

CHAPTER 6 - IRRIGATION SYSTEM DESIGN

B - TRAVELING GUN SPRINKLER IRRIGATION SYSTEM

GENERAL

The example problem in this chapter is intended to illustrate the procedure to follow in the design of traveling gun irrigation systems. It should be understood that one example cannot explain all design situations or alternatives to consider when designing traveling gun sprinkler irrigation systems. 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 root depth.

DEPTH CRITERIA

Design criteria for traveling gun sprinkler irrigation systems are contained in the Alabama NRCS Conservation Practice Standard (CPS), Irrigation System, Sprinkler, Code 442, Field Office Technical Guide. All traveling gun 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 design steps to follow in the design of traveling gun sprinkler irrigation systems. A standard form (Exhibit AL6-B-1) is used; which is a useful tool in designing and recording data.

Given:

1. Existing Nelson 200 gun, 240° trajectory, 1½ in. Ring Nozzle.
2. Crop and Acres: 40 acres soybeans.
28 acres tobacco.
3. Soil: (Evaluated in field).
4. Location: Tanner Hill, Alabama (Mobile Co.)
5. Slope: Maximum 2%.
6. Pump capability (existing): 400 gpm @370 ft TDH; 450 gpm @350 ft TDH; 500 gpm @ 320 ft TDH; RPM 2200.
7. Crop Rows: North and South.

Solution:

All item numbers mentioned in the step-by-step solution refer to the items in Exhibit AL6-B-1, form entitled "Irrigation Data Sheet - Traveling Gun."

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

Step 2. Complete Item 5. Make a drawing (to scale) of the field, locating trees, building, the well, and other features.

Step 3. Complete Item 6. Refer to chapters 3 and 4 to obtain the moisture extraction root depths and the peak consumptive use rates. (Note: This example is for illustration only and the values used may not be as shown in these chapters.)

Step 4. Complete Item 7. Obtain the soil series from a published soil survey report or an on-site investigation. For this example, the moisture holding capacity and intake rate are evaluated in the field.

Step 5. Complete the following parts of Item 8. (The figures used in the following steps will be specifically oriented to the tobacco.)

a. Available water capacity (AWC) within the root zone is the product of the root zone moisture extraction depth (18 in.) times the moisture holding capacity of the soil (.052 in/in) $AWC = (18 \text{ in}) \times (0.052 \text{ in/in}) = 0.94 \text{ in}$.

b. The percent depletion allowed prior to irrigation is selected to be 50 percent.

c. The net water applied per irrigation (in.) is the product of the percent depletion allowed prior to irrigation (50%) times the water available within the root zone. The net water applied per irrigation is = $(0.50) \times (0.94 \text{ in}) = 0.47 \text{ in}$.

d. The water application efficiency is selected to be 75% (average for day and night irrigation).

e. The gross water applied per irrigation (in) is the net water applied (.47 in) divided by the water application efficiency (75%). Gross water applied = $(0.47 \text{ in}) / (0.75) = 0.63 \text{ in}$.

f. The irrigation interval (days) is the net water applied (0.47 in) divided by the crop peak consumptive use rate (0.25 in/day). Irrigation interval = $(0.47 \text{ in}) / (0.25) = 1.9 \text{ days}$.

g. The irrigation period to be used in the formula for determining the quantity of water required (Q_R) is the irrigation interval 1.9 days.

h. The hours operating per day were discussed with the owner who advised that he irrigated continuously until completed. Therefore, the 22 hours were agreed upon providing another 2 hours for moving the equipment.

i. Now determine the quantity of water required (in gpm) for each crop using the formula as follows:

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$$Q = \frac{453 \times A \times d}{H \times F} \text{ (See AL6-2 for explanation of formula.)}$$

$$Q = \frac{453 \times 28 \text{ acres} \times 0.63 \text{ in. gross application}}{22 \text{ hr opr/day} \times 1.9 \text{ days/irrigation}}$$

