The Centre Pivot Irrigation System

Centre pivots are the most common irrigation system used in Saskatchewan. They have a relatively high water application efficiency and are able to irrigate in a wide range of topography. Lower labour requirements compared to wheel move and flood systems also make centre pivots a favourable method of irrigation.

The centre pivot is a sprinkler irrigation system that applies small amounts of water at frequent intervals to a unit area of crop. It consists of a span of pipe that is supported on wheeled A-frame towers and is self-propelled around a central pivot point. The pipe delivers the water to the sprinklers. Water is usually delivered to the pivot point through a buried mainline pipe.

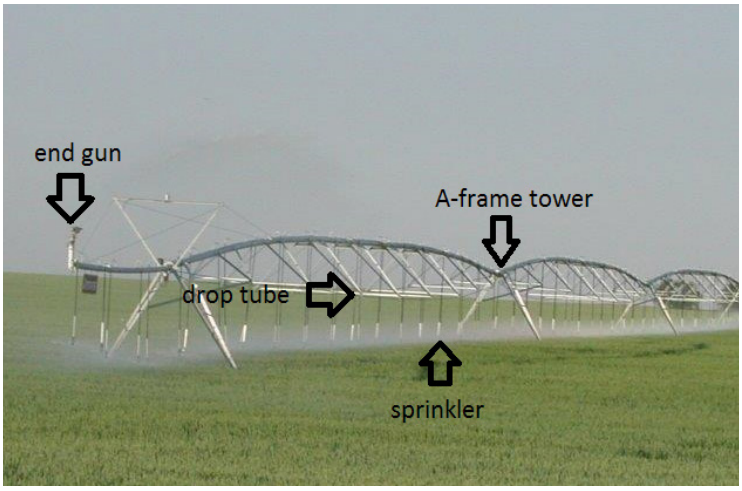


Figure 1. The span of the end tower of an irrigation pivot.

In-line pressure regulators can prevent over-watering as the topography of a field changes. For example, in low-lying areas of a field, regulators maintain constant pressure for consistent flow, compensating for the higher system pressure normally resulting from such variable terrain conditions. The systems can also be adapted with corner sections that rotate to more completely irrigate rectangular or odd-shaped fields. Corner systems can increase the irrigated area under a centre pivot by more than 15 per cent.

Figure 2. The centre pivot point.

The system may vary in length from approximately 60 m to 790 m (200 to 2,600 ft.) and is capable of irrigating a circular area up to 200 ha (500 ac.). The most common system irrigates a circle of approximately 54 ha (133 ac.) of a square quarter section. Pressure required at the pivot may vary from approximately 70 kPa (15 psi) when low-pressure spray nozzles are used, to 550 kPa (80 psi) when high-pressure impact sprinklers are used. The required pressure is heavily influenced by the topography of that land and soil type.

The current Saskatchewan recommendations for matching pivot and pressures to soil and topography are listed in Tables 1 and 2.

Low-pressure systems (LPS) represent a considerable savings in energy costs, compared to high-pressure systems. Choosing the proper sprinkler package for your LPS is critical to ensure your application rate corresponds to the soil texture on the land you're irrigating.

Table 1: Definition of Pressure Ranges Based on Pivot End Pressures

	kPA	psi
Low Pressure Spray Nozzle (LPS)	175	<25
Low Pressure Impact or Spray (LPI)	175-275	25-40
Medium Pressure	275-380	40-55
High Pressure	380+	55+
[1]Pressure conversion: 1 kPa = 0.145 psi		

Table 2: Recommended Minimum Pivot End Pressures for Soil Texture and Topography Conditions

Topography	Soil Texture		
	Coarse	Medium	Fine
None – Level to Nearly Level Less Than 2% Slopes	LPS	LPI	Medium
Slight – Very Gently Rolling 2-5% Slopes	LPS	LPI	High-Medium
Moderate – Slightly Rolling 6-9% Slopes	LPI	Medium	High
Severe – Rolling to Hilly 9-30% Slopes	Medium	High-Medium	High

Table 3: Soil Texture Ranges

Coarse	Sandy (S), Loamy Sand (LS), Sandy Loam (SL), Fine Sandy Loam (FSL)
Medium	Loam (L), Silt Loam (SiL), Very Fine Sandy Loam (VL)
Fine	Clay Loam (CL), Sandy Clay Loam (SCL), Sandy Clay (SC), Silty Clay (SiC), Clay (C), Heavy Clay (HC)

Sprinkler packages with high application rates could result in ponding of water, erosion and run-off on fine-textured soil or hilly landscapes.

Surface drainage to eliminate potential wet areas is essential on all fields, no matter what system is being used.

