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EC821

Water Development Costs for Grazing Livestock

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A plentiful supply of good quality water, conveniently located, is highly desirable for grazing livestock. The location of watering sites impacts grazing distribution patterns and the ability of an operator to implement rotational grazing programs. Costs are an important consideration when replacing a failing or inadequate water system or adding new water sites. Anticipated future water needs, maintenance costs, life expectancies of the systems, and flexibilities to accommodate management changes must be considered in choosing the most efficient alternative.

The purpose of this publication is to provide water development information and a system to help estimate costs. It describes three different pumping systems — windmills, solar submersible pumps, AC submersible pumps — and underground pipe as a delivery system.

In 2002, separate survey questionnaires were sent to well drillers, underground pipeline installers, and tank providers. The questionnaires sent to well developers included questions on pumps, tanks, and other related equipment as well as inquiring about the costs of drilling and developing wells. The questionnaire sent to underground pipeline installers also contained questions about tanks and related items.

The mailing list was based on the public list of approved contractors from local Farm Service Agency (FSA) offices. Questionnaires were mailed to 302 people. Sixteen were returned undeliverable. Sixty-eight respondents returned questionnaires, which is 24 percent of those that were deliverable. Ten questionnaires were returned with comments indicating they were no longer in business so the instrument was not filled out.

Survey results were summarized to provide an estimate of water development costs. Individual costs will vary widely depending on local providers, local conditions, and the needs of the individual. These cost estimates are offered as a planning tool only.

Drilling and Developing Wells

The cost of developing a new well is often associated with three types of pumping systems: windmill, solar submersible pump, and AC submersible pump. Using an existing well reduces the cost of these systems considerably. Some older wells may not work for all of the systems mentioned above, so an accurate assessment of an existing well's capabilities is crucial for planning.

Twenty-one firms responded to the well portion of the survey. Six were from the Sandhills, five each from the south central and the northeast, three from the Panhandle, and two from the southeast regions of Nebraska. Reported well depths ranged from 20 to 550 feet. The usual well depth varied from 100 to 300 feet with the average being 180 feet. Fourteen of the 19 drillers who reported casing size indicated that one of the casing sizes they used was 4 inch. Both drillers in the Panhandle and three out of the six drillers in the southwest and northeast did not list 4-inch casing as an alternative. The average costs for a 4-, 4.5-, and 5-inch casing were $2.70, $3.45 and $3.95 respectively. Those who charged less for drilling commonly charged more for casing. This means one cannot add the lowest costs for drilling and casing together to derive a realistic estimate of costs. *Table I* lists both the separate and combined costs to provide a more reliable estimate of total costs for drilling and casing a well.

Perforated casing is placed in the well to permit water to enter the pumping area. Well installers

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Table I. Well development costs (2002).

Component	Range of Cost ($)	Average or Typical Cost ($)
Drilling	4.25 - 13.00 per foot	7.75 per foot
Solid Casing – 4 inch	1.90 - 4.50 per foot	2.70 per foot
Total Drilling and 4 inch Casing	8.30 - 14.90 per foot	10.00 per foot
Perforated Casing – 4 inch	3.60 - 7.50 per foot	4.90 per foot
Solid Casing – 4.5 inch	3.15 - 3.70 per foot	3.45 per foot
Total Drilling and 4.5 inch Casing	9.80 - 13.50 per foot	11.50 per foot
Perforated Casing – 4.5 inch	3.60 - 6.75 per foot	5.15 per foot
Solid Casing – 5 inch	3.50 - 4.70 per foot	3.95 per foot
Total Drilling and 5 inch Casing	10.45 - 13.00 per foot	11.60 per foot
Perforated Casing – 5 inch	4.45 - 6.67 per foot	5.50 per foot
Grout	5.50 - 12.60 per sack	
	10 - 60.00 per well	30.00 per well
Gravel Pack	4.30 - 30.00 per cubic yd	
	10 - 120.00 per well	50.00 per well
Labor and Sanitary Seal	20 - 330.00 per well	150.00 per well
Registration (state)	60.00 per well	

reported using from 5 to 80 feet of perforated casing per well. Larger lengths of the perforated casing were reported to be used in the Panhandle and south central regions. The average perforated casing used was 20 feet. The cost of perforated casing varied from $3.60 to $7.50 per foot. The typical costs were $4.90, $5.15, and $5.50 per foot for 4-, 4.5-, and 5-inch diameters, respectively. The maximum cost for the different sizes of perforated casing in *Table I* appears to be less as the diameter of the casing increases. This appearance is misleading since not all drillers use all three sizes of casing, so the cost range for each casing size reflects different respondents. In every case except one where drillers reported costs for multiple sizes of casing, the larger diameter casing cost more than the smaller. One driller indicated that the cost of 4.5- and 5-inch diameter perforated casing was the same.