$$Q = 191.2 \text{ gpm for tobacco}$$

Step 5 was completed for soybeans. The consumptive use for soybeans that overlaps the growth stage of tobacco is 0.06 in/day. The rooting depth during this early growth stage is 18 inches. Completing the computations, the irrigation interval for soybeans is 7.8 days compared to 1.9 days for tobacco. This means that the tobacco would be irrigated approximately 4 times to the soybeans being irrigated 1 time (7.8 days - 1.9 days = 4.1). If the irrigator wanted to irrigate the 40 acres of soybeans at one time, then on approximately every fourth irrigation he would need to irrigate 68 acres (28 acres tobacco + 40 acres soybeans) which would require a larger capacity system. An alternative would be to irrigate the 28 acres of tobacco and 10 acres of soybeans every 1.9 days. The water requirement for 10 acres of soybeans would be:

$$\begin{aligned} Q_R &= \frac{453 \times A \times D}{H \times F} \\ &= \frac{(453)(10)(0.63)}{(22)(1.9)} = 68.3 \text{ gpm} \end{aligned}$$

The Q_R for the system is 191.2 gpm + 68.3 gpm = 259.5 gpm

Now check the Q required for soybeans using a peak consumptive use rate of 0.30 in. per day which occurs in August, long after tobacco is harvested. The Q required is 329.4 gpm which is greater than the 259.5 gpm needed earlier in the year for the tobacco and soybeans. Therefore, the Q_R for the system is 329.4 gpm.

Step 6. Complete Item 9.

a. Keeping in mind the capability of the pump (See Sheet AL6-B-1) and the minimum Q required of 329.4 gpm, check the nozzle size, sprinkler gpm, and nozzle pressure using the Nelson Volume Gun performance tables. From past experiences, the TDH for this size system should compute to be about 320 to 340 feet. Therefore, the pump should be able to deliver about 460 gpm at 340 feet TDH. Using the Nelson Volume Gun Performance Tables with a nozzle size of 1 ½ in., a capacity of 460 gpm at 85 psi and a wetted diameter of 418 feet was selected.

b. Determine the lane spacing using approximately 60 - 65% of the wetted diameter of the sprinkler. The total length of the field is 2,660 feet. Realizing that the PVC pipe comes in 40 ft.

lengths, it is desirable to select a spacing that does not require field cutting of the pipe. The spacing of 260 ft between risers was tentatively selected, which is 62% of the wetted diameter. In order to properly irrigate the ends of the field, the riser needs to be approximately 75% of the wetted radius away from the field boundary (i.e., .75 x 209 ft) or 157 feet. Now determine the distance actually available by dividing the distance 2,660 ft by 260 ft = 10.23 spaces. Take 1.23 spaces x 260 ft/space = 320 ft and place half of this (160 ft) distance at each end of the field between the riser and field boundary. The 160 ft is adequate.

c. The application rate is computed using the following formula:

$$\begin{aligned} \text{Application rate (in/hr)} &= \frac{110 \times \text{sprinkler gpm}}{\text{Area of wetted circle, sq ft}} \\ &= \frac{110 \times 460 \text{ gpm}}{137,228 \text{ sq ft}} = 0.37 \text{ in/hr} \end{aligned}$$

Note: The value 110 is the conversion factor (96.3) plus a safety factor to account for uneven distribution from the traveling gun type system.

d. The travel speed is computed by the following formula:

$$\begin{aligned} \text{Travel Speed (ft/min)} &= \frac{1.605 \times \text{sprinkler gpm}}{\text{lane spacing (ft)} \times \text{gross water applied (in.)}} \\ &= \frac{1.605 \times 460}{260 \times 0.63} = 4.51 \text{ ft/min for tobacco} \end{aligned}$$

$$\begin{aligned} \text{e. Time per 660 ft run (hr)} &= \frac{660 \text{ ft}}{4.51 \text{ ft/min}} \times \frac{1 \text{ hr}}{60 \text{ min}} \\ &= 2.44 \text{ hours} \end{aligned}$$

Step 7. Complete Item 10.

Step 8. Make a scaled plan layout of the system. Pipe sizes, etc., will be added later.

Step 9. Size the mainline and determine the total dynamic head (TDH) required for the pump:

a. Complete Item 11 for sizing the pipe. Use a 6-inch diameter: PVC, SDR 26 & IPS pipe. A length of 1,690 ft was determined from the layout. The friction head loss is 1.23 ft/100 ft and is taken from Appendix b. The total head loss for the 6-inch PVC is 1.23 ft/100 ft x 1,690 ft = 20.8 ft.

b. Using 660 ft of 4½ in. flexible hose the irrigator has on hand, the friction loss taken from Figure AL6-B-1 is 1.7 psi/100 ft or 3.93 ft/100 ft. Total head loss for the hose is 660 ft x 3.93 ft/100 ft = 25.9 ft. Table AL6-B-1 is a guide for flexible hose selection.

