http://www.ext.nodak.edu/extnews/spouts/

water spouts

No. 235 MAY 2008

Upcoming Field Days

Streeter Central Grasslands Research Extension Center	June 26	(701) 424-3606
Minot – Canola Day North Central Research Extension Center	June 30	(701) 857-7677
Williston – Pulse Tour Research Extension Center	July 1	(701) 774-4315
Minot – Pulse Crops Day North Central Research Extension Center	July 8	(701) 857-7677
Hettinger Research Extension Center	July 8	(701) 567-4323
Dickinson Research Extension Center	July 9	(701) 483-2348
Williston Research Extension Center	July 10	(701) 774-4315
Casselton Agronomy Seed Farm	July 14	(701) 347-4743
Carrington Research Extension Center	July 15	(701) 652-2951
Minot North Central Research Extension Center	July 16	(701) 857-7677
Sidney, Montana Eastern Agricultural Research Center	July 16	(406) 482-2208
Langdon Research Extension Center	July 17	(701) 256-2582
Mandan USDA/ARS Northern Great Plains Research Lab	July 17	(701) 663-3018
Outlook, Saskatchewan Canada-Saskatchewan Irrigation Diversification Centre	July 17	(306) 867-5400
Oakes Irrigation Research Site	July 29	(701) 742-2189

NDSU
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Now is the Time to Replenish Subsoil Moisture

Much of North Dakota is experiencing drought conditions. Irrigation is certainly a good insurance policy for drought (assuming a reliable water supply), but if the subsoil is depleted and not replenished, yield reduction is a possibility. Subsoil moisture (the deep root supply) helps supply moisture during the high water use months of July and August. If little subsoil moisture is available during these months, then the crop is dependent on the application capacity of your irrigation system.

The sprinkler packages on many center pivots are designed to apply around 6 gallons per minute per irrigated acre. This is equivalent to applying about 0.27 inch of water into the root zone every day. However, on many days in July and August, the daily crop water use will exceed this amount, and that is when subsoil moisture can help. If water use exceeds the application capacity of the irrigation system on too many successive days, the crop can suffer water stress.

To help avoid this problem, check your subsoil moisture using a soil probe after crop emergence. Use the feel method to check the soil moisture content in the deep root zone (18 to 36 inches below the surface). If it is low, consider starting your irrigation system early and applying a couple of inches of water to replenish the deep root zone. Applying extra water early in the season when crop water use is low will pay dividends during the hot, dry months ahead.

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Implementing Site-specific Sprinkler Irrigation

Researchers at the U.S. Department of Agriculture's Agricultural Research Service in Sidney, Mont., believe that one of the greatest constraints to managing for enhanced productivity, as well as water quality, is the inability of agricultural producers to control inputs in ways that accommodate variable growing conditions across a field. Consequently, they are working on site-specific irrigation practices that have the potential to increase certain economic efficiencies by optimally matching inputs to yields in each area of a field. Using wireless in-field sensors and specially modified self-propelled linear move irrigation systems, researchers are showing the large potential of site-specific systems to increase yield and water use efficiencies while reducing potential nitrate nitrogen leaching losses and saving water and energy. The same systems are equally suited for center pivot systems.

These systems have been installed on three linear move sprinkler irrigation systems used for research: two at the NDSU "Mon-Dak Irrigation Research and Development Project Farm" (Nesson Valley) about 25 miles east of Williston and on one machine, owned by Montana State University, near Sidney. Another NDSU linear move machine will have site-specific capabilities installed during summer 2008, bringing the total to four. A distributed in-field wireless sensor network, remote individual sprinkler head control, Wide Area Augmentation System-enabled global positioning system (GPS) position determination and user-friendly software have been designed, tested and used for the control of these variable-rate, site-specific sprinkler irrigation systems.

Control systems

The control systems utilize the same basic off-the-shelf control and valve system components. Two use a PLC, or programmable logic controller (Siemens 226), and one uses a digital on-board computer. Each control system activates electric solenoids to control banks of individual sprinklers by activating a pneumatic system to close normally open, 1-inch plastic globe valves on the gooseneck above each drop in groups of five or 10 heads. (Note: Normally open valves were used because they still would permit full irrigation if a failure of the site-specific system occurred.)

A GPS unit is on each machine for determining and tracking machine position as it moves across the plots. The GPS readings are used to determine when to switch between water application methods or to differentially apply water to the different crops, depending on treatments.

