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Minnesota Irrigator

PUBLICATION OF THE IRRIGATORS ASSOCIATION OF MINNESOTA SPRING 2016

Comments by the IAM President

Dear Irrigators,

This year the legislative session will be much shorter than previous years because of construction at the capital. Even though the session is short, there are still many issues that concern irrigators. I would encourage all of you to contact your state representatives and state senators. Invite them out to your farm and explain how irrigation is very vital to your farming operation. There are not many legislators that are from a farm and most are not familiar with irrigation and the importance it has on rural economies.

I also would like to urge you to become involved in your local SWCD boards and watershed districts. I believe they both will become more important in the future. A good example would be the new buffer law where SWCD's will play an important part implementing the new buffer regulations. SWCD board elections will take place this fall. If you are interested in running; May 17th thru May 31st is when you would go to the county auditor's office and sign up to be on the ballot.

Many watershed districts have had TMDL (total maximum daily load) assessments done on them. Measures are being developed to cleanup these watersheds that have been found to be impaired. Positions on watershed districts are appointed by county commissioners; so visit with your commissioner if you are interested.

PRESIDENT continued on page 9

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Nitrogen Management

Nitrogen Management for Corn Production and Groundwater Quality in Minnesota's Irrigated Sands

Fabián G. Fernández, John A. Lamb, and Anne M. Struffert

Corn in irrigated coarse-textured soils can be very productive with nitrogen applications, but excess nitrogen can increase groundwater contamination. To understand how much nitrogen is needed to optimize corn production and minimize the environmental impact of nitrogen fertilizers, a four-year study was done at the Rosholt Farm in Pope County and in Dakota County farmers' fields.

Urea nitrogen rates ranged from 0 to 280 lb N/acre in 40 lb increments with half of the rate applied pre-plant and the other half at V4. Single pre-plant applications of enhanced efficiency fertilizers: ESN (a polymer coated urea), a blend of urea and ESN, and SuperU (urea with nitrification and urease inhibitors) were also studied. Lysimeters installed below the root-zone and water-balance calculations along with drain gauges were used to quantify the nitrate concentration and the amount of water and nitrate moving pass the root-zone.

The University of Minnesota recently revised their Maximum Return to Nitrogen Rate (MRTN) guidelines for irrigated continuous corn grown in coarse-textured soils http://www.extension.umn.edu/agriculture/nutrient-management/nutrient-lime-guidelines/docs/AG_NM_1501.pdf .

The new guideline suggests a MRTN of 209 lb N/acre at a nitrogen price to corn value ratio of 0.1. The MRTN for continuous corn in the four-year study was very similar to the new guidelines. For corn after soybean the MRTN was 164 lb N/acre. A split-application of urea was as good as or better than a single pre-plant application with enhanced efficiency fertilizers. Averaged across all years, the split-urea application increased corn grain yield by 5.4% compared to the averaged corn grain yield of enhanced efficiency fertilizers. A key finding was: in irrigated sandy soils, the large rate of nitrogen application needed for economic optimum yield is best accomplished by splitting the application.

In May-June excess precipitation – while the crop is small and not taking large amounts of water or nitrogen—caused most of the nitrogen loss. During that time, 75% of the total leaching and 73% of the total nitrate-nitrogen load below the root-zone occurred. During July-August nitrate concentrations in the soil-water were large, but even though substantial water (precipitation and irrigation) was applied, little or no nitrate leaching occurred as the crop was actively using water and nitrogen. Two key take away points are: one, the amount of nitrogen applied in May-June, when

NITROGEN continued on page 2

Welcome to the Spring 2016 Newsletter

Jerry Wright, IAM Membership Secretary

This newsletter comes to you thanks to the support of the enclosed advertisers, current IAM irrigators & industry membership and those Extra Mile Supporters listed in the newsletter. IAM Directors welcome and encourage you to become a member today if you have not already joined. We all benefit by each other's ideas, experiences and support to continue the IAM activities in the new year including keeping a watchful eye on MN Irrigation Water Rights; telling personal stories about benefits of irrigation with Legislators as well as represent the interests of irrigation practices across the state.

To become a member or renew your elapsed membership, simply return the membership form located on the last page of this newsletter. There are many benefits in belonging to IAM with the best one being just knowing that you are in partnership with your neighboring irrigators in supporting your IAM officers and the board of directors' legislative and agency contact activities. As a member you can also be placed on the IAM email alert list if you submit your email address.

If you have a topic that you would like to see discussed in a future newsletter issue, drop a note to IAM president, Alan Peterson at <alpetefarm@frontiernet.net>
Articles for the newsletter are solicited and gathered by the IAM officers and Membership Secretary, Jerry Wright can be contacted at <wrightsj@charter.net>
Crow River Press, in Hutchinson, MN manages advertiser space and edits, prints and mails the newsletter.
If you are not interested in receiving future mailings from Irrigators Association of Minnesota (IAM), please send a note to: wrightsj@charter.net or IAM, 24 S. Edquist St., Appleton, MN 56208

Getting Ready to Irrigate

By Joshua Stamper

Let's face it. Your life as an irrigator is about to get crazy. You will juggle the logistics of planting multiple crops, over dozens of different locations, and with many different people and businesses that you will rely on to go from seed to harvest, *Tillage, Chemical, Seed and Fertilizer.* You have a checklist and a plan, because the financial consequences of forgetting something in the era of $3.50 corn are pretty tough.

But it's really important to remember the little things that may not have reached the "towering inferno" level of urgency in your mind, but can have huge impacts of yield. That's right. I am talking about irrigation uniformity testing.

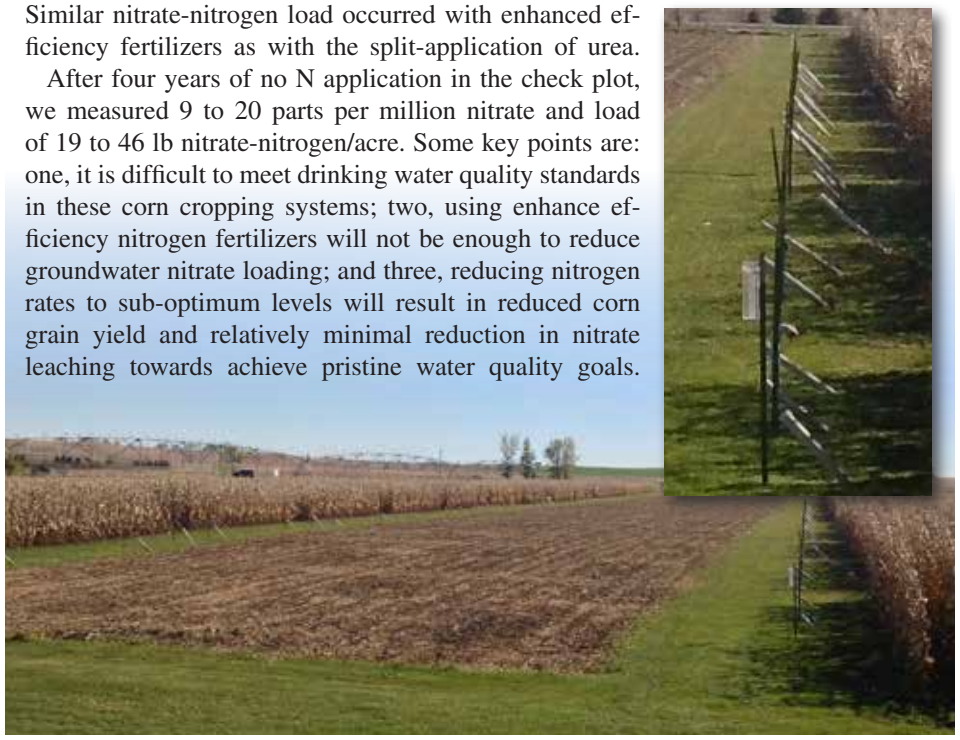
READY continued on page 16

NITROGEN continued from page 1.

potential for loss is greatest, should be minimized; and two, during July-August irrigation management is critical to supply adequate amounts of water to the crop without creating excess water supply that could result in nitrate leaching.

