United States Department of Agriculture

NRCS Natural Resources Conservation Service

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Technical Note ENG FL-25 - Watering Facility Design Procedure June 2007

General

This technical note is intended to illustrate the procedure used in the design of a watering facility for livestock or wildlife. It is understood that the example used in this technical note cannot show all design situations or all alternatives to consider when designing a watering facility. Designers should study other references to become knowledgeable of watering facilities.

Design Criteria

Design criteria for watering facilities are contained in the Florida NRCS conservation practice standards (CPS), Watering Facility, Code 614 and Pipeline, Code 516. All watering facilities must be designed in accordance with the applicable requirements contained in CPS 614 and 516.

Example Problem

The following example illustrates a typical watering facility situation. The watering facility design will be solved long hand using the worksheet FL-ENG-516 "Pipeline Design Data Sheet" and Watering Facility job sheet FL614JS. The example watering facility design will also be solved using the computer workbook "Florida Watering Facility.xls".

Given

1. Animals: 11 beef cows in one pasture.
2. Well: Existing 4 inch diameter with estimated capacity of 15 gpm; water level 300 feet below ground surface
3. Pump: New pump required.
4. Pressure tank: New pressure tank required.
5. Elevations: Watering facility – 95 feet NGVD, pump location – 90 feet NGVD. These elevations were obtained from a USGS Quad sheet.
6. Distance from well to watering facility is 1000 feet.
7. Landowner desires to use a 175 gallon trough if feasible.

Solution

Step 1. Determine the volume of water per day needed for the type of animal(s) that will use the watering facility. This information can be obtained from the landowner or use the minimum values in CPS 614 for the animal type. If the type of animal needed is not listed in CPS 614, the landowner or extension service may have the needed information. The beef cows in this example will be designed for 12 gal/day/hd as shown in Table 1 of CPS 614.

Step 2. Determine the total daily water requirement needed. This can be calculated by multiplying the number of animals by the daily requirement per animal. If more than one type of animal will use the facility, determine the daily requirement for each type of animal and sum requirement for all animal types. For this example: 11 cows x 12 gal/day/hd = 132 gal/day.

Step 3. Determine the minimum replenishment rate (or the minimum flow rate) in gallons per minute (gpm) for the facility. According to CPS 614, the daily requirement of water must be supplied to the trough in 6 hours or less. In this example:

$$Q = \frac{132 \text{ gallons}}{6 \text{ hours}} \times \frac{1 \text{ hour}}{60 \text{ min}}$$

$$Q = 0.37 \text{ gpm}$$

The maximum delivery time is 6 hours. A shorter time period could have been used.

Step 4. Select the design flow rate. This flow rate must equal or exceed the minimum flow rate calculated in Step 3 and the minimum flow rate of 3 gpm set forth in CPS 614. This flow rate also must not exceed the pump or well capacity. In this example 5 gpm was selected because the landowner knew that the well could supply at least 15 gpm.

Step 5. Select a pipeline size to the watering facility. Determine the friction head loss for the pipe. The friction head loss in the pipeline can be calculated from the PDF fillable version of worksheet FL-ENG-516 or determined using the tables in Chapter FL16 of the National Engineering Handbook, Part 652, Irrigation Guide. The velocity in the pipeline should not exceed 5 feet per second (ft/sec).

In this example, 1000 feet of 1-inch diameter SCH 40 PVC was selected. Using the PDF fillable version of worksheet FL-ENG-516, the velocity was calculated to be 1.9 ft/sec with a friction head loss of 1.53 ft/100 ft. Neglecting minor losses due to valves and fittings, total head loss due to friction is:

$$1.53 \text{ ft}/100 \text{ ft} \times 1000 \text{ ft} = 15.3 \text{ ft.}$$

Step 6. Determine the minimum pump discharge pressure. The minimum pump discharge pressure is the sum of the design outlet pressure, pipeline friction head loss, and elevation difference (+ for uphill and – for downhill). Worksheet FL-ENG-516 can be used for this calculation.

The minimum design outlet pressure at the watering facility should be at least 10 psi (or 23.1 ft.) to activate the float valve.

The elevation difference can be obtained from a USGS Quad sheet or from a field survey.