Other costs in well development include a gravel pack, grout, a sanitary seal, and a registration fee. Gravel is placed between the casing and the walls of the well up to 10 feet from the surface. The amount of gravel depends on the difference in the size of the well diameter and casing diameter and the depth of the well. Grout is used to fill from the top of the gravel pack to the surface. State Health Department regulations require a sanitary seal, which is usually constructed with concrete. State registration of a livestock well is required. The current registration fee is $60. The cost of labor and the sanitary seal are combined in *Table I* because well drillers who showed a low cost for the sanitary seal generally showed more for labor, while those showing a higher cost for the seal generally indicated less for labor.

Pumps for Lifting Water

Windmills

Windmills are a popular source of power to pump water in the Sandhills and in some other regions of Nebraska. They are commonly used at sites that are distant from electrical power lines and where water levels are relatively shallow. They require limited maintenance and have a long expected life. The unreliability of wind is the main disadvantage. Because of this unreliability, ample water storage is highly recommended, and water supplies must be monitored on a regular basis. Water storage is normally accomplished by using a large tank to water livestock. Another disadvantage of windmills is their susceptibility to damage by severe weather. That risk is insurable.

New windmills and their towers are expensive. In order to reduce these costs, producers often purchase rebuilt mills and used towers. The survey specifically requested prices for used towers and rebuilt mills. In addition to the tower and mills, a windmill system requires anchors to hold the tower in place, a drop pipe to carry the water to the surface, a cylinder pump, and sucker rod to transfer power from the mill to the cylinder. Substantial labor is required to install this system. Windmill systems do not require pressure tanks, hydrants, or floats.

Fifteen firms provided information on tower, mill, or installation costs. Six of these were from the Sandhills, three each from the south central and Panhandle regions of Nebraska, two from the southwest, and one from the northeast. Four other firms or individuals provided information on the cost of sucker rod and drop pipe.

Drop pipe length varied from 18 to 180 feet, with an average of 100 feet. Only three firms or individuals indicated they installed drop pipe, and their charges varied from $100 to $216 per installation. Well depth accounted for most of the variation. Seventeen firms or individuals provided price information for 1 1/4 inch drop pipe, nine for 2 inch, and seven for 3 inch. Variations in the prices for each size were greater among respondents than variations between averages for the different sizes.

Twelve firms or individuals provided price information for 2 3/4 inch cylinders compared to nine for 1 3/4 inch and five for 1 1/4 inch. Twelve individuals responded for 3/8 inch sucker rod, 14 for 7/8 inch, and four for 1/2 inch.

The size of the mill, cylinder, drop pipe, and sucker rod have to be matched on a system. A larger cylinder will lift more water if the well will produce it but will require larger drop pipe to carry the water and a larger mill and sucker rod to power it. Deeper wells also require more power so may require a larger mill and larger sucker rod.

The material and installation costs for windmills are summarized in *Table II*.

AC Powered Submersible Pumps

AC submersible pumps are a popular choice where there is ready access to electrical service. The use of float control devices along with pressure tanks with switches provides an economical and relatively reliable source of constantly available water with minimal maintenance. Not counting the cost for accessing a public power source, this alternative usually requires the least initial cost, and the ongoing operating costs are reasonable. These pumps are susceptible to damage from lightening strikes, an insurable risk. Although these pumps are very reliable, they may malfunction and so must be monitored. The frequency of required monitoring depends on water storage

Table II. Costs for windmills (2002).

