Travis County Low Pressure Dosed Design Method

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TRAVIS COUNTY LOW PRESSURE DOSED (LPD) DRAINFIELD DESIGN METHOD

BACKGROUND:

Since its publication in 1982, the North Carolina Sea Grant College Publication UNC-SG-82-03, "“Design and Installation of Low-Pressure Pipe Waste Treatment Systems” has become the “bible’ for design of LPD systems. This publication grew out of research done on pressure distribution systems, and was intended to be used as a design pattern by facility designers in both the public and private sectors. At that time most Designers did not have an extensive background in the soil sciences, hydraulics or engineering, and the authors of the North Carolina publication wrote to the technical level of the expected readers.

Since 1982 the general understanding of the technical aspects of system design has grown by leaps and bounds, and currently Designers are more likely to be knowledgeable in the fields of soil science, hydraulics, electrical controls, etc. than ever before. In light of the greater level of general knowledge in the field, this Writer is of the opinion that most Designers can understand a more complex and more accurate approach to the design of LPD systems.

DESIGN PROCESS BY THE 1982 PUBLICATION

The design process for an LPD system, using the referenced publication, begins by determining the length of trench to be installed for a particular case. The trenches are laid out on a topographic map of the site, taking care to arrange the individual trenches along a contour, until a sufficient length of trench has been planned. Most Designers, following the examples in the referenced document, lay out all the trenches with the same length. These trenches are connected by a manifold, or header pipe, and divided into groups such that the difference in elevation between the highest and lowest trench in each group is less than about 2 feet. The piping and valving is arranged to allow one group of trenches to be pressurized at one time through one valve, but more than one group may be pressurized at the same time. The transmission pipe from the pump tank to the trenches may connect to the highest or the lowest trench in the drainfield, with no preference being given to either method.

The Designer is to first select a hole spacing, suggested as between 3 and 5 feet. (Nearly all Designers select a 5 ft. spacing, no reason being given) A discharge hole head loss is then selected, usually 2 to 4 feet, for the holes in the highest trench and a discharge hole head loss calculated for the holes in the remaining trenches by adding the change in elevation from trench to trench. Usually a minimum difference of 0.5 ft. between trenches is assumed. Using the charts provided in the referenced publication a flow rate per hole at the calculated head loss is found and, when multiplied by the number of holes in the distribution pipe, provides the flow rate per trench. These flow rates are summed to obtain the necessary flow rate provided by the pump.

With a flow rate found, the friction losses in the piping from the pump to the drainfield can be calculated and the total dynamic head (TDH) can be found. With a TDH and flow rate known a pump is selected such that the TDH/flow rate point falls below the pump curve.

The referenced publication suggests the use of a valve to adjust the discharge pressure to the selected level, as measured in a standpipe connected to the piping in the highest trench. These are the valves, mentioned above, that separate the groups from each other.

DISCUSSION OF THE LOGIC FLAWS IN THE 1982 DESIGN METHOD

There are several incorrect and/or simplifying assumptions made in the above detailed process. The more important corrections to be made include:

1. A pump does not work at some point below the pump curve—IT CAN ONLY WORK ON THE CURVE.
2. The one means of head loss control within each group of trenches is totally discounted; that being the friction losses in the manifold pipe between the trenches.
3. The actual elevation change from trench to trench may be very little, or it may be more than 0.5 ft. The actual elevation change is important to an accurate calculation of discharge pressures.
4. The location of the connection of the transmission line to the drainfield is actually critical to an improved method of calculation.
5. The calculated flow rate is presented as the actual flow rate, which IS NOT ACCURATE.

RATIONAL FOR THE TRAVIS COUNTY LPD CALCULATION METHOD

The basis for the Travis County method of calculation is the realization that the selected pump is the determining factor in the hole spacing, and the pump selection is based on the hydraulic characteristics of the piping system. The piping system includes the geometry of the piping from the pump to the connection at the drainfield at the highest trench and includes the valves, fittings, meters, etc. in the piping. The pump is selected based on a point on the pump curve, NOT ON A POINT BELOW THE CURVE. This usually leads to the more efficient use of the selected pump OR the selection of a smaller, less expensive pump.

DESIGN PROCESS FOR THE TRAVIS COUNTY METHOD OF LPD CALCULATION

First, determine the required length of trench and do a trial trench layout on the site plan. This site plan should be accurate and show all features that would influence the layout. The topographic information should be sufficient to allow judging the change in elevation across the drainfield to about 0.2 ft. The trenches can be, and often are, of various lengths and there is no particular advantage to having all trenches the same length. With a complete layout at hand;

1. Divide the trenches into groups of approximately equal size. There may be one or more groups. For most residential systems, using one or two groups will result in no more than about 600 feet of trench per group. Remember that the length of trench per group is a major factor in determining pump size. Select a transmission pipe route and pipe size to connect to the highest trench in each group. It is a requirement that the connection be made to the

highest trench in each group. For trenches longer than about 50 feet the connection should be made near the midpoint of the trenches. Individual trenches should be no longer than about 120 feet.