At the MRTN, season-long nitrate-nitrogen load was 77 lb of nitrate-nitrogen/acre for continuous corn and 95 lb of nitrate-nitrogen/acre for corn after soybean. In the soybean phase of the corn-soybean rotation, where no nitrogen was applied, the season-long nitrate-nitrogen load was 47 lb of nitrate-nitrogen/acre. In continuous corn, reducing the MRTN by 20% reduced corn grain yield by 4% and nitrate-nitrogen load by 9%, and a 25% reduction in MRTN resulted in an additional 2% reduction for both, while no significant reduction occurred for corn after soybean. Similar nitrate-nitrogen load occurred with enhanced efficiency fertilizers as with the split-application of urea.

After four years of no N application in the check plot, we measured 9 to 20 parts per million nitrate and load of 19 to 46 lb nitrate-nitrogen/acre. Some key points are: one, it is difficult to meet drinking water quality standards in these corn cropping systems; two, using enhance efficiency nitrogen fertilizers will not be enough to reduce groundwater nitrate loading; and three, reducing nitrogen rates to sub-optimum levels will result in reduced corn grain yield and relatively minimal reduction in nitrate leaching towards achieve pristine water quality goals.



Corn-Soybean rotation blocks. The sticks you see between blocks are the access tubes for the lysimeters used to measure nitrate below the root zone.

ADVERTISING DEADLINE: Minnesota Irrigator Newsletter Deadline for ads is August 1, 2016

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Nitrogen Fertilizer Rule by MDA

By Katie E. Wolf, State Program Administrator Senior

The Minnesota Department of Agriculture (MDA) is currently drafting a Nitrogen Fertilizer Rule. The scope of the rule will address agronomic crops that require nitrogen fertilizer. These crops include corn, small grains, edible beans, sugarbeets and irrigated potatoes grown in the crop rotation. The proposed Nitrogen Fertilizer Rule will require the regulatory provisions discussed in the state's blueprint for preventing or minimizing the impact of nitrogen fertilizer on groundwater, called the Nitrogen Fertilizer Management Plan (NFMP)

The proposed rule will consist of two parts. The first part of the rule will apply to areas of the state where groundwater is vulnerable to contamination from the land surface. These vulnerable groundwater areas will have restrictions on applying nitrogen fertilizer in the fall and to frozen soils. The second part of the rule will apply to areas where nitrate levels in groundwater are elevated and it has been determined that the nitrogen fertilizer Best Management Practices (BMPs) are not being adopted. Requirements will vary for different regions and soil types and will be based on the nitrogen BMPs developed by the University of Minnesota and adopted by the MDA.

MDA recently requested comments on eight different issues regarding the proposed rule. The Request for Comments was published on October 26, 2015 and was open until January 29, 2016.

The MDA received 23 original comments and over 100 form letters during the comment period. A copy of the Request for Comments and all comments received can be found on the Request for Comments page on MDA's Nitrogen Fertilizer Rule website www.mda.state.mn.us/nfr.

The Irrigators Association of Minnesota along with the Minnesota Farmers Union and Area II Potato Growers Association submitted a comment to the MDA during the Request for Comments period. These comments along with other comments received will be taken into consideration while the MDA drafts the Nitrogen Fertilizer Rule. There will be more opportunities for public comment once the MDA has a drafted the rule.

If you have questions about the rule or the rulemaking process, please contact

Larry Gunderson,
larry.gunderson@state.mn.us or

Katie E. Wolf, State Program Administrator Senior, or 651-201-6659
katie.wolf@state.mn.us
Minnesota Department of Agriculture
Pesticide and Fertilizer Management Division

MINNESOTA DEPARTMENT OF AGRICULTURE

Minnesota Department of Agriculture

Chemigation Permit Reminder

Chemigation Permits: Not Transferable; *New Operators Must Obtain New Permit*

This is a reminder that chemigation permits are not transferable from operator to operator. If a chemigation system is leased, sold or operated by a new person or business, then a NEW chemigation permit is required.

The Minnesota Department of Agriculture (MDA) issues chemigation permits to operators of chemigation systems. An "operator" is considered a person or business who will use the chemigation system. Operators can change from year-to-year, and existing permits are not transferable so new chemigation permits must be obtained by new operators prior to chemigation.

You can apply for your chemigation permit by completing:

Chemigation Permit Application found on the MDA website
http://www.mda.state.mn.us/chemicals/fertilizers/chemigation.aspx

OR BY COMPLETING AN APPLICATION ON–LINE:
http://www2.mda.state.mn.us/webapp/erenewal/apply.jsp

Please contact the MDA at 651 201–6540 if you have questions or are no longer operating your chemigation system so the permit can be deactivated and MDA records can be updated.

Irrigation Season Dates Vanish From DNR Permits

Once in a while, as in April 2015, the weather warms up early and you'd like to get some moisture in the field. We heard the call and, with some effort, moved the starting date on agricultural irrigation permits up to mid-April 2015.

For decades, DNR irrigation permits had dates indicating when the irrigation season started and ended. Since these were developed based on the average annual precipitation and the experience of irrigators and agricultural industry, they were usually not a problem.

From our collaboration with Irrigators Association of Minnesota leadership, we understand there is a need in some years to irrigate earlier or later. Your organization's leadership has also helped us better understand how technology improvements and best practices implemented by irrigators can reduce water waste.

We have come to the conclusion that an irrigation "season" usually isn't necessary for maintaining sustainable water supplies. Instead of handling every permit and removing the dates, we decided to issue a general permit that waives the date restriction. Your individual permits will still have the dates on them, but the general permit waives them. Going forward, as permits are modified or new permits are issued, normal season dates will be omitted in most cases.

There is nothing the irrigator needs to do to take advantage of this. The permit is issued and will be available on the DNR website for those wishing to see it.

This waiver of irrigation season dates will let you take advantage of early warm weather, or perhaps getting a cover crop germinated if needed outside of the normal season, without having to modify your individual permit.

Here's what general permit No. 2016-0188 does and does not do:

- It waives the normal start and stop dates for the irrigation season;
- It does not change the source of water, pumping rate or volume authorized by your individual permits;
- It does not affect fisheries exclusion dates; and
- All water used must still be recorded monthly and reported annually.

The waiver of irrigation season dates is for most types of irrigation, including agricultural, golf course, cemetery, landscaping, athletic field, nursery, pasture, orchard, vineyard, sod farm, and (with limits) wild rice.

If you have questions, please feel free to contact Water Regulations Unit Supervisor Tom Hovey, Water Regulation Unit Supervisor, DNR Division of Ecological and Water Resources, 500 Lafayette Road St. Paul, Minnesota 55155, 651-259-5654, or *tom.hovey@state.mn.us.*

Filing for SWCD Supervisor Candidates is May 17–31, 2016

Minnesota citizens interested in influencing natural resources issues at the local level are encouraged to run for supervisor of their local Soil and Water Conservation District (SWCD).

