

CHAPTER 6 - IRRIGATION SYSTEM DESIGN

D - TRICKLE IRRIGATION SYSTEM

GENERAL

The example problem in this chapter is intended to illustrate the procedure to follow in the design of trickle irrigation systems. It should be understood that one example cannot illustrate all design situations, site conditions, or alternatives to consider when designing a trickle irrigation system. This example illustrates a design method for supplying water to the total root zone. A common practice is to establish and manage a moisture control zone which is usually 50% of the rooting depth.

DESIGN CRITERIA

Design criteria for trickle irrigation systems are contained in the Alabama NRCS Conservation Practice Standard (CPS), Irrigation System, Sprinkler, Code 442, Field Office Technical Guide. All trickle systems must be designed in accordance with applicable requirements contained in CPS 442.

EXAMPLE PROBLEM

The following example problem is intended to cover the basic steps to follow in the design of a trickle irrigation system for orchard crops. A standard form (Exhibit AL6-D-1) is used and is a useful tool in designing and in recording data. Use of a computer program to design pipelines for this example problem is presented in Exhibit AL6-D-2.

Given:

1. Location: Baldwin County (Climatic Zone 8).
2. Field Shape: 1,250 ft north to south and 1,250 ft east to west (35.9 acres).
3. Soil: Determined in field.
4. Crop: Peaches.
5. Row direction and spacing: North and south, 25 feet between rows.
6. Plant spacing in row: 15 feet.
7. Water supply: Existing well, measure capacity is 1,200 gpm.
8. Owner would like to operate the entire system at one time.

Solution:

The item numbers mentioned in the step-by-step solution refer to the items on the standard form "Irrigation Data Sheet - Trickle Irrigation System for Orchard Crops" in Exhibit AL6-D-1.

Step 1. Complete Items 1-4. These items provide pertinent data of the site.

Step 2. Complete Item 5. Make a drawing of the field locating trees, the well, and other features on Sheet 2 of this form, or on a standard drawing.

Step 3. Complete Item 6, Crop Information. The moisture extraction depth or rooting depth (RZD) in the soil is 42 inches. The peak consumptive use rate (Upd) is taken from Chapter 4, for the Climatic Zone. (NOTE: This example is for illustration only and the values used may not be as shown in the tables.) The peak daily transpiration rate, Tpd, can then be calculated based on percent area shaded, Ps.

$$Ps = \frac{\text{canopy area}}{Sp \times Sr} = \frac{255 \text{ sq ft}}{15 \text{ ft} \times 25 \text{ ft}} = 0.68$$

$$Tpd = Upd [Ps + 0.15(1.0 - Ps)] = 0.20$$

$$[0.68 + 0.15(1.0 - 0.68)]$$

$$Tpd = 0.15 \text{ in/day}$$

Step 4. Complete Item 7, Soil Information. The basic intake rate and water holding capacity (WHC) can be taken from Chapter 2. The adjustment to wetted area (Se') accounts for lateral movement of water. Se' is approximately 1.5 for a homogeneous, coarse textured soil with root depth of 3.5 feet.

Step 5. Complete Item I, Emitter.

a. The system will be designed for one emitter per tree. Based on a well capacity of 1,200 gpm and 4,000 trees, the maximum discharge rate, qa, per emitter is:

$$qa = \frac{1200 \text{ gpm} \times 60 \frac{\text{min}}{\text{hour}}}{4,000 \text{ trees}} = 18.0 \text{ gph}$$

b. Determine the design area of the crop for "e" emitters. The design area may be less than 100% of the field area but not less than the mature crop root zone area. The mature crop root zone area for the peaches in this example was determined to be the tree spacing,

$$Sp \times Sr = 15' \times 25' = 375 \text{ sq ft}$$

c. The greater the percent of root zone area wetted the better, because of a greater storage reservoir for soil moisture. The minimum area to be wetted is 33 % of the root zone area. In this example, the minimum wetted area recommended would be:

$$0.33 \times 375 \text{ sq ft} = 125 \text{ sq ft}$$

A spray type emitter with a discharge rate, qa = 16.0 gph was selected. The larger emitter was chosen because the best available research indicates an increase in production when the percent of root zone area wetted is increased.

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The emitter selected will provide a flow rate of 16.0 gph at a design pressure head (ha) of 20 psi, with an orifice size of 0.05 inches.

The rated wetted diameter (Wd) of the emitter may be obtained from field observations or from the emitter manufacturer's literature. The selected emitter has Wd = 18.0 feet. The surface area wetted:

$$As = \frac{\pi (Wd)^2}{4} = \frac{3.14 (18 \text{ ft})^2}{4} = 254.5 \text{ sq ft}$$

The perimeter of the area wetted:

$$PS = (\pi)Wd = 3.14(18.0 \text{ ft}) = 56.6 \text{ ft}$$

Step 6. Complete Item 9, Design Procedure.

a. The WHC is the rooting depth (RZD) equals the weighted WHC from Item 7 multiplied by RZD.

$$0.035 \text{ in/in} \times 42 \text{ in} = 1.47 \text{ in}$$

b. Compute management allowed deficiency (Mad) as a percent of WHC.

$$30\% \times 1.47 \text{ in} = 0.44 \text{ in January thru July,}$$

$$50\% \times 1.47 \text{ in.} = 0.74 \text{ in August thru December}$$

c. Determine percent of area wetted (Pw) in the upper too zone (RZD).

$$Pw = \frac{e [As + 0.5 Se'] (PS)}{SpSR} 100$$

$$Pw = \frac{1 [254.5 + (0.5)(1.5)(56.6)] (100)}{(15)(25)} = 79.2\%$$

d. Enter the water application efficiency (E). It is estimated to be 0.80 in this example.