For this example, minimum pump discharge pressure =

23.1 ft. – outlet pressure (10 psi to operate float valve)
\+ 15.3 ft. – friction loss (from Step 5)
\+ 5.0 ft. – uphill elevation difference (from Quad sheet)
43.4 ft. = 18.8 psi (2.31 ft = 1 psi).

If the minimum pump discharge seems excessive or exceeds the existing pump, select a larger pipe size and re-evaluate Steps 5 and 6. Normally, the calculated minimum pump discharge should not exceed 50 psi. In this example there is not an existing pump and the minimum pump discharge calculated is acceptable.

Typically, a pressure tank is used to prevent the pump from operating each time a small amount of water is used at the watering facility. When a pressure tank is used, the pump discharge pressure must exceed the tank shut off pressure (i.e., for a tank with a 50 psi shut off pressure, the pump must exceed 50 psi.).

Step 7. Size the pressure tank. Since a pump generates heat when starting and cools while operating, it is recommended practice to allow the pump to operate for at least one minute before shutting off. Using that criteria, calculate the drawdown for the tank.

Drawdown (gal) = Flow rate (gpm) x pump run time (min)

With the drawdown known, the total volume of the tank can be calculated. As a rule of thumb, the total volume of the tank will be approximately three times the drawdown volume when operating in the 20-40 psi range. The total volume of the tank can be calculated by:

$$\frac{\text{Drawdown (gal)}}{\text{Drawdown Factor}}$$

Where Drawdown Factor = $\frac{\text{Precharge pressure + 14.7}}{\text{Tank start pressure + 14.7}} - \frac{\text{Precharge pressure + 14.7}}{\text{Tank off pressure + 14.7}}$

The tank start pressure and the tank off pressure is selected to allow the minimum pump discharge pressure calculated in Step 6 to be in the middle to low end of the range. The range between the start and off pressure is usually 20 psi for tanks with an off pressure of less than 80 psi. For a tank off pressure of 80 psi or greater, a range of 30 psi is typical. However, most tanks are not designed for pressures greater than 100 psi. Tank precharge pressure is typically 2 psi below tank start pressure.

In this example, drawdown needed = 5 gpm x 1 min run time = 5 gal.

Since the minimum discharge pressure needed is 18.8 psi, it was determined that the pressure tank would operate between 20 psi and 40 psi to ensure the minimum flow rate is met. That would give a tank precharge of 18 psi. So with these parameters, the drawdown factor is

$$\frac{18 \text{ psi} + 14.7 \text{ psi}}{20 \text{ psi} + 14.7 \text{ psi}} - \frac{18 \text{ psi} + 14.7 \text{ psi}}{40 \text{ psi} + 14.7 \text{ psi}} = 0.34$$

Total volume of tank = $\frac{5 \text{ gal}}{0.34}$ = 14.7 gal.

14.7 gallons is the minimum tank size for this example. Depending on the manufacturer, available tank sizes are 20 gallons, 30 gallons, 40 gallons, and up to 200 gallons. A 30 gallon tank was selected for this application to allow for more storage between pump cycles.

Step 8. Determine the minimum pump size required. In order to do this, the total dynamic head (TDH) is needed.

TDH (ft) = Pump discharge head (ft) + elevation difference between pump and well water elev.

Since this pump will be connected to a pressure tank, the maximum tank pressure of 40 psi (or 92.4 ft) will be used in calculating the TDH. In this example, TDH =

92.4 ft. (40 psi shut off pressure)
+ 300.0 ft. (elevation difference between pump and water level)
= 392.4 ft.

Assuming a pump efficiency of 80% and a motor efficiency of 90%, pump horsepower is then calculated by the equation:

$$\text{Pump Horsepower} = \frac{\text{GPM x TDH (ft)}}{\text{3960 x Pump eff. x Motor eff.}} = \frac{\text{5 gpm x 392.4 ft}}{\text{3960 x 0.80 x 0.90}} = 0.69 \text{ hp}$$

A 1 hp pump was selected.

It should be noted that this is an estimate of pump size. Each pump has a recommended operating range and operating a pump outside this range will cause it to be less efficient. Because of this, the pump supplier should make final selection of pump and pressure tank size.

