a time sufficient to determine the stabilized water level in the borehole. The water level shall be measured with reference to a known bench mark that can relate the water table elevation to the proposed floor elevation. Soils at or immediately below the water table shall be sampled and texturally classified using an approved classification method.

Water levels measured during dry summer months or during the winter may be lower than water levels during the spring. The applicant should be required to make an effort to determine the likely amount of seasonal fluctuation in the water table in the area. Water level records from wells completed in the area could be used. If information is unavailable, the applicant should be required to add a value to the measured water table elevation. One suggestion would be to assume 25% of the total annual precipitation (29 inches), divided by the average effective porosity for non-cohesive soils (0.3), which is:

(29 inches/4) x (1 foot/12 inches)/0.3 = 2 feet

If the seasonally adjusted maximum water-table elevation is eight (8) feet or below the bottom of the slab of the lowest floor, it is unlikely that temporary flood conditions in the pond will cause the water table to rise to the level of the floor.[1]

Determining Soil Type at the Water Table

The textural classification from the soil borings will be necessary for determining the

[1] This assumes that the pond level begins to return to normal within about 30 days and the pond level's increase is not greater than 6 feet.

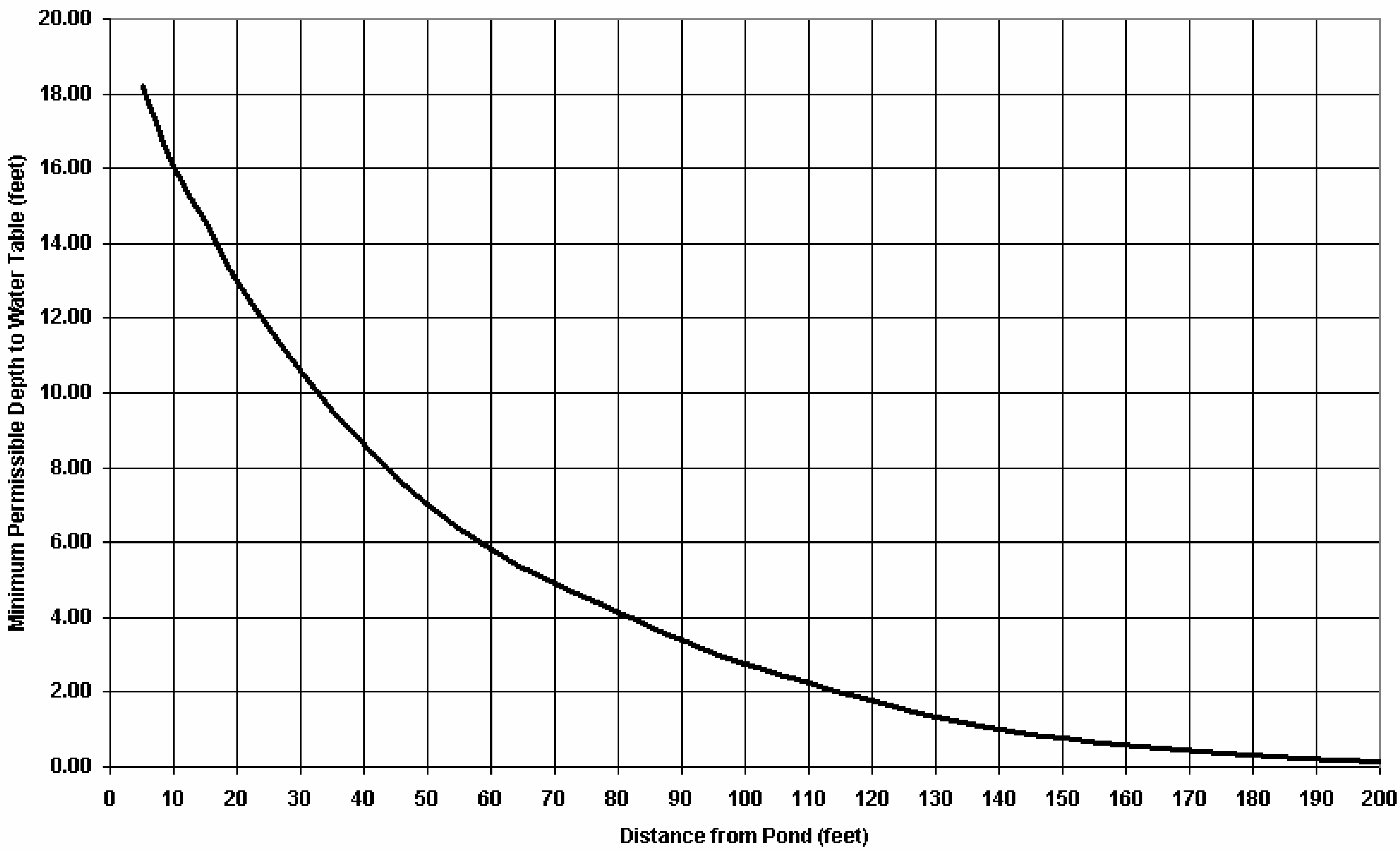
expected rise in the water table caused by an increase in pond elevation. At a minimum, the soil should be classified as one of the following:

1) Sandy or gravely soils – consisting of predominantly sand or gravel, with minor amounts of silt and clay

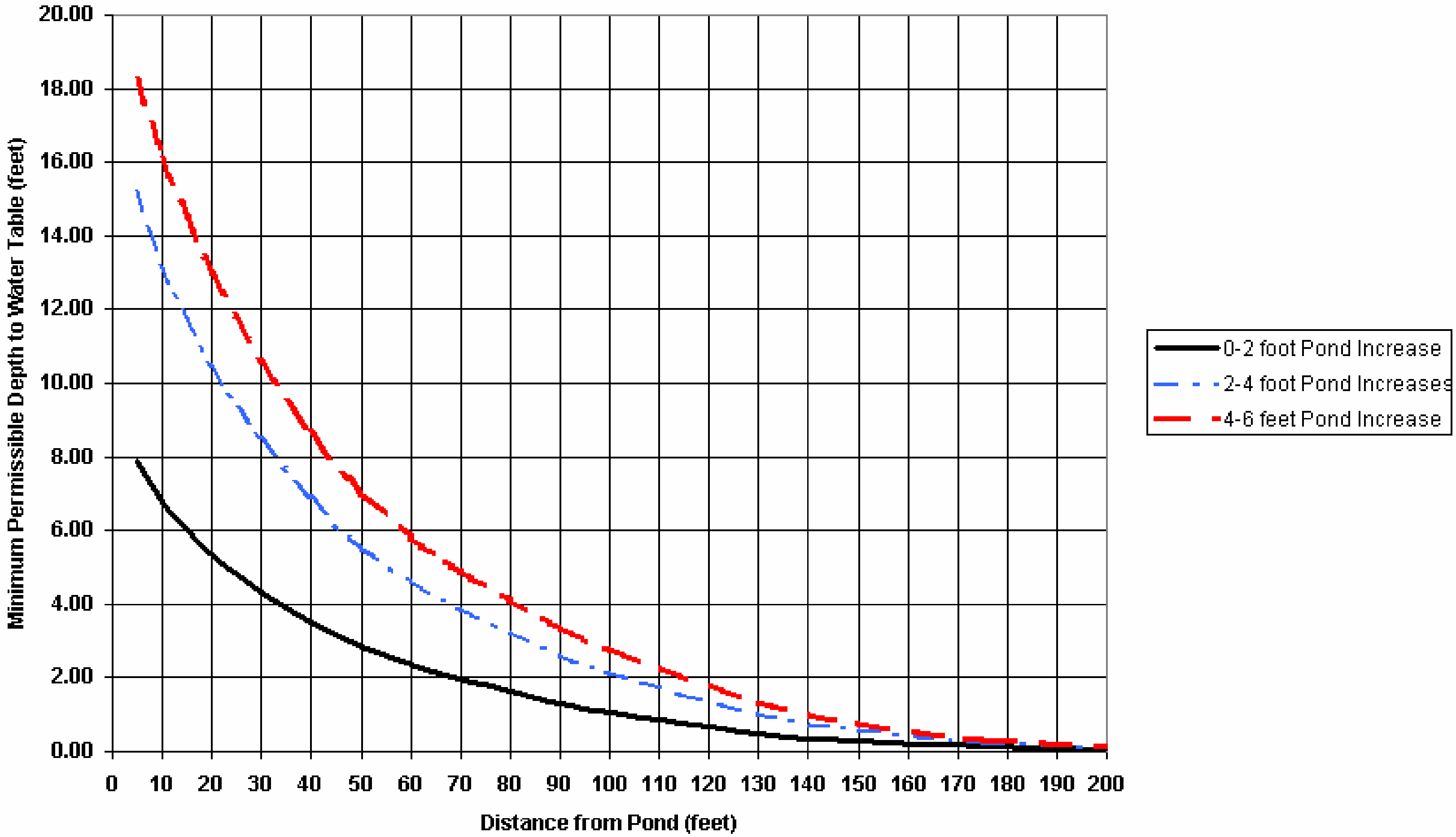
2) Silty soils – consisting predominantly of silt