e. Determine the gross volume of water required to replace peak daily transpiration rate, F(gp/d), in gallons/tree/day.

$$F(gp/d) = \frac{0.623 Sp Sr Tpd}{E} = \frac{0.623 (15)(25)(0.15)}{.80}$$

$$= 43.8 \text{ gal/tree/day}$$

f. Determine the hours of operation per day (Ta) to apply F(gp/d).

$$Ta = \frac{F(gp/d)}{e qa} = \frac{43.8}{(1)(16.0)} = 2.75 \text{ hrs}$$

g. Determine the system capacity (Qs) in gpm, for total number of emitters per unit (n). From Item 8, n = 4,000 emitters per unit or the total number of emitters for the system since this system will operate at one time.

$$Qs = \frac{n qa}{60} = \frac{(4000)(16.0)}{60} = 1067 \text{ gpm}$$

Step 7. Complete Item 10, Determining Total Dynamic Read.

a. The procedure for determining total dynamic head is similar to that described for sprinkler irrigation in Chapter 6-A. Friction loss tables are included in Appendix. Elevation difference within the irrigation unit is significant in this example. It was evaluated for its affect on the emitter pressure variation and corresponding flow rate variations. Sheets 5, 6, and 7 of Exhibit AL6-D-AL1, Pipe Sizing Data Sheet, were used to compute friction and elevation differences for sections uphill and downhill of the pump.

b. When an emitter is selected, the manufacturer's discharge rates for the emitter should be obtained. Lateral lines and submains should be designed so that all emitters operating simultaneously in an irrigation unit will have a discharge rate that does not exceed a variation of $\pm 15\%$ of the design discharge rate (See Field Office Technical Guide, Alabama NRCS Conservation Practice Standard, Irrigation System, Microirrigation, Code 441). For this example, 10% variation was used.

The flow rate variations and corresponding pressure variations from the manufacturer's discharge rates for the emitter selected are:

$$16.0 \text{ gph} + 10\% = 17.6 \text{ gph @ 24.0 psi}$$

$$16.0 \text{ gph} - 10\% = 14.4 \text{ gph @ 16.0 psi}$$

It is impossible to manufacture any two emitters exactly alike. The small differences between them cause significant discharge variations. To insure that the discharge rate of all emitters in the operating irrigation unit will not exceed a variation of $\pm 10\%$ of the design discharge rate, the manufacturer's allowable pressure variation has been reduced 25% for design purposes. The allowable pressure variation used in this example will be:

$$(24.0 \text{ psi} - 16.0 \text{ psi}) - .25 (24.0 \text{ psi} - 16.0 \text{ psi})$$

$$= 8.0 \text{ psi} - 2.0 \text{ psi}$$

$$= 6.0 \text{ psi}$$

or a range of 17.0 psi to 23.0 psi

This allowable variation can be entered in the appropriate part of Item 10.

c. The design emitter pressure was determined in Step 5. An explanation of the use of factors in footnote 5 of Item 10 to calculate required pressures is as follows:

For pipelines of ne size running on the level with uniform outlets, the most representative pressure (average pressure head) is at a point about 40% of the distance from the inlet to the terminal end. At this point, the friction loss is about 75% of the total

loss in the lateral line. This is illustrated graphically in Figure AL6-D-1. As the number of pipe sizes increases the friction loss becomes more uniform and the average pressure approaches a point where the friction loss is about 50% of the total loss in the pipeline. A numerical calculation to locate the point of average pressure is shown in Exhibit AL6-D-2, Computer Design of Pipelines.

The inlet pressure head (h) that will give (h_a) for a pipeline of one size, laid on a uniform slope with uniform outlets, can be computed by the following equation: $h = h_a + 0.75 h_f + 0.5$ (Change in elev.)

Change in elevation is + for pipelines running uphill from the inlet and - for laterals running downhill.

d. The filter selected should be based on water quality and manufacturers recommendations. In the absence of the manufacturers' recommendations, the net opening diameter of the filter should not be larger than one-fourth the diameter for the emitter opening. The mesh or sieve sizes for screen filters can be taken from Appendix, Table AL6-A27. The filter should be designed for a head loss of 3 psi or less. The #50 mesh size was selected for this system.

e. Pump Requirements. This is the maximum gpm the pump must produce at a given TDH. In this example, the pump requirements are 1067 gpm at 66.9 ft of head.

f. Check the design pressure variation to the allowable pressure variation that was selected. The pressure at the first emitter is 66.9 ft (pump discharge pressure) - 6.93 ft (filter loss) - 4.59 ft (mainline loss) - 2.31 ft (misc. loss) - 53.1 ft or 23.0 psi. This is equal to the maximum allowable of 23.0 psi. The pressure at the last emitter is 66.9 ft (pump discharge pressure) - 6.93 ft (filter loss) - 4.59 ft (mainline loss) - 2.31 ft (misc. loss) - 3.18 ft (submain loss) - 7.04 ft (lateral loss) = 42.8 ft or 18.5 psi. This is greater than the minimum allowable of 17.0 psi.

g. Complete the plans. Include as needed a chlorinator, check valves, backflow prevention devices, pressure relief valves (where the maximum pressure the pump can develop exceeds the rated pipe pressures), combination air and vacuum relief valves (continuous acting) at pump discharge summit and summits in the system, flow meters, pressure gages, gate valves, thrust blocks, and other devices normally needed. See Exhibit AL6-D-AL1, Sheet 2 of 5.

MATERIAL AND CONSTRUCTION REQUIREMENTS

Construction should be to the lines and grades determined by the design, and the equipment and materials shall be of type, size, and quantities specified in the plans.