SWCD supervisor positions are filled through general elections which will take place on November 8, 2016. Those interested in running for Supervisor should file at the County Auditor's office from May 17 through May 31, 2016.

"An SWCD is a special purpose unit of government comprised of nonpartisan, elected supervisors who are passionate about conserving Minnesota's remarkable natural resources," said MASWCD President and Pipestone SWCD Supervisor Ian Cunningham. "SWCDs focus on building community relationships and collaborate with private landowners to conserve and protect our state's land and water resources."

SWCDs are a primary source of conservation information, support, and program management for landowners and other local units of government. They are the technical experts that understand their specific communities' needs and help landowners navigate conservation programs from start to finish. An elected board of Supervisors governs each of Minnesota's 90 SWCDs.

MASWCD

Candidates are elected county wide*, but must reside in one of the nomination districts up for election. SWCD Supervisors serve four year terms.

Supervisors meet monthly to discuss the business of the SWCD, including state grant allocations to landowners, district conservation priorities, coordination with other local units of government and state and federal agencies. Supervisors do not receive a salary, although they do receive compensation for attending meetings and are reimbursed for expenses.

Contact your local County SWCD for more information.

** Except for SWCDs in 7 county metro Area, where candidates are elected by the voters within that nomination district of the SWCD. Minnesota Association of Soil and Water Conservation Districts www.maswcd.org*

Check Your Soil Moisture

PART ONE–Tom Scherer, Extension Agricultural Engineer, NDSU

It's an Important Part of Irrigation Water Management

Part One, written by Tom Scherer, of a two part series on soil moisture and irrigation management, Part Two is written by Dean Steele and begins on page 10.

After a relatively dry fall, no-snow winter and dry spring up to May, soil moisture in many fields will be highly variable. Knowing the status of the soil moisture in your field is necessary for good irrigation water management. The soil in the root zone provides storage for nutrients and water that plants need for growth and development.

Monitoring the amount of soil moisture not only indicates when to start irrigating but also the amount to apply.

Measuring soil moisture accurately always has been difficult. The makeup of soil and the way it interacts with water poses many problems. Soil is composed of grains of minerals that can vary in size from less than 8/10,000 inch (0.002 millimeter) to more than 1/32 inch (1 millimeter) that are all mixed together. Mixed in with the grains are pieces of organic matter (old roots, crop residue, manure, etc.) that act like sponges and can make up from 0.5 to 6 percent of the soil volume in the root zone. Add water to this mixture in liquid or vapor form, and you can appreciate why measuring soil moisture is difficult.

Basic Soil Moisture Concepts:

Soil moisture commonly is expressed as soil water content or soil water potential.

Soil Water Content:

The amount of water in a volume of soil often is expressed as the percent of water by weight, percent of water by volume or by the inches of water per foot of soil. The percent of water by weight is determined by obtaining a soil sample, weighing it, then drying the sample in an oven (at 220 F) for 24 hours and weighing it again when it's dry. The weight of water in the sample is the difference between the wet weight and the dry weight of the soil sample. Divide this amount by the dry weight and multiply by 100 to get the percent of water content by weight. The percent of water by volume, a more useful value for irrigation design and management, is obtained by multiplying the percent of water content by weight by the bulk density of the soil. The bulk density of the soil is the ratio between the dry weight of a soil sample and the volume of the soil sample with units of grams per cubic centimeter (g/cm3). Agricultural soils can have bulk densities that range from 1.2 to 1.6 g/cm3.

Soil Water Potential:

How tightly soil particles and organic matter hold water is a measure of the soil water potential. Soil tension is another term often used to describe soil water potential. Soil tension is a measure of how hard pulling water away from the soil particles is for a plant's roots. Wet soil gives up water easily and has a low value of tension. Drier soil holds water tightly because the water is bound to the surface of the soil particles and has a high tension. For irrigation purposes, the amount of water available for plant use is the difference between the soil "feld capacity" and the "wilting point."

Field capacity is the moisture content at which soil holds water against the force of gravity. This is the moisture content at which many of the large pore spaces between soil particles will drain, but many of the small pore spaces will be full of water. For most irrigated soils in North Dakota, field capacity is the water content at a soil water tension of 1/10 of a bar (1 bar is almost atmospheric pressure and is equal to 14.5 pounds per square inch). The wilting point is at which most agricultural crops experience permanent wilting and will not recover. It is the soil water content at a soil water tension of 15 bars. Subtracting the water content by volume at the wilting point from the water content by volume at field capacity

PART ONE continued on page 15

Central Lakes College Ag and Energy Research Center

Hannah Barrett, Central Lakes College, Research Coordinator

As spring approaches, we all begin to look with anticipation on the blackened soils recharged and refreshed from the cold winter months. As a research farm in Central Minnesota, we also begin to plan for the various plots that are located on the farm and the different parameters that need to be followed for each plot.

We plan to improve irrigation management this year. A contact from Nelson Irrigation initiated at the Valley Irrigation Meeting in Wadena, MN, agreed to work with us to re-nozzle both the small linear and large linear located on the farm site. With all of the drops renozzled and outfitted with regulators, the goal is to improve the efficiency of water applications and to create uniformity across the entire linear systems. With equal pressure across the entire systems and continued uniformity, water variability will be reduced and research data obtained from underneath these systems will be more accurate as variables are reduced or eliminated.

Another area we plan to improve this year is our management of irrigation through the use of Valley Tracker and soil moisture sensors. Ron Nelson, farm manager, found these tools to be great time savers. Instead of continuously driving to various fields to make sure the irrigators were operating properly, time was saved by simply observing the fields through smart phone apps. Soil water moisture was also observed in this manner. This eliminated the guesswork behind knowing whether "to irrigate or not to irrigate".

A growing interest in the agriculture community is the use of cover crops. Cover crops have been shown to have great benefits in various regions around the United States, and the Central Lakes College Center is interested in researching the various benefits of cover crops here in our region and the positives and negatives that we find associated with them. Last year we established a cover crop across a ninety-six acre field that proved to be rather ineffective for grazing, but it did provide soil armor throughout the fall and winter months eliminating soil erosion and capturing snow. In the future we hope to see improvements in the field of organic matter and water and nutrient retention. We also plan to dive into a larger demonstration of cover crops complete with a variety of different crops established followed by fencing the fields off to be managed intensely through grazing.

As the season progresses and data and results are collected, we hope to demonstrate them at our Field Day, August 26, 2016. This will be a day with tours ranging from irrigation management, drone demonstrations, local food initiatives, and water quality management. The event is open to the public and lunch is provided with fresh sweet corn as the main highlight!

If you have any questions, please contact us at 218-894-5123, or go online www.clcmn.edu/agcenter/

NEW FACT SHEET–

Water Appropriations Permits for Livestock Producers

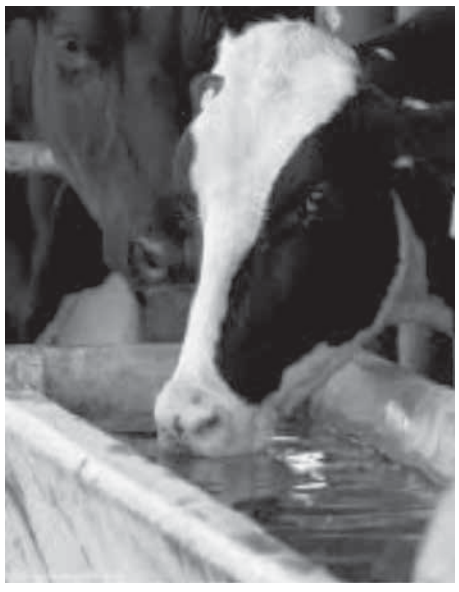
In response to frequent inquiries from livestock producers about Minnesota Department of Natural Resources (DNR) water appropriations permit rules and guidelines, the MAWRC has developed a simple fact sheet to help answer many of the most common questions, and point farmers toward additional agency resources.

