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Selecting a Sprinkler Irrigation System

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The four basic methods of irrigation are: sprinkler, surface or gravity, trickle (also called drip) and subsurface ("subirrigation," which uses tile drain lines). In North Dakota, more than 87 percent of irrigated land has some type of sprinkler system, with most using a center pivot.

If the sprinkler system is for a ***new*** installation, you must perform two important tasks prior to purchasing the system. First, you must determine whether the soil types in the field can be irrigated. Second, you must have a readily available source of water near the field and an **irrigation permit issued by the Appropriations Division of the Department of Water Resources** for that water. The water source must be of sufficient quantity and quality for successful irrigation. NDSU Extension publication AE92, "Planning to Irrigate: A Checklist," provides more information about the process required to begin irrigating.

A sprinkler "throws" water through the air 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 sprinkler or many. When many sprinklers are used, they are attached to a pipeline at a predetermined spacing to achieve a uniform application amount.

When selecting a sprinkler system, the most important ***physical*** parameters to consider are:

- The shape and size (acres) of the field
- The topography of the field: Does the field have many hills with steep slopes?
- The amount of time and labor required to operate the system throughout the growing season: How much time and labor do you have available?

Although the center pivot is the most common sprinkler system, it doesn't fit very well on irregularly shaped fields; long, narrow fields; and fields that contain obstructions (trees, farmsteads, etc.). In these situations, other sprinkler systems may be used more effectively.

Sprinkler System Capacity

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

- Peak crop water requirements during the growing season
- Maximum effective crop root depth
- Texture and infiltration rate of the soil
- Available water-holding capacity of the soil
- Pumping capacity of the well or wells
- Department of Water Resources-permitted pumping rate

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

For example, if you plan a three-year rotation of potatoes, corn and soybeans on loamy sand, you can determine from Table 1 that potatoes require 7 gpm/acre, corn 5.9 gpm/acre and soybeans 6.4 gpm/acre. Select a design system capacity for the potatoes at 7 gpm/acre.

If you install a center pivot system covering 130 acres, ideally you would need about 910 gpm (7 x 130). The most common irrigated soils are loamy sands or sandy loams that require a flow rate of about 6 gpm/acre for full-season irrigation. A lesser flow rate can be used, but more intensive water management

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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 nine out of 10 years. An application efficiency of 80 percent and a 50 percent 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
Sugar beets	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 percent depletion of available water.

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Center Pivot

This self-propelled sprinkler system rotates around a central pivot point and has the lowest labor requirements of the systems being compared. It is constructed using a span of pipe connected to moveable towers. Sprinkler heads are spaced at set distances on each span along the length of the center pivot. From the pivot point, each sprinkler head covers more area, thus the nozzle diameter in the sprinklers increases the farther they are located from the pivot point.

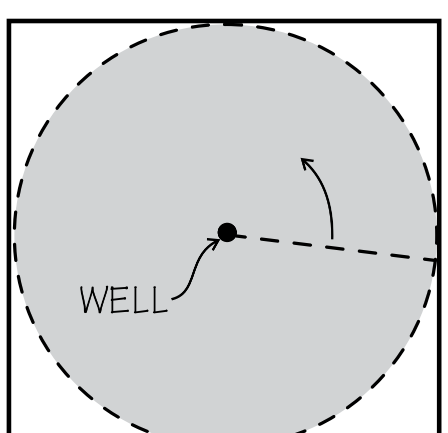
Many center pivots are installed with an “endgun,” a large-volume sprinkler on the last tower farthest away from the pivot point. With an endgun, a center pivot can irrigate approximately 132 acres, and without an endgun, it can irrigate about 125 acres of a square quarter section.

Center pivot systems are electric or oil-drive and can handle slopes up to 15 percent. Electric-drive pivots are the most popular due to flexibility of operation. Center pivots are adaptable for any height crop and are particularly suited to lighter soils. They can be used on heavy soils with low infiltration rates but must be managed more carefully. Deep wheel tracks under the towers can be a problem on some soils; however, a number of management methods are available to control this problem.