Emitters should be installed as recommended by the manufacturer. Spray emitters may require risers to direct discharge above-ground cover and obtain the wetted area used in design. Maintenance is needed to control vegetation in the emitter spray pattern. The manufacturer provides the maximum allowable operating pressure for pipe (tubing) used as laterals in the system. Trenches excavated for pipe placement should have a straight alignment.

The filter system should be such that flushing, cleaning, or replacement can be performed as required without introducing contaminants or foreign particles upstream of the filter system, except for injectors equipped with separate filters. When chemicals are injected, backflow prevention devices are to be provided, as required by law.

When completed, the system should be tested for operating pressures, strength, leakage, and satisfactory operation. During the initial start up, the lateral lines should be flushed to remove any sediment or foreign materials before placement of end plugs..

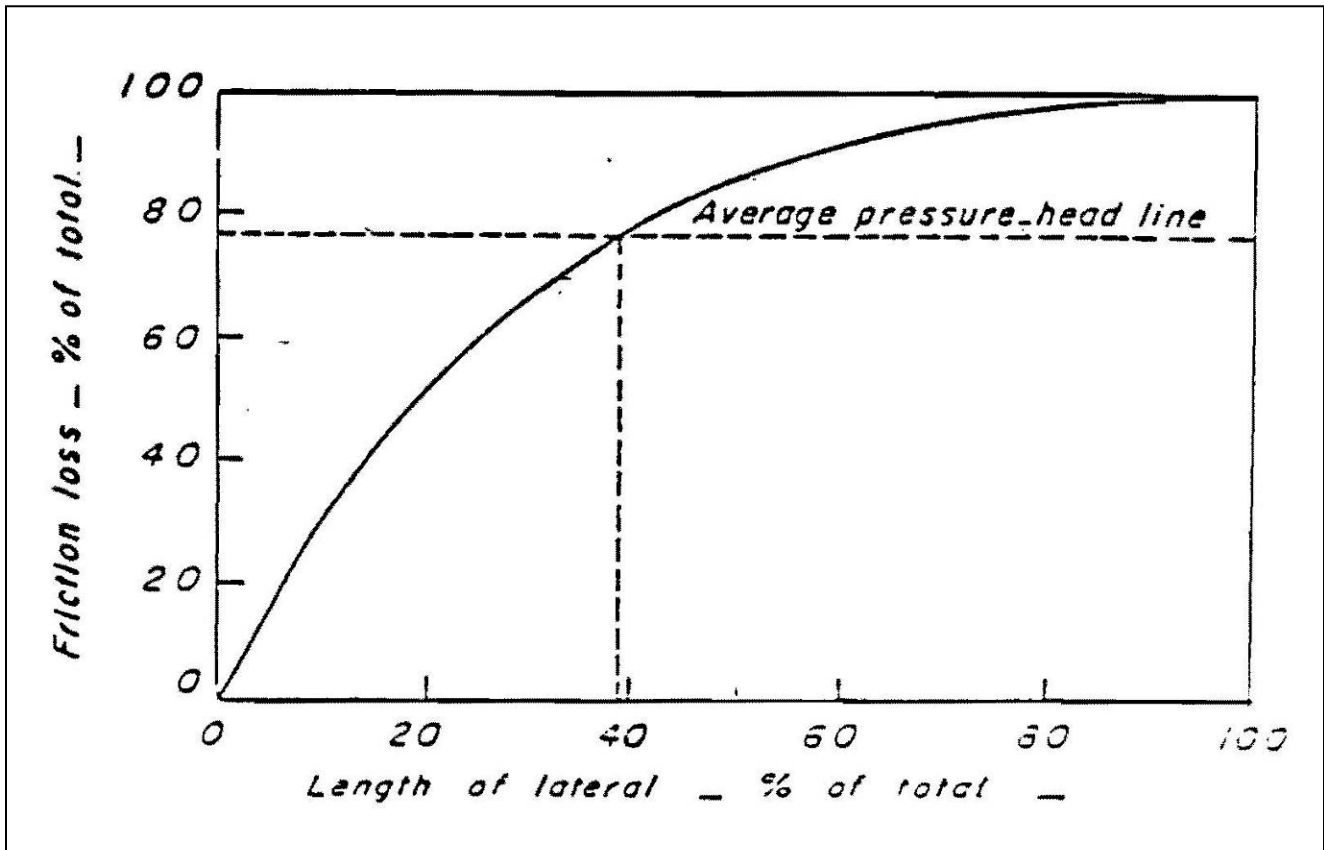


Figure AL6-D-1. Loss of Pressure due to Friction Along a Pipeline Having only One size of Pipe with Uniform Outlets.

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U.S. Department of Agriculture
Natural Resources Conservation Service

IRRIGATION DATA SHEET TRICKLE IRRIGATION SYSTEM FOR ORCHARD CROPS

Sheet 1 of 7

CONSERVATION DISTRICT Baldwin Co. FIELD OFFICE Foley
COOPERATOR Peach Tree Groves, Inc. LOCATION 1 mi. S. of Foley
IDENTIFICATION NO. - FIELD NO. 8

1. Design area 35.9 acres
Description of soils Sands with low WHC and Fast Intake. They are Deep Well-Drained soils with droughty problems

Soil Series: _____		Soil Series: _____		Soil Series: _____	
Soil Depth	Average WHC	Soil Depth	Average WHC	Soil Depth	Average WHC
(in.)	(in./in.)	(in.)	(in./in.)	(in.)	(in./in.)
<u>0-12</u>	<u>0.035</u>	_____	_____	_____	_____
<u>12-24</u>	<u>0.035</u>	_____	_____	_____	_____
<u>24-36</u>	<u>0.035</u>	_____	_____	_____	_____
<u>36-48</u>	<u>0.035</u>	_____	_____	_____	_____

