SECTION A: WATERING FACILITY DESIGN PROCEDURE

The procedure described in this section is intended to illustrate the procedure used in the design of a watering facility for livestock or wildlife. It is understood that this example 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 standard (CPS), Watering Facility, Code 614. All watering facilities must be designed in accordance with all applicable requirements contained in CPS 614.

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.xlsx".

Given

1. Animals: 50 beef cows in one pasture. The cows are checked daily and have access to a dry weather pond.
2. Well: Existing 4 inch diameter with estimated capacity of 15 gpm; water level 55 feet below ground surface
3. Pump: New submersible pump required.
4. Pressure tank: New pressure tank required.
5. Elevations: Watering facility – 93 feet NGVD, pump location – 90 feet NGVD. These elevations were obtained from a USGS Quad sheet
6. Distance from well to watering facility is 1,000 feet.
7. Landowner desires to use a plastic trough, SCH 40 PVC pipe, and a minimum flow rate of 5 gpm to the trough.

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: 50 cows x 12 gal/day/hd

= 600 gal/day.

Step 3. Determine the trough capacity. According to CPS 614, the trough must store at least a 1-day supply of water since the cows are checked daily and have access to a pond. In this example, the minimum trough capacity is 600 gallons. Select a round 8' x 2' trough that has a capacity listed at 625 gallons.

Step 4. Calculate the required trough perimeter access. According to CPS 614, the trough should accommodate 5% of the herd at one time and allow for 20 inches of perimeter per animal for circular tanks. In this example:

Required Perimeter = 0.05 (50 cows) x 20 inches

= 50 inches.

Step 5. Determine the available perimeter on the 625 gallon trough.

Available Perimeter = π x D = π x 96 inches

= 302 inches.

The selected trough is acceptable.

Step 6. Determine the minimum replenishment rate (or the minimum flow rate) in gallons per minute

(gpm) for the facility. According to CPS 614, the inflow rate in a 2 hour period plus the trough capacity must equal or exceed one-half the daily requirements for the livestock using the trough (Equation 1). Also, the flow rate shall be adequate enough to re-fill the trough in 10 hours or less (Equation 2). In this example:

Q = Flow rate, gph

DR = Daily requirements, gallons

TC = Trough capacity, gallons

Equation 1:

$$(Q \times 2\ hrs) + TC = \frac{1}{2}DR$$

$$Q = \frac{\frac{1}{2}DR - TC}{2\ hrs} \times \frac{1}{60\ min}$$

$$Q = \frac{\frac{600\ gallons}{2} - 625\ gallons}{2\ hrs} \times \frac{1}{60\ min}$$

Q = -2.7 gpm

Note: The flow rate, Q, is negative because the trough capacity is *greater than 1/2 day supply.*

Or

Equation 2:

$$Q = \frac{TC}{10\ hrs}$$

$$Q = \frac{625\ gallons}{10\ hrs} = \frac{1\ hr}{60\ mins}$$

$Q = 1.0\ gpm$

Step 7. Select the design flow rate. This flow rate must equal or exceed both minimum flow rates calculated in Step 6 and the minimum flow rate of 2 gpm set forth in CPS 614. This flow rate also must not exceed the pump or well capacity. In this example select 5 gpm because both calculated flow rates are less than the minimum requested by the landowner.

Step 8. 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 ft/100 ft x 1,000 ft = 15.3 ft.

Step 9. 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).

Determine the minimum operating pressure of the pressure tank. The minimum operating pressure of the tank 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 tank operating discharge pressure =

23.1 ft. – outlet pressure (10 psi to operate float valve)
+ 15.3 ft. – friction loss (from Step 8)
+ 3.0 ft. – uphill elevation difference (from Quad sheet)
+ 2.0 ft. – elevation difference from ground to float valve
43.4 ft. = 18.8 psi (2.31 ft = 1 psi).

If the minimum tank discharge pressure seems excessive or exceeds the existing pump, select a larger pipe size and re-evaluate Steps 8 and 9. Normally, the calculated minimum tank discharge pressure should not exceed 50 psi. In this example there is not an existing pump and the minimum tank discharge calculated is acceptable.

