AE-91 (Revised)

Selecting a Sprinkler Irrigation System

Tom Scherer
Extension Agricultural Engineer

The four basic methods of irrigation are: subsurface irrigation ("subirrigation" which uses tile drain lines), surface or gravity irrigation, trickle irrigation (also called drip irrigation), and sprinkler irrigation. Of the acres currently irrigated in North Dakota, over 75 percent use some type of sprinkler system. Statewide, the center pivot is the most popular sprinkler system.

If the sprinkler system is for a **new** installation, you have two important tasks you must perform before purchasing the system. First, you must check the county soil survey maps to make sure the soils in the field are **irrigable**. Second, you must have a readily available source of water near the field and have a State Water Commission-issued water permit for that water. The water source must be of sufficient quantity and quality for successful irrigation. Extension circular AE-92, Planning to Irrigate... A Checklist, provides more information on the requirements to begin irrigating.

A sprinkler "throws" water through the air in an effort to simulate rainfall whereas the other three irrigation methods apply water directly to the soil, either on or below the surface. A sprinkler system can be composed of one or many sprinklers. In systems that use many sprinklers, the sprinklers are attached to a pipeline at a predetermined spacing in order to achieve a uniform application amount. When selecting a sprinkler system, the most important *physical* parameters to consider are:

1. The shape and size (acres) of the field.
2. The topography of the field. Are there many hills with steep slopes?
3. The amount of time and labor required to operate the system. How much time and labor do you have available?

The center pivot system is very adaptable but doesn't work very well on irregularly shaped fields, long narrow fields and fields that contain some type of obstruction (trees, farmsteads, etc.). In these situations, other sprinkler systems may be more effective.

Sprinkler System Capacity

The sprinkler system capacity is the flow rate the system needs to irrigate an area adequately. It is expressed in gallons per minute per acre (gpm/acre). The system capacity is dependent on the:

1. Peak crop water requirements during the growing season.
2. Effective crop rooting depth.
3. Texture and infiltration rate of the soil.
4. The available water holding capacity of the soil.
5. Pumping capacity of the well or wells (if wells are the water source).
6. The State Water Commission permitted pumping rate.

Table 1 shows the system capacity you need for the most common irrigated crops in North Dakota and various soil textures. To use this table, you must determine the dominant soil texture in the field and what type of crops you will grow (the crop rotation), then determine the appropriate system capacity.

For example, if you plan a rotation of potatoes, corn and alfalfa on a loamy sand, you can determine from Table 1 that potatoes require 7.0 gpm/acre, corn 5.9 gpm/acre and alfalfa 5.6 gpm/acre. You would select a design system capacity for the crop requiring the largest amount, in this case the potatoes at 7.0 gpm/acre. If you installa center pivot system covering 130 acres, you would need about 910 gpm

(Continued on back page)

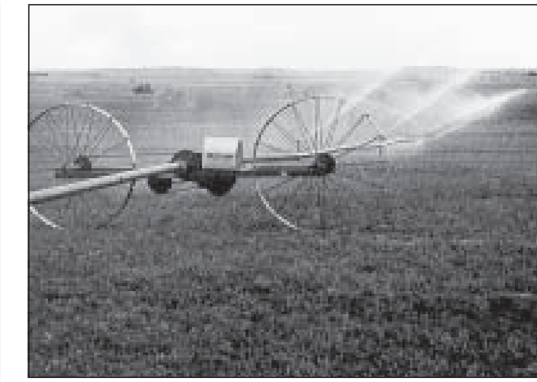
Table 1. System Capacity in gallons per minute per acre (gpm/acre) for different soil textures needed to supply sufficient water for each crop in 9 out of 10 years. An application efficiency of 80% and a 50% depletion of available soil water were used for the calculations.

Crop	Root Zone Depth (ft)	Coarse Sand and Gravel	Sand	Loamy Sand	Sandy Loam	Fine Sandy Loam	Loam and Silt Loam
POTATOES**	2.0	8.2	7.5	7.0	6.4	6.1	5.7
DRY BEANS	2.0	7.9	7.1	6.4	6.1	5.7	5.4
SOYBEANS	2.0	7.9	7.1	6.4	6.1	5.7	5.4
CORN	3.0	7.3	6.6	5.9	5.5	5.3	4.9
SUGARBEETS	3.0	7.3	6.6	5.9	5.5	5.3	4.9
SMALL GRAINS	3.0	7.3	6.6	5.9	5.5	5.3	4.9
ALFALFA	4.0	6.8	5.9	5.6	5.1	5.0	4.5

** Adjusted for 40% depletion of available water

NDSU
Extension Service
North Dakota State University
Fargo, North Dakota 58105
AUGUST 2005

What It Looks Like



Brief Description

Center Pivot

This self-propelled sprinkler system rotates around the pivot point and has the lowest labor requirements of the systems considered. It is constructed using a span of pipe connected to moveable towers. It will irrigate approximately 130 acres out of a square quarter section. Center pivot systems are either electric, water, or oil-drive and can handle slopes up to 15 percent. Sprinkler packages are available for low to high operating pressures (25 to 80 psi at the pivot point). Sprinklers can be mounted on top of the spans or on drop-tubes which put them closer to the crop. The speed of the rotation controls the water application amount. Center pivots are adaptable for any height crop and are particularly suited to lighter soils. They are generally not recommended for heavy soils with low infiltration rates.