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c. Enter the sprinkler pressure at the nozzle, miscellaneous losses and elevation differences between the well, and the nozzle when located on the high point in the field.

d. The sum of a, b, and c gives a pump discharge pressure required of 256.1 feet of head or 110.8 psi.

e. The TDH is the pumping lift plus the pump discharge pressure. $256.1 + 60 \text{ ft} = 316.1 \text{ ft} = 136.8 \text{ psi}$.

f. The pump requirement of 460 pgm at 316.1 feet of head is within the capability of the pump.

Step 10. Complete the plans. The specifications, location of the pipe, check valve, air vents, pressure relief valve, risers, thrust blocks, etc., should be shown on the plans. See Sheet 2 of 4 of Exhibit AL6-B-1.

LAYOUT CONSIDERATIONS

Items that must be considered are as follows:

a. Plant spacing and/or row direction so that travel lanes can be located properly.

b. Location of obstacles and safety hazards.

c. Whenever possible, place the risers a full hose length away from the edge of the field. This facilitates laying out the hose and reeling it back up.

d. Soil limitations such as surface texture may necessitate a part-circle volume gun so that the area is not irrigated in front of the gun as it moves, providing a dry footing.

e. Topography may dictate the lane direction to prevent misalignment of the traveler while in operation.

CONSTRUCTION REQUIREMENTS

The following is a list of construction items that should be checked to assure quality installation:

a. The depth of cover over the buried mainline must be adequate for protection from vehicular traffic and the farming operation.

b. Dimensions and location of the thrust blocks to prevent pipe joint separation.

c. Location and size of air vents and pressure relief valve.

d. Size and proper direction of installed check valve.

e. Riser material, size, number, and location.

f. Pipe requirement verifications such as SDR number pressure rating, ASTM designation, PVC material, pipe diameter, and if PIP or IPS size.

g. Verify pump, motor, well size. Check nozzle pressure.

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Table AL6-B-1. Guide for Flexible Irrigation Hose Selection	
FLOW RANGE (gpm)	HOSE DIAMETER (in.)
50 - 150	2.5
150 - 250	3.0
200 - 350	3.5
250 - 500	4.0
500 - 700	4.5
> 700	5.0