Step 10. 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 tank discharge pressure calculated in Step 9 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

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

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

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 11. 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 ground 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)
+ 55.0 ft. (elevation difference between pump and water level)
= 147.4 ft.

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

$$\text{Pump Horsepower} = \frac{\text{GPM} \times \text{TDH (ft)}}{3960 \times \text{Pump eff.} \times \text{Motor eff.}}$$

$$= \frac{5\text{ gpm} \times 147.6\text{ ft}}{3960 \times 0.80 \times 0.90} = 0.26\text{ hp}$$

A 1/2 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 12. 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 (Exhibit 1) and job sheet FL614JS (Exhibits 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.xlsx". Exhibits 4 and 5 show screen shots of the example. The workbook is available from the eFOTG under SECTION IV/Florida Engineering Computer Programs. Instructions for the use of the workbook can be found on the "Instructions" worksheet in the workbook.

Exhibit FL12A-1. Example of Form FL-ENG-516B

United States Department of Agriculture
NRCS Natural Resources Conservation Service

FL-ENG-516B
10/09
Sheet 1 of 3

PIPELINE DESIGN DATA SHEET - SUBMERSIBLE PUMP

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 gpm
Source of water supply (stream, well, reservoir, etc.): Well
Well: Static water level 55 ft
Design pumping lift 55 ft
Existing Pump Measured Capacity: NA gpm @ NA ft

Pipeline No. (see plan for location)	Kind of Pipe, Material, SDR, ect.	Design Capacity (gpm)	Nominal Pipe Diam. (in)	Pipe Inside Diam. (in)	Pipeline Length (ft)	Coefficient of Roughness, C	Velocity (ft/sec)	Friction Head Loss (ft)	Friction Loss Used for Design[1]
1	SCH 40 PVC	5	1	1.049	1000	150	1.85	15.34	15.30
Total pipeline friction head loss used for design (ft)									15.30

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

Maximum elevation difference from pipe inlet to outlet = 5.00 ft (- downhill, + uphill)

Designed outlet discharge pressure[2] = 23.10 ft
+ 15.30 ft total pipe friction head loss
+ 5.00 ft elevation difference (- downhill, + uphill)
Minimum pipeline inlet pressure = 43.40 ft = 18.8 psi
OR
Pump shut off pressure[3] = 40.0 psi = 92.40 ft
+ 55.0 ft, elevation difference between pipeline inlet and water elevation in well during drawdown
Total Dynamic Head (TDH)[4] = 147.40 ft

[2] Outlet discharge pressure should be > 10 psi (23.1 feet) for watering facilities; 1 psi = 2.31 feet
[3] Only if using a pressure tank. If not, enter zero.
[4] TDH calculation uses the greater of the pipeline inlet pressure and the pump shut off pressure.

Exhibit FL12A-1 (Cont'd). Example of Form FL-ENG-516B

United States Department of Agriculture
NRCS Natural Resources Conservation Service

FL-ENG-516B
10/09
Sheet 2 of 3

Pump design requirements: 5.00 gpm @ 147.40 ft or 64 psi @ TDH

Existing pump (mark one): ____ adequate x inadequate ____ not applicable

New pump required (mark one)? x yes ____ no

Pump efficiency (%) = 80
Minimum Horsepower = 0.26

Motor efficiency (%) = 90
Selected Horsepower = 0.50

Remarks:

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

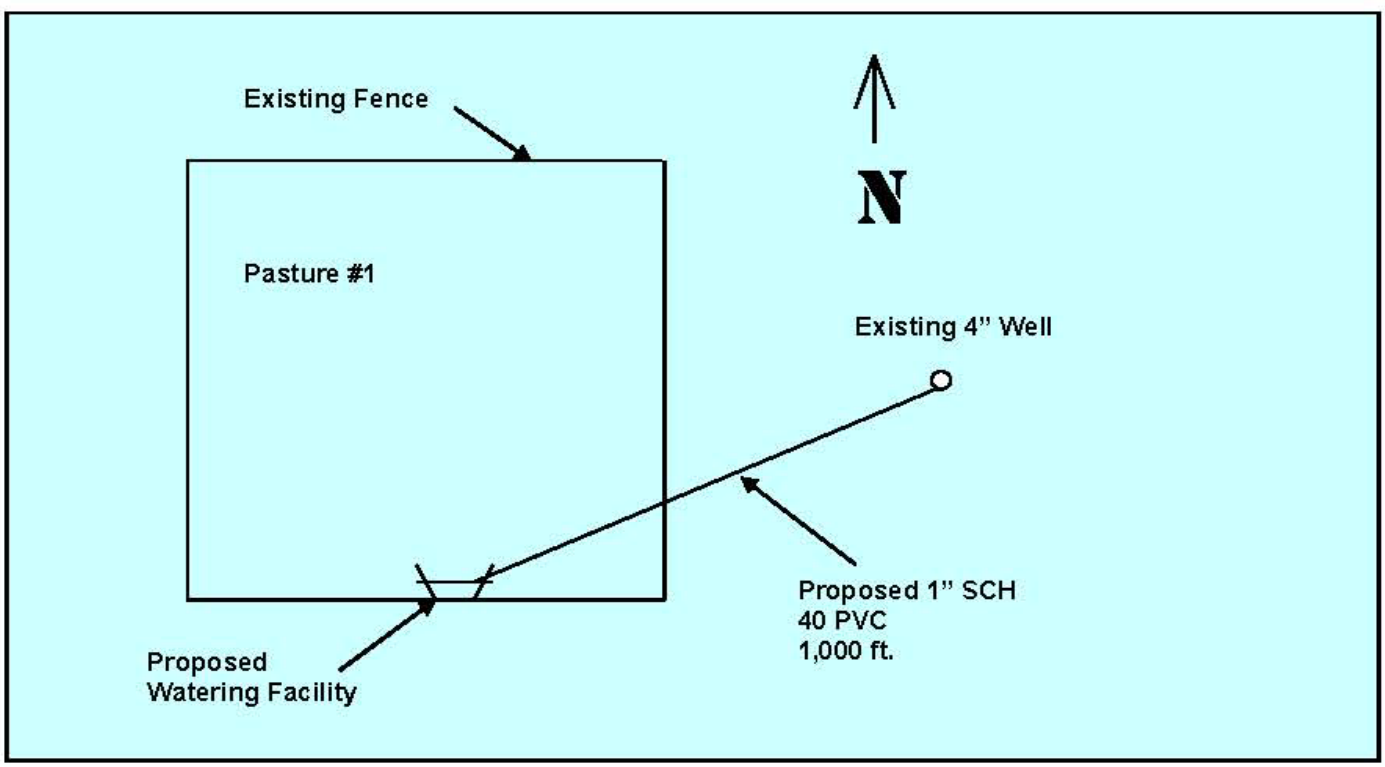

Exhibit FL12A-1 (Cont'd). Example of Form FL-ENG-516B

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FL-ENG-516B
10/09
Sheet 3 of 3

Pipeline No.	Nominal Pipeline Diam. (in)	PIP or IPS	SDR No. or SCH	Material (PVC 1120, etc.)	Pressure Rating (psi)	Total Length (ft)	Minimum Depth of Cover (in)
1	1"	IPS	SCH 40	PVC 1120	450	1000.0	18

Designed by: D. Conservationist Date: 02/03/11
Checked by: Date: 02/03/11
Approved by: A. Engineer Date: 02/03/11
This practice meets NRCS standards and specifications. _____ Date: _____
(Signature)