Minnesota statutes require all water users withdrawing more than 10,000 gallons per day or more than one million gallons per year to obtain a water appropriation permit from the DNR. While this permit requirement has been in place for more than a decade, the DNR had done little to publicize the requirement. In recent months, livestock producers have begun receiving letters from the DNR notifying them of the requirement.

One of the first questions for many livestock farmers – how many animals does it take to consume one million gallons of water per year? Estimating water use can be very difficult, so our fact sheet incorporates information from the University of Minnesota which has previously been used by the DNR to determine permit thresholds.

The MAWRC's fact sheet can be found at *http://mawrc.org/assets/livestock-water-use-permit.pdf.*

Livestock farms using more than one million but less than five million gallons of water annually can apply for a simplified general permit for a one-time fee of $100. Those using more than five million but less than fifty million gallons must obtain an individual permit, which costs $150, and pay an annual water use fee of $140. All water permit holders are required to report water use annually to the DNR. For more information, go to *http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/permits.html*



Nearly 500 Attend Nutrient Management Conferences

Perhaps driven by headlines about nitrates in groundwater, the Des Moines Water Works lawsuit and lower crop prices, crowds totaling nearly 500 attended a pair of nutrient management conferences hosted by the Minnesota Agricultural Water Resource Center in February. Researchers and industry experts from across the Midwest provided updates on the very latest news in soil fertility, crop production and water quality concerns. These conferences provide an opportunity to hear a broad range of presentations in a forum that attracts farmers, agronomy professionals and regulatory agency staff all in one place.

The eight annual Nutrient Management Conference was held February 9th in Morton, featuring information on in-season nitrogen applications, crop nutrient uptake and phosphorus basics. Much of the information is related to research projects funded by farmers through various check-off programs, including AFREC, the Agricultural Fertilizer Research and Education Council. More information on AFREC-funded projects can be found at *http://www.mda.state.mn.us/chemicals/fertilizers/afrec.aspx.*

Dr. Fabian Fernandez, University of Minnesota Nutrient Management Specialist, served as lead organizer for the second annual ***Nitrogen: Minnesota's Grand Challenge and Compelling Opportunity Conference***, held February 23 in Rochester. Presentations included weather trends and their implications for nitrogen management, cover crops, nitrogen sources and additives, nitrogen losses in manured fields, and a summary of the Minnesota Department of Agriculture's private drinking water well nitrate monitoring program.

PowerPoint presentations from the conferences can be found on the "Events" page at *www.mawrc.org*

The Minnesota Department of Agriculture is the primary sponsor and our partner in organizing these events. Planning assistance is also provided by U of M Extension and MN NRCS. Additional funding is provided by numerous sponsors.

MAWRC continued on page 11

42nd Annual Irrigators of Minnesota Convention

Speaker of the House Representative Kurt Daudt discussing present and future MN Environment & Natural Resources Policies with convention attendees.

UPPER LEFT PHOTO IAM Alan Peterson, president, presenting ISM annual Irrigator Service award to the Anderson Family Farm of Belgrade with Grant Anderson (at left) accepting for the family, a fifth generation farm.

UPPER RIGHT PHOTO – Representative Paul Anderson (left) 12B from Pope County discussing water sustainability issues with some farmers

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JOHN & TAMMY SCHULTZ–FRAZEE

IAM 2016 Annual Convention–members and businesses come together to discuss irrigation issues, legislation and solutions.

Alan Peterson, President
Irrigation Association of MN

PRESIDENT continued from page 1

Another area to become involved in is your county water plan. Ask your county commissioner or SWCD office where your county is at in developing this plan.

Here, on our farm, we check the static water level in four wells every May before we start irrigating and every November after irrigation season is over. We want to know how our water table level is each year. I have found that over the last three years our water table has had no decline and has actually risen. In selecting the four wells, one is the deepest, one is the shallowest, and two are in between. Another check we do is take samples of irrigation water and have them tested for nitrates.

You can send them into a lab to be tested. You can also check at your SWCD office to see if they have the ability to test. Another option is the MAWRC (Minnesota Agriculture Water Resource Center.) They tested water samples at Farm Fest last year for nitrates. When we've done this in the past we didn't find any pattern (i.e: shallowest being higher deepest being lower.) We find this information interesting to know for myself and valuable when visiting with my elected officials.

If you are not a member please help us by becoming one today. There is a form in the back of this newsletter that you can fill out and send in. And lastly be safe this spring.

Alan Peterson, IAM President

Soil Moisture Sensors: An Important Part of Irrigation Water

PART TWO–Dean Steele, Professor of Irrigation and Environmental Engineer, NDSU

Part One article (beginning on page 5), Soil Water in the Root Zone, reviewed fundamental concepts of soil moisture, including soil water content and soil water potential, measuring soil moisture by the gravimetric and feel methods, and where in the field to sample soil moisture. In this article, we discuss soil moisture measurement methods and sensors and their application to irrigation water management.

Soil water content is the amount of water per unit weight or volume of soil and is a measure of the total amount of water present in a soil or available for crop use. Soil water potential is a measure of the energy status of the water in the soil, or how hard the plants must work to extract water from the soil. The relationship between soil water content and soil water potential is called the soil water retention curve, which is shown for three North Dakota soils in ***Figure 1***.

Coarse-textured soils such as sands tend to have a lower soil water content than fine-textured soils such as loams and clays at the same soil water potential. For irrigation scheduling purposes, this means coarse textured soils run out of crop-available water sooner than fine-textured soils.

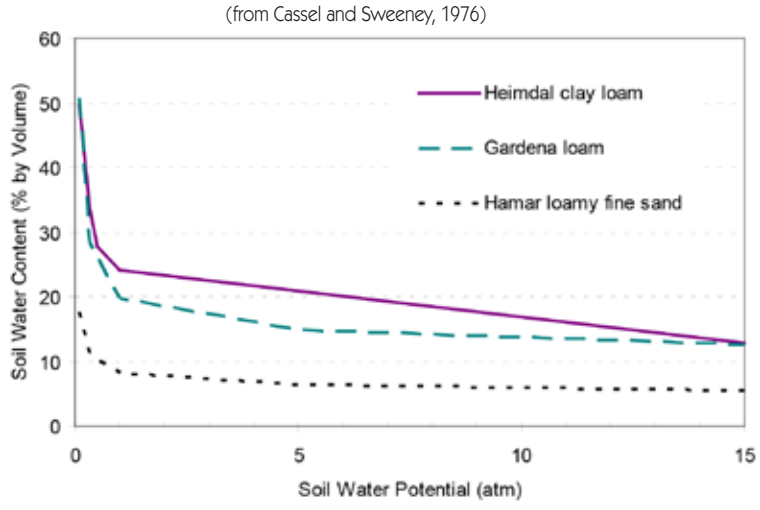
Some soil moisture sensors measure soil water content, while others measure soil water potential. We will review a few types of sensors and discuss their advantages and disadvantages. Some example sensors are shown in ***Figure 2*** on the next page.