Deep wheel tracks can be a problem on some soils, but a number of management methods are available to control this problem. Electric-drive pivots are the most popular due to flexibility of operation. Computerized control panels allow the operator to specify speed changes at any place in the field, reverse the pivot, turn on auxiliary pumps at a specified time and many other features.

Center Pivot With Corner Attachment

Corner attachment systems are available which allow irrigation of most of the corner area that a conventional center pivot system misses. Depending on the type of corner system, pivot systems with corner attachments will irrigate 145 to 152 acres out of a 160 acre quarter section. The most common method of corner irrigation has an additional span, complete with tower, attached to the end of the center pivot system mainline which swings out in the corners. As it swings out, sprinklers turn on to irrigate the corners. Either a buried wire or mechanical switch controls the movement of the moving span.

Another type of corner system uses several large sprinklers mounted on the end of the center pivot system mainline. The system activates the sprinklers in sequence from smallest to largest and back again as the machine moves past the corners. A corner span generally costs about half as much as the rest of the pivot, increasing the capital cost per acre on a square 160 acres. However, if the field is rectangular, the corner span can be extended on one or both ends, increasing the amount of irrigated acreage from 170 to 185 acres. High value crops and/or high land value as well as scarcity of irrigable land is necessary to justify the additional costs over a "plain" center pivot.

Linear Move

The linear move (sometimes called a lateral move) irrigation system is built the same way as a center pivot, with moving towers and spans of pipe connecting the towers. The main difference is that all the towers move at the same speed and in the same direction. Water is pumped into either one of the ends or into the center. Water can be supplied to the linear system either through a canal, by dragging a supply hose which is connected to a mainline, or by connecting and disconnecting from hydrants as the system moves down the field. To gain acreage and make the transition from one side of the field to the other, some linear systems pivot at the end of the field.

The lateral movement makes powering a linear system with electricity difficult. Usually, it has a diesel motor with a generator mounted on the main drive tower that supplies the power to operate the irrigation system.

The primary advantage of the linear is that it can irrigate rectangular fields up to a mile long and a half mile wide. Due to the high capital investment cost, linear systems are used on high value crops such as potatoes, vegetables and turf.

Traveling Big Gun

The traveling big gun system uses a large capacity nozzle (¾ to 1½ inches in diameter) and high pressure (90 to 125 psi) to throw water out over the crop (175 to 350 foot radius) as it is pulled through an alley in the field. Traveling big guns come in two main configurations: hard hose or flexible hose feed. With the hard hose system, a hard polyethylene hose is wrapped on a reel mounted on a trailer. The trailer is anchored at the end or center of the field. The gun is connected to the end of the hose and is pulled to the end of the field. The hose wrapping up on the reel pulls the gun across the field.

With the flexible hose system, the gun is mounted on a four-wheel cart. A flexible hose from the mainline supplies water to the gun. A winch cable on the cart pulls the cart through the field. The cable is anchored at the end of the field. Most traveling big gun systems have their own power unit and cable winch mounted directly on the machine. The power unit may be an internal combustion engine or a water drive.

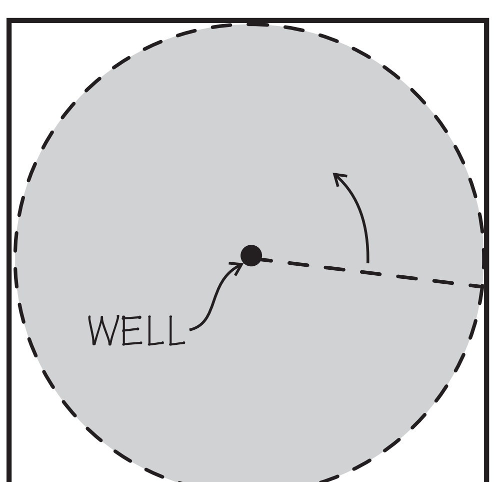
Particularly adaptable to various crop heights, variable travel speeds, odd shaped fields, and rough terrain, the big gun requires a moderate initial investment, more labor and higher operating pressures than center pivots and linear systems. One 1,320-foot (quarter-mile) long set usually covers 8 to 10 acres, but many variations are available using different water quantities and operating pressures. This system sacrifices irrigated cropland because the alley generally is two rows wide. Most big gun systems are used on a maximum of 80 to 100 acres per gun.