Exhibit FL12A-2. Example of Job Sheet FL-614

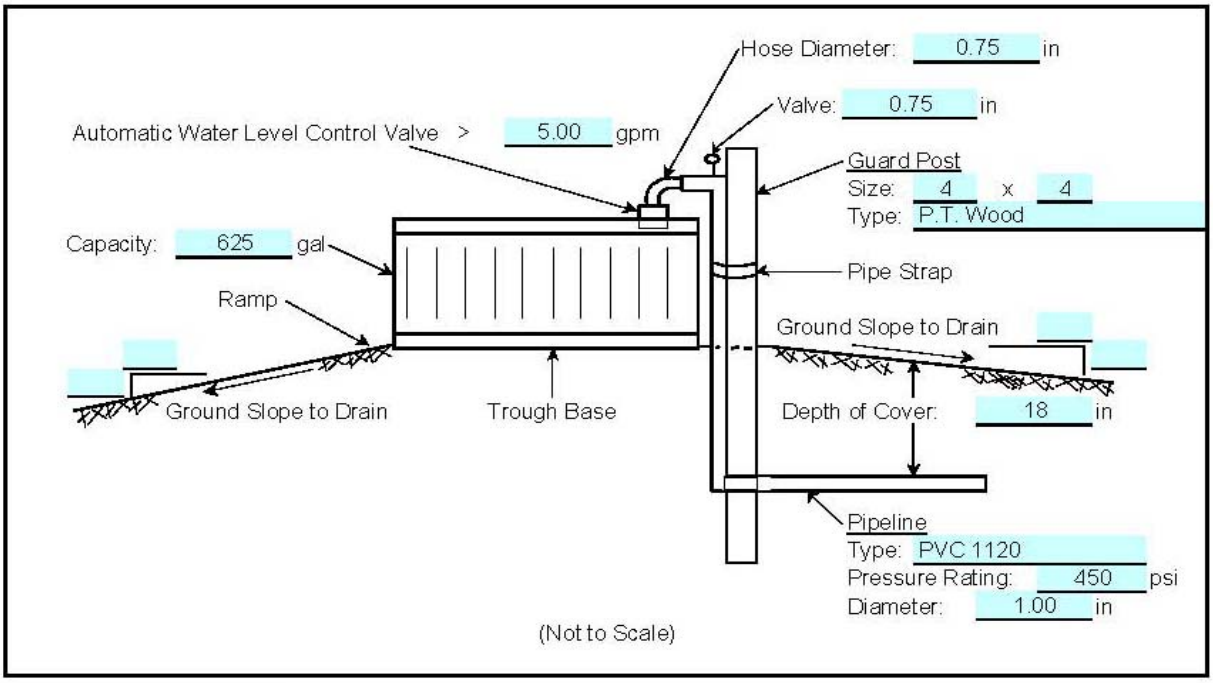
United States Department of Agriculture
NRCS Natural Resources Conservation Service

FL-ENG-614
10/09
Sheet 1 of 1

WATERING FACILITY - CHECK SHEET

Cooperator: E. Sadler
Conservation District: Madison
Identification No.: 1

Location: Sec. 29, T 1N, R 11E
Field Office: Madison
Field No(s).: P1



Trough or tank material: Plastic
Trough base material and thickness: Natural Ground
Ramp material and thickness: N/A

Designed by: D. Conservationist Date: 02/03/11
Checked by: A. Engineer Date: 02/03/11
Approved by: A. Engineer Date: 02/03/11

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)