Soil water content methods and sensors

The "feel method" for estimating soil moisture was reviewed in last month's article. To obtain a sample from below the surface of the soil, a soil probe or shovel is required. A probe is useful because the soil core that is retrieved may indicate the depth to which irrigation or rain water moves into the soil. This boundary between wet soil on top and dry soil beneath it is called the wetting front.

Figure 1. Soil water retention curves for three soils

(from Cassel and Sweeney, 1976)



In addition to direct measurements of soil water content such as gravimetric sampling, there are indirect measurements based on various physical properties of the soil-air-water mixture in which we grow crops. An example is measurement of capacitance, an electrical property, by time domain reflectometry (TDR) or frequency domain reflectometry. The capacitances of soil, air, and water all differ, enabling calibration of capacitance readings against gravimetric methods.

An example sensor consists of two parallel 8-inch long stainless steel rods that are inserted into the soil. An electrical signal is sent into the rods or waveguides and reflected back into a sensing unit that measures the transmission time. This is converted into a soil water content value, either through a calibration provided by the manufacturer or developed by the user. Research-grade measurements with the TDR method can be quite accurate, but the equipment is expensive, typically costing several thousand dollars.

A handheld sensor with a readout meter is a portable approach to capacitance measurements. Some of these sensors have stainless steel rods as part of the sensing unit which are inserted into the soil and a reading is obtained from the meter. The cost is about $1,000 or somewhat more per unit. The units are easy to move from one location to another. Other types of capacitance sensors have plastic sensing surfaces and are meant to be buried in the soil and used in fixed installations for the entire growing season. Often used for research, they range in cost from about $140 to $400 or more per sensor; additional costs are incurred for data logging equipment.

A disadvantage is that while the manufacturer may provide a built-in calibration for direct readout of soil water content, the sensors may require a calibration for each soil type on which they are used.

Some capacitance-based systems monitor soil moisture at several depths in the profile at a single monitoring station. Several sensors are contained within a plastic pipe or tube installed in the soil profile.

The sensors are left in place for continuous measurement of soil water content at multiple depths throughout the growing season. An advantage of this type of sensor is that measurements deeper in the soil profile can be made without coring or digging every time you want to make a measurement. Another advantage is that these systems measure the total soil moisture in the profile and thus give good indications of the water available to the crop.

Neutron scattering is a soil water content measurement method commonly used in research, and to a limited extent for very high value crops. It is considered by many to be the best indirect method of soil moisture measurement. It involves installation of a

vertical access tube—typically steel—in the soil, into which is placed a sensor-detector with a radioactive source of fast neutrons that are slowed down or thermalized by hydrogen in the soil and detected by the unit. Since water contains hydrogen, a readout device can be calibrated against gravimetric methods to indicate soil water content. Multiple access tubes are often installed in a field. This unit is successively lowered to various depths in each access tube, then removed for use at the next monitoring station or transported to a secure storage location.

The cost may be several thousand dollars and use and transport are regulated by the Nuclear Regulatory Commission.

Soil water potential methods and sensors

Tensiometers consist of a porous ceramic tip attached to the lower end of a tube which is inserted vertically into a hole bored into the soil. The top has cap that can be removed to fill the tip, tube, and reservoir with water. When the soil dries, it pulls a small amount of water out of the tensiometer through the ceramic tip. This "pull" is registered on the vacuum gauge and is a direct indication of how hard the plant must work to extract water from the soil.

Cost is typically under $100 per sensor. An advantage of tensiometers is that they directly measure soil water potential, while disadvantages include maintenance requirements, a limited operating range, and damage to the unit in freezing conditions.

Granular matrix sensors and gypsum blocks use the principle of electrical resistance to indirectly measure soil water potential. Two electrodes are embedded in granular or gypsum material in the sensor head, which is buried in the soil at the desired depth. As the soil becomes wetter or drier, the electrical resistance of the material surrounding the electrodes changes. Lead wires to the surface are connected to a readout device for measurement. Advantages include relatively low cost ($35-39 per sensor and $280 for a meter to read the sensors), simplicity, and low maintenance. Limitations include sensitivity to changes in soil temperature—which may be accounted for in readout devices—and possible sensor degradation over time.

Irrigation trigger points

Irrigation scheduling consists of determining when and how much water to apply to the crop. The "when" question depends on the soil type and its water holding capacity, the crop, and the stage of growth.

From the standpoint of soil water content, checkbook irrigation scheduling recommendations for North Dakota are to avoid exceeding 50% depletion of the available soil water for corn and small grains, irrigating when depletions reach 35% to 40% of the available water for drought-sensitive crops such as potatoes, and allowing higher depletions for drought-tolerant crops such as sunflowers.

Using soil water tension as the basis for scheduling decisions, research in North Dakota has used a soil water tension of 50 centibars as a trigger point for corn and 30 centibars for potatoes (1 centibar = 1/100 of a bar, and 1 bar is slightly less than atmospheric pressure).

Additional considerations

Near-real-time access to sensor readings via cell phones and the Internet has been a big advance in recent years. Many companies

PART TWO continued on page 14

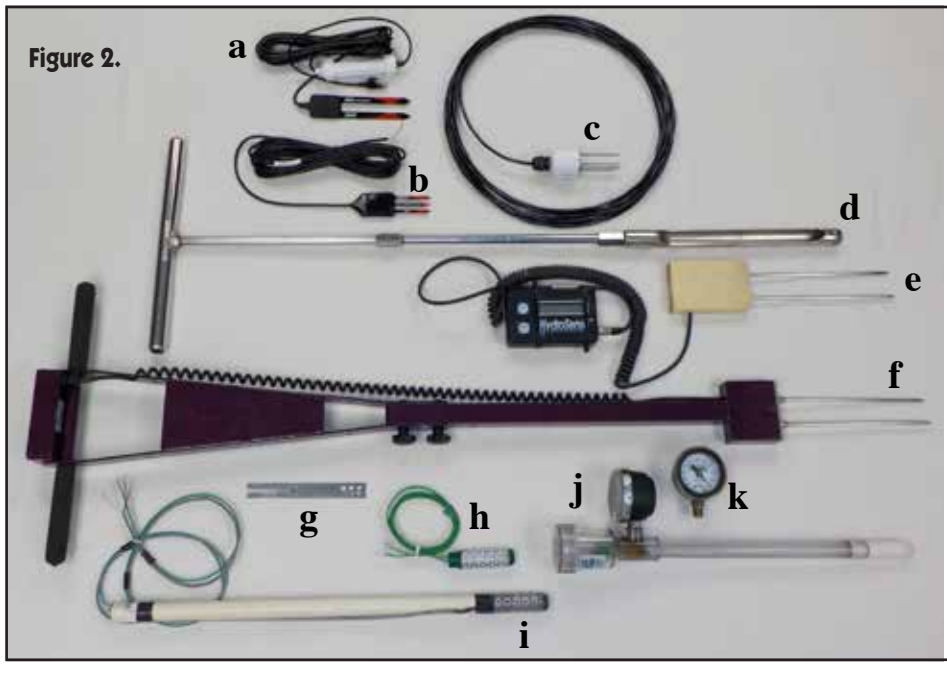


Figure 2. Some example sensors are shown
EXAMPLES OF SOIL MOISTURE SENSORS:

a) Decagon 10HS;

b) Decagon 5TE sensor for soil moisture, temperature and electrical conductivity;

c) Stevens Hydra-Probe II for soil moisture, salinity and temperature; d) 3-foot soil probe;

e) Campbell Scientific HydroSense;

f) Spectrum Technologies FieldScout 300 TDR;

g) 6-inch ruler to indicate sizes;

h) Irrometer Watermark block (a type of granular matrix sensor);

i) Watermark block with PVC extension pipe and temperature sensor;

j) Irrometer tensiometer; and

k) tensiometer vacuum gauge.