Step 9. Select a watering facility size. CPS 614 states that the watering facility capacity shall equal or exceed 50% of the daily water requirements of the livestock using the facility. Also, Table 1 of CPS 614 lists minimum sizes of watering facilities depending on animal type.

Minimum capacity = 132 gal/day x 0.50 = 66 gallons

In this example, the landowner desires to use a 175 gallon trough, which exceeds the minimum.

Step 10. Complete job sheet FL614JS and prepare engineering plans. Construction specifications for the pump, pipeline, watering facility and appurtenances should be attached to the engineering plans.

Worksheet FL-ENG-516 (Figure 1) and job sheet FL614JS (Figures 2 and 3) are attached showing this example.

Alternative Solution

An alternative to the procedure above is to use the Excel workbook "Florida Watering Facility.xls". Figures 4 and 5 show screen shots of the example. The workbook is available from the Florida NRCS webpage http://www.fl.nrcs.usda.gov/technical/program.html. Instructions for the use of the workbook can be found on the "Instructions" worksheet in the workbook.

Figure 1. Example of form FL-ENG-516

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FL-ENG-516
10/04
Sheet 1 of 2

PIPELINE DESIGN DATA SHEET

Cooperator: E. Sadler Location: Sec. 29, T 1N, R 11E

Conservation District: Madison Field Office: Madison

Identification No.: 1 Field No(s).: P1

Design water requirement 5.0 gpm

Source of water supply: (stream, well, reservoir, etc.) Well

Well: Static Water Level 300 feet Design pumping lift 300.0 feet

Pump [ ] Measured capacity _____ gpm @ _____ feet

Pipeline number (see plan for location)	Kind of pipe, material, SDR, etc.	Design Capacity gpm	Nominal Pipe Diam. in.	Pipe inside diameter in. (decimal)	Pipeline Length feet	Coefficient of roughness C	Friction Head Loss ft/100ft	Velocity ft/sec	Friction Head Loss feet	Friction loss used for design [1/]
1	SCH 40 PVC	5.0	1.0	1.049	1000	150	1.53	1.9	15.34	15.3
Total pipeline friction head loss used for design, feet										15.3

[1/] Use the friction loss for the pipeline that has the most head loss.

Maximum elevation difference from pump discharge to outlet 5.0 feet (- downhill, + up hill)

Designed outlet discharge pressure = 23.1 feet [1/]

\+ 15.3 feet total pipe friction head loss

(-) (+) 5.0 feet elevation difference (- downhill, + up hill)

Required pump discharge pressure = 43.4 feet [2/]

[1/] Outlet discharge pressure should be equal to greater than 10 psi for watering facilities. (23.1 feet); 1 psi = 2.31 feet

[2/] The existing or new pump discharge must be ≥ to this value, if not try different pipe sizes or increase pump discharge pressure.

Pump design requirements: 5.0 gpm @ 43.4 feet or 19.0 psi @ pump discharge

Existing pump: adequate [ ] inadequate [ ] not applicable [X] New pump required Yes [X] No [ ]

Remarks: Since a pressure tank will be used, the required discharge pressure of the pump will be 92.4 feet or 40 psi