Sensor systems

The ARS researchers have developed, tested and used an integrated, distributed in-field wireless sensor network utilizing Bluetooth® technology (2.4 GHz) to assist management of variable-rate, site-specific sprinkler irrigation systems. The key features behind selection of the Bluetooth technology are robustness, low power and low cost. Wireless networks work well for agricultural applications because their mobility and easy self-configuration eliminate the need to hard wire sensor stations across the field and reduce installation and maintenance costs.

The in-field wireless sensing stations monitor field conditions, including soil moisture, soil temperature and air temperature. Rain gauges can be added to monitor rain and irrigation amounts. A nearby weather station monitors micrometeorological information, including air temperature, relative humidity, precipitation, wind speed, wind direction and solar radiation. These sensory data are transmitted wirelessly into a computer base station and are used to calculate actual crop water use.

Management

Real-time, on-the-go irrigation scheduling could be very effective in improving water management when guided by sensor data from across the field and applied according to rules set by the producer. Thus, user-friendly Windows-based decision support software has been developed for real-time control and monitoring of irrigation sprinklers. The program on the base station reads the GPS data, monitors the distributed sensor network and weather station, and calculates actual crop water use. Based on settings predetermined by the grower for each zone, the base station sends control signals back to the machine. The software running in the PLC or on-board computer then transfers the application depth instructions to each bank of individual sprinklers.

Additional information can be found at *www.ars.usda.gov/npa/nparl*.

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The Cost of Energy to Pump Water Keeps Increasing

Electricity and diesel fuel are the most common energy sources for pumping irrigation water. The cost of farm-delivered diesel fuel has risen to unprecedented levels and is quickly approaching $4 per gallon.

Figures 1 and 2 show the costs of pumping 1 acre-inch of water with a high-, medium- and low-pressure pumping plant for a wide range of fuel costs. An acre-inch is the amount of water required to cover one acre to a depth of 1 inch. An acre-inch is 27,500 gallons of water. To apply an inch of water to the land under a standard quarter-section center pivot requires about 128 acre-inches of water. These graphs were developed for center pivot sprinkler systems that obtain water from wells.

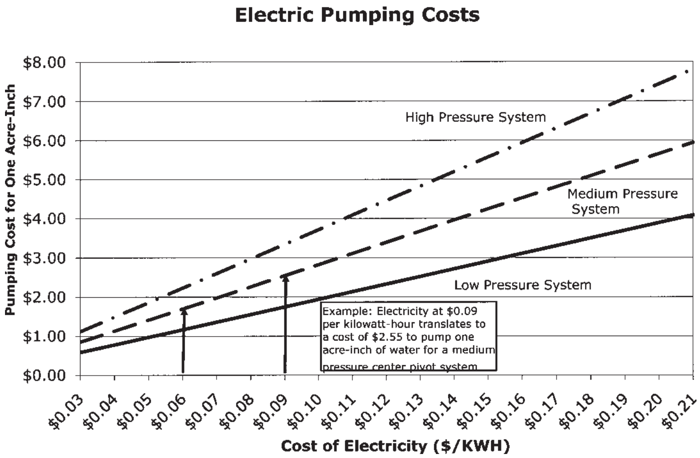

Figure 1. Electric pumping costs for a high-, medium- and low-pressure irrigation pumping plant. The two arrows show the pumping costs for 6- and 9-cent-per-kwh electricity on a medium-pressure pumping plant are $1.70 and $2.55 per acre-inch, respectively.

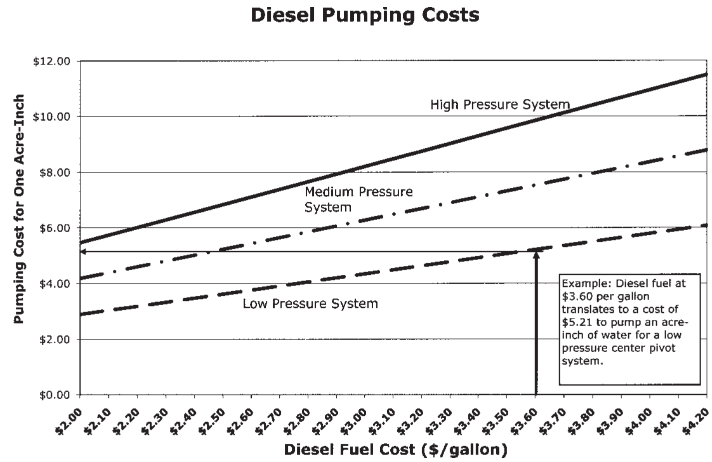

Figure 2. Diesel pumping costs for a high-, medium- and low-pressure irrigation pumping plants. The arrow shows that with farm-delivered diesel fuel at $3.60 per gallon, pumping an acre-inch of water through a low-pressure irrigation system will cost $5.21. If the arrow is extended up to the medium-pressure system, the cost of pumping is $7.53 per acre-inch.