2. Make a selection of discharge hole size. The usual "best size" is 5/32" diameter, as a larger hole will require a significantly larger pump or too great of a hole spacing and a 1/8" diameter hole will usually become clogged. For 5/32" holes, estimate the flow rate at 0.1 GPM per foot of trench being dosed at one time and calculate the flow rate for the group of trenches. Repeat for each group of trenches. The 0.1 GPM per foot of trench estimate will usually result in a hole spacing of about 4 feet. For 3/16" holes the flow rate estimation should be 0.15 GPM per foot of trench if the same approximate hole spacing is desired.
3. Establish a "fixed head loss" for each group, which is the sum of the following:
   a) The selected discharge hole loss in the highest trench, usually set as 2.0 feet.
   b) The elevation change from the pump off level in the pump tank to the ground level at the point the transmission line connects to the trench group. This may be a negative value if the field is downhill from the tank location.
   c) The selected value of head loss in the pressure adjustment valve and, commonly taken as 4 to 6 feet.
   d) A misc. loss factor that is usually lumped into c), above to cover minor unknown losses.
4. Using a flow rate that is less than the estimated flow rate (Step 2), calculate the pipe friction losses from the pump to the trench group. To account for the fittings, check valves, etc., multiply the pipe length by 1.2 or determine the equivalent pipe length for each fitting, valve, etc. and add these lengths to the actual pipe length. If an automatic switching valve is part of the design, find the head loss through the valve at the trial flow rate. Repeat these calculations for a flow rate approximately equal to the estimated flow rate and again for a flow rate greater than the estimated flow rate.
5. Add the "fixed head loss' to each of the calculated system friction losses to get the Total Dynamic Head (TDH) at the three flow rates. Plot these three points on the pump curve for the tentatively selected pump and draw a curve through the points. This curve is the "systems curve" for the piping layout being used, and its intersection with the pump curve defines the ACTUAL flow rate and TDH that will be experienced in the system. This is called the balance point. If the system curve does not intersect the pump curve, calculate a fourth TDH point for an appropriate flow rate to extend the curve to an intersection with the pump curve, or select a different pump and replot the system curve on the new pump curve.
6. Each group of trenches will have its' own balance point. If the flow rate is considered to be too high, a different pump can be selected or a greater head loss can be assumed at the pressure adjustment valve and a different system curve can be plotted to find a new balance point. A change in transmission line size will also change the TDH for all groups.
7. With a balance point defined, the flow rate to the first trench in each group is known. Note that the flow rates for the groups can be, and often are, different. For each group of trenches, divide the flow rate by the length of trench being dosed to find the ideal flow rate per foot of trench. Multiply this by the individual trench lengths to find the flow rate for each trench in the group.

At this point the Designer knows the flow rate to each trench group, the desired flow to each trench, and the available pressure (the selected discharge hole pressure) at the highest trench. All of this information, plus the change in elevation from trench to trench, can be put in a useable form using the attached worksheet. Those Designers that are computer-wise can develop a spreadsheet to do the same, but should do a few designs by hand to completely understand the process.

8. At the highest trench, there are no added friction losses or elevation changes to consider, so the available head is the selected hole loss, usually 2 feet. From the attached chart, using the selected hole size, a flow rate per hole is found. This chart is a graphic display of the table in the North Carolina document. Divide the ideal flow rate for the first trench by the flow rate per hole to find the number of holes needed. Since this is usually not a whole number, round up or down to a whole number. Rounding up will load the highest trench at a slightly higher rate than the average.
9. Multiply the number of holes to be used by the flow rate per hole to obtain the flow rate for the highest trench. Subtract this flow from the total flow earlier found to obtain the bypass flow, which is the flow being passed on to the remaining trenches.
10. Select a pipe size for the manifold pipe between the highest trench and the second trench. If the ground slope across the field is severe a smaller pipe diameter can be selected. Using the trench spacing plus 0.5 ft. as the pipe length, calculate the friction loss in the pipe between the first and second trench. The available head for the discharge holes in the second trench is the head available in the first trench, plus the elevation drop between the trenches, minus the friction loss in the section of pipe. The "extra" 0.5 ft is added to account for the friction losses generated as the water is divided in the tee at each trench. Note that there is no 1.2 multiplier used as is often done for flow through a pipe. This is because the pipe length is so short and the fitting loss is addressed by adding the extra 0.5 ft. Also note that the trench spacing can vary across the field as necessary to fit the terrain or avoid trees.

At this point it should be realized that the size of the pipe between the trenches, commonly called the header pipe or the manifold, plays a critical role in the Travis County Design Method. By changing the pipe size the Designer will change the friction loss, and can thereby control, at least to some extent, the change in available head in each trench.

11. With an available head calculated for the second trench the flow per hole is found and the number of holes calculated as for the first trench. Again, the calculated number of holes is rounded to the nearest whole number and the actual flow rate found. This leads to the bypass flow rate for the header pipe section going to the third trench. With a pipe diameter selected the pipe friction is calculated and the hydraulic conditions in the third trench are found, as before.
12. This process is repeated until the last trench is reached. Here the remaining bypass flow should be nearl the ideal flow for the last trench, if no math errors have been made.

The hole spacing for each trench is calculated by dividing the actual distribution pipe length by the number of holes minus 1 (because there is one less space than there are holes). The result can be in feet or inches, but there is no point in expressing a spacing closer than plus or minus one–half inch.

Note that the pipe length will be less than the trench length, usually two to four feet shorter. If the hole spacing is laid out from each end of the pipe to the manifold connection there will be one odd space at the manifold.

This process can best be understood by following through several examples. Four examples are attached for reference, and the first example is discussed in detail, as follows:

EXAMPLE #1

See the accompanying sketch for the layout of the fields and transmission line.

Determine fixed losses:
Set discharge hole loss at 2.0 ft.
Assume misc. losses, including the adjusting valve loss, at 4.0 ft.
Ground elevation at high trench (both fields) = 98.0
Low level cutoff float in tank at 96.5
Elevation change = 1.5 ft.

Fixed losses = 2.0 + 4.0 + 1.5 = 7.5 ft.

As a first trial, assume a 1-1/2" dia. sch. 40 PVC transmission line.
Total length to field A = 140 feet
Total length to field B = 115 feet.

The trench layout for the two fields results in field A having 325 feet of trench and field B having 365 feet of trench. Therefore, a flow rate of about 35 GPM would be a good compromise for the two fields.

For field A,
With Q = 30 GPM, Pf = 1.40x1.2 x 5.95 ft./100 ft.= 10.0 feet and TDH = 10.0 + 7.5 = 17.5 ft.
Q = 35 GPM, Pf = 1.40x1.2 x 7.95 ft./100ft.= 13.36 feet and TDH = 13.36 + 7.5 = 20.86 ft.
Q = 40 GPM, Pf = 1.40x1.2 x10.15 ft./100 ft.=17.05 feet and TDH =17.05 + 7.5 = 24.55 ft.

For field B,
With Q = 30 GPM, Pf = 1.15x1.2x5.95 ft./100 ft.= 8.21 feet and TDH = 8.21 + 7.5 = 15.71 feet
Q = 35 GPM, Pf = 1.15x1.2x7.95 ft./100 ft.=10.97 feet and TDH = 10.97 + 7.5 = 18.47 feet
Q = 40 GPM, Pf = 1.15x1.2x10.15 ft./100 ft.=14.01 feet and TDH =14.01+ 7.5 = 21.51 feet

Plotting these points on the pump curve for the Barnes model BP-314 pump, a balance point for field A is found at 37 GPM and 22.3 feet and for field B at 39.6 GPM and 21.4 feet. This means that if the components are constructed as described the specified pump will provide 37 GPM to field A or 39.6 GPM to field B, and there will be at least 2 feet of available head at the discharge holes in the highest trench in each field. The exact head desired is obtained by adjustment of the in-line valve that is installed for this specific purpose. The head loss at the adjustment valve will be slight, as the preceding calculations only allowed for 4 feet of miscellaneous head losses, which includes the valve loss.