Drive System

Electric drive has become the most common system for irrigation pivots. Some oil hydraulic systems are still available, while water drive systems are almost entirely obsolete. In electric drive systems, the wheels are driven by the electric motor, which is mounted in the centre on the tower mainframe between the wheels. Drive shafts run from the motor to a gearbox on each wheel, which provides the power transfer from the motor to the wheels. The pivot can be moved with or without water running through the system. This allows an irrigator to move the pivot out of the way of field operations.

The speed of the pivot is controlled by controlling the motor on the end tower — the tower farthest from the pivot point. The control panel (Figure 3), which is located at the pivot point, is equipped with a timer that controls the percentage of time per minute that the motor on the lead tower is operating. Computerized control panels are capable of determining their position in the field, and an irrigator can program different application rates in different parts of the field.

The movement of the end tower causes the other towers of the pivot to move, responding to an alignment system designed to keep the pivot towers in a straight line formation. Alignment is controlled in electric pivots by either a cable system or by a micro switch linkage system. As a tower lags behind the lead tower, a micro switch is triggered to start the motor and move the lagging tower back into alignment.

Safety systems are built to shut the whole system off if a tower fails to come back into alignment. The system will also shut down if the pressure drops below a set working pressure or if the system is not advancing through the field fast enough.

Figure 3. Control panel for a centre pivot system.

Variable Rate Irrigation

Variable Rate Irrigation (VRI) is precision agriculture applied to irrigation. VRI systems allow irrigators to define different management zones within the field based on varying soil or landscape conditions. Water can then be applied at varying amounts to ensure water isn't being over or under applied in the different parts of the field. Sprinklers apply the prescribed amount of water by cycling on and off.

Operators use provided software to develop a "prescription" to indicate the desired application depths for defined areas under the system (Figure 4). Prescriptions are uploaded to the centre pivot's electronic control panel, which references the prescription when sending out control signals and cycles the signal to associated control valves to achieve the desired water application.

Remote Operation

Technology that allows remote operation of centre pivot systems is becoming more common and accessible. Irrigation manufactures can provide devices that allow you to monitor, operate and troubleshoot a system from a smart phone or computer. These systems also can provide you alerts for when a problem occurs and allow you to view the equipment history.

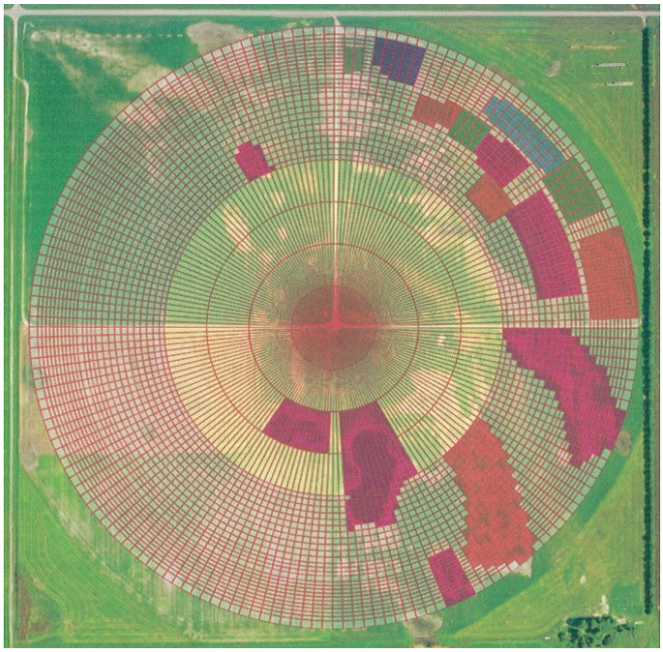


Figure 4. Diagram showing 5,400 irrigation management zones in a field with VRI, and a prescription to vary irrigation amounts in areas of special soil types and research trials.

This technology can save fuel and time, especially for producers who manage a high number of systems spread out over a large distance. It is important to ensure your pivot is in an area where there is mobile service coverage so the data can be transmitted to the user's device. It is possible, but expensive, to create a local network to provide coverage to your system.

Centre Pivot Water Application

A centre pivot's water application is fixed by the pumping flow rate, regardless of the speed of the pivot's revolution. The pumping flow rate is measured in U.S. gallons per minute (gpm). A centre pivot that puts out 800 U.S. gpm will apply about 1.8 acre inches per hour.

Not all of the water pumped enters the soil for crop use and evaporation losses do occur. For design purposes, a figure of 80 to 84 per cent efficiency is used. In other words, 80 to 84 per cent of the pumped water gets to the crop.

A rule of thumb is 450 U.S. gpm equals 1 acre-inch per hour.