Figure 1 (Cont'd). Example of form FL-ENG-516

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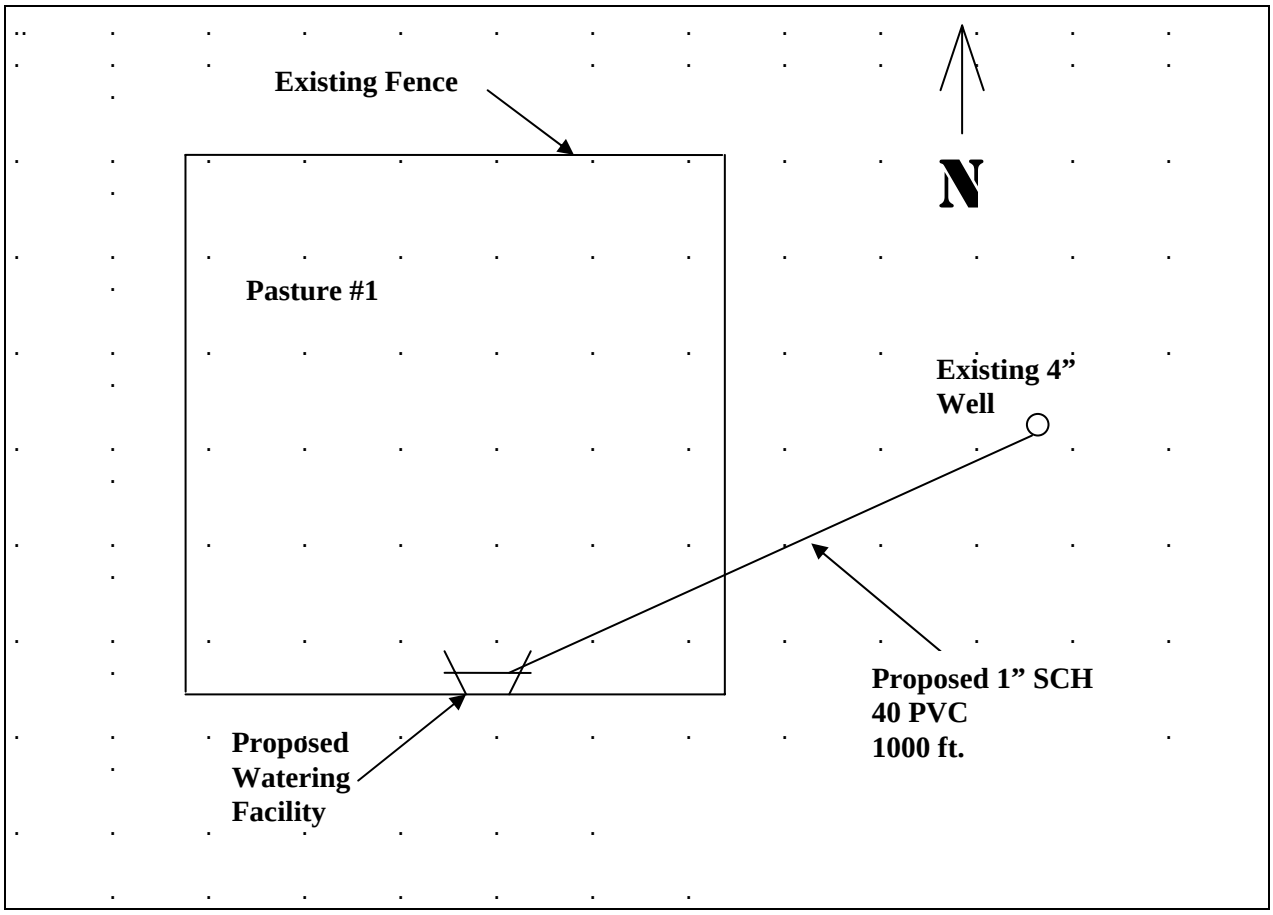
FL-ENG-516
10/04
Sheet 2 of 2

Plan of pipeline design. Scale 1" = NTS feet. Show on plan north arrow, source of water, pipeline diameter and pipeline location. In lieu of plan below, attach aerial photo with same information.



Pipeline number	Nominal pipeline diam. in.	PIP or IPS	SDR No.	Material (PVC 1120, etc.)	Pressure rating, psi	Total length, feet	Minimum depth of cover, inches
1	1"	IPS	SCH 40	PVC 1120	450	1000	18

Designed by: D. Conservationist Date: 5-3-06 Checked By: A. Engineer Date: 5-17-06

Approved by: A. Engineer Date: 5-17-06

This practice meets NRCS standards and specifications. _____ Date: _____
(Signature)

Figure 2. Example of job sheet FL614JS.