The energy to power the center pivot (whether electric or hydraulic) has been included in the pumping costs.

The high-pressure system assumes a 50-foot lift in the well and 100 pounds per square inch (psi) of pressure at the pump. The medium-pressure system assumes a 50-foot lift in the well and 70 psi of pressure at the pump. The low-pressure system assumes a 50-foot lift in the well and 40 psi of pressure at the pump.

The statewide average irrigation cost for off-peak electric power is about 6 cents per kilowatt-hour (kwh) in North Dakota when adjusted to include the energy charge, the demand charge and/or annual charges. As shown by the arrow on Figure 1, the cost to pump water at this price for a **medium**-pressure pumping plant is about $1.70 per acre-inch of pumped water.

The statewide average irrigation cost for regular-rate power is about 9 cents per kwh when adjusted to include the energy charge, the demand charge and/or annual charges. As shown on Figure 1, this corresponds to a pumping cost for a **medium**-pressure irrigation system of $2.55 per acre-inch of pumped water.

The current price for farm-delivered diesel fuel is about $3.60 per gallon. As shown on Figure 2, this results in a pumping cost for a **low**-pressure pumping plant of $5.21 per acre-inch of pumped water. At this fuel price, the cost to pump 1 acre-inch to a **medium**-pressure center pivot is about $7.21. Comparing this with electric pumping costs for a **medium**-pressure center pivot using off-peak electric power rates, the difference is $5.51 per acre-inch of pumping costs ($7.21 minus $1.70). Compared with regular electric power rates, the cost difference is $4.66 per acre-inch.

For the last 10 years, the annual statewide average of pumped water per acre of irrigated land has been about 10 acre-inches. Using this amount, the additional pumping cost using diesel on a per-acre basis is $47 and $55, compared with regular and off-peak electricity, respectively. For a typical center pivot irrigating about 128 acres, the annual difference in pumping cost between diesel and electric would be about $5,965 at regular power rates and $7,053 with off-peak electric rates. These huge differences in pumping costs are pushing many irrigators to consider changing their diesel engines to electric motors.

Diesel or electric power?

Due to the large motor sizes (25 to 100 horsepower), three-phase electricity is the preferred power source for pumping irrigation water. The reason many irrigators originally installed diesel engines instead of electric motors was the cost of access to three-phase power. The cost of access to three-phase power still may be too high even with the large energy cost differential between electric and diesel.

Based on a survey of electric cooperatives and investor-owned electric suppliers, the cost of extending three-phase power to an irrigation pump site varies from $30,000 to $40,000 per mile. Many electric suppliers have programs to help reduce the cost of installing three-phase line, including cost-share and multiyear power-use contracts. Single-phase electricity can be used for pumping irrigation water, but it must be converted to three-phase power. To do this requires the purchase of phase converters or a variable-frequency drive. In addition, you still will have line extension charges for the single-phase power. Some electric suppliers are very leery of using

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single-phase power lines for irrigation pumping loads at certain locations on the distribution system, so visiting with them and discussing your plans is very important.

In addition to the line extension charges, you have to factor in the cost of an electric motor, electric shutoff and control panels, along with labor. Additional costs could involve phase conversion equipment, transformers and underground line installation. These could add $12,000 to $20,000 to the cost. Of course, you have some salvage value for the diesel engine, fuel tank and other parts.

Other factors to consider are the reliability of electricity, not having to maintain the diesel engine (changing oil and filter every 150 hours) and whether you can live with controlled (off-peak) electric service. If you are considering changing from diesel to electric, plan to visit both your electric supplier and irrigation dealer.

If connecting to electricity is too expensive, here are some options to reduce pumping energy requirements:

- First, reduce pressure requirements. Check with your irrigation dealer to see if you can install a lower-pressure sprinkler package. For example, at a pumping rate of 800 gallons per minute (gpm), a 10-pound-per-square-inch (psi) reduction at the pump will reduce pumping power by 6.5 horsepower. This would save about one-third of a gallon of diesel per hour.
- Second, improve the efficiency of the diesel engine. If your diesel engine is more than 15 years old, upgrading to a newer model can improve fuel use by 10 percent to 25 percent.
- Third, maintain your well. Plugging of well screens increases drawdown, which increases pumping energy requirements.
- Fourth, plug all leaks in the pipeline and on the pivot. Leaks put water where you don’t want it.

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