To calculate your centre pivot's application rate:

a. Divide your total U.S. gallons per minute by your irrigated acreage. For example:
   800 U.S. gpm ÷ 133 acre = 6.0 U.S. gpm per acre
b. Use Table 4 to determine your application rates.

Table 4: Centre Pivot Application Rates

Litres per minute per hectare	U.S. gpm per acre	Inches per day 80% efficiency	Inches per week 80% efficiency	Hours to apply 12 in. to 133 ac.
47	5.0	.20	1.5	1,400
51	5.5	.24	1.7	1,200
56	6.0	.26	1.8	1,100
61	6.5	.28	1.9	1,000
66	7.0	.30	2.1	950
70	7.5	.32	2.2	900
75	8.0	.34	2.4	850

Operating Tips

Land Preparation

- Drain all sloughs prior to installing pivot.
- Over-cut drains to ensure water drains out of low areas prior to accumulation.
- If drains are grassed, mow grass periodically during and after season.
- Avoid building "roads" across a slough instead of draining. Roads do not solve water accumulation problems.
- Once the pivot rut is established, fill the bottom six inches with crushed rock where traction problems occur.

Pivot Design Considerations

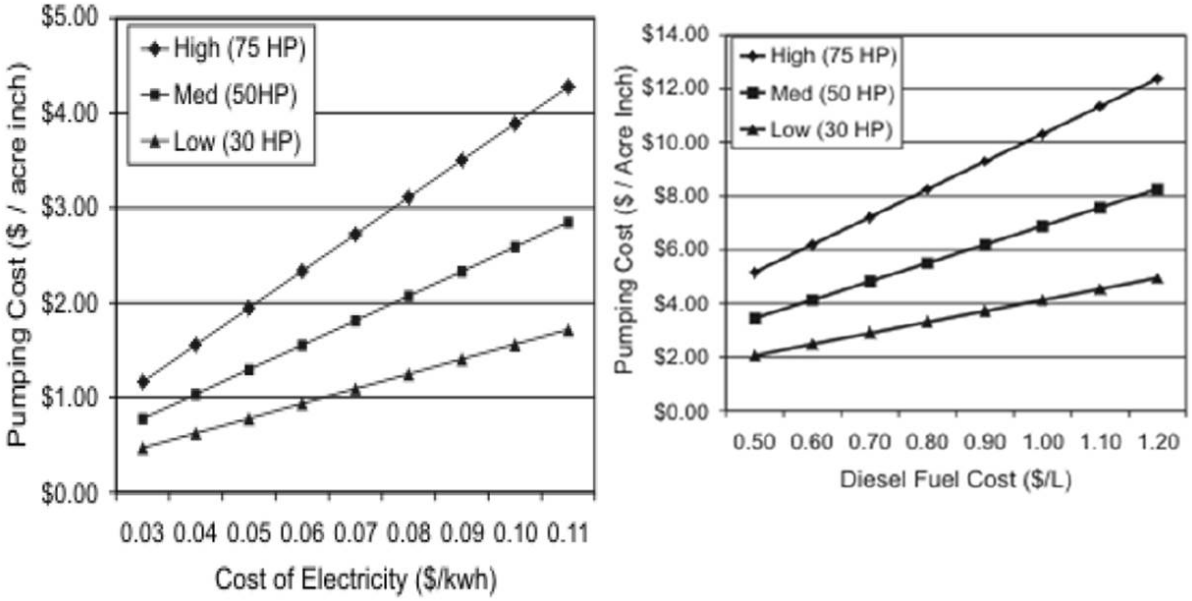
- High pressure machines cause less runoff, but are less efficient.
- Pick a sprinkler system suited to your soil type and topography.
- Tall tires provide better traction than wide tires and produce ruts easier to farm over
- Low pressure systems have sprinkler options available that keep the area in front of the tower dry. Boom backs and part circle sprinklers are examples of this technology.

Pivot Operations Considerations

- Run the first full circle at high speed to allow packing of the wheel track to occur.
- Watch your system for runoff. Run fast enough to avoid runoff down the wheel tracks into the low areas, but run as slow as the soil, avoiding excessive pivot traffic throughout the year.
- Most pivots are run at three-quarters to one inch per pass. Vary this on your land according to your own experience.

Pivots as Multi-use Tools

- Pivots are often used to apply liquid fertilizer.
- They can also be used to apply fungicide.
- Centre pivots can also be used to distribute municipal and agricultural effluent on agricultural lands.



Assumptions: 900 U.S. gpm centre pivot (80 per cent efficient) irrigating 133 acres; continuous horsepower; no lift. Add the basic electricity charge to obtain the total irrigation electricity charge. Non-fuel costs (oil, filters etc.) for a diesel system are not included in this example.

For more information, contact Ministry of Agricultural irrigation staff in Outlook at 306-867-5500.