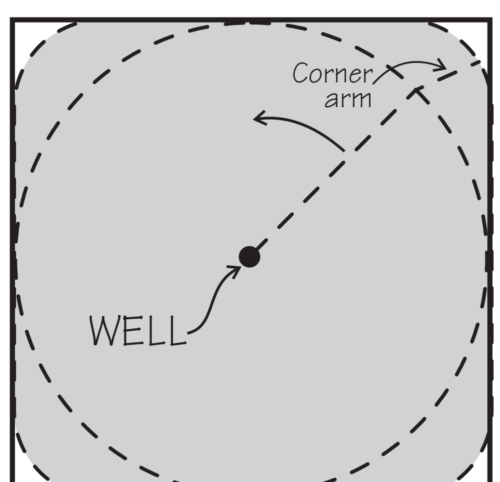
Side Roll

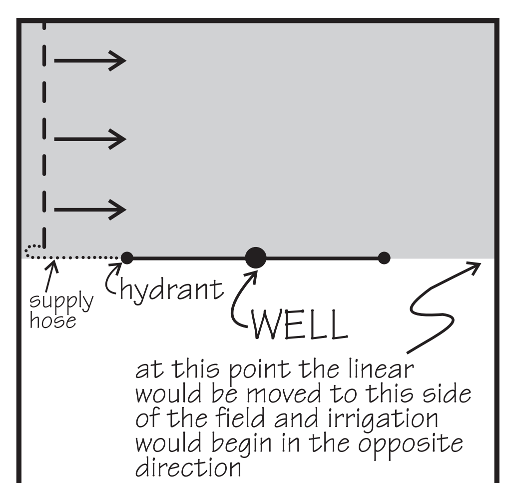
The side roll (sometimes called a wheel roll) system, consists of a lateral, usually one-quarter mile long, mounted on 4- to 10-foot diameter wheels with the pipe acting as an axle. Common pipe diameters are 4 and 5 inches. The side roll irrigates an area from 60 to 90 feet wide. When the system has applied the desired amount or water to this set area, a gasoline engine located at the center moves the side roll to the next set. The sprinklers generally are mounted on weighted, swivelling connectors so that no matter where the side roll stops, the sprinklers will always be right side up. This type of system is not recommended for slopes greater than 5 percent and should be used mainly on flat ground. When not being used, side rolls are subject to damage from high winds.

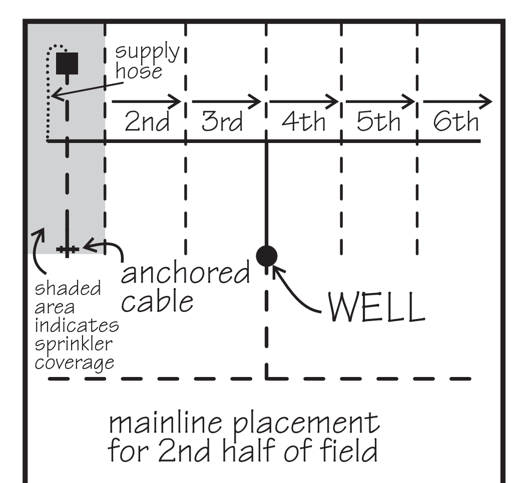
Other characteristics include: adapted only to low-growing crops, medium labor requirements, moderate initial investment, medium operating pressure (50 psi at inlet), generally rectangular field requirements, and each lateral capable of irrigating a maximum of 40 acres. The side roll is better adapted to heavier soils than a continuous moving system. You must purchase special wheels for moving this system from field to field without disassembly. One variation of the side roll system has trail lines with up to three additional sprinklers on a 60-foot spacing. This reduces the number of sets required to irrigate a particular field.

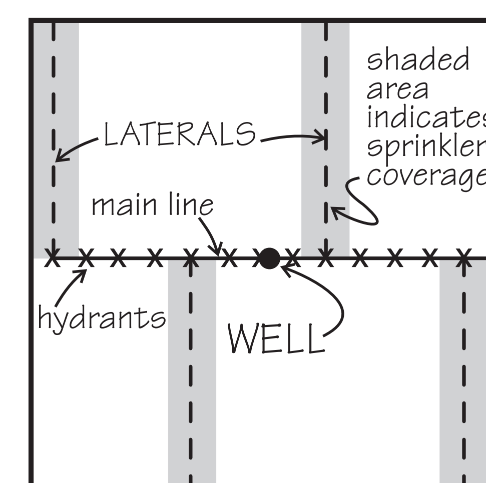
Sample 160 Acre Layout











(Continued from front page)
for proper design. However, what you need for proper design and what a well will produce is frequently different. As a general rule, under full season irrigation, you need a minimum of 6 gpm/acre is required because most of the soils irrigated in North Dakota are loamy sands or sandy loams. You can use a lesser flow rate, but you will need to do more intensive water management.