Component	*Range of Cost ($)*	*Average or Typical Cost ($)*
Towers (used) – 27 ft (for 8 ft mill)	$150 - 1,000	500
Installation Labor	100 - 450	280
Material and Labor	450 - 1,500	800
Towers (used) – 33 ft (for 8 ft mill)	150 - 1,500	740
Installation Labor	200 - 450	300
Material and Labor	450 - 1800	1,000
Towers (used) – 27 ft (for 10 ft mill)	150 - 1,500	800
Installation Labor	200 - 450	300
Material and Labor	450 - 1,785	1,100
Towers (used) – 33 ft (for 10 ft mill)	150 - 1,750	900
Installation Labor	200 - 450	300
Material and Labor	450 - 1,960	1,280
Mills (rebuilt) – 8 ft	390 - 1,680	1,490
Installation Labor	70 - 370	200
Material and Labor	950 - 2,000	1,700
Mills (rebuilt) – 10 ft	1,150 - 2,540	2,320
Installation Labor	100 - 350	225
Material and Labor	1,425 - 2,890	2,500
Anchors (4) to hold tower	40 - 190	100
Drop pipe installation	100 - 216	125
Drop (hanging) pipe – 1 1/4 inch galvanized	2.25 - 3.50/ft	3.00/ft
Drop (hanging) pipe – 2 inch galvanized	1.90 - 6.05/ft	5.00/ft
Drop (hanging) pipe – 3 inch galvanized	6.56 - 12.72/ft	10.00/ft
Sucker (pump) rod – 3/8 inch	.55 - 1.53/ft	1.05/ft
Sucker (pump) rod – 7/16 inch	.70 - 1.65/ft	1.25/ft
Sucker (pump) rod – 1/2 inch	1.19 - 1.60/ft	1.39/ft
Cylinder – 1 3/4 inch	137 - 354	190
Cylinder – 1 7/8 inch	139 - 377	220
Cylinder – 2 3/4 inch	175 - 550	340

Table III. AC pump system costs (2002).

Component		*Range of Cost ($)*	*Average or Typical Cost ($)*
Pump	0.5 hp	331 - 772	520
	1.0 hp	430 - 900	700
	1.5 hp	575 - 1100	950
	2.0 hp	800 - 1400	1,200
Pressure Tank		380 - 890	500
Electrical Boxes and Wires		75 - 310	140
Drop Pipe	— Galvanized	2.55 - 3.50/ft	3.15/ft
	— PVC	0.73 - 1.92/ft	1.20/ft
Well Plate		15 - 50	30
Labor		45 - 500	250
Hook Up[1]		30 - 450	150

[1] Does not include cost of power line extension.

capacity and daily water consumption requirements. Other factors to consider when choosing water storage capacity is the response time of your public power district and replacement parts availability. Access to a portable generator may alleviate the need for some water storage.

The cost of accessing electrical service increases as the distance increases from the watering site to the closest access point. Rates for a single-phase electric line obtained from seven public power districts varied from $2 per linear foot to $3.85 per linear foot plus the cost of a transformer and hook up fee. One district indicated they furnished the first 1/4 mile without charge. Another district charged less per foot for longer runs. Reliable, localized information from your power provider is available with only a telephone call. Since this cost is substantial, it is important that it be accurate for planning purposes. The availability of electrical power may benefit other areas of your operation, helping to offset this expense.

Twenty-six firms responded to the AC Submersible Pump questionnaire. Eight were from the Sandhills, six from the northeast, five from the south central, three each from the southeast and the Panhandle, and one from the southwest regions. Response rates were generally good for all items except usual lengths of drop pipes. Only four responded to the request for the price of galvanized pipe and eight provided prices for PVC pipe. *Table III* summarizes the responses to the remainder of this section.

Solar Powered Submersible Pumps

Solar powered submersible pumps are a relatively new technology designed for locations that are not served by public electrical systems. The system is simpler and uses newer technology than windmills but is similar in that energy forces that occur naturally power it. Like windmills, water storage is highly recommended as cloud cover adversely affects the functioning of the solar panels, causing this power source to be unreliable.

Four firms from different regions of Nebraska provided information about solar powered submersible pumps. Pump costs varied from $1,455 to $1,850 and the solar panel costs varied from $225 to $380 per panel. Only one respondent included $120 for solar panel frames so maybe that cost was included as part of the panel cost by the others. The pumping rate will depend on the distance to the static water level and the number of panels used, assuming the well is not the limiting factor. Most situations will require from two to four panels. The cost for drop pipe and well plates should be similar to that for AC submersible systems. No pressure tanks, floats, or hydrants are required.