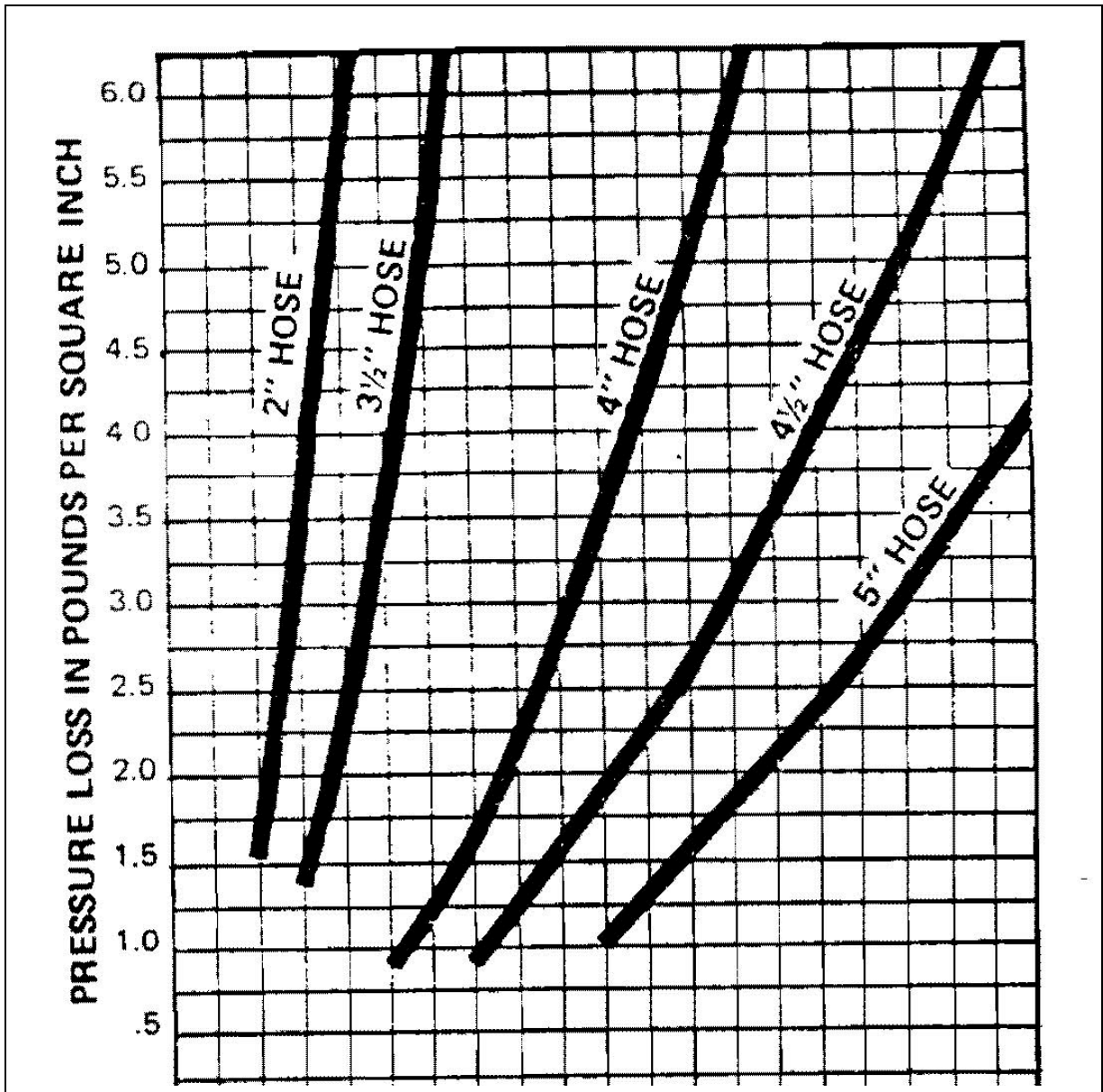


Figure AL6-B-1. Irrigation Hose Pressure Loss Per 100 feet.

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U.S. Department of Agriculture
 Natural Resources Conservation Service

IRRIGATION DATA SHEET
 TRAVELING GUN IRRIGATION SYSTEM

Sheet 1 of 4

CONSERVATION DISTRICT Mobile Co. FIELD OFFICE Mobile
 COOPERATOR C. Andrews LOCATION 1/2 mi. SE of Tanner Hill
 IDENTIFICATION NO. — FIELD NO. 1

1. Design area 68 acres
 Description of soils 0-99 in. 1s FS

Design Soil Series: _____

Soil Depth (in.)	Average AWC (in./in.)
<u>0-12</u>	<u>0.056</u>
<u>12-24</u>	<u>0.050</u>
<u>24-36</u>	<u>0.050</u>
<u>36-48</u>	<u>0.050</u>
<u>48-60</u>	<u>0.063</u>

2. Crops:

Crop	Acres	Planting Date	Maturity Date
<u>Tobacco</u>	<u>28</u>	<u>Mar 15</u>	<u>June 15</u>
<u>Soybeans</u>	<u>40</u>	<u>May 1</u>	<u>Aug 1</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
Total	<u>68</u>		

3. Water Supply:

Source of supply: (stream, well, reservoir, etc.) 10"
 Reservoir: Storage — ac-ft Available for Irrigation — ac-ft
 Well: Static Water Level 48 gpm ft.
 Measured Capacity 600 gpm @ 12 ft drawdown
 Design Pumping Lift 60 ft
 Stream: Measured flow (season of peak use) _____ gpm
 Quality of water (evidence of suitability): good

 Distance supply source to field _____ ft

4. Other Data:

Type of power unit and pump to be used: LP gas, Chrysler Industrial,
8 cylinder, pump: Berkley Model 804H

Exhibit AL6-B-1. Irrigation Data Sheet - Traveling Gun Irrigation System.