(Disclaimer: Inclusion or exclusion of specific sensors does not imply endorsement or lack of endorsement by the author or NDSU. (Trade names are the property of their respective owners.)

MAWRC continued from page 7

Curious about tile nitrate levels?

Headlines ranging from Des Moines drinking water to Gulf of Mexico hypoxia are heightening interest in nitrate levels in tile drainage. It is more important than ever to know the nitrate levels in the tile draining your fields. To help better understand nitrate levels in tile drainage, the MAWRC is offering free, confidential nitrate screening.

When tiles are flowing, collect samples of 2 to 4 ounces of water in clean plastic bags or bottles. Multiple samples are preferred to assess nitrate levels throughout the year. Discovery Farms Minnesota monitoring indicates that greater than 90% of annual tile flow occurs from March through July. In fact, tiles may not be running in August, so we recommend collecting samples starting right now, and repeating every week or two as long as tiles flow. It is important to label each sample with the date and source of the water. If not immediately analyzed, the samples should be frozen until the day of analysis.

Samples can be brought to the MAWRC booth at Farmfest, which will be in Morton on August 2-4, 2016. Samples will be analyzed immediately at the booth and results will be ready in about 20 minutes. Well water samples can also be screened.

There are no water quality standards for tile water, but some regulatory agencies and activist organizations are pushing for significant reductions. This screening program will help farmers better understand relative nitrate nitrogen levels on their own fields.

Pressures on Minnesota Farmland Continue

Increased urban development coupled with accelerated land acquisition by state and federal agencies continues to reduce the area of land in farms in Minnesota. According to the USDA census of agriculture, land in farms declined by 5.5% between 1997 and 2012, from 27.56 million acres to 26.04 million acres.

The MAWRC is a non-profit research and education corporation comprised of 24 agricultural organizations working together to address water issues.

For more information, go to *www.mawrc.org*

DNR - Definitions and Thresholds for Negative Impacts to Surface Waters

Executive Summary of the Report to the Minnesota State Legislature January 2016 by Minnesota Department of Natural Resources

This report was prepared in response to Laws 2015, 1st Special Session, chapter 4, article 4: Sec. 143. NEGATIVE SURFACE WATER IMPACTS; RECOMMENDATIONS. By December 15, 2015, the commissioner of natural resources shall consult with interested stakeholders and submit a report to the Legislative Water Commission and the chairs and ranking minority members of the house of representatives and senate committees and divisions with jurisdiction over the environment and natural resources policy and finance on recommendations for statutory or rule definitions and thresholds for negative impacts to surface waters as described in Minnesota Statutes, sections 103G.285 and 103G.287, subdivision 2. Stakeholders must include but are not limited to agricultural interests; environmental interests; businesses; community water suppliers; state, federal, and local agencies; universities; and other interested stakeholders.

Executive Summary

BACKGROUND AND PURPOSE

This report was prepared in response to Laws 2015, chapter 4, article 4, which directed the Department of Natural Resources (DNR) to consult with interested stakeholders and develop recommendations for statutory or rule definitions and thresholds for negative impacts to surface waters.

The DNR is charged with managing water resources to assure an adequate and sustainable supply for multiple uses. Minnesota has a modified riparian water law system, in which landowners have the right to make reasonable use of the abutting surface waters or the groundwater beneath their land, as defined and regulated by the water appropriation permitting program.

The water itself is a public trust resource, and the state grants the right to water beyond personal use – above 10,000 gallons per day or one million gallons per year – through water appropriation permits.

In recent years, it has become increasingly clear that Minnesota's water resources, while abundant in many areas, are not unlimited. In some areas, increasing water withdrawals are using more groundwater than is naturally being recharged. In other areas, groundwater supplies are limited due to the underlying geology. Groundwater contamination is also a limiting factor in many areas.

The variability of Minnesota's climate and geography mean that rainfall is not always available in the quantities we need at the times when it is most needed. Increasing demands on both surface water and groundwater supplies can cause negative impacts to the ecosystems and riparian uses of streams, lakes,and wetlands. While water levels fluctuate naturally throughout the year and across multiple years,water appropriations can push low levels lower, significantly reducing stream flows and more frequently putting fish, wildlife, plant communities and riparian uses at risk.

This report examines the effects of groundwater use on rivers and streams, lakes, and wetlands. DNR's analysis and recommendations are based on the fact that surface water bodies go through seasonal and multi-year cycles of high and low water levels. The seasonal patterns, known as the seasonal hydrograph, are primary drivers in creating and maintaining the unique ecology and associated aquatic and riparian habitats of each water body.

To preserve the seasonal hydrograph, protected flows must be established for streams, and protection elevations for lakes and some wetlands. These protection levels can then be translated into a quantity of water that can be sustainably withdrawn. Multi-year dry cycles and extreme droughts also serve important ecological functions, but may require a different approach to determining sustainable water use—e.g., water use that is ecologically sustainable under the normal seasonal hydrograph may need to be reduced during extreme drought.

This report was prepared with input from a broad range of stakeholders, as described in the Introduction and Appendix A. This report also incorporates and summarizes scientific studies, including an examination of approaches used in other states and countries. The recommendations in this report represent the DNR's suggestions to further define and describe methods of determining protected flows and protection elevations. These recommendations are based on the DNR's assessment of available information, analytical tools and the practicality of applying them in Minnesota.

Recommendations

The recommendations in this report fall into three categories:

1) definitions to be added in statute;

2) integration of statutory provisions dealing with surface water and groundwater; and

3) approaches to determining the thresholds for streams, lakes, and wetlands.

The following definitions are recommended to be added in statute:

- Negative impact to surface waters – in relation to water appropriations, a change in hydrology sufficient to cause ecosystem harm or alter riparian uses long-term.
- Ecosystem harm – in relation to water appropriations, to change the biological community and ecology in a manner that results in a less desirable and degraded condition.
- Sustainable diversion limit – in relation to water appropriations, a maximum amount of water that can be removed directly or indirectly from a surface water body in a defined geographic area on an annual basis without causing a negative impact to the surface water body.

Statutory changes:

The DNR also recommends combining many of the provisions in section 103G.285, which deals with surface water appropriations, and 103G.287, which deals with groundwater, into a single "Water Appropriations" section. This revision would recognize the interconnected and interdependent nature of surface and groundwater resources while removing the circular references between the two sections of statute that make it difficult to identify and assess 'negative impacts.'

Approach to determining thresholds

A "threshold" is essentially the point at which negative impacts occur. Thresholds can be estimated based on data and scientific literature. Calculating thresholds at a statewide scale is not appropriate or practical, however, given the number of variables involved – e.g., which species or which riparian uses are negatively impacted.

The diversity of Minnesota's surface water and groundwater resources, land use, and climatic factors would make a single number misleading and inappropriate for many locations and conditions. The precautionary principle would require that any such statewide threshold be set to be protective of the most vulnerable resource, thereby unnecessarily restricting water use in many areas. Therefore, the DNR proposes establishing specific thresholds for specific watercourses, water basins, watersheds, or hydrologic areas in those parts of the state where water use is at risk of causing negative impacts.