One advantage of solar powered submersible pumps is they are movable so can be used throughout the grazing season by those practicing rotational grazing. Mounting the solar panels on a trailer can reduce the effort required to move the system.

Moving Water with Underground Pipe

Underground pipe from a central source may be the only system available if groundwater supplies either do not exist or are impractical to access. It may be a viable alternative even if groundwater supplies are available, depending on a number of factors. Water supplied by an underground pipe is no more reliable than the source. A potential advantage of underground pipe is the elimination and expense of developing and maintaining additional wells. It eliminates the expense of developing a well or accessing electrical power. The main drawback to underground pipe is installation expense, which increases linearly as the distance between the water source and water site being developed increases. Underground pipe is often used to improve grazing management by

Table IV. Underground pipe costs (installed) (2002).

Component		*Range of Cost ($)*	*Average or Typical Cost ($)*
Trenching Only		$0.30 - 1.25/ft	0.65/ft
PVC Pipe	1 1/4 inch	0.45 - 2.00/ft	1.00/ft
(Installed including	1 1/2 inch	0.50 - 2.10/ft	1.00/ft
trenching)	2 inch	0.55 - 2.50/ft	1.26/ft
	3 inch	0.70 - 3.25/ft	2.12/ft
Polyethylene Pipe	1 1/4 inch	0.60 - 2.15/ft	1.30/ft
(Installed including	1 1/2 inch	0.80 - 3.50/ft	1.70/ft
trenching)	2 inch	0.90 - 3.25/ft	2.00/ft
Hydrant		60 - 254	105
Float and Valve		33 - 300	90
Hook-Up		15 - 300	100

developing multiple watering sites along the pipe's route.

Forty firms returned the questionnaire on underground pipe. Fourteen of these were from the Sandhills, 11 from the south central, six each from the northeast and Panhandle, and four from southwest regions of Nebraska. The survey requested cost information for four different sizes of PVC and Polyethylene Pipe. Thirty firms provided information on 1 1/4 inch PVC pipe and 29 on 2 inch PVC pipe. Only eight firms provided information on 3 inch PVC pipe and three on 3 inch polyethylene pipe. Because there were so few responses for these last two, they are not included in the summary.

Table IV summarizes the cost data for underground pipe. The prices shown for both PVC and polyethylene pipe are installed including the trenching costs. Trenching costs are also shown separately in *Table IV*.

Tanks

Tanks come in many sizes. The optimal size tank depends on the number and kind of animals that it services, the water flow rate, and reliability of the water source. Different types of livestock require different amounts of water. Time of year also impacts the water requirement for a specific type of livestock. A system should be designed to provide in excess of that required for the period of time of maximum livestock use.

For example, peak water requirement of cows nursing calves occurs three to four months after parturition. Peak water use for spring calving cows is 17.5 gallons per day in June and September. Multiplying individual water required by lactating cows by the number of pairs utilizing a watering system will provide the amount of water that needs to be available during the period of time cows normally spend at the watering site. In this example, each 100 cows will require 1,750 gallons of water. Dry, bred cows will require less water, and less will be required during cooler months of the year.

A reserve supply of water needs to be available for times the wind does not blow or there are cloudy days, depending on the power source. A 3-5 day supply of water is a rule of thumb for determining adequate storage capacities. Large tanks, 20 feet or more in diameter, are commonly used as water reservoirs as well as drinking facilities. The capacity of a tank is calculated using the following formula:

$$\text{Gallons} = (3.14) \times (1/2 \text{ diameter})^2 \times \text{height} \times (7.484).$$

The capacities of 10-foot, 20-foot, and 30-foot tanks that are 2 feet deep are 1,175, 4,700, and 10,580 gallons respectively.

Large, bottomless tanks are commonly used where windmills or solar powered submersible pumps supply water. Ordinarily these systems pump whenever power is available so no valves, floats, or pressure tanks are needed. Concrete and bentonite are used to seal bottomless tanks.

AC submersible pumps usually supply a substantially greater and more dependable water flow than windmills or solar submersible pumps. The better water supply permits the use of smaller and less expensive steel bottom tanks that are easier to install. Since it costs to operate these pumps, water flow is controlled either by hydrants or by valves with automatic float systems that keep stock tanks full without allowing them to overflow. The pump's operation is controlled by water pressure in the system so a pressure tank is required.