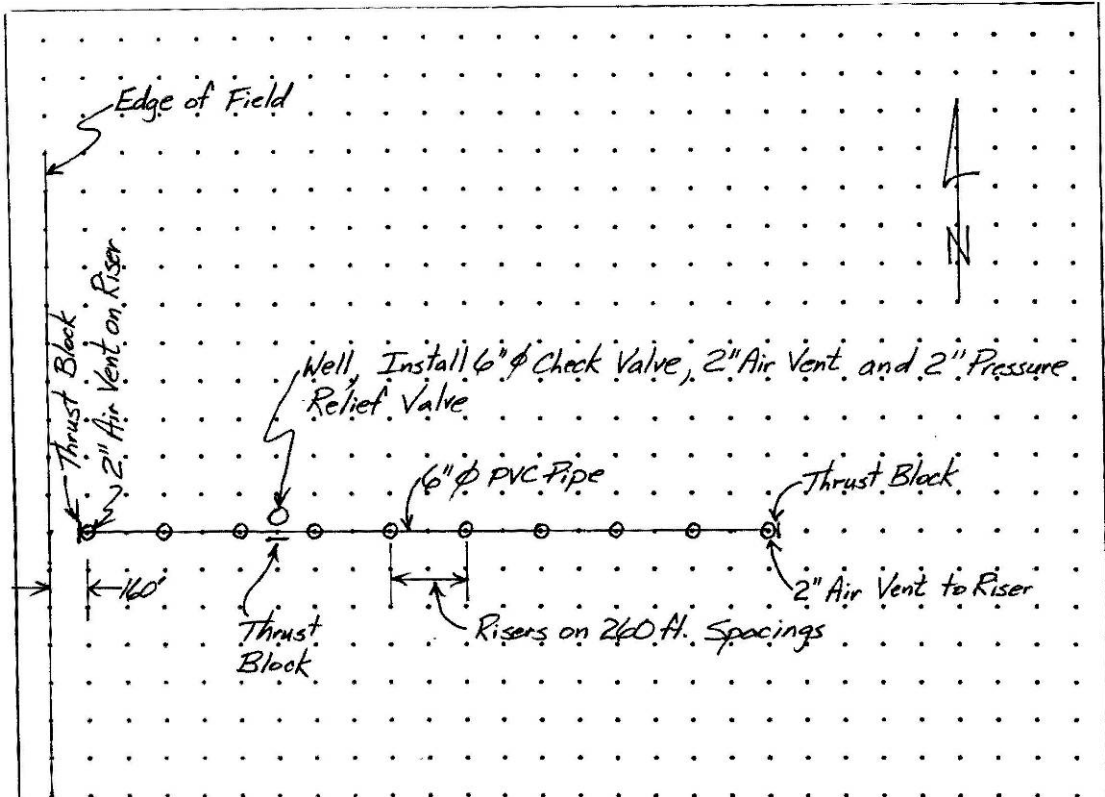
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TRAVELING GUN IRRIGATION SYSTEM

Sheet 2 of 4

Cooperator: C. Andrews Designed by: Ima Wright Checked by: I. R. Too

5. Map of design area - Scale 1" = 660 ft
Sketch map on grid or attach photo or overlay.



SPECIFICATIONS

- (1) Pipe - 6" PVC, 160 psi rated.
- (2) Pipe - Cover 30" minimum
- (3) Risers - 6" x 42" Epoxy coated steel.
- (4) 2" Air vents as shown on drawing and on all summits.
- (5) Thrust blocks: locate as shown above. 3ft² surface area.
- (6) 6" Downspout
- (7) System to be in accordance with Technical Guide Code 442.