Watering Facility – Check Sheet FL614JS

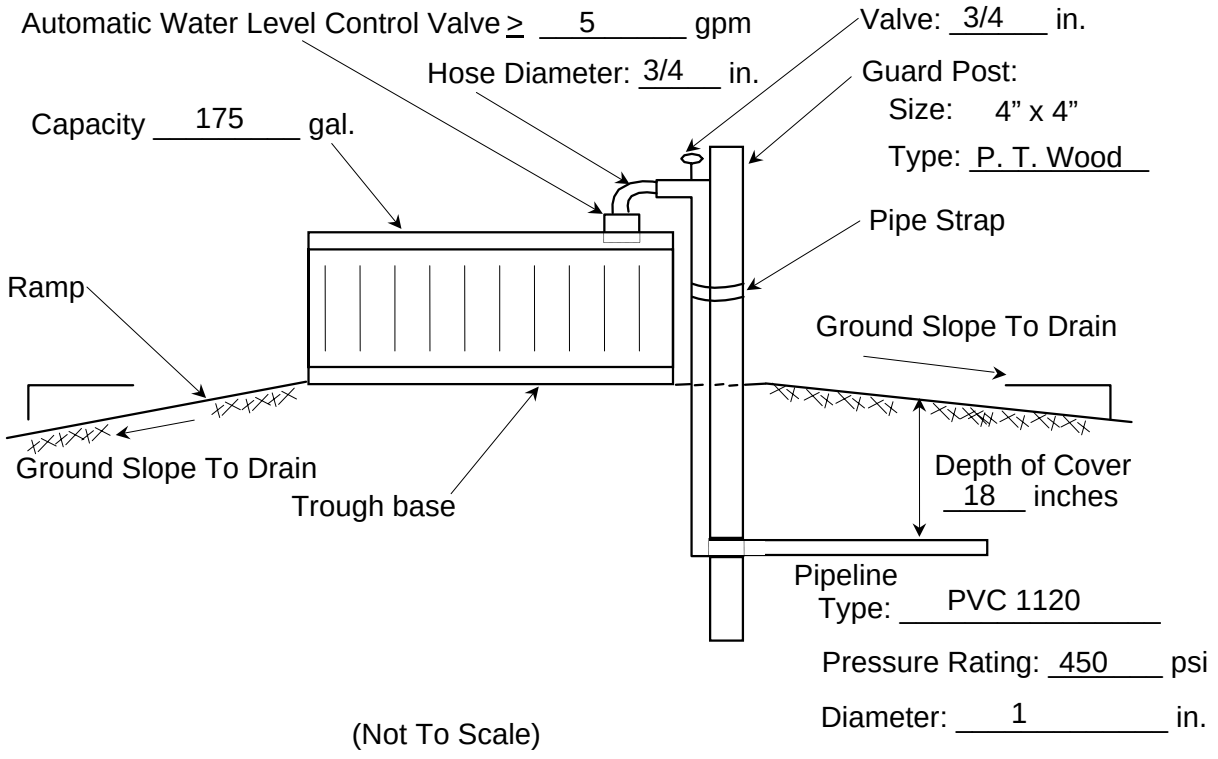
Sheet 1 of 2

WATERING FACILITY - CHECK SHEET

Cooperator: E. Sadler Location: Sec. 29, T 1N, R 11E

Conservation District: Madison Field Office: Madison

Identification No.: 1 Field No.: P1



Trough or tank material: 20 Gauge Minimum Galvanized Metal

Trough base material and thickness: Natural Ground

Ramp material and thickness: N/A

Designed by: D. Conservationist Date: 5-3-06 Checked By: A. Engineer Date: 5-17-06

Approved by: A. Engineer Date: 5-17-06

Construction Check

Tank #								
Size of trough, gal								

Material used for trough: _____

Type of ramp used and condition: _____

Comments: _____

Condition of valves, outlet pipe, float, etc.: _____

This practice meets NRCS standards and specifications. _____ Date: _____

(Signature)