For field A the loading rate per foot of trench = 37/325 = 0.1138 GPM per foot, and the design flow rate to the first trench, which is 60 feet long, is 0.1138 x 60 = 6.83 GPM. By design, the available discharge head in the first trench is 2.0 feet, so the flow rate per 5/32 inch diameter hole is 0.41 GPM. By division the number of holes needed is 6.83 GPM/0.41 GPM per hole = 16.67 holes, rounded up to 17 holes. The actual flow rate into the first trench is 17 holes x 0.41 GPM per hole = 6.97 GPM, only about 2% over design.

The discharge pipe in the 60 foot trench will be shorter, say 56 feet. Then, the hole spacing, assuming a hole near the end of the pipe, would be 56 feet/ 16 spaces between holes = 3.5 feet or 42 inches.

The bypass flow = 37.0 – 6.97 = 30.03 GPM. This is the flow passing through the manifold pipe between the first and second trenches. If a 1-1/2" dia. sch. 40 PVC pipe is used for the manifold between the trenches, which are spaced at 4 feet, the head loss will be about 0.27 feet (0.045 feet x 6.0 feet per 100 feet). Using the provided topographic map, the change in elevation between these two trenches is determined to be approximately 0.22 feet. The available head in the second trench is the head in the first trench plus the elevation change minus the friction loss in the connecting pipe. Or, head in #2 trench = 2.0 +0.22 -- .027 = 1.95 feet. It should be noted that if the flow was uphill, both the elevation change and the friction losses would be negative. This is the reason that the connection is to always be made to the highest trench.

The hole discharge rate for this head is about 0.405 GPM per hole. The second trench is 35 feet long, so the design flow is 35 x 0.1138 GPM per foot = 3.98 GPM. Therefore the number of holes = 3.98/0.405 = 9.83 holes, rounded to 10 holes, and the actual flow rate to this trench = 0.405 x 10 = 4.05 GPM. Again, the bypass flow rate to the third trench is 30.03 – 4.05 = 25.98 GPM.

The pipe friction loss between the second and third trenches, using 1-1/2" dia. pipe, will be about 0.20 feet and the change in elevation is again about 0.22 feet. Therefore the available head in the third trench = 1.95 + 0.22 – 0.20 = 1.97 feet. This results in a flow rate per hole of 0.405 GPM per hole. With a trench length of 35 feet, the required number of holes is found to be 10 and the actual flow rate is again 4.05 GPM. Bypass flow is 25.98 –4.05 = 21.93 GPM.

Again using the 1-1/2" dia. manifold pipe, the pipe friction loss is found to be 0.045 x 3.30 = 0.15 feet, and the available head in trench #4 = 1.97 + 0.22 – 0.15 = 2.04 feet. This allows a flow rate per hole of 0.415 GPM per hole. The 60 foot long #4 trench has a design flow rate of 60 x 0.1138 = 6.83 GPM, so the hole number = 6.83/0.415 = 16.45, rounded down to 16 holes. The actual flow rate = 16 x 0.415 = 6.64 GPM and the bypass flow rate is 21.93 –6.64 = 15.29 GPM.

Based on the trend in the reduction in the pipe friction from trench to trench as the flow rate is reduced, the 1-1/2" dia. pipe will provide very little pipe friction loss to offset the gain in head provided by the change in elevation. Therefore, a smaller diameter pipe will be used between trenches #4 and #5. At the bypass rate of 15.29 GPM a 1-1/4" diameter pipe has a friction loss of about 3.50 feet per 100 feet, so the 4 foot manifold section has a loss = 0.045 x 3.5 = 0.16 feet. Then, the available pressure in trench #5 = 2.04 + 0.22 –0.16 = 2.10 feet. This results in a hole flow rate of 0.42 GPM. The design flow rate for the 55 foot long trench is 55 x 0.1183 = 6.26 GPM, so the number of holes needed is 6.26/0.42 = 14.9, or 15 holes. The actual flow rate is 15 x 0.42 = 6.30 GPM and the bypass flow rate is 15.29 –6.30 = 8.99 GPM.

A trial calculation shows that the 1-1/4" dia. pipe with a flow rate of about 9 GPM will have a very low friction head loss, so a further reduction, to 1" diameter, will be made for the manifold pipe between trenches #5 and #6. The pipe friction is found to be 0.045 x 5.15 = 0.23 feet and the available head in trench #6 is 2.10 + 0.22 –0.23 = 2.09 feet. The flow rate would be 0.42 GPM per hole. With a 50 foot trench the design flow rate is 50 x 0.1138 = 5.69 GPM and the hole number would be 5.69/0.42 = 13.55, rounded to 14. The actual flow rate is found as 0.42 x

14 = 5.88 GPM, leaving 3.11 GPM as the bypass flow rate going to the last trench. Trench #7, 30 feet long, has a design flow rate of 30 x 0.1138 = 3.41 GPM, so the flow reaching the last trench is somewhat less than the design flow. This means that the lowest trench will be loaded a bit lighter than the upper trenches.
Again using the 1" dia. manifold pipe, the pipe friction is about 0.04 feet, resulting in a head in the last trench of 2.09 + 0.22 –0.04 = 2.27 feet. The flow rate of 0.435 will require 8 holes to pass the bypass flow rate of 3.11 GPM. For this last trench the distribution pipe length would be about 26 feet long in the 30 foot trench, so the hole spacing would be 26/7 = 3.7 feet or 44-1/2".

All of the above calculations can be done on a worksheet that organizes the calculations and presents them in a tabular arrangement. See the example #1 for the filled out worksheets on both fields.