Jason Moeckel, MDNR sharing draft policies at annual meeting on setting sustainable Thresholds for GWMAs at the 2016 Annual IAM Convention.

STREAMS: The DNR's research and a review of scientific literature indicate that a 20% change in hydrologic regime (relative to the August median base flow) will negatively affect the ecosystem, while a change less than 10% is not likely to be detectable. Setting a diversion limit of no more than 10% of the August median base flow will preserve the seasonal variability of the natural hydrology under all but the establish the sustainable diversion limit.

WETLANDS: Different types of wetlands have distinct and characteristic seasonal water levels that maintain their characteristic plant and animal communities. Most wetland types in Minnesota depend to some extent on groundwater for at least

some part of the growing season. Some wetland types, such as fens, are highly connected to and dependent on groundwater, while others, such as floodplain forests, are more directly influenced by surface-water. However, as yet there is no systematic method for evaluating potential negative impacts on wetlands due to groundwater appropriations, due to limited wetland-related hydrologic data.

The DNR is proposing to establish a comprehensive wetland hydrology characterization and monitoring program statewide. An initial step in this process is to begin testing the feasibility of establishing target hydrographs for the various wetland types, with a particular focus on areas of the state experiencing a heavy demand for groundwater appropriation. A target hydrograph is a range of acceptable water levels throughout the year for each various wetland types, extending from "normal" levels to infrequent or rare low levels that stress the characteristic plant and animal communities. The target hydrograph would be used as a guide for developing allowable diversion limits throughout the growing season to maintain the characteristic hydrologic regime.

Impacts to wetlands are also regulated under other authorities, primarily the Minnesota Wetland Conservation Act and the Public Waters Permit Program. The DNR's goal under this approach would be to avoid wetland drainage that would trigger regulation under those programs.

Methodology

The DNR would focus its efforts to set thresholds for negative impacts primarily in those areas of the state where the intensity of groundwater use and/or scarcity of groundwater supplies is causing concern, such as the groundwater management areas or individual water bodies known to be negatively affected by groundwater use. In these areas, the DNR will implement the following steps:

1) establish negative impact thresholds for surface water bodies;
2) establish sustainable diversion limits that will maintain protected flows and protection elevations of those water bodies;
3) conduct groundwater modeling to determine the effects of groundwater withdrawals on the surface water bodies; and
4) assess to what degree individual groundwater withdrawals may need to be adjusted.

Applying this approach to water use permitting

Water users, whether they are public suppliers, agricultural irrigators, industry, businesses or golf courses, need reliability and predictability. Establishing negative impact thresholds and sustainable diversion limits should ultimately improve the predictability and consistency of water appropriation decisions. It should also reduce the need to modify permits during drought and thus allow water users to rely on a fixed quantity in most years, although extreme drought conditions extending over multiple years may still call for emergency water use restrictions.

Establishing negative impact thresholds and sustainable diversion limits is the first step in the process of allocating water resources among individual appropriators. Further discussion is needed as to how best to engage current and prospective water users in allocation decisions once we have determined the amount of available water in a given hydrologic area.

Minnesota's water appropriation statutes were formulated in an era when groundwater resources were viewed as essentially unlimited. Allocating water resources in an environment where those resources may in fact be limited calls for additional research and discussion. Our statutes and rules may need to be revised to provide better guidance. The DNR is currently researching potential models of water allocation systems used in other states and regions as part of this larger discussion.

Local governments also play a significant role in the water allocation process through their planning and land use controls, which help to determine the number and nature of residential, commercial, and industrial water users in a given community. In planning for future development, local governments should carefully consider the sustainability of their water supplies and the extent to which new water intensive uses should be allowed or encouraged. A planning process that considers the needs of all water users, future needs, and opportunities for water conservation can help to sustainably manage existing and proposed water use.

Conclusions

- Minnesota is in the "urgency room," not the "emergency room," in terms of water use management.
- The state's water management policies, statutes, and rules are strong and conceptually sound.

However, the state's water management statutes could be improved by clarifying terminology and better recognizing the interconnected nature of surface water and groundwater.

- There is a strong scientific basis for maintaining the natural dynamic patterns of surface water bodies by establishing protected flows for individual streams, protection elevations for individual basins, and target hydrographs for wetlands.
- Over the next five years, the DNR intends to set protected flows, protection elevations, and target hydrographs for water bodies in places where demand for water may be exceeding sustainable supplies. The changes to statute recommended in this report would help support that work.

For access to the full report to the Legislature, check out the DNR website at http://www.dnr.state.mn.us/gwmp/gw_thresholds/index.html

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have data logging units, wireless capabilities, or cellular communications which can be dedicated to measuring and recording soil water content or soil water potential data and provide features for transfer of the data to the Internet, mobile devices, and computers. The sensors and data loggers often have very low power requirements, which may enable the use of only a few batteries for the entire growing season.

Users may also want to consider monitoring and logging of rainfall and irrigation amounts, as well as soil temperature, all of which can be done at a relatively low cost.

Users of soil water sensors must consider both location within a field and depth of installation when installing sensors. The user should recognize that the sensors mentioned here apply only to specific locations within the field rather than to large areas, so it is important to select representative locations as discussed in last month's article. Sensors are typically placed between plants and in the crop row to avoid damage by wheel traffic and cultural operations.

The sensors should be installed in the active rooting zone of the crop. For row crops, small grains, and alfalfa, a sensor depth of 12 inches is common. A shallower depth may be used for drought-sensitive crops such as potatoes, for shallow-rooted crops such as onions, or early in the season when the crop's rooting depth is close to the surface. If two sensors are used at a monitoring station, one may be placed 9 to 12 inches deep and another 18 to 24 inches deep. The shallow sensor will tend to change the most in response to crop water use and can be used to indicate when to irrigate, while the deeper sensor will help indicate whether irrigations and rainfall are sufficient to meet the needs of the crop.

It is important to recognize the distinction between absolute measurements and relative changes in soil water content or soil water potential. The sensors described here may not provide a research-grade measurement of soil moisture without calibration, but with built-in memory, display screens, or the ability to transfer data to the Internet and mobile devices, they allow the user to easily see recent data. The ability of sensors and loggers to monitor trends in soil moisture is perhaps their most important feature for irrigation scheduling purposes. For example, if soil moisture readings indicate a drying trend, then recent irrigation and rainfall events have not been sufficient to meet the needs of the crop. If under- or over-irrigation are indicated by soil moisture measurements, then adjustments can be made in irrigation scheduling decisions.

Two excellent webinars on the subject of soil moisture sensing were recently presented by Dr. Steve Evett of the USDA Agricultural Research Service. The webinar titles and links are:

Soil Water Sensors for Agriculture - Theory and Issues
http://www.conservationwebinars.net/webinars/soil-water-sensors-for-agriculture-theory-and-issues

Soil Water Sensors for Agriculture - Applications and Usefulness
http://www.conservationwebinars.net/webinars/soil-water-sensors-for-agriculture-applications-and-usefulness

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(Spreadsheet, user's manual, and technical article available at https://www.ag.ndsu.edu/irrigation/irrigation-scheduling.)

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water spouts

Reprinted from NDSU Extension Water Spouts No. 281 July 2015. Author: Associate Professor Dean Steele, Irrigation and Environmental Engineer, Dean.Steele@ndsu.edu or (701) 231-7268.