Design Soil Series: _____

2. Crops:

Irrig. Unit	Crop	Acres	No. of Trees
<u>A</u>	<u>Peaches</u>	<u>35.9</u>	<u>4,000</u>
Total:		<u>35.9</u>	<u>4,000</u>

3. Water Supply:

Source of Supply: (stream, well, reservoir, canal, etc.) Well

Reservoir: Storage _____ ac-ft Available for Irrigation _____ ac-ft

Well: Static Water Level 6.98 ft

Measured Capacity 1200 gpm @ 2 ft drawdown

Design Pumping Lift 700 ft

Stream: Measured flow (season of peak use) _____ gpm

Quality of Water (Evidence of suitability: Area of known water quality or water analysis attached) Satisfactory - Irrigation with water source the past 20 years is evidence of its suitability

Distance supply source to field 0 ft

4. Other Data:

Type of power unit and pump to be used: Diesel motor with turbine pump.

Exhibit AL6-D-1. Irrigation Data Sheet - Trickle Irrigation System for Orchard Crops - Example Problem.

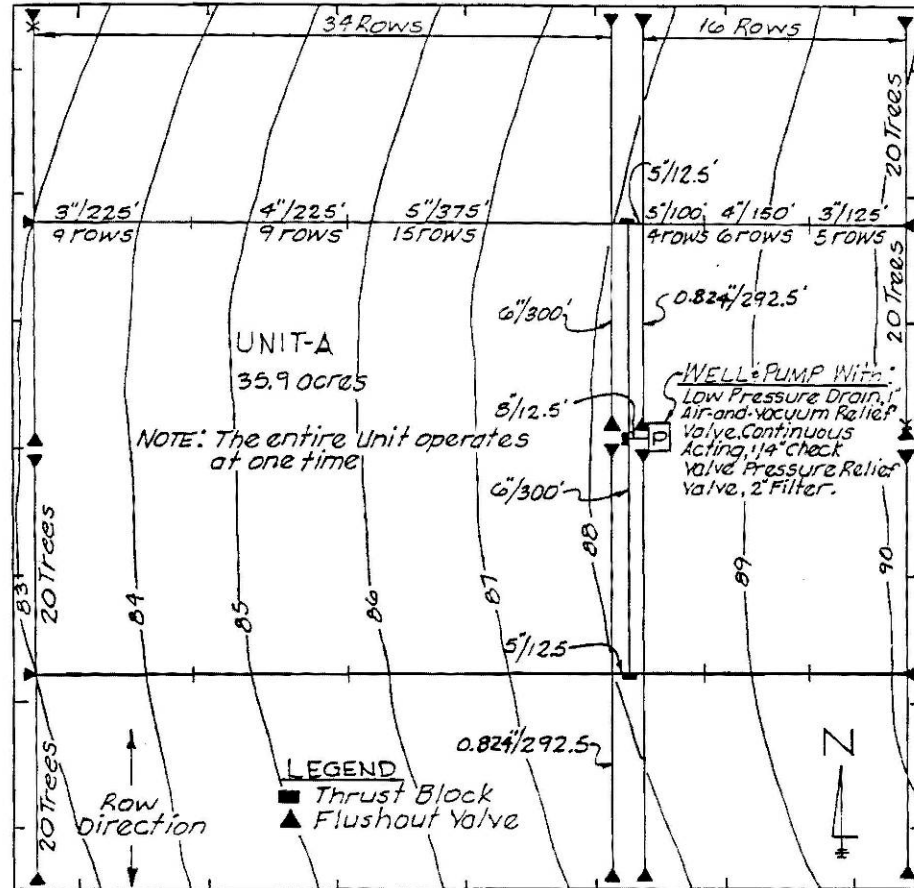
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TRICKLE IRRIGATION SYSTEM

Sheet 2 of 7

Cooperator: Peach Tree Groves, Inc. Designed by: J.A. Jones Checked by: J. Smith

5. Map of design area - Scale 1" = Not to Scale
Sketch map on grid or attach photo or overlay.



- Sketch map should show:
- Source of water
 - Elevation differences
 - Row direction
 - Trickle system layout
 - Plan of operations
 - Field obstructions (canals, trees, buildings, etc.)
 - North arrow

Pipe Material-Mains and Submains							
Nominal Pipe Size in.	PIP or IPS	SIR No.	Material (PVC 1120, etc.)	Pressure Rating, psi	Inside Diam., in.	Total Length ft	Minimum Depth Cover, in.
8	IPS	325	PVC 1120	125	8.095	12.5	30
6	"	"	"	"	6.217	600	30
5	"	"	"	"	5.221	1000	24
4	"	"	"	"	4.224	750	24
3	"	"	"	"	3.284	700	24

Laterals (tubing) shall withstand a working pressure of 50 psi based on manufacturer's data with an inside diameter of 0.824 in. Total Length 58,500 ft.

Exhibit AL6-D-1. (con't).