NOTES ON EXAMPLE #1:
Note that the two fields do not receive the same loading rate, although the highest trench in both fields are at a common elevation. Also note that the flow rates to the two fields is not determined by the length of trench in each field, only by the hydraulic conditions existing between the pump and the connection to each field. In this case the difference is in the length of transmission lines.
Also note that the calculations apply only when the pump is running and the piping network is under pressure; that is, under dynamic conditions. Under these conditions the pressure in the lines can vary up and down from trench to trench, and a lower distribution pipe can have a lower pressure that a higher one, due to the effect of the manifold pipe friction losses.
The flow rates per hole are estimated to three decimal places from the plotted curve. This is to some extent "gilding the lily" as there are unknowns and approximations that will overshadow the difference between two and three places in the flow rate. The Designer can choose to use only two decimal places if preferred.

EXAMPLE #2

See the accompanying sketch for the layout of the fields and transmission line.

Determine fixed losses:
Set discharge hole loss at 2.0 ft.
Assume misc. losses, including the adjusting valve loss, at 4.0 ft.

	Field A	Field B
Ground elevation at high trench,	98.8 ft.	98.0 ft.
Low level cutoff float in tank	93.1 ft.	93.1 ft.
Elevation change	5.7 ft.	4.9 ft.

Fixed losses, Field A, 2 + 4 + 5.7 = 11.7 ft.
Fixed losses, Field B, 2 + 4 + 4.9 = 10.9 ft.

As a first trial, assume a 1-1/2" dia. sch. 40 PVC transmission line.
Total length to field A = 160 feet

Total length to field B = 175 feet.

For field A,
With Q = 30 GPM, Pf = 1.6 x 1.2 x 5.95 = 11.42 feet and TDH = 11.7 + 11.42 = 23.12 feet
Q = 35 GPM, Pf = 1.6 x 1.2 x 7.95 = 15.26 feet and TDH = 11.7 + 15.26 = 26.96 feet
Q = 40 GPM, Pf = 1.6 x 1.2 x 10.15 = 19.49 feet and TDH = 11.7 + 19.49 = 31.19feet
For field B,
With Q = 30 GPM, Pf = 1.75 x 1.2 x 5.95 = 12.50 feet and TDH = 10.9 + 12.50 = 23.40 feet
Q = 35 GPM, Pf = 1.75 x 1.2 x 7.95 = 16.70 feet and TDH = 10.9 + 16.70 = 27.60 feet
Q = 40 GPM, Pf = 1.75 x 1.2 x 10.15 = 21.32 feet and TDH = 10.9 + 21.32 = 32.22 feet

Plotting these points on the pump curve for the Barnes model EVH 0.5 hp pump, a balance point for field A is found at 34 GPM and 26.2 feet and for field B at 33.5 GPM and 26.5 feet.

See the calculation sheet for the hydraulic calculations necessary for the hole number and spacing.

NOTES ON EXAMPLE #2:
Note that the two fields receive very nearly the same loading rate (GPM) although there is almost one foot difference in elevation between the two fields. The longer transmission line to the lower field balances the difference in elevation. In this example the friction loss in the header pipe was adjusted by use of smaller and smaller diameter pipe to almost exactly balance the change in elevation from trench to trench, resulting in a very uniform dynamic pressure in the system.

In the event a K-Rain automatic switching valve is used to alternate the field use, the friction losses through the valve at the various flow rates must be added to the calculations for TDH. Then, the TDH is the sum of the fixed losses, the pipe friction and the valve friction. The use of the K-Rain valve can boost the TDH by 5 to 8 feet in most cases. This may require a higher head pump. Note that the head loss for the K-Rain valves varies from model to model and also varies with the number of outlets. A head loss curve is provided for the 6400 and 6600 models.

EXAMPLE #3

Same as example #2, except all the trenches are dosed as one field.
See the accompanying sketch for the layout of the fields and transmission line.

Determine fixed losses:
Set discharge hole loss at 2.0 ft.
Assume misc. losses, including the adjusting valve loss, at 4.0 ft.

	Field A
Ground elevation at high trench,	98.0 ft.
Low level cutoff float in tank	93.1 ft.
Elevation change	5.7 ft

Fixed losses, Field A, 2 + 4 + 5.7 = 11.7 ft.

As a first trial, assume a 2" dia. sch. 40 PVC transmission line.
Total length to field A = 160 feet

For field A,
With Q = 60 GPM, Pf = 1.6 x 1.2 x 6.37 = 12.23 feet and TDH = 11.7 + 12.23 = 23.93 feet
Q = 65 GPM, Pf = 1.6 x 1.2 x 7.40 = 14.21 feet and TDH = 11.7 + 14.21 = 25.90 feet
Q = 70 GPM, Pf = 1.6 x 1.2 x 8.50 = 16.32 feet and TDH = 11.7 + 16.32 = 28.02feet

Plotting these points on the pump curve for the Barnes model SE512L pump, a balance point for field A is found at 63.2 GPM and 25.1 feet.

See the calculation sheet for the hydraulic calculations necessary for the hole number and spacing.

NOTES ON EXAMPLE #3:
By comparing these two examples that have identical field layouts, note that the pump horsepower demand was the same for both arraignments, although the pumps are different. However, the pump selected for the two field plan would not be adequate for the single field plan if a hole spacing less than five feet is required. It would be interesting to calculate a third trial, using a 3" diameter transmission line. What would be the effect of the larger pipe? Would the EVH 0.5 hp pump be adequate?

EXAMPLE #4

See the accompanying sketch for the layout of the fields and transmission line.

Determine fixed losses:
Set discharge hole loss at 2.0 ft.

Assume the misc. losses at 4.0 ft.	Field A	Field B
Ground elevation at high trench	99.9 ft.	91.3 ft.
Low level cutoff float in tank	91.0 ft.	91.0 ft.
Elevation change	8.9 ft.	0.3 ft.

Fixed losses, Field A, 2 + 4 + 8.9 = 14.9 ft.
Fixed losses, Field B, 2 + 4 +0.3 = 6.3 ft.