The IAM Board of Directors would like to thank Dean Steele, Associate Professor, Irrigation and Environmental Engineer and Tom Scherer, Extension Agricultural Engineer at North Dakota State University for contributing "Part One" and "Part Two" articles to this issue of the Minnesota Irrigator.

PART ONE continued from page 5

Table 1. Range of available water plants for different soil textures.

Soil Texture	*Inches of water per foot of soil*
Coarse sand and gravel	0.2 to 0.7
Sands	0.5 to 1.1
Loamy sands	0.7 to 1.4
Sandy loams	1.3 to 1.8
Fine sandy loams	1.7 to 2.2
Loams and silt loams	2.0 to 2.8
Clay loams and silty clay loams	1.7 to 2.5
Silty clays and slays	1.6 to 2.2

and multiplying the difference by 12 will give you the "inches per foot" of available water for plants. (Table 1 on page 15) However, not all the available water is obtained easily. For irrigation management, we commonly assume that only 50 percent is readily available for plant use. If the amount of water is depleted by more than 50 percent, the plants will experience water stress. If it happens during the critical growth stage of fruiting, yield potential can be affected.

Measuring Soil Moisture:

Many methods and devices have been developed to measure soil moisture, and many companies offer these devices for irrigation water management. Some devices measure soil water content and some measure soil water potential. The standard for soil moisture measurement is the "gravimetric method," and the procedure is described in the section on soil water content. The gravimetric method is used to calibrate and check all the other soil moisture measurement methods.

The "feel method" is the oldest and most common method of checking soil moisture for irrigation management. It involves obtaining a handful of soil from a desired depth and location in the field, then squeezing it to see if it makes a ball. Based on how the soil reacts to the pressure, the moisture content can be determined. For finer soils, an additional indicator is how the soil ribbons when pressed between the thumb and forefinger. Many crop consultants and experienced irrigators use the feel method, but for new irrigators, it can be a challenge.

Where to Check Soil Moisture:

Checking the soil moisture content at many locations in a field can be time-consuming, so the irrigator has to select representative locations. Selection of ideal locations for soil moisture checking should be based on ease of access, and crop and soil types in the field. The best access for soil sampling would be next to roads or near the pivot access road. However, the locations also should be selected based on the type of soil and crop.

Reprinted with permission from NDSU Water Spouts No. 279 May 2015
author: Tom Scherer, NDSU Extension Agricultural Engineer (701) 231-7239 or Thomas.Scherer@ndsu.edu

READY continued from page 1

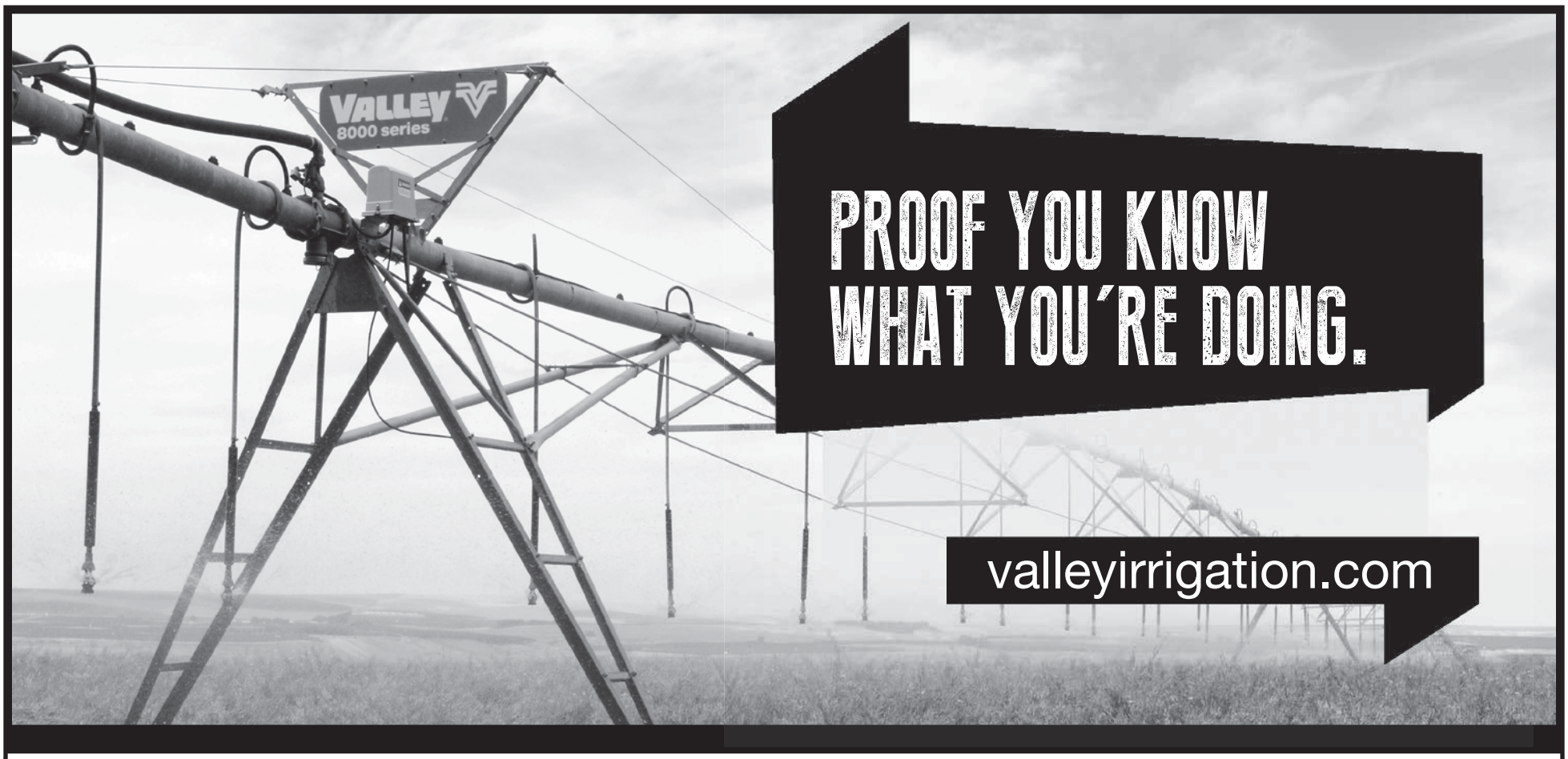
But before you mutter the words, "ain't nobody got time for that!" consider this:

One broken nozzle body on the outer pivot span can impact over 2 acres. That one nozzle could cost you over $600 dollars in lost yield, plus decreasing the return on your initial investment in this year's crop.

In a perfect world, we would conduct full-on uniformity tests every 5-7 years. But in the real world, the next best thing is jump on the ATV and just drive the length of your pivots to visually inspect nozzles and drops. Many major issues with spray pattern uniformity can be identified visually, and can be fixed quickly and easily.

I still encourage you to consider conducting an irrigation uniformity test. This is especially true if you cannot remember the last time you had the uniformity on your nozzle package tested, or if you cannot remember when the nozzle package was installed. Details for conducting a uniformity test are here http://z.umn.edu/uniformity and many of the Soil and Water Conservation Districts in the irrigated areas of Minnesota offer uniformity testing as a service.

Joshua Stamper, Irrigation Extension Specialist, CPAg/CCA University of Minnesota - St. Paul campus Google Voice/Cell: 612-405-3006 jstamper@umn.edu



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