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TRICKLE IRRIGATION SYSTEM FOR ORCHARD CROPS

Sheet 3 of 7

Cooperator Peach Tree Groves Designed by: J.A. Jones Checked: J. Smith

		Irrigation Unit			
6.	Crop Information for Climatic Zone No. <u>4</u>	<u>A</u>			
	Sp x Sr - tree spacing (ft x ft)	<u>15x25</u>			
	Canopy area (ft ²) <u>Hedged 15x17 (8' Travel Lane)</u>	<u>255</u>			
	Ps - % area shaded (decimal) <u>1/</u>	<u>0.68</u>			
	RZD - rooting depth (in.)	<u>42</u>			
	Upd - peak daily consumptive use (in/day) <u>2/</u>	<u>0.20</u>			
	Tpd - peak daily transpiration rate (in/day) <u>1/</u>	<u>0.15</u>			
7.	Soil Information				
	Weighted WHC for RZD (in/in)	<u>0.035</u>			
	Basic intake rate (in/hr)	<u>3.0</u>			
	Se - adjustment to wetted area (ft) <u>3/</u>	<u>1.5</u>			
8.	Emitter				
	Type <u>360x12 holes</u>	<u>Spray</u>			
	Orifice size (in.) <u>(diameter)</u>	<u>0.05</u>			
	ha - design pressure head (psi)	<u>20.0</u>			
	qa - rated discharge @ ha (gph)	<u>16.0</u>			
	Wd - rated wetted diameter (ft)	<u>18.0</u>			
	Se x Sl - emitter spacing (ft x ft)	<u>15x25</u>			
	e - number of emitters per tree	<u>1</u>			
	n - number of emitters per unit	<u>4.000</u>			
	As - surface area wetted (ft ²)	<u>254.5</u>			
	PS - perimeter of area wetted (ft)	<u>56.6</u>			
9.	Design Procedure				
	WHC in RZD (in.)	<u>1.47</u>			
	30% Mad (in.)	<u>0.44</u>			
	50% Mad (in.)	<u>0.74</u>			
	Pw - % area wetted in upper RZD (%) <u>1/</u>	<u>79.2</u>			
	E - water application efficiency (decimal)	<u>0.80</u>			
	F(gp/d) - gross volume of water required (gal/tree/day) <u>1/</u>	<u>43.8</u>			
	Ta - time to apply F(gp/d) (hours) <u>1/</u>	<u>2.75</u>			
	Qs - system capacity (gpm) <u>1/</u>	<u>106.7</u>			

1/ Use the following formulas: $P_s = \frac{\text{canopy area}}{S_p \times S_r}$ $T_{pd} = U_{pd} [P_s + 0.15(1.0 - P_s)]$

$$P_w = \frac{e[As + (0.5 S_e)(PS)]}{S_p S_r} \quad F(gp/d) = \frac{0.623 S_p S_r T_{pd}}{E} \quad T_a = \frac{F(gp/d)}{e q_a} \quad Q_s = \frac{n q_a}{60}$$

2/ See Florida Irrigation Guide, Table 4-2.

3/ See NEH-15, Irrigation, Chapter 7, Page 7-20, Table 7-2.

Exhibit AL6-D-1. (con't).

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TRICKLE IRRIGATION SYSTEM

Sheet 4 of 7

Cooperator: Peach Tree Groves Designed by: J.A. Jones Checked by: J. Smith

10. Determining Total Dynamic Head ^{4/}

10. Determining Total Dynamic Head								Design Pressure		
Irrigation Unit	Pipe Section	Design Capacity (gpm)	Pipe Diameter (in)	Pipe Length (ft)	Friction Head Loss (ft/100 ft)	Multiple Outlet Factor F	Head Loss H _f (ft)	(ft)	(psi)	
^A NE 1/4	South Half Lateral	See Attached Pipe Sizing Data Sheet						7.04	XXX	XXX
	Lateral							XXX	XXX	
	Lateral							XXX	XXX	
Pressure required at inlet of lateral with emitter of design discharge rate: $h = h_a + [H_f (\text{Lateral}) \times 0.75]^{5/}$								51.5	22.3	
^A NE 1/4	Sub main	See Attached Pipe Sizing Data Sheet					XXX	3.18	XXX	XXX
	Sub main					XXX		XXX	XXX	
	Sub main					XXX		XXX	XXX	
Pressure required at first emitter of first lateral: $h_1 = h + [H_f (\text{Submain}) \times 0.50]^{5/}$								53.1	23.0	
^A N 1/2	Main	See Attached Pipe Sizing Data Sheet					XXX	4.59	XXX	XXX
	Main					XXX		XXX	XXX	
	Main					XXX		XXX	XXX	
Miscellaneous Losses (Pipe Bends, Valves, etc.)							2.31	XXX	XXX	
Pressure required at filter discharge: Misc. Loss + h_1 + H_f (Main)								=	60.0	26.0
Friction Loss in Filter System							6.93	XXX	XXX	
Pump Discharge Pressure: Filter Loss + Misc. Loss + h_1 + H_f (Main)								=	66.9	29.0
Pumping Lift							700.0	XXX	XXX	
Total Dynamic Head, TDH = Pump Discharge Pressure + Pumping Lift								=	766.9	

Pump Requirements: 1067 gpm @ Pump Discharge Pressure, 29.0 psi or 66.9 ft

Check allowable pressure variation that will provide a $\pm 10\%$ flow rate

Allowable = 17.0 psi to 23.0 psi (taken from manufacturer's curve) Reduced 25%

6/ Actual = 18.5 psi to 23.0 psi (designed)

Filter Requirements: Screen type with #50 mesh size

Remarks: Back flow prevention devices shall be provided when chemical/s are injected as required by state law.

^{4/} Use pipe sizing data sheets where elevation differences are present and/or additional data lines needed.

^{5/} Use: 0.75 for laterals and submains of one pipe size; 0.66 for two pipe sizes and 0.50 for three or more pipe sizes.

^{6/} Consider elevations and location. Adjust design to meet allowed variation.

Design approved by: J.P. Lane Date: 9-30-86

Exhibit AL6-D-1. (con't).

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U.S. Department of Agriculture
Natural Resources Conservation Service

Cooperator Peach Tree Groves, Inc.
Field Office Foley

PIPE SIZING DATA SHEET

Sheet 5 of 7

Designed by J. A. Jones

Checked by J. Smith

[illegible]

Exhibit AL6-D-1. (con't).

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Natural Resources Conservation Service

PIPE SIZING DATA SHEET

Sheet 6 of 7

Cooperator Peach Tree Groves, Inc.