As a first trial, assume a 2" dia. sch. 40 PVC transmission line from the pump to Field A.
Assume a 1-1/2" dia. pipe from the switching valve to Field B.
Total length to field A = 14 + 90 = 104 feet of 2" pipe
Total length to field B = 14 feet of 2" pipe and 110 feet of 1-1/2" pipe

For field A,
With Q = 35 GPM, Pf = 1.04 x 1.2 x 2.38ft./100 ft. = 3.0feet and TDH = 14.9 + 3.0 = 17.9 feet
Q = 40 GPM, Pf = 1.04 x 1.2 x 3.05ft./100 ft. = 3.8 feet and TDH = 14.9 + 3.8 = 18.7 feet
Q = 45 GPM, Pf = 1.04 x 1.2 x 3.75ft./100 ft. = 4.7 feet and TDH = 14.9 + 4.7 = 19.6 feet

For field B,
With Q = 35 GPM, Pf = (0.14 x 1.2 x 2.38) + (1.10 x 1.2 x 7.95) = 10.89 feet and TDH = 6.3 + 10.89 = 17.2 feet
Q = 40 GPM, Pf = (0.14 x 1.2 x 3.05) + (1.10 x 1.2 x 10.15) = 12.79 feet and TDH = 6.3+ 12.79 = 19.1 feet
Q = 45 GPM, Pf = (0.14 x 1.2 x 3.75) + (1.10 x 1.2 x 12.65) = 17.33 feet and TDH = 6.3+ 17.33 = 23.6 feet

Plotting these points on the pump curve for the Barnes model SE 411 pump, a balance point for field A is found at 43.0 GPM and 19.3 feet and for field B at 40.8 GPM and 19.5 feet.

See the calculation sheet for the hydraulic calculations necessary for the hole number and spacing.

NOTES ON EXAMPLE #4:
In this example the two fields have a significant difference in elevation. By using a smaller diameter transmission pipe for the lower field the pipe friction losses partially compensate for the elevation head difference. In fact, the smaller diameter transmission line provides more friction losses than needed to balance the two hydraulic conditions and the piping to the lower field actually has a higher system head loss. The effect of the pipe friction on the TDH over-rides the effect of the fixed losses, resulting in a system head loss curve for Field B that is much steeper than the system head loss curve for Field A.

GENERAL NOTES ON THE SYSTEM CURVES PLOTTED ON THE PUMP CURVES

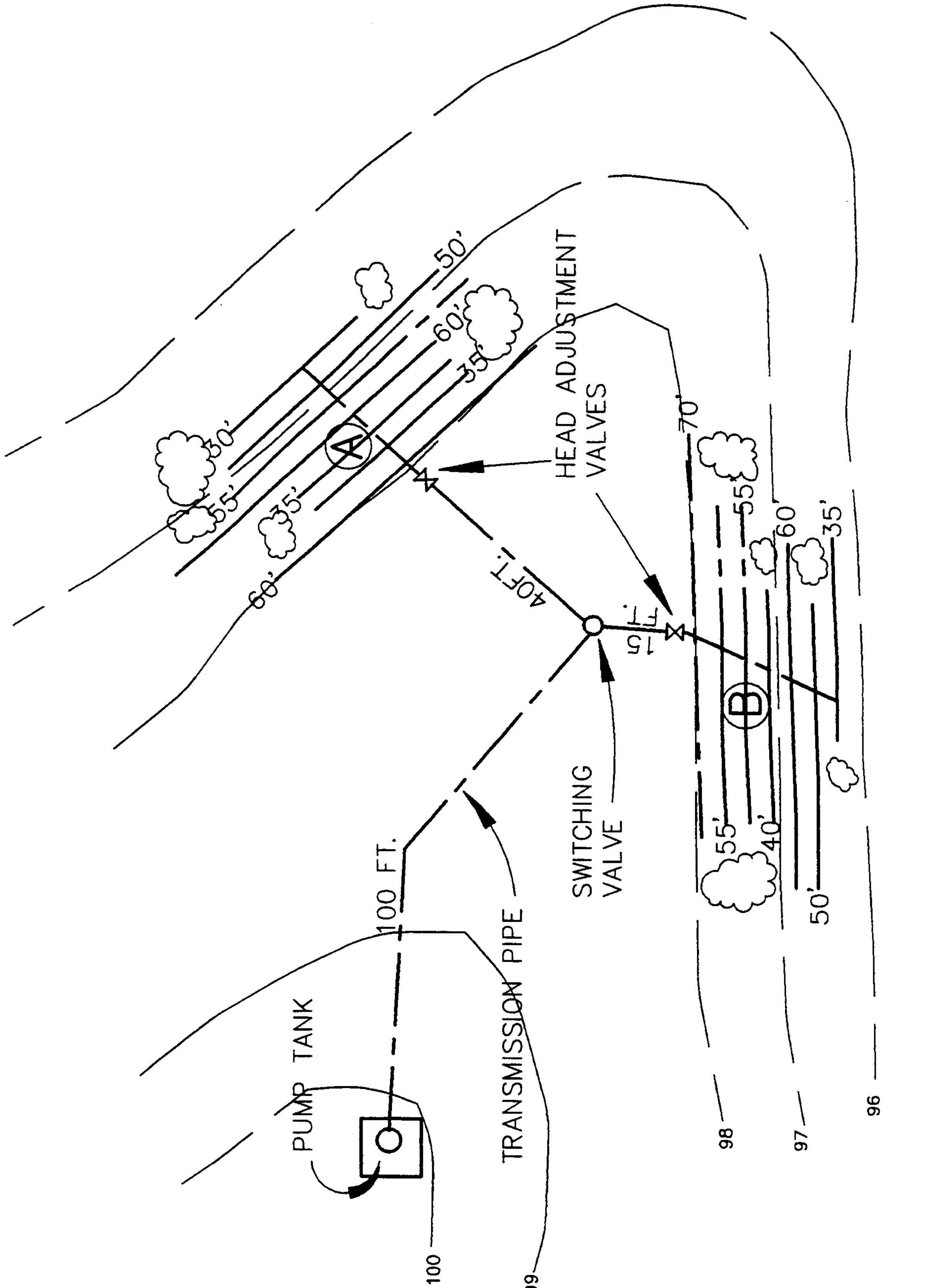
The selected pump for each example is not the only pump that would be suitable. By plotting the system curves on a composite pump curve chart, the effect of a different pump choice can be seen. As an example, if a lower flow rate was acceptable for the facility of Example #1, the Barnes model SE 411 pump could be selected. A higher flow rate could be satisfied by the Barnes model SE-51. For the Example #2 facility either the Barnes model SE-51 or the Barnes model BP-314 could be selected if a lower flow rate was acceptable.
The composite pump curve chart shows that a high head or high flow rate condition system curve will have fewer suitable pumps. Do other pump brands offer a better pump selection for these conditions?
The plotting of a number of pump curves on one chart also highlights the fact that all pumps with the same horsepower motor are not alike.