Sprinkler packages are available for low to high operating pressures (25 to 80 pounds per square inch [psi] at the pivot point). The sprinklers can be mounted on top of the span pipe or on drop-tubes, which put them closer to the crop.

On most center pivots, the amount of applied water is controlled by the speed of rotation. Recently, variable-rate irrigation (VRI) systems have become available. These systems allow an irrigator to control the applied amount of water at individual or banks of sprinklers the full length of the center pivot.

The computerized control panels on center pivots allow the operator to program speed changes and vary the amount of water applied at any place in the field, reverse the pivot and turn on auxiliary pumps at specified times. Many center pivots are controlled remotely with smart-phones and computers via cellular modems, satellite or radio communications.



Sample 160 Acre Layout

Center Pivot With Corner Attachment

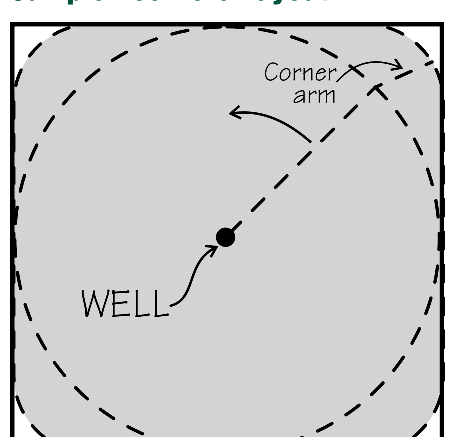
This special sprinkler attachment to the center pivot is designed to water the corner areas of a field. Depending on the type, these attachments will increase the irrigated acreage from 145 to 156 acres in a square 160-acre quarter section.

The most common method of corner irrigation has an additional span, tower and overhang attached to the end of the center pivot’s main line. This span swings out in the corners. As it swings out, the area increases so the sprinklers are turned on in sequence.

If the field is rectangular, the corner span can be extended on one or both ends, thereby increasing the irrigated area from 170 to 185 acres. The track the tower follows is guided by a signal from a buried wire or by using a global positioning system (GPS).

A corner span generally costs about half as much as the rest of the pivot, thereby increasing the capital cost per acre on a square 160 acres. High-value crops and/or high land values, as well as scarcity of irrigable land, are necessary to justify additional costs for more than a standard center pivot.

Sample 160 Acre Layout



Linear Move

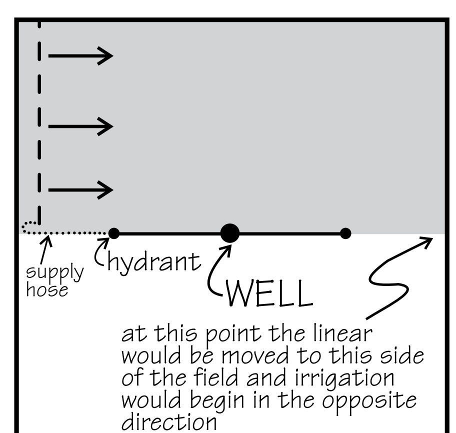
The linear move (sometimes called a lateral move) irrigation system is built the same way as a center pivot; that is, it has moving towers and spans of pipe connecting the towers. The main difference is that all the towers move at the same speed and in the same direction.

Water is pumped into one of the ends or into the center. Water can be supplied by a canal running the length of the field near the center of the linear move or at one of the ends. A more common water supply method is to drag a hose, which is connected to a buried water supply pipe through one or more hydrants, as the linear moves down the field.

To gain acreage and make the transition from one side of the field to the other, some linear move systems pivot at the end of the field. Due to the lateral movement, powering a linear with electricity is difficult and requires a mining grade dragline. Usually, a diesel motor with a generator is mounted on the main drive tower and supplies the power needed to operate the irrigation system.