Figure 3. Example of job sheet FL614JS

Watering Facility – Check Sheet FL614JS

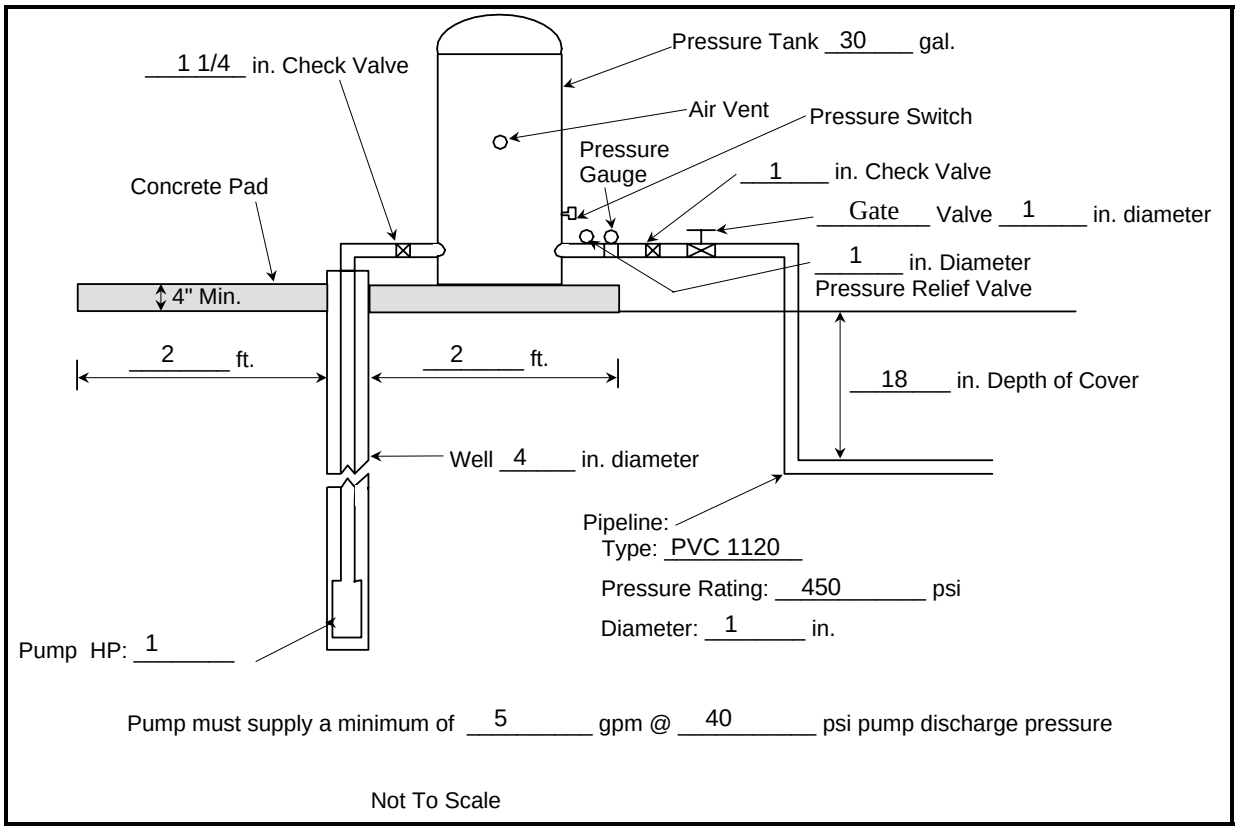
Sheet 2 of 2

WATERING FACILITY APPURTENANCES - CHECK SHEET

Cooperator: E. Sadler Location: Sec. 29, T 1N, R 11E

Conservation District: Madison Field Office: Madison

Identification No.: 1 Field No.: P1



Note: Cross out items in sketch not required. Attach additional drawings as needed.

Designed by: D. Conservationist Date: 5-3-06 Checked by: A. Engineer Date: 5-17-06

Approved by: A. Engineer Date: 5-17-06

Construction Check

	Well Capacity, gpm	Well Diameter, in.	Well Depth, feet	Pump Capacity, gpm
Planned				
Check				

Verify items on sketch by initialing by each item.

Length, quality and type of casing material: _____

_____

Well Driller's log attached: _____

Pump type, make, model, and stages: _____

Comments: _____

This practice meets NRCS standards and specifications. _____ Date: _____
(Signature)

Figure 4. Example of Florida Watering Facility Well Design worksheet.