GENERAL NOTES ON PUMP SELECTION

The pump curves for the fractional horsepower pumps used in LPD systems usually show only the flow rate vs. the TDH curve. A study of the pump curves for larger pumps, which include the horsepower demand and the efficiency curves, show that pumps are usually the most efficient at flow rates of about 55% to 70% of their maximum flow rates. Furthermore, flow rates over about 95% of the maximum often overload the motor normally provided. This is true for the smaller pumps as well, so a good pump selection would avoid the extremes at both ends of the pump curve.

Equally important to pump suitability is pump availability. Since all pumps will eventually fail, a replacement will someday be needed. Some pump models are not carried in stock, even at the distributor level, so pump replacement can be time consuming. A commonly stocked pump that is a bit less efficient will often be a better selection than the perfect pump that is a special order item. Some Dealers stock a broader selection of models, so the Designer should become acquainted with more than one local Dealer and their stocks.

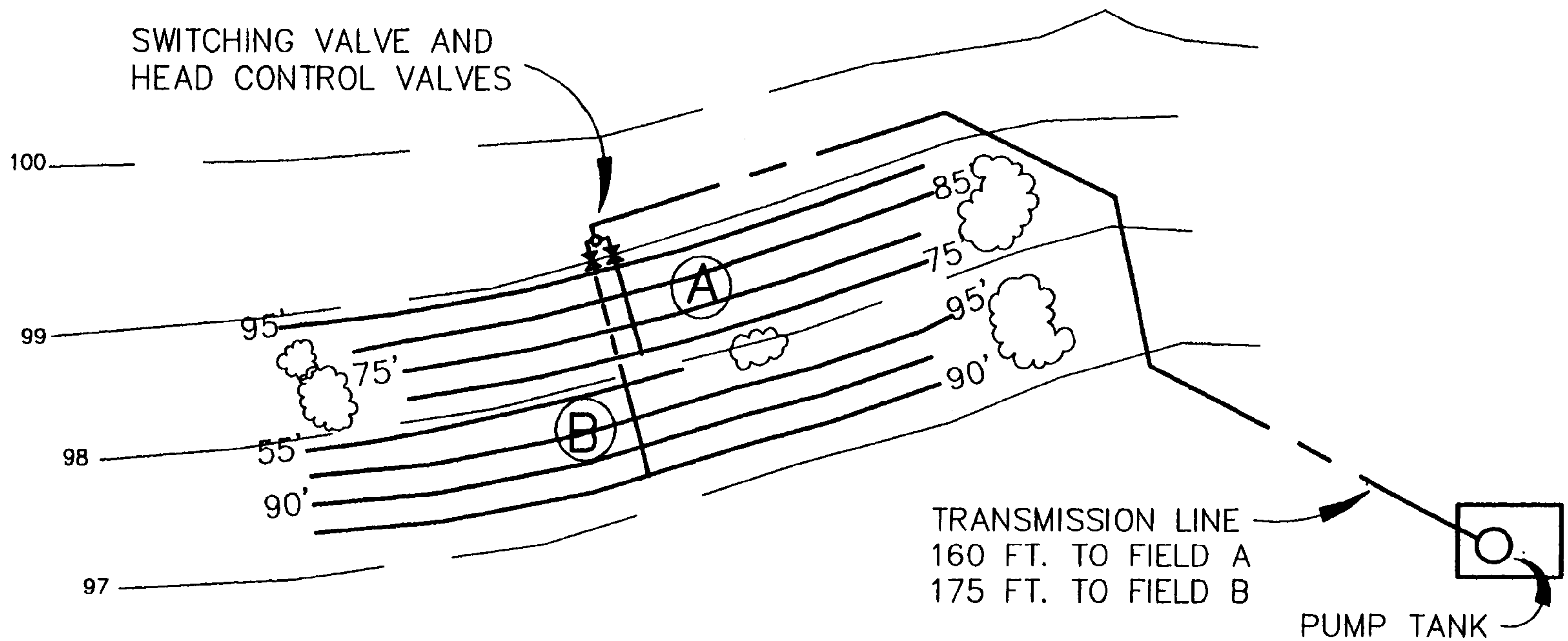
A primary point to remember is this: THERE IS NO ALL-PURPOSE PUMP.