Twenty-six firms responded to the questions about tank costs. Eighteen were from the Sandhills, three each from the south central and southwest, and two from the Panhandle. The prices quoted for

Table V. Tank costs (2002).

Description	*Component*	*Range of Cost ($)*	*Average or Typical Cost ($)*
Bottomless Tank 21 Foot	Sides	345 - 975	600
	Cement	390 - 570	500
	Bentonite	5 - 60	25
	Labor	150 - 860	315
Total			1440
Bottomless Tank 30 Foot	Sides	525 - 1450	865
	Cement	490 - 945	600
	Bentonite	20 - 75	44
	Labor	175 - 980	450
Total			1959
Steel Bottom 8 Foot	Tank	175 - 290	200
	Installation	25 - 312	125
Steel Bottom 10 Foot	Tank	250 - 400	295
	Installation	25 - 400	170
Steel Bottom 12 Foot	Tank	320 - 500	385
	Installation	25 - 500	200
Float, Valve, and Fixtures	Material	35 - 160	80
	Installation	5 - 187	85

concrete and bentonite were similar among those responding but the amount used varied greatly. The variation in the amount of concrete used probably reflects different construction techniques, some of which may be caused by different conditions from one geographic area to the next. Most of the variation in bentonite use probably reflects the variability in soil types throughout Nebraska. Labor costs for installation were also highly variable.

Table V summarizes the costs for the different tanks and their installation. The "Average or Typical Costs" are totaled for each of the bottomless tanks so comparisons can be made.

Cost Sharing

Cost sharing is sometimes available for range conservation programs offered through USDA's Natural Resource Conservation Service Agency (NRCS) or the Natural Resource Districts (NRD). Access to these programs varies from one location to the next, and they are subject to the availability of funds. Different programs may have different requirements that may change over time. Contact your local NRCS and NRD offices for reliable information. Note that your application for cost share must be approved before work is started.

Estimation Worksheets

The following worksheets are provided to help you make estimates for cost comparisons. The information in this bulletin provides rough estimates of costs. It is still important that you secure estimates from local contractors before you begin, as costs vary widely throughout the state. Local conditions may cause these costs to vary, so the information in this bulletin should not be used as a guide for what contractors should charge.

Although no room is provided in these worksheets for cost share funding, funds from these programs may well change which system is most economical.

Cost Estimate Worksheet

These worksheets are designed to work together. The costs from Worksheets 1 through 3 are carried into Worksheets 4 through 6 where appropriate to determine the total system costs. An Excel version of these worksheets is available at *http://www.ianrpubs.unl.edu/epublic/live/ec821/build/ec821.xls*.

Worksheet 1 — Well Cost

Component	*Unit Cost*	*Total Units*	*Total Cost*
Drilling	______/foot	______ feet	__________
Solid Casing	______/foot	______ feet	__________
Perforated Casing	______/foot	______ feet	__________
Gravel	______/cu yd	______ cu yd	__________
Grout	______/sack	______ sacks	__________
Sanitary Seal			__________
Registration			__________
		Total Well Cost	__________

Worksheet 2 — Bottomless Tank Costs

Component	*Unit Cost*	*Total Units*	*Total Cost*
Tank Sides			__________
Cement	______ / cu yd	______/ cu yd	__________
Bentonite	______/ sack	______ sacks	__________
Installation Labor			__________
		Total Tank Cost	__________

Worksheet 3 — Steel Bottom Tank Costs

Component	*Cost*
Tank	__________
Installation	__________
Float, Valve and Fixtures	__________
Installation	__________
Total Tank Cost	__________

Worksheet 4 — Windmill Costs

Component	*Unit Cost*	*Total Units*	*Total Cost*
Tower			__________
Mill			__________
Anchors	______ / anchor	______	__________
Drop Pipe	______ / foot	______ feet	__________
Sucker Rod	______ / foot	______ feet	__________
Cylinder			__________
Installation Labor			
		Total Windmill Cost	__________
		add Bottomless Tank Cost (from *Worksheet 2*)	__________
		add Well Cost (from *Worksheet 1*)	__________
		System Cost	__________