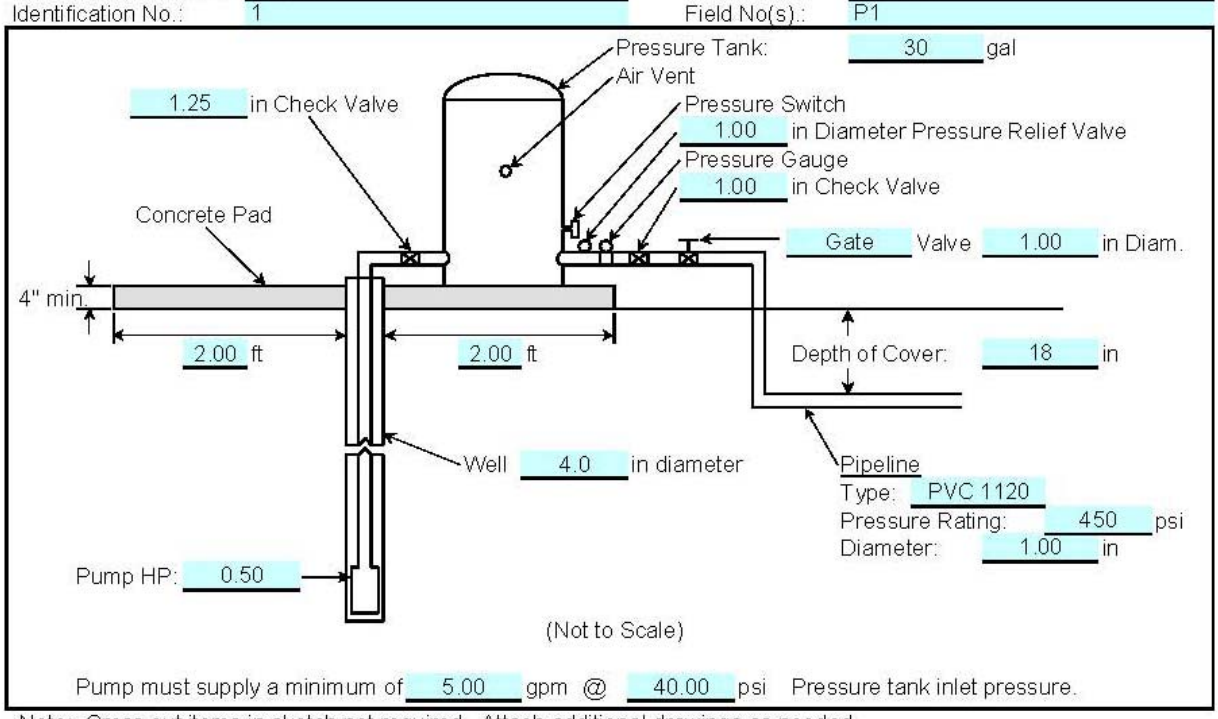
Exhibit FL12A-3. Example of Job Sheet FL-516D Check Sheet

United States Department of Agriculture
NRCS Natural Resources Conservation Service

FL-ENG-516D
10/09
Sheet 1 of 1

WATERING FACILITY APPURTENANCES - CHECK SHEET
Submersible Pump Schematic

Cooperator: E. Sadler
Conservation District: Madison
Identification No.: 1
Location: Sec. 29, T 1N, R 11E
Field Office: Madison
Field No(s).: P1



Pump must supply a minimum of 5.00 gpm @ 40.00 psi Pressure tank inlet pressure.

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

Designed by: D. Conservationist Date: 02/03/11
Checked by: A. Engineer Date: 02/03/11
Approved by: A. Engineer Date: 02/03/11

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)

Exhibit FL12A-4. Example of Florida Watering Facility Well Design Worksheet

United States Department of Agriculture
NRCS Natural Resources Conservation Service

WATERING FACILITY DESIGN FOR WELL SYSTEMS

Cooperator	E. Sadler	Location	S29,T1N,R11E
Conservation District	Madison	Field Office	Madison
Identification No.	1	Field No.	P1, P2
Operation Type	Beef Cattle		
Designed By	D. Conservationist	Date	5/6/2008
Checked By	A. Engineer	Date	5/16/2008

PLEASE READ INSTRUCTIONS ON "INSTRUCTIONS" WORKSHEET BEFORE BEGINNING

Input cell
Calculated cell, requires no input

Well Information		
Distance to Power	1500	feet
Well Capacity	15.0	gpm
Elevation at Well	90.00	ft
Pipe Length in Well	55.0	ft
Pipe Dia. in Well	1.25	in
Actual Well Pipe Dia.	1.38	in
Depth to Water in Well	55.0	ft
Well Pipe Friction Loss	0.22	ft.