Sketch map should show:

- | | |
|--------------------------------|---|
| a. Source of water | e. Plan of operation |
| b. Major elevation differences | f. Field obstructions (gullies, trees, buildings, etc.) |
| c. Row direction | g. North arrow |
| d. Sprinkler system layout | |

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

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TRAVELING GUN IRRIGATION SYSTEM

Sheet 3 of 4

Cooperator: C. Andrews Designed by: Ima Wright Checked by: I. R. Too

6. Crop Information	CROP NUMBER				
	1	2	3	4	5
Kind of Crop	Tobacco	Soybeans			Soybeans
Acreage to be grown (acres) ^{1/}	28	10			40
Rooting depth (in.)	18	18			30
Peak use rate (in./day)	0.25	0.06			0.31
7. Soil Information					
Weighted AWC for rooting depth (in./in.)	0.052	0.052			0.052
Basic intake rate (in./hr)	3	3			3
8. Design Procedure					
AWC within root zone (in.)	0.94	0.94			1.56
Depletion allowed prior to irrigation (%)	50	50			50
Net water applied per irrigation (in.)	0.47	0.47			0.78
Water application efficiency (%)	75	75			75
Gross water applied per irrigation (in.) ^{1/}	0.63	0.63			1.04
Irrigation interval (days)	1.9	7.8			2.5
Irrigation period (days per irrigation) ^{1/}	1.9	1.9			2.5
Hours operating per day ^{1/}	22	22			22
Q _R ^{1/} = Quantity of water required (gpm)	191.2	68.3	259.5 ^{3/}		329.4 ^{4/}
9. Irrigation Unit Design					
Q _A ^{2/} = Quantity of water actual (gpm)	460	460			460
Application rate (in./hr) ^{3/}	0.37	0.37			0.37
Travel Speed (ft/min) ^{4/} Lane Spacing, <u>260</u> ft	4.51	4.51			2.73
Lane Spacing, _____ ft					
Lane Spacing, <u>260</u> ft	2.44	2.44			4.03
Lane Spacing, _____ ft					
Time per 660' run (hrs) Lane Spacing, _____ ft					
10. Sprinkler Specifications:	^{5/} Req'd for Overlap of Peak use during May.				
a. Lane Spacing <u>260</u> ft	^{6/} Req'd for Peak use during August.				
b. Nozzle Size <u>1 1/2</u> in., Wetted Diam. <u>418</u> ft Capacity <u>460</u> gpm @ <u>85.0</u> psi	Make and model of sprinkler <u>Existing Nelson 200 gun, 24° Trajectory</u>				
c. No. of sprinklers operating simultaneously <u>1</u>					
d. Total design capacity all sprinklers <u>460</u> gpm					

$$1/ Q_R = \frac{453 \times \text{acres} \times \text{inches gross application}}{\text{hours opr. per day} \times \text{days per irrigation}} = \text{gpm}$$

$$2/ Q_A \text{ must be } \geq Q_R$$

$$3/ \text{Application rate (in./hr)} = \frac{110.0 \times \text{sprinkler gpm}}{\text{Area of wetted circle, sq ft}} \text{ MUST BE } \leq \text{BASIC INTAKE RATE}$$

$$4/ \text{Travel Speed} = \frac{1.605 \times \text{sprinkler gpm}}{\text{Lane Spacing, ft} \times \text{gross water applied, in.}}$$

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

CHAPTER 6 - APPENDIX

TRAVELING GUN IRRIGATION SYSTEM

Sheet 4 of 4

Cooperator: C. Andrews Designed by: Ima Wright Checked by: I. R. Too

11. Determining Total Dynamic Head:

Total main line length 2,340 ft

Kind of Pipe	Pipe Size (in.)	Design Capacity (gpm)	PIPE SIZING		HOSE SIZING		Total Head Loss	
			Length (ft)	Friction Head Loss (ft/100 ft)	Length (ft)	Friction Head Loss (ft/100 ft)	(ft)	(psi)
PVC	6	460	1690	1.23			20.8	9.0
Hose	4½	460			660	3.93	25.9	11.2
Sprinkler pressure at nozzle							196.4	85.0
Misc. & fitting losses							3.0	1.3
Elevation difference ^{5/}							10.0	4.3
Pump discharge pressure							256.1	110.8
Pumping lift							60.0	26.0
Total Dynamic Head, TDH							316.1	136.8

12. Pump Requirements:

Capacity 460 gpm @ 136.8 psi or 316.1 ft of head

13. Remarks Existing pump capability: 400 gpm @ 370 ft. TDH;
450 gpm @ 350 ft. TDH; 500 gpm @ 320 ft TDH;
RPM = 2,200

^{5/} Difference in elevation of the centerline of the pump discharge and the elevation of the highest sprinkler (plus or minus).

Design Approved By: I. R. Too Date: 12/92

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