A sprinkler system must be designed to apply water uniformly without runoff or erosion. **The application rate of the sprinkler system must be matched to the intake rate of the most restrictive soil in the field**. If the application rate exceeds the soil intake rate, the water will run off the field or relocate within the field resulting in over- and underwatered areas. Using tillage that improves surface storage, such as deep cultivation or making basins, will help control runoff. The intake rate of the soils in your field can be found in the county soil survey avail-able at your local Natural Resources Conservation Service or extension office.

Selecting the Most Appropriate Sprinkler Systems

Five of the most common sprinkler systems in use in North Dakota are compared in this circular using the following criteria:

1. A square 160 acre field.
2. A 100-foot deep well near the center of the field.
3. The water supply is adequate for any sprinkler system.
4. The soils are suitable for the system application rate.

Table 2 shows costs of irrigation development using these criteria. The costs shown are averages; actual costs for most farms will vary depending on the distance from the water source to the field, whether you purchase a new or used sprinkler system, options you select and the type of financing package. You should take care to ensure that the cash flow generated is sufficient to cover payments on the irrigation investment.

Table 2. Comparative Cost of New Sprinkler Irigation Systems (square 160 acres, 100-foot-deep well in middle of property).

	Center Pivot	Pivot w/Corner	Linear Move	Big Gun	Side Roll
CAPITAL COSTS:					
Number of Systems Required	1	1	1	2	4
Acres Irrigated (in 160)	130	152	158	157	158
Required Flow Rate (GPM)	780	912	948	942	948
Irrigation System Cost	$50,000.00	$70,000.00	$76,000.00	$42,000.00	$40,000.00
Well, Pump, Motor	$30,000.00	$30,000.00	$30,000.00	$30,000.00	$30,000.00
Pipe, Meter, Valves	$3,000.00	$3,000.00	$7,500.00	$34,000.00	$17,500.00
Electric Panel and 1,400 ft of Wire	$7,000.00	$7,000.00	$7,000.00	$7,000.00	$7,000.00
TOTAL CAPITAL COST	$90,000.00	$110,000.00	$120,500.00	$113,000.00	$94,500.00
CAPITAL COST PER ACRE	$692.31	$723.68	$762.66	$719.75	$598.10
OWNERSHIP COST (per acre)					
Depreciation on System (25 yr)	$15.38	$18.42	$19.24	$10.70	$10.13
Depreciation on Well, Pump, Motor and Pipe (25 year life, straight line depreciation)	$12.31	$10.53	$11.27	$18.09	$13.80
Interest on Investment	$34.62	$36.18	$38.13	$35.99	$29.91
Insurance ($.50/$100)	$3.46	$3.62	$3.81	$3.60	$2.99
TOTAL ANNUAL OWNERSHIP COST	$65.77	$68.75	$72.45	$68.38	$56.82
OPERATING COSTS (per acre)					
Power (electric)[1]	$18.65	$18.65	$20.16	$36.80	$24.70
Labor (@ $10.00/hr)	$7.50	$7.50	$10.00	$20.00	$25.00
Maintenance (1.5% New Cost)	$10.38	$10.86	$11.44	$10.80	$8.97
TOTAL ANNUAL OPERATING COST	$36.53	$37.01	$41.60	$67.60	$58.67
OPERATING AND OWNERSHIP COST	**$102.30**	**$105.76**	**$114.06**	**$135.97**	**$115.49**
Kilowatts Hours of Power	31.69	37.06	41.64	75.53	51.02
Pressure at Well (psi)	40	40	45	100	60

[1] Based on an electric rate of 4.5¢ per Kilowatt-Hour (KWH), an electric demand charge of $9.00 per KW per month (4 months of operation) and 1050 hours of pump operation per growing season.

For more information on this and other topics, see: www.ag.ndsu.edu

NDSU Extension Service, North Dakota State University of Agriculture and Applied Science, and U.S. Department of Agriculture cooperating. Duane Hauck, director, Fargo, N.D. Distributed in furtherance of the acts of Congress of May 8 and June 30, 1914. We offer our programs and facilities to all people regardless of race, color, national origin, religion, sex, disability, age, Vietnam era veterans' status or sexual orientation; and are an equal opportunity employer. 1500-9-94, 2M-9-98, 1M-8-05
This publication will be made available in alternative formats for people with disabilities upon request, (701) 231-7881.