Trough #1 Information			
Animal Type	beef		
Daily Requirements	12.0	0.0	gpd/animal
Number of Animals	50	0	
Total Daily Requirement	600	0	gallons
Trough Capacity	625	gallons	
Minimum Flow Rate	1.04	gpm	
Selected Flow Rate	5.0	gpm	
Water Elevation at Trough	95.00	ft	
Elevation Difference From Well to Trough	5.00	ft	
Outlet Pressure	10	psi	
Pipeline #1A Information			
Selected Flow Rate	5.0	gpm	
Pipe Material	PVC		
Pipe Wall Designation	Schedule 40		
Nominal Pipe Diameter	1	in	
Actual Pipe Diameter	1.049	in	
Flow Coefficient	150		
Velocity	1.86	fps	
Pipe Low Point Elevation	88.50	ft	
Pipe Length	990.0	ft	
Adapters	0	no.	
Couplers	0	no.	
45 Degree Elbows	0	no.	
90 Degree Elbows	3	no.	
Straight Flow Tees	2	no.	
Angle flow tees	1	no.	
Gate Values	1	no.	
Globe Values	0	no.	
Check Values	0	no.	
Pipe/Fittings Friction Loss	15.36	ft.	
Pipe Pressure Rating	56	psi	
Pipeline #1B Information			
Selected Flow Rate	0.0	gpm	
Pipe Material	PVC		
Pipe Wall Designation	Schedule 40		
Nominal Pipe Diameter	1	in	
Actual Pipe Diameter	1.049	in	
Flow Coefficient	150		
Velocity	0.00	fps	
Pipe Low Point Elevation	93.50	ft	
Pipe Length	0.0	ft	
Adapters	0	no.	
Couplers	0	no.	
45 Degree Elbows	0	no.	
90 Degree Elbows	0	no.	
Straight Flow Tees	0	no.	
Angle flow tees	0	no.	
Gate Values	0	no.	
Globe Values	0	no.	
Check Values	0	no.	
Pipe/Fittings Friction Loss	0.00	ft.	
Pipe Pressure Rating	56	psi	
Pipeline #1C Information			
Selected Flow Rate	0.0	gpm	
Pipe Material	PVC		
Pipe Wall Designation	Schedule 40		
Nominal Pipe Diameter	0.75	in	
Actual Pipe Diameter	0.824	in	
Flow Coefficient	150		
Velocity	0.00	fps	
Pipe Low Point Elevation	93.50	ft	
Pipe Length	0.0	ft	
Adapters	0	no.	
Couplers	0	no.	
45 Degree Elbows	0	no.	
90 Degree Elbows	0	no.	
Straight Flow Tees	0	no.	
Angle flow tees	0	no.	
Gate Values	0	no.	
Globe Values	0	no.	
Check Values	0	no.	
Pipe/Fittings Friction Loss	0.00	ft.	
Pipe Pressure Rating	56	psi	
Total Pipeline #1 Head Required	43.46	ft.	
Max pressure @ Trough	37.8	psi	

Trough #2 Information			
Animal Type	beef		
Daily Requirements	12.0	0.0	gpd/animal
Number of Animals	0	0	
Total Daily Requirement	0	0	gallons
Trough Capacity	0	gallons	
Minimum Flow Rate	0.00	gpm	
Selected Flow Rate	0.0	gpm	
Warning, Selected Flowrate must be at least 2 gpm			
Water Elevation at Trough	97.00	ft	
Elevation Difference From Well to Trough	7.00	ft	
Outlet Pressure	10	psi	
Pipeline #2A Information			
Selected Flow Rate	0.0	gpm	
Pipe Material	PVC		
Pipe Wall Designation	Schedule 40		
Nominal Pipe Diameter	1	in	
Actual Pipe Diameter	1.049	in	
Flow Coefficient	150		
Velocity	0.00	fps	
Pipe Low Point Elevation	93.50	ft	
Pipe Length	0.0	ft	
Adapters	0	no.	
Couplers	0	no.	
45 Degree Elbows	0	no.	
90 Degree Elbows	3	no.	
Straight Flow Tees	2	no.	
Angle flow tees	1	no.	
Gate Values	1	no.	
Globe Values	0	no.	
Check Values	0	no.	
Pipe/Fittings Friction Loss	0.00	ft.	
Pipe Pressure Rating	56	psi	
Pipeline #2B Information			
Selected Flow Rate	0.0	gpm	
Pipe Material	PVC		
Pipe Wall Designation	Schedule 40		
Nominal Pipe Diameter	0.75	in	
Actual Pipe Diameter	0.824	in	
Flow Coefficient	150		
Velocity	0.00	fps	
Pipe Low Point Elevation	93.50	ft	
Pipe Length	0.0	ft	
Adapters	0	no.	
Couplers	0	no.	
45 Degree Elbows	0	no.	
90 Degree Elbows	3	no.	
Straight Flow Tees	2	no.	
Angle flow tees	1	no.	
Gate Values	1	no.	
Globe Values	0	no.	
Check Values	0	no.	
Pipe/Fittings Friction Loss	0.00	ft.	
Pipe Pressure Rating	56	psi	
Pipeline #2C Information			
Selected Flow Rate	0.0	gpm	
Pipe Material	PVC		
Pipe Wall Designation	Schedule 40		
Nominal Pipe Diameter	0.75	in	
Actual Pipe Diameter	0.824	in	
Flow Coefficient	150		
Velocity	0.00	fps	
Pipe Low Point Elevation	93.50	ft	
Pipe Length	100.0	ft	
Adapters	0	no.	
Couplers	0	no.	
45 Degree Elbows	0	no.	
90 Degree Elbows	3	no.	
Straight Flow Tees	2	no.	
Angle flow tees	1	no.	
Gate Values	1	no.	
Globe Values	0	no.	
Check Values	0	no.	
Pipe/Fittings Friction Loss	0.00	ft.	
Pipe Pressure Rating	56	psi	
Total Pipeline #2 Head Required	0.00	ft.	
Max pressure @ Trough	37.0	psi	