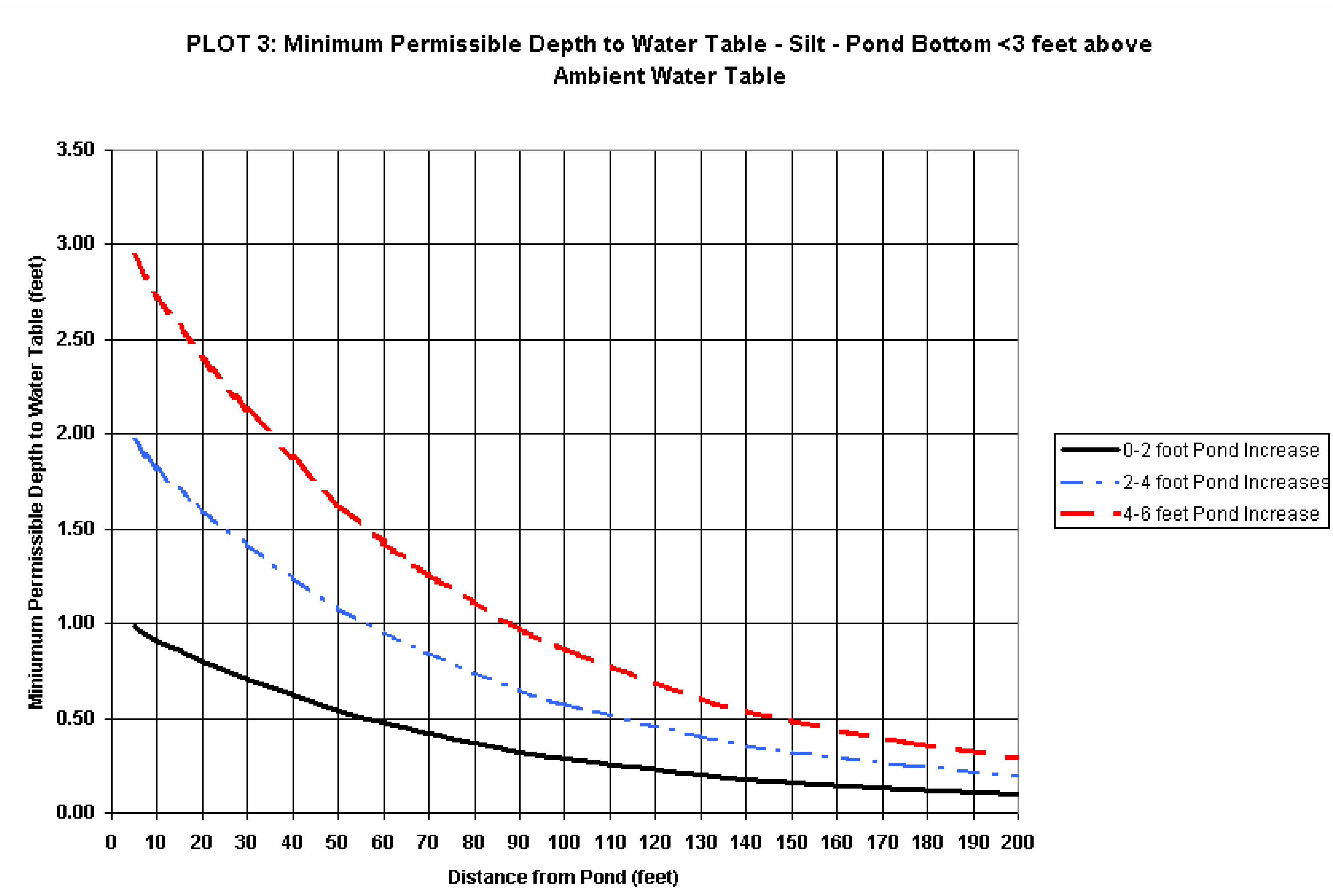
3) Clayey soils – consisting predominantly of clay