The primary advantage of the linear move is that it can irrigate rectangular fields up to a mile in length and a half-mile wide. A general rule is the length of run should be about five times longer than the length of the linear move. The plan view below is for comparison purposes because a linear would not be installed on a square 160-acre field except under special circumstances. Due to the high capital investment, linear moves commonly are used to irrigate high-value crops such as potatoes, vegetables and turf.

Like center pivots, linear moves have computerized control panels that allow the operator to program speed changes and vary the amount of water applied at any location in the field. They can also be controlled remotely with smartphones and computers via cellular modems, satellite or radio communications.



Sample 160 Acre Layout

Traveling Big Gun

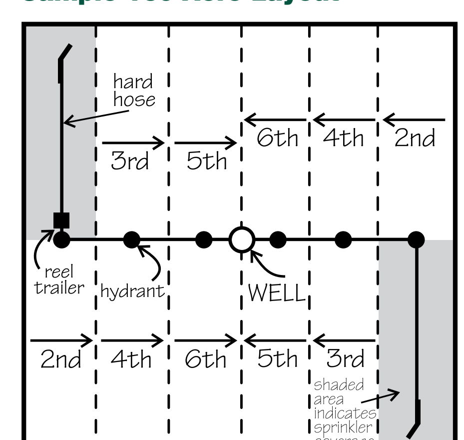
The traveling big gun system uses a large-capacity nozzle (3/4 to 2 inches in diameter) and high pressure (90 to 125 psi) to throw water out over the crop (175- to 350-foot radius) as it is pulled through an alley in the field.

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 pulled to the end of the field. The gun is pulled across the field by the hose wrapping up on the reel.

With the flexible-hose system, the gun is mounted on a four-wheel cart. Water is supplied to the gun by a flexible hose from the main line. 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 moves. One 1,320-foot-long (quarter mile) set usually covers eight to 10 acres, but many variations using different water quantities and operating pressures are available. Irrigated cropland is sacrificed because the alley is generally two rows wide. Most big-gun systems are used on a maximum of 80 to 100 acres per gun.

Sample 160 Acre Layout



Wheel Roll

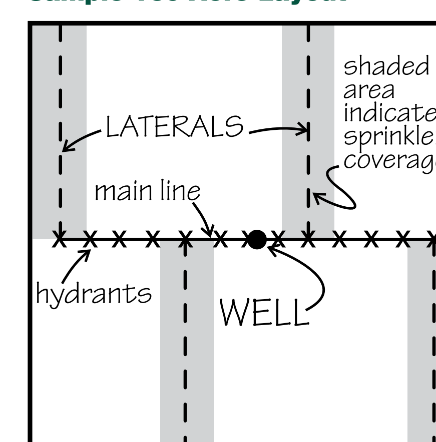
The wheel roll (sometimes called a side roll) system, as shown, consists of a lateral, usually a quarter mile long, mounted on 4- to 10-foot-diameter wheels, with the pipe acting as an axle. Common pipe diameters are 4 and 5 inches. The wheel roll irrigates an area from 60 to 90 feet wide. When the desired amount of water has been applied to this set area, a gasoline engine at the center is used to move the wheel roll to the next set.

The sprinklers generally are mounted on weighted, swiveling connectors so that no matter where the wheel roll is stopped, the sprinklers always will 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, wheel rolls are subject to damage from high winds.

Wheel roll systems also are adapted only to low-growing crops, and have medium labor requirements, moderate initial investment, medium operating pressure (50 psi at inlet) and generally rectangular field requirements. Each lateral is capable of irrigating a maximum of 40 acres. The wheel roll is better adapted to heavier soils than a continuous moving system.

Special wheels must be purchased for moving this system from field to field without disassembly. One variation of the wheel roll system has trail lines with up to three additional sprinklers on 60-foot spacing. This reduces the number of sets required to irrigate a particular field.