Exhibit FL12A-4 (Cont'd.). Example of Florida Watering Facility Well Design Worksheet

Mainline Information

Minimum Flow Rate	5.00	gpm
Selected Flow Rate	5.0	gpm
Pipe Material	PVC	
Pipe Wall Designation	Schedule 40	
Nominal Pipe Diameter	1	in
Actual Pipe Diameter	1.049	in
Flow Coefficient	150	
Velocity	1.86	fps
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

Pressure Tank Selection Guidelines:

Minimum Operating Pressure	19	psi
Minimum Tank Drawdown	5.0	gal
Minimum Tank Capacity	14.5	gal

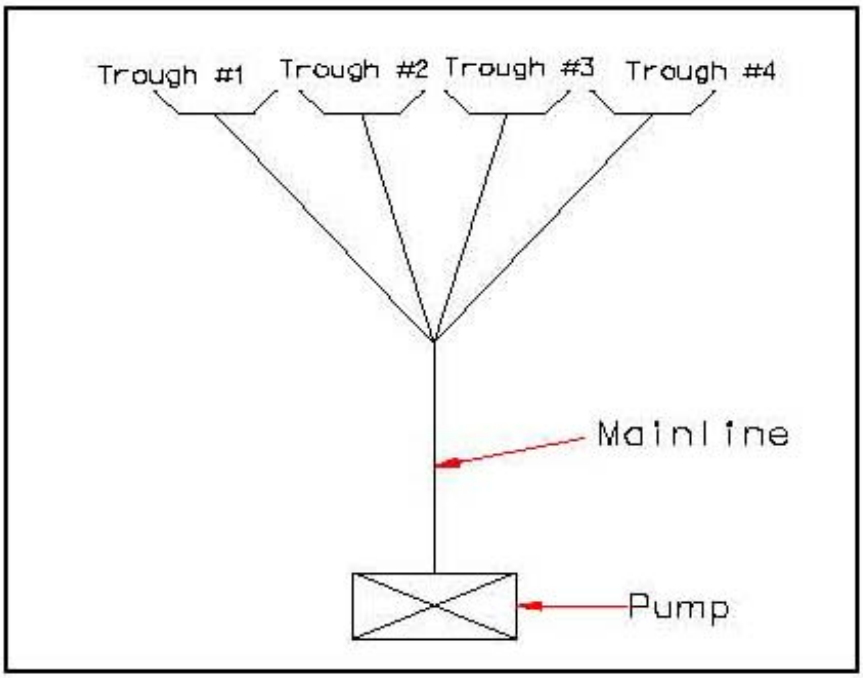
Pressure Tank Settings

Switch-on Setting	20	psi
Switch-off Setting	40	psi

Pump Selection

Total System Loss	44.02	ft.			
Total Pumping Head (Pump to Trough)	99.2	ft	Total Pumping Head (Pump to Pressure Tank)	147.6	ft
Pump Efficiency	0.80				
Motor Efficiency	0.90				
Calculated Pump Size	0.26	HP	Selected Pump Size	0.5	HP

Example Schematic



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