EXAMPLE #1 NO SCALE

LPD CALCULATIONS
EXAMPLE #1

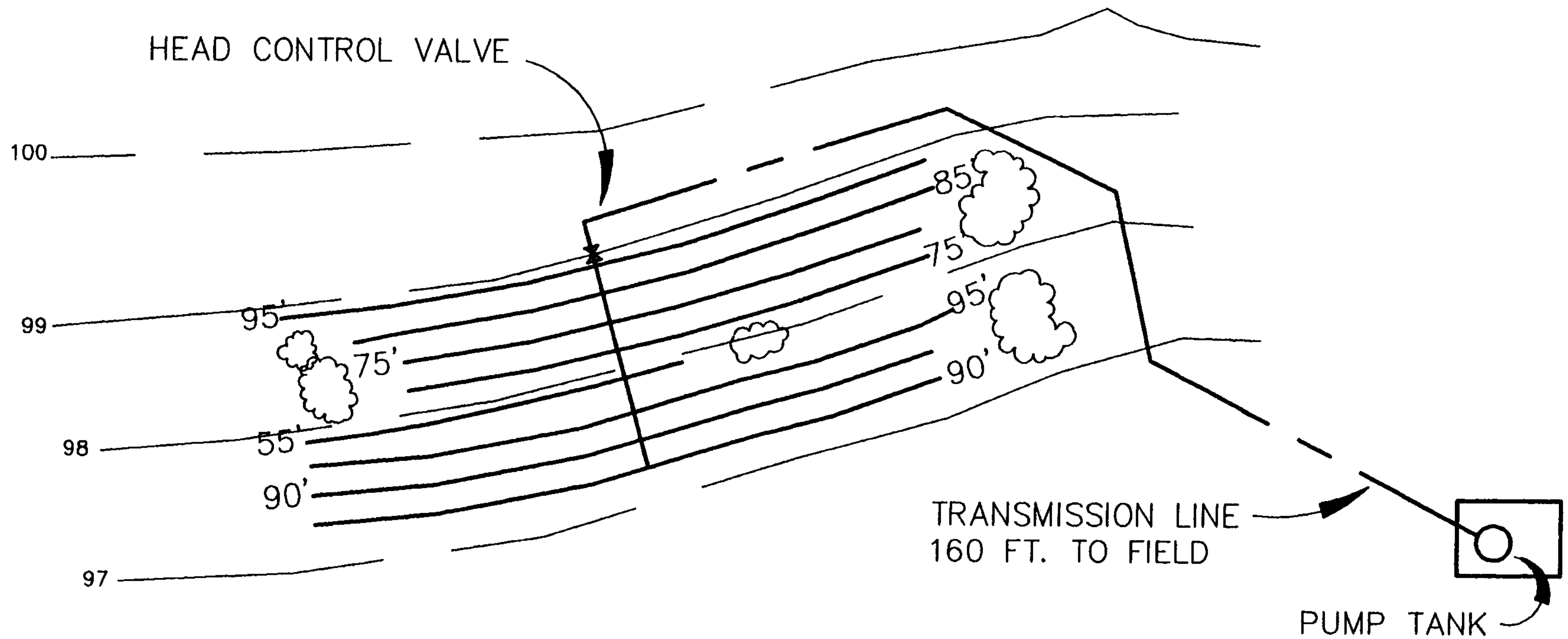
TRENCH #	TRENCH LENGTH ft	DESIGN FLOW RATE	START HEAD	CHANGE IN ELAVATION	FRICTION LOSS	SUMMATION OF HEAD	FLOW RATE 5/32	# OF HOLES	ACTUAL FLOW	BYPASS FLOW	HOLE SPACING	HEADER SIZE in
FIELD "A"		Q = 37.0 GPM				HOLE SIZE = 5/32"						
1	60 FT.	6.83	2	0	0	2	0.41	17	6.97	30.03	42"	1.5"
2	35	3.98	2	0.22	0.27	1.95	0.405	10	4.05	25.98	41.5"	1.5"
3	35	3.98	1.95	0.22	0.2	1.97	0.405	10	4.05	21.93	41.5"	1.5"
4	60	6.83	1.97	0.22	0.15	2.04	0.415	16	6.64	15.29	45"	1.25"
5	55	6.26	2.04	0.22	0.16	2.1	0.42	15	6.3	8.99	43.5"	1"
6	50	5.69	2.1	0.22	0.23	2.09	0.42	14	5.88	3.11	42.5"	1"
7	30	3.41	2.09	0.22	0.04	2.27	0.435	8	3.48	O.K.	44.5"	
FIELD "B"		Q = 39.6 GPM				HOLE SIZE = 5/32"						
1	70	7.59	2	0	0	2	0.41	19	7.79	31.81	44"	1.5"
2	55	5.97	2	0.3	0.3	2	0.41	15	6.15	25.56	44"	1.5"
3	55	5.97	2	0.3	0.2	2.1	0.42	14	5.88	19.68	47"	1.25"
4	40	4.34	2.1	0.3	0.26	2.14	0.425	10	4.25	15.43	48"	1"
5	60	6.51	2.14	0.25	0.62	1.77	0.385	17	6.55	8.88	42"	1"
6	50	5.42	1.77	0.25	0.23	1.79	0.39	14	5.46	3.42	42.5"	1"
7	35	3.8	1.79	0.25	0.04	2	0.41	9	3.69	CLOSE	46.5"	
TRENCHES ARE SPACED AT 4 FEET, CENTER TO CENTER												