Sample 160 Acre Layout



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will be required, especially during years with less than average growing season precipitation.

A sprinkler system must be designed to apply water so no runoff or erosion occurs. 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. Conservation tillage and residue management can help control runoff.

Selecting the Most Appropriate Sprinkler System

In this publication, you'll find comparisons of five of the most common sprinkler systems being used in North Dakota. The comparisons are based on the following criteria:

- A square 160-acre field
- A 100-foot-deep well near the center of the field
- An adequate water supply for any sprinkler system
- Suitable soils for the system application rate

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

NDSU Extension Publications With Additional Irrigation Information

- AE92 – "Planning to Irrigate: A Checklist"
- AE1637 – "Compatibility of North Dakota Soils for Irrigation"
- AE1675 – "Soil, Water and Plant Characteristics Important to Irrigation"

Table 2. Comparative cost of new sprinkler irrigation systems (square 160-acre field, 100-foot-deep well in middle of property). Assumes three-phase electric power lines run along the edge of the field.

	Center Pivot	Pivot w/Corner[1]	Linear Move[2]	Big Gun	Side Roll
Capital Costs					
Number of systems required	1	1	1	2	4
Acres irrigated (in 160)	128	152	156	154	156
Required flow rate (GPM)	768	912	936	924	936
Irrigation system cost	$105,000.00	$157,500.00	$175,000.00	$100,000.00	$110,000.00
Well, pump, motor	$58,000.00	$58,000.00	$58,000.00	$58,000.00	$58,000.00
Pipe, meter, valves (turnouts)	$12,000.00	$12,000.00	$20,000.00	$28,000.00	$30,000.00
Buried power wire and electrical panel	$25,000.00	$25,000.00	$25,000.00	$25,000.00	$25,000.00
Total capital cost	$200,000.00	$252,500.00	$278,000.00	$211,000.00	$223,000.00
Capital cost per irrigated acre	$1,562.50	$1,661.18	$1,782.05	$1,370.13	$1,429.49
Annual Ownership Costs (per acre)					
Depreciation on system (25-year life, straight-line depreciation)	$27.34	$34.54	$37.39	$21.65	$23.50
Depreciation on well, pump, motor and pipe (25-year life, straight-line depreciation)	$29.69	$25.00	$26.41	$28.83	$28.97
Interest on investment (6% rate averaged over 25 years)	$46.88	$49.84	$53.46	$41.10	$42.88
Insurance ($0.50/$100 of capital investment)	$17.19	$18.27	$19.60	$15.07	$15.72
Total annual ownership cost	$89.65	$97.70	$109.13	$84.25	$87.98
Operating costs (per acre)	$121.09	$127.65	$136.87	$106.65	$111.09
Power (electric)[3]	$27.57	$27.35	$29.24	$43.51	$30.85
Labor (@ $20/hr)	$15.00	$17.50	$20.00	$40.00	$47.00
Maintenance (1.5% new cost)	$23.44	$24.92	$26.73	$20.55	$21.44
Total annual operating cost	$66.00	$69.76	$75.97	$104.06	$99.29
Operating and ownership cost	**$187.10**	**$197.41**	**$212.84**	**$210.72**	**$210.38**
Annual cash cost of ownership	$130.07	$137.87	$149.03	$160.24	$157.90
Kilowatts hours (kwh) of energy (pumping energy plus tower motor energy on pivot and linear)	33.7	41.4	46.4	72.9	49.5
Pressure at well (psi)	40	40	45	100	60

[1] Buried wire guidance. For GPS guidance system, add $12,000.

[2] Guidance uses a furrow-sensing wheel. For GPS guidance system, add $20,000.

[3] Based on an off-peak electric rate of 9 cents per kilowatt-hour (kwh); annual meter charge of $800 and 900 hours of pump operation per growing season.

All photos from NDSU.

For more information on this and other topics, see www.ndsu.edu/extension

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