Flow Meter Spacing