EXAMPLE #2 NO SCALE

LPD CALCULATIONS
EXAMPLE #2

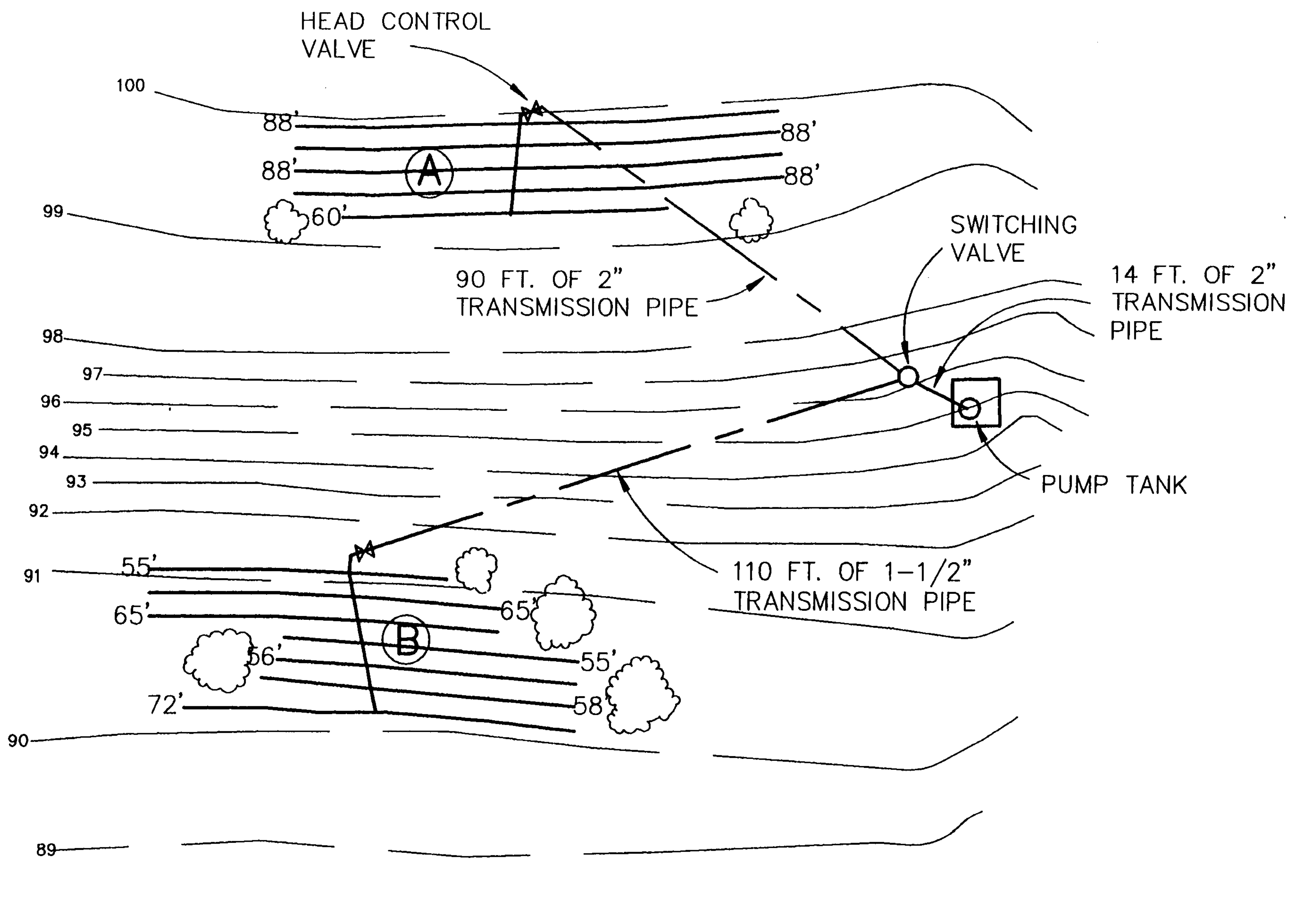
TRENCH #	TRENCH LENGTH ft	DESIGN FLOW RATE	START HEAD	CHANGE IN ELAVATION	FRICTION LOSS	SUMMATION OF HEAD	FLOW RATE 5/32	# OF HOLES	ACTUAL FLOW	BYPASS FLOW	HOLE SPACING	HEADER SIZE in
		FIELD "A"				Q = 34.0GPM		HOLE SIZE = 5/32"				
1	95	9.79	2	0	0	2	0.41	24	9.84	24.16	47.5"	1.5"
2	85	8.76	2	0.2	0.22	1.98	0.41	21	8.61	15.55	48.5"	1.25"
3	75	7.73	1.98	0.2	0.18	2	0.41	19	7.79	7.76	47.5"	1"
4	75	7.73	2	0.2	0.21	1.99	0.41	19	7.79	CLOSE	47.5"	
		FIELD "B"				Q = 33.5 GPM		HOLE SIZE = 5/32"				
1	55	5.58	2	0	0	2	0.41	14	5.74	27.76	47"	1.5"
2	95	9.64	2	0.2	0.28	1.92	0.405	24	9.72	18.04	47.5"	1.5"
3	90	9.14	1.92	0.2	0.13	1.99	0.41	22	9.02	9.02	49"	1"
4	90	9.14	1.99	0.2	0.29	1.9	0.4	22	8.8	CLOSE	49"	
		TRENCH SPACING IS 5 FEET, CENTER TO CENTER										



EXAMPLE #3 NO SCALE

LPD CALCULATIONS
EXAMPLE #3

TRENCH #	TRENCH LENGTH ft	DESIGN FLOWRATE	START HEAD	CHANGE IN ELAVATION	FRICTION LOSS	SUMMATION OF HEAD	FLOW RATE 5/32	# OF HOLES	ACTUAL FLOW	BYPASS FLOW	HOLE SPACING	HEADER SIZE in
			ONE FIELD			Q = 63.2 GPM		HOLE SIZE = 5/32"				
1	95	9.1	2	0	0	2	0.41	22	9.02	54.18	52"	2"
2	85	8.14	2	0.2	0.29	1.89	0.4	20	8	46.18	51"	2"
3	75	7.18	1.89	0.2	0.22	1.87	0.395	18	7.11	39.07	50"	2"
4	75	7.18	1.87	0.2	0.16	1.91	0.4	18	7.2	31.87	50"	2"
5	55	5.27	1.91	0.25	0.11	2.05	0.415	13	5.39	26.48	51"	1.5"
6	95	9.1	2.05	0.2	0.26	1.99	0.41	22	9.02	17.46	52"	1.25"
7	90	8.62	1.99	0.2	0.25	1.94	0.405	22	8.91	8.55	49"	1.25"
8	90	8.62	1.94	0.2	0.07	2.07	0.415	21	8.72	O.K.	51.5"	
	THESE TRENCHES SPACED AT 5 FT., CENTER TO CENTER											



EXAMPLE #4 NO SCALE

LPD CALCULATIONS
EXAMPLE #4

TRENCH #	TRENCH LENGTH ft	DESIGN FLOW RATE	START HEAD	CHANGE IN ELAVATION	FRICTION LOSS	SUMMATION OF HEAD	FLOW RATE 5/32	# OF HOLES	ACTUAL FLOW	BYPASS FLOW	HOLE SPACING	HEADER SIZE in
		FIELD "A"			Q = 43.0 GPM			HOLE SIZE = 5/32"				
1	88	9.18	2	0	0	2	0.41	23	9.43	33.57	46"	2"
2	88	9.18	2	0.15	0.1	2.05	0.415	22	9.13	24.44	48"	1.5"
3	88	9.18	2.05	0.15	0.18	2.02	0.41	22	9.02	15.42	48"	1.5"
4	88	9.18	2.02	0.15	0.08	2.09	0.42	22	9.24	6.18	48"	1"
5	60	6.26	2.09	0.15	0.11	2.13	0.42	15	6.3	O.K.	48"	
		FIELD "B"			Q = 40.8 GPM			HOLE SPACING = 5/32"				
1	55	5.27	2	0	0	2	0.41	13	5.33	35.47	51"	2"
2	65	6.23	2	0.2	0.11	2.09	0.42	15	6.3	29.17	52"	1.5"
3	65	6.23	2.09	0.2	0.25	2.04	0.415	15	6.23	22.94	52"	1.5"
4	55	5.27	2.04	0.2	0.14	2.1	0.42	13	5.46	17.48	51"	1.25"
5	56	5.36	2.1	0.2	0.21	2.09	0.42	13	5.46	12.02	52"	1"
6	58	5.55	2.09	0.2	0.4	1.89	0.4	13	5.2	6.82	54"	1"
7	72	6.9	1.89	0.2	0.14	1.95	0.405	17	6.88	CLOSE	51"	

TRENCH SPACING IS 4 FEET, CENTER TO CENTER