PLOT 1: Minimum Depth to Water Table for No Further Evaluation

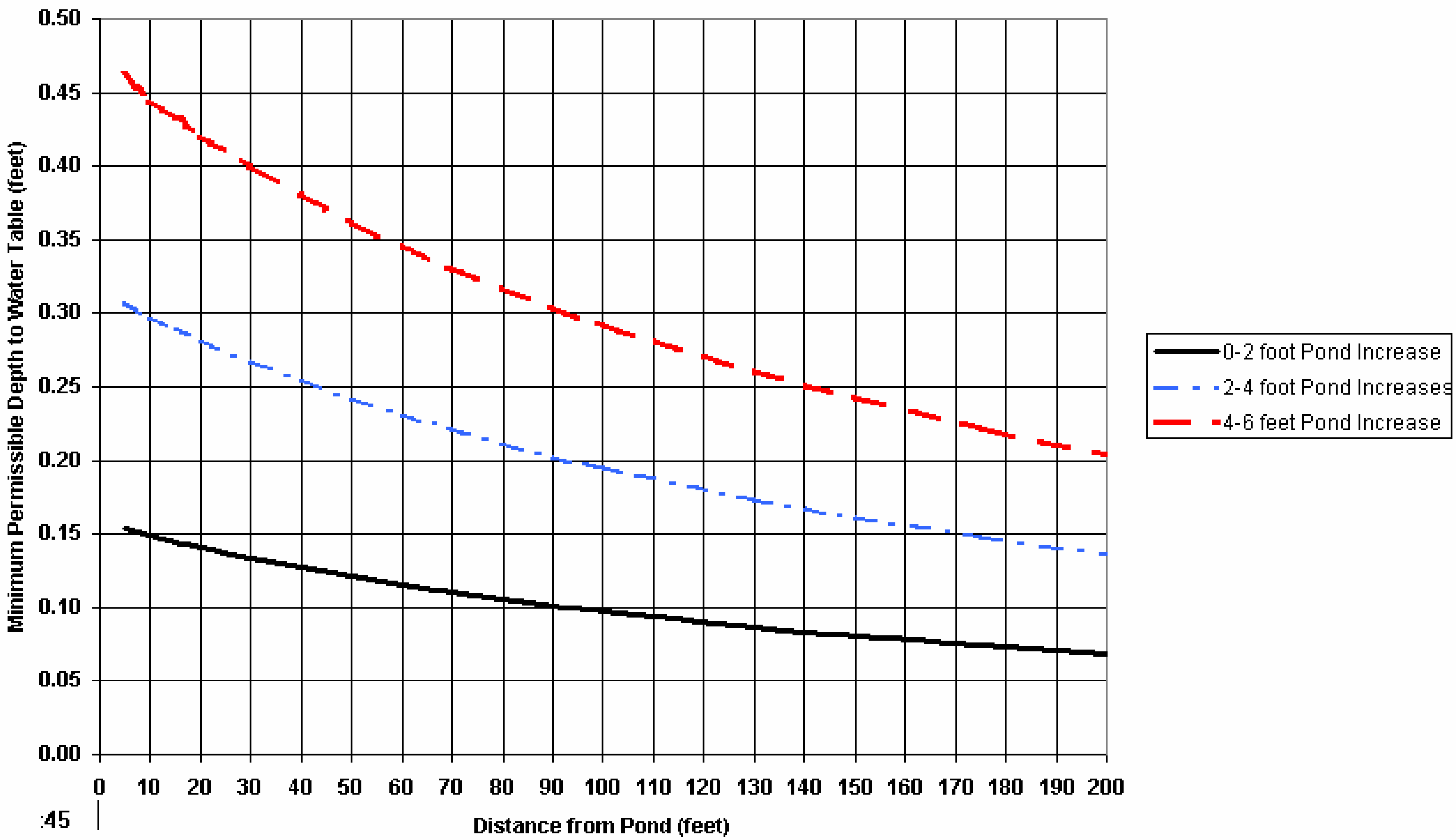


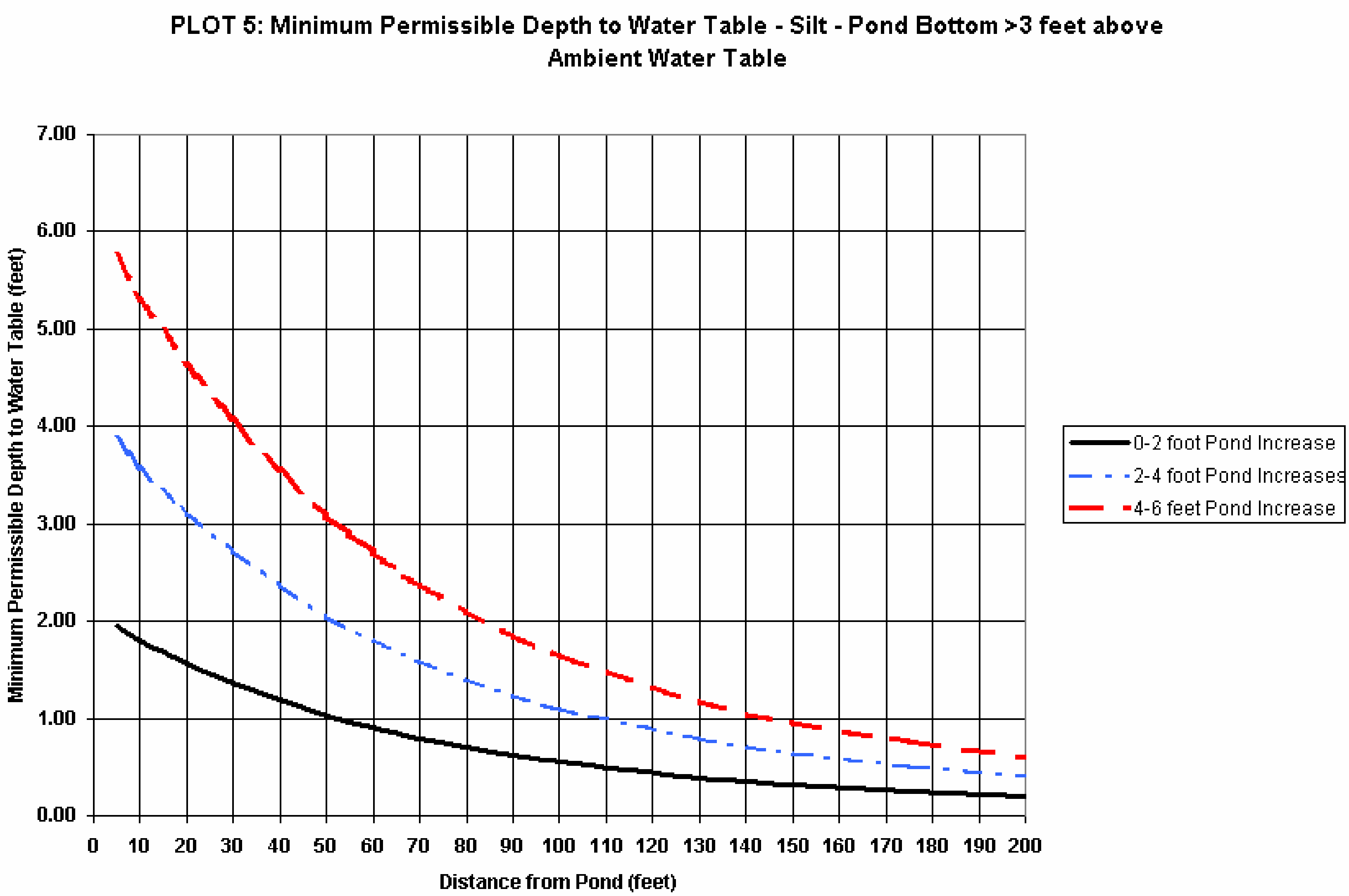
PLOT 2: Minimum Permissible Depth to Water Table - Clay or Perched Conditons
(Perched Conditions = Water Table <5 feet above a continuous clay layer)




PLOT 3: Minimum Permissible Depth to Water Table - Silt - Pond Bottom <3 feet above Ambient Water Table
Miniumum Permissible Depth to Water Table (feet)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
Distance from Pond (feet)
0-2 foot Pond Increase
2-4 foot Pond Increases
4-6 feet Pond Increase

PLOT 4: Minimum Permissible Depth to Water Table - Sand & Gravel - Pond Bottom <3 feet above Ambient Water Table




PLOT 5: Minimum Permissible Depth to Water Table - Silt - Pond Bottom >3 feet above Ambient Water Table
Minimum Permissible Depth to Water Table (feet)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200
Distance from Pond (feet)
0-2 foot Pond Increase
2-4 foot Pond Increases
4-6 feet Pond Increase

PLOT 6: Minimum Permissible Depth to Water Table - Sand & Gravel - Pond Bottom >3 feet above Ambient Water Table