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WATERING FACILITY DESIGN FOR WELL SYSTEMS

Cooperator	E. Sadler	Location	S29,T1N,R11E		Input cell
Conservation District	Madison	Field Office	Madison		Calculated cell, requires no input
Identification No.	1	Field No.	P1		
Operation Type	Beef Cattle				
Designed By	D. Conservationist	Date	5/3/2006		
Checked By	A. Engineer	Date	5/17/2006		

PLEASE READ INSTRUCTIONS ON "INSTRUCTIONS" WORKSHEET BEFORE BEGINNING

Total System Capacity			Animal Type #1	beef		Animal Type #4			Animal Type #7		
Total Daily Requirement of all animals (#1 - #9)	132	gallons	Daily Requirements	12.0	gpd/animal	Daily Requirements	0.0	gpd/animal	Daily Requirements	0.0	gpd/animal
Minimum Flow Rate	0.37	gpm	Number of Animals	11		Number of Animals	0		Number of Animals	0	
			Total Daily Requirement	132	gallons	Total Daily Requirement	0	gallons	Total Daily Requirement	0	gallons
Well Information			Animal Type #2			Animal Type #5			Animal Type #8		
Well Capacity	15.0	gpm	Daily Requirements	0.0	gpd/animal	Daily Requirements	0.0	gpd/animal	Daily Requirements	0.0	gpd/animal
Elevation at Well	90.00	ft	Number of Animals	0		Number of Animals	0		Number of Animals	0	
Pipe Length in Well	300.0	ft	Total Daily Requirement	0	gallons	Total Daily Requirement	0	gallons	Total Daily Requirement	0	gallons
Pipe Dia. in Well	1.25	in									
Actual Well Pipe Dia.	1.38	in	Animal Type #3			Animal Type #6			Animal Type #9		
Depth to Water in Well	300.0	ft	Daily Requirements	0.0	gpd/animal	Daily Requirements	0.0	gpd/animal	Daily Requirements	0.0	gpd/animal
Well Pipe Friction Loss	1.21	ft.	Number of Animals	0		Number of Animals	0		Number of Animals	0	
			Total Daily Requirement	0	gallons	Total Daily Requirement	0	gallons	Total Daily Requirement	0	gallons

Trough #1 Information				**Trough #2 Information**			
Animal Type	beef			Animal Type			
Daily Requirements	12.0	0.0	gpd/animal	Daily Requirements	0.0	0.0	gpd/animal
Number of Animals	11	0		Number of Animals	100	20	
Total Daily Requirement	132	0	gallons	Total Daily Requirement	0	0	gallons
% of Daily Requirement	50			% of Daily Requirement	50		
Minimum Trough Capacity	66		gallons	Minimum Trough Capacity	0		gallons
Delivery Time	6.0		hours	Delivery Time	6.0		hours
Minimum Flow Rate	0.37		gpm	Minimum Flow Rate	0.00		gpm
Selected Flow Rate	5.0		gpm	Selected Flow Rate	0.0		gpm
				Warning, Selected Flowrate must be at least 3 gpm			
Elevation at Trough	95.00		ft	Elevation at Trough	97.00		ft
Elevation Difference From Well to Trough	5.00		ft	Elevation Difference From Well to Trough	7.00		ft
Outlet Pressure	10		psi	Outlet Pressure	10		psi
Pipeline #1 Information				**Pipeline #2 Information**			
Pipe Material	PVC			Pipe Material	PVC		
Pipe Wall Designation	Schedule 40			Pipe Wall Designation	Schedule 40		
Nominal Pipe Diameter	1		in	Nominal Pipe Diameter	1		in
Actual Pipe Diameter	1.049		in	Actual Pipe Diameter	1.049		in
Flow Coefficient	150			Flow Coefficient	150		
Velocity	1.86		fps	Velocity	0.00		fps
Pipe Low Point Elevation	88.50		ft	Pipe Low Point Elevation	0.00		ft
Pipe Length	990.0		ft	Pipe Length	0.0		ft
Adapters	0		no.	Adapters	0		no.
Couplers	0		no.	Couplers	0		no.
45 Degree Elbows	0		no.	45 Degree Elbows	0		no.
90 Degree Elbows	2		no.	90 Degree Elbows	0		no.
Straight Flow Tees	0		no.	Straight Flow Tees	0		no.
Angle flow tees	0		no.	Angle flow tees	0		no.
Gate Valves	1		no.	Gate Valves	0		no.
Globe Valves	0		no.	Globe Valves	0		no.
Check Valves	0		no.	Check Valves	0		no.
Pipe/Fittings Friction Loss	15.24		ft.	Pipe/Fittings Friction Loss	0.00		ft.
Total Head Required	43.34		ft.	Total Head Required	0.00		ft.
Max pressure @Trough	37.8		psi	Max pressure @Trough	36.97		psi
Pipe Pressure Rating	56		psi	Pipe Pressure Rating	110		psi