Worksheet 5 — Submersible Pumps

Component	*Unit Cost*	*Total Units*	*AC*	*Solar*
Pump			______	______
Solar Panels	______/ Panel	______ pnls		______
Pressure Tank			______	
Drop Pipe	______ / foot	______ feet	______	______
Electrical Boxes and Wires			______	
Well Plate			______	______
Labor			______	______
Hook-Up			______	
AC Line	______ / foot	______ feet		
Total Pump Costs			______	______
add Bottomless Tank Cost (from *Worksheet 2*)				______
add Steel Bottom Tank Cost (from *Worksheet 3*)			______	
add Well Cost (from *Worksheet 1*)			______	______
System Cost			______	______

Worksheet 6 — Underground Pipe

Component	*Unit Cost*	*Total Units*	*Total Cost*
Trenching and Pipe	______ / foot	______ feet	__________
Hydrant (if used)			__________
Hook-Up			__________
		Total Underground Pipe Costs	__________
		add Steel Bottom Tank Cost plus fixtures (from *Worksheet 3*)	__________
		System Cost	__________

*For multiple water sites multiply the per tank cost by the number of sites.

2002 Cost Estimate Example

In this sample problem we use 100 feet as the depth to water and plan on using 20 feet of perforated casing. The water site being developed is 0.7 miles from a farmstead served by AC power that has a pressure water system. Average costs for 30-foot bottomless and 12-foot steel bottom tanks are used. Cost for the windmill is similar to a 33-foot tower with an 8-foot mill. Cost for the submersible pump is similar to averages for a 1 HP pump using PVC drop pipe. Underground pipe costs are similar to normal costs for 1 1/2 poly pipe.

Worksheet 1 — Well Cost

Component	*Unit Cost*	*Total Units*	*Total Cost*
Drilling	7.75 /foot	120 feet	930
Solid Casing	2.70 /foot	100 feet	270
Perforated Casing	3.50 /foot	20 feet	70
Gravel	5.00 /cu yd	10 cu yd	50
Grout	10.00 /sack	3 sacks	30
Sanitary Seal			150
Registration			60
		Total Well Cost	1,560

Worksheet 2 — Bottomless Tank Costs

Component	*Unit Cost*	*Total Units*	*Total Cost*
Tank Sides			865
Cement	25.00 / cu yd	24 / cu yd	600
Bentonite	7.00 / sack	6 sacks	42
Installation Labor			450
		Total Tank Cost	1,957

Worksheet 3 — Steel Bottom Tank Costs

Component	*Cost*
Tank	385
Installation	200
Float, Valve and Fixtures	80
Installation	85
Total Tank Cost	750

Worksheet 4 — Windmill Costs

Component	*Unit Cost*	*Total Units*	*Total Cost*
Tower			1,000
Mill			1,700
Anchors	25.00 / anchor	4	100
Drop Pipe	5.00 / foot	100 feet	500
Sucker Rod	1.25 / foot	100 feet	125
Cylinder			220
Installation Labor			
		Total Windmill Cost	3,645
		add Bottomless Tank Cost (from *Worksheet 2*)	1,957
		add Well Cost (from *Worksheet 1*)	1,560
		System Cost	7,162

Worksheet 5 — Submersible Pumps

Component	*Unit Cost*	*Total Units*	*AC*	*Solar*
Pump			700	1,455
Solar Panels	250 / Panel	3 pnls		750
Pressure Tank			500	
Drop Pipe	1.20 / foot	100 feet	120	120
Electrical Boxes and Wires			140	
Well Plate			30	30
Labor			250	350
Hook-Up			150	
AC Line	2.50 / foot	3,700 feet	9,250	
		Total Pump Costs	11,140	2,705
		add Bottomless Tank Cost (from *Worksheet 2*)		1,957
		add Steel Bottom Tank Cost (from *Worksheet 3*)	750	
		add Well Cost (from *Worksheet 1*)	1,560	1,560
		System Cost	13,450	6,222

Worksheet 6 — Underground Pipe

Component	*Unit Cost*	*Total Units*	*Total Cost*
Trenching and Pipe	1.70 / foot	3,700 feet	6,290
Hydrant (if used)			
Hook-Up			100
		Total Underground Pipe Costs	6,390
		add Steel Bottom Tank Cost plus fixtures (from *Worksheet 3*)	750
		System Cost	7,140

*For multiple water sites multiply the per tank cost by the number of sites.