Designed by J.A. Jones

Field Office Foley

Checked by J. Smith

Irrigation Unit		Pipe Sizing Calculations								Pipe Material	
No.	Sub-Main	Lateral	Q Design Capacity (gpm)	Pipe Diam. (in.)	L Length (ft)	Friction Head Loss J (ft/100')	Multiple Outlet Factor F	Total Head Loss Hf (ft)	Elevation Difference ΔE_1 (ft)	Total $\Delta H_1 = H_f + \Delta E_1$ (ft)	Remarks
			5.33	0.824	292.5	6.40	0.376	7.04	-0.50	6.54	PE Tubing, 50 psi rated, C=170
	✓		352.1	5.221	25	1.65	-	0.41	-0.15	0.26	V=5.28 fps
	✓		341.4	5.221	25	1.55	-	0.39	-0.15	0.24	V=5.12 fps
	✓		330.8	5.221	25	1.47	-	0.37	-0.15	0.22	V=4.96 fps
	✓		320.1	5.221	25	1.38	-	0.35	-0.15	0.20	
	✓		309.4	5.221	25	1.30	-	0.33	-0.15	0.18	
	✓		298.8	5.221	25	1.21	-	0.30	-0.15	0.15	
	✓		288.1	5.221	25	1.14	-	0.29	-0.15	0.14	
	✓		277.4	5.221	25	1.06	-	0.27	-0.15	0.12	
	✓		266.8	5.221	25	0.99	-	0.25	-0.15	0.10	
	✓		256.1	5.221	25	0.91	-	0.23	-0.15	0.08	
	✓		245.4	5.221	25	0.84	-	0.21	-0.15	0.06	
	✓		234.7	5.221	25	0.78	-	0.20	-0.15	0.05	
	✓		224.1	5.221	25	0.71	-	0.18	-0.15	0.03	
	✓		213.4	5.221	25	0.65	-	0.16	-0.15	0.01	
	✓		202.7	5.221	25	0.59	-	0.15	-0.15	0	
	✓		192.1	4.224	25	1.50	-	0.38	-0.15	0.23	V=4.4 fps
	✓		181.4	4.224	25	1.35	-	0.34	-0.15	0.19	
	✓		170.7	4.224	25	1.21	-	0.30	-0.15	0.15	
	✓		160.1	4.224	25	1.07	-	0.27	-0.15	0.12	
	✓		149.4	4.224	25	0.94	-	0.24	-0.15	0.09	

Exhibit AL6-D-1. (con't).

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Exhibit AL6-D-2. Computer Design of Pipelines

This exhibit presents a computer design for the pipelines in the example problem in Exhibit 6-D-1. A numerical calculation to locate the point of average pressure is computed for the lateral line and submain.

The approved, "Pipeline Evaluation Program," developed by David A. Sleeper was used. This program will check or design a pipeline.

The design procedure chooses pipe sizes based on maximum velocity and maximum friction loss desired for the entire pipeline.

Friction loss is calculated using Hazen-Williams equation.

One section of pipe is considered to be the entire length of pipe between two outlets.

EXAMPLE PROBLEM - AVERAGE LOSS FOR PIPELINE = -5.04 FT ^{1/}

PEACH TREE GROVES - BALDWIN CO - UNIT A - NE 1/4 - LATERAL									
SECT NO	LENGTH (ft)	OUTLET (GPM)	FLOW (GPM)	EL DIFF ^{2/} (ft)	PIPE ID (in)	C	FR LOSS (ft)	TOTAL LOSS ^{3/} (ft)	VEL (FPS)
1	7.5	0.27	5.40	0.000	0.824	140	- 0.48	- 0.48	3.2
2	15.0	0.27	5.13	0.000	0.824	140	- 0.88	- 1.36	3.1
3	15.0	0.27	4.86	0.000	0.824	140	- 0.80	- 2.16	2.9
4	15.0	0.27	4.59	0.000	0.824	140	- 0.72	- 2.88	2.8
5	15.0	0.27	4.32	0.000	0.824	140	- 0.64	- 3.52	2.6
6	15.0	0.27	4.05	0.000	0.824	140	- 0.57	- 4.08	2.4
7	15.0	0.27	3.78	0.000	0.824	140	- 0.50	- 4.58	2.3
8	15.0	0.27	3.51	0.000	0.824	140	- 0.44	- 5.02	2.1
9	15.0	0.27	3.24	0.000	0.824	140	- 0.38	- 5.40	1.9
10	15.0	0.27	2.97	0.000	0.824	140	- 0.32	- 5.72	1.8
11	15.0	0.27	2.70	0.000	0.824	140	- 0.27	- 5.98	1.6
12	15.0	0.27	2.43	0.000	0.824	140	- 0.22	- 6.20	1.5
13	15.0	0.27	2.16	0.000	0.824	140	- 0.18	- 6.38	1.3
14	15.0	0.27	1.89	0.000	0.824	140	- 0.14	- 6.52	1.1
15	15.0	0.27	1.62	0.000	0.824	140	- 0.10	- 6.62	1.0
16	15.0	0.27	1.35	0.000	0.824	140	- 0.07	- 6.70	0.8
17	15.0	0.27	1.08	0.000	0.824	140	- 0.05	- 6.75	0.6
18	15.0	0.27	0.81	0.000	0.824	140	- 0.03	- 6.78	0.5
19	15.0	0.27	0.54	0.000	0.824	140	- 0.01	- 6.79	0.3
20	15.0	0.27	0.27	0.000	0.824	140	- 0.00	- 6.79	0.2

^{1/} This locates the point of average pressure or design pressure, ha 46.2 ft, at the end of SECT NO. 8 (emitter No. 8 from the inlet end of the lateral). The pressure (h) at the inlet end of lateral will be:

$$h = -46.2 \text{ ft} - 5.0 \text{ ft} = -51.2 \text{ ft}$$

^{2/} + for downhill flow, - for uphill flow.

^{3/} This is a running total of pressure loss from inlet end.

NOTE: The + and - signs in computer design are reverse of the signs used in Exhibit AL6-D-1 Example Problem.

CHAPTER 6-D - TRICKLE IRRIGATION SYSTEM

Exhibit AL6-D-2. Computer Design of Pipelines (con't)

EXAMPLE PROBLEM - AVERAGE LOSS FOR PIPELINE = - 1.78 FT ^{1/}

PEACH TREE GROVES - BALDWIN CO - UNIT A - NE 1/4 - LATERAL									
SECT NO	LENGTH (ft)	OUTLET (GPM)	FLOW (GPM)	EL DIFF (ft)	PIPE ID (in)	C	FR LOSS (ft)	TOTAL LOSS (ft)	VEL (FPS)
1	25.0	10.67	160.05	0.133	5.221	150	- 0.10	- 0.23	2.4
2	25.0	10.67	149.30	0.133	5.221	150	- 0.08	- 0.45	2.2
3	25.0	10.67	138.71	0.133	5.221	150	- 0.07	- 0.65	2.1
4	25.0	10.67	128.04	0.133	5.221	150	- 0.06	- 0.85	1.9
5	25.0	10.67	117.37	0.133	4.224	150	- 0.15	- 1.14	2.7
6	25.0	10.67	106.70	0.133	4.224	150	- 0.13	- 1.40	2.4
7	25.0	10.67	96.03	0.133	4.224	150	- 0.10	- 1.63	2.2
8	25.0	10.67	85.36	0.133	4.224	150	- 0.08	- 1.85	2.0
9	25.0	10.67	74.69	0.133	4.224	150	- 0.07	- 2.05	1.7
10	25.0	10.67	64.02	0.133	4.224	150	- 0.05	- 2.23	1.5
11	25.0	10.67	53.35	0.133	3.284	150	- 0.12	- 2.48	2.0
12	25.0	10.67	42.68	0.133	3.284	150	- 0.08	- 2.70	1.6
13	25.0	10.67	32.01	0.133	3.284	150	- 0.05	- 2.88	1.2
14	25.0	10.67	21.34	0.133	3.284	150	- 0.02	- 3.03	0.8
15	25.0	10.67	10.67	0.133	3.284	150	- 0.01	- 3.17	0.4
^{1/} -1.78 ft is located approximately at the end of SECT No. 8 (lateral No. 8). The pressure h ₁ , at the first emitter of first lateral will be: $h_1 = -51.2 \text{ ft} - 1.80 = - 53.0 \text{ ft}$									

Chapter 6-D - TRICKLE IRRIGATION SYSTEM

Exhibit AL6-D-2. Computer Design of Pipelines (con't)

EXAMPLE PROBLEM - AVERAGE LOSS FOR PIPELINE = - 3.11 FT

PEACH TREE GROVES - BALDWIN CO - UNIT A - NE 1/2 - MAIN									
SECT NO	LENGTH (ft)	OUTLET (GPM)	FLOW (GPM)	EL DIFF ^{2/} (ft)	PIPE ID (in)	C	FR LOSS (ft)	TOTAL LOSS ^{3/} (ft)	VEL (FPS)
1	12.5	533.00	1067.00	0.100	8.095	150	- 0.19	- 0.09	6.7
2	300.0	267.00	534.00	0.200	6.217	150	- 4.61	- 0.50	5.6
3	12.5	267.00	267.00	- 0.100	5.221	150	- 0.12	- 4.72	4.0

Loss in main, H_f = - 4.72 ft

The pump discharge pressure can now be computed as follows:

$$\begin{aligned}
 \text{Pump Discharge Pressure} &= h_1 + H_f (\text{main}) + \text{misc. loss} + \text{filter loss} \\
 &= -53.0 \text{ ft} - 4.7 \text{ ft} - 2.3 \text{ ft} - 6.9 \text{ ft} \\
 &= -66.9 \text{ ft or } 29.0 \text{ psi}
 \end{aligned}$$

This result is comparable to the value we computed in Exhibit AL6-D-1.

Losses will be the same for south ½ of main.

CHAPTER 6-D - TRICKLE IRRIGATION SYSTEM

Exhibit AL6-D-2. Computer Design of Pipelines (con't)

EXAMPLE PROBLEM - AVERAGE LOSS FOR PIPELINE = -2.09 FT

PEACH TREE GROVES - BALDWIN CO - UNIT A - NE 1/4 - SUBMAIN									
SECT NO	LENGTH (ft)	OUTLET (GPM)	FLOW (GPM)	EL DIFF (ft)	PIPE ID (in)	C	FR LOSS (ft)	TOTAL LOSS (ft)	VEL (FPS)
1	25.0	10.67	352.11	0.150	5.221	150	- 0.41	- 0.26	5.3
2	25.0	10.67	341.44	0.150	5.221	150	- 0.39	- 0.51	5.1
3	25.0	10.67	330.77	0.150	5.221	150	- 0.37	- 0.73	5.0
4	25.0	10.67	320.10	0.150	5.221	150	- 0.35	- 0.92	4.8
5	25.0	10.67	309.43	0.150	5.221	150	- 0.33	- 1.10	4.6
6	25.0	10.67	298.76	0.150	5.221	150	- 0.31	- 1.26	4.5
7	25.0	10.67	288.09	0.150	5.221	150	- 0.29	- 1.39	4.3
8	25.0	10.67	277.42	0.150	5.221	150	- 0.27	- 1.51	4.2
9	25.0	10.67	266.75	0.150	5.221	150	- 0.25	- 1.61	4.0
10	25.0	10.67	256.08	0.150	5.221	150	- 0.23	- 1.69	3.8
11	25.0	10.67	245.41	0.150	5.221	150	- 0.21	- 1.75	3.7
12	25.0	10.67	234.74	0.150	5.221	150	- 0.20	- 1.79	3.5
13	25.0	10.67	224.07	0.150	5.221	150	- 0.18	- 1.82	3.4
14	25.0	10.67	213.40	0.150	5.221	150	- 0.16	- 1.84	3.2
15	25.0	10.67	202.73	0.150	5.221	150	- 0.15	- 1.84	3.0
16	25.0	10.67	192.06	0.150	4.224	150	- 0.38	- 2.06	4.4
17	25.0	10.67	181.39	0.150	4.224	150	- 0.34	- 2.25	4.2
18	25.0	10.67	170.72	0.150	4.224	150	- 0.30	- 2.41	3.9
19	25.0	10.67	160.05	0.150	4.224	150	- 0.27	- 2.53	3.7
20	25.0	10.67	149.38	0.150	4.224	150	- 0.24	- 2.61	3.4
21	25.0	10.67	138.71	0.150	4.224	150	-0.21	- 2.67	3.2
22	25.0	10.67	128.04	0.150	4.224	150	-0.18	- 2.70	2.9
23	25.0	10.67	117.37	0.150	4.224	150	-0.15	- 2.70	2.7
24	25.0	10.67	106.70	0.150	4.224	150	-0.13	- 2.68	2.4
25	25.0	10.67	96.03	0.150	3.284	150	-0.36	- 2.88	3.6
26	25.0	10.67	85.36	0.150	3.284	150	-0.29	- 3.02	3.2
27	25.0	10.67	74.69	0.150	3.284	150	-0.22	- 3.09	2.8
28	25.0	10.67	64.02	0.150	3.284	150	-0.17	- 3.11	2.4
29	25.0	10.67	53.35	0.150	3.284	150	-0.12	- 3.08	2.0
30	25.0	10.67	42.68	0.150	3.284	150	-0.08	- 3.01	1.6
31	25.0	10.67	32.01	0.150	3.284	150	-0.05	- 2.91	1.2
32	25.0	10.67	21.34	0.150	3.284	150	-0.02	- 2.78	0.8
33	25.0	10.67	10.67	0.150	3.284	150	-0.01	- 2.63	0.4
Loss in submain, H _f = -2.63 ft									

CHAPTER 6 - APPENDIX

Exhibit AL6-D-2. Computer Design of Pipelines (con't)

EXAMPLE PROBLEM - AVERAGE LOSS FOR PIPELINE = -4.77 FT

PEACH TREE GROVES - BALDWIN CO - UNIT A - NE 1/4 - SUBMAIN									
SECT NO	LENGTH (ft)	OUTLET (GPM)	FLOW (GPM)	EL DIFF (ft)	PIPE ID (in)	C	FR LOSS (ft)	TOTAL LOSS (ft)	VEL (FPS)
1	7.5	0.27	5.40	0.025	0.824	140	- 0.48	- 0.46	3.2
2	15.0	0.27	5.13	0.025	0.824	140	- 0.88	- 1.31	3.1
3	15.0	0.27	4.86	0.025	0.824	140	- 0.80	- 2.08	2.9
4	15.0	0.27	4.59	0.025	0.824	140	- 0.72	- 2.78	2.8
5	15.0	0.27	4.32	0.025	0.824	140	- 0.64	- 3.39	2.6
6	15.0	0.27	4.05	0.025	0.824	140	- 0.57	- 3.93	2.4
7	15.0	0.27	3.78	0.025	0.824	140	- 0.50	- 4.41	2.3
8	15.0	0.27	3.51	0.025	0.824	140	- 0.44	- 4.82	2.1
9	15.0	0.27	3.24	0.025	0.824	140	- 0.38	- 5.17	1.9
10	15.0	0.27	2.97	0.025	0.824	140	- 0.32	- 5.47	1.8
11	15.0	0.27	2.70	0.025	0.824	140	- 0.27	- 5.71	1.6
12	15.0	0.27	2.43	0.025	0.824	140	- 0.22	- 5.90	1.5
13	15.0	0.27	2.16	0.025	0.824	140	- 0.18	- 6.06	1.3
14	15.0	0.27	1.89	0.025	0.824	140	- 0.14	- 6.17	1.1
15	15.0	0.27	1.62	0.025	0.824	140	- 0.10	- 6.25	1.0
16	15.0	0.27	1.35	0.025	0.824	140	- 0.07	- 6.30	0.8
17	15.0	0.27	1.08	0.025	0.824	140	- 0.05	- 6.32	0.6
18	15.0	0.27	0.81	0.025	0.824	140	- 0.03	- 6.33	0.5
19	15.0	0.27	0.54	0.025	0.824	140	- 0.01	- 6.31	0.3
20	15.0	0.27	0.27	0.025	0.824	140	- 0.00	- 6.29	0.2

Checking the NW ¼:

Using the pump discharge pressure calculated for the NE ¼, we compute the pressure at the first emitter of the first lateral in the NW ¼ to be:

66.9 ft (pump discharge) - 6.9 ft (filter) – 2.3 ft (misc.) - 4.7 ft (main) 53.0 ft or 22.9 psi.

Pressure at the last emitter in the NW ¼ will be:

53.0 ft (first emitter) -2.6 ft (submain) -6.3 ft (lateral) = 44.1 ft or 19.1 psi. The pressure variation of 19.1 psi to 22.9 psi meets requirements. By observation, the SE ¼ and SW ¼ have identical pipe layouts and elevation differences as the NE ¼ and SW ¼, respectively.