Mainline Information			**Pressure Tank Selection Guidelines:**		
Minimum Flow Rate	5.00	gpm			
Selected Flow Rate	5.0	gpm	Minimum Operating Pressure	19	psi
			Minimum Tank Drawdown	5.0	gal
			Minimum Tank Capacity	14.5	gal
Pipe Material	PVC				
Pipe Wall Designation	Schedule 40				
Nominal Pipe Diameter	1	in			
Actual Pipe Diameter	1.049	in	**Pressure Tank Settings**		
Flow Coefficient	150		Switch-on Setting	20	psi
Velocity	1.86	fps			
			Switch-off Setting	40	psi
Pipe Low Point Elevation	88.50	ft			
Pipe Length	10.0	ft			
Adapters	0	no.			
Couplers	0	no.			
45 Degree Elbows	0	no.			
90 Degree Elbows	2	no.			
Straight Flow Tees	0	no.			
Angle flow tees	0	no.			
Gate Valves	1	no.			
Globe Valves	0	no.			
Check Valves	1	no.			
Pipe/Fittings Friction Loss	0.56	ft.			
Pipe Pressure Rating	56	psi			

Pump Selection					
Total System Loss	43.89	ft.			
Total Pumping Head (Pump to Trough)	345.1	ft	Total Pumping Head (Pump to Pressure Tank)	393.6	ft
Pump Efficiency	0.80				
Motor Efficiency	0.90				
Calculated Pump Size	0.69	HP	Selected Pump Size	1	HP

Figure 5. Example of Florida Watering Facility Well Summary worksheet.

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DESIGN SUMMARY AND LIST OF MATERIALS

Cooperator	E. Sadler	Location	S29,T1N,R11E
Conservation District	Madison	Field Office	Madison
Identification No.	1	Field No.	P1
Operation Type	Beef Cattle		
Designed By	D. Conservationist	Date	5/3/2006
Checked By	A. Engineer	Date	5/17/2006

Well Capacity	15.0	gpm
Designed Pump Flowrate	5.0	gpm
Selected Well Pump Size	1	hp

Input cell
Calculated cell, requires no input

Minimum Pressure Tank Draw-down Capacity	5.0	gal
Minimum Pressure Tank Capacity	14.5	gal

Trough #1

Minimum Capacity	66	gallons
Selected Trough Size	175	gallons
No. of Troughs	1	ea

Trough #2

Minimum Capacity	0	gallons
Selected Trough Size	0	gallons
No. of Troughs	0	ea

Pressure Tank Switch Settings

Switch - on Pressure	20	psi
Switch - off Pressure	40	psi

Pipeline #1

Pipe Material	PVC	
Wall Designation	Schedule 40	
Minimum Pressure Rating	56	psi
Nominal Pipe Diameter	1	in.
Pipe length	990.0	lin.ft.
Adapters	0	
Couplers	0	
45 degree elbows	0	
90 degree elbows	2	
Straight Flow Tees	0	
Angle Flow Tees	0	
Gate valves	1	
Globe valves	0	
Check valves	0	

Pipeline #2

Pipe Material	PVC	
Wall Designation	Schedule 40	
Minimum Pressure Rating	110	psi
Nominal Pipe Diameter	1	in.
Pipe length	0.0	lin.ft.
Adapters	0	
Couplers	0	
45 degree elbows	0	
90 degree elbows	0	
Straight Flow Tees	0	
Angle Flow Tees	0	
Gate valves	0	
Globe valves	0	
Check valves	0	

Mainline

Pipe Material	PVC	
Wall Designation	Schedule 40	
Minimum Pressure Rating	56	psi
Nominal Pipe Diameter	1	in.
Pipe length	10	lin.ft.
Adapters	0	
Couplers	0	
45 degree elbows	0	
90 degree elbows	2	
Straight Flow Tees	0	
Angle Flow Tees	0	
Gate valves	1	
Globe valves	0	
Check valves	1	

Other Pipe and Items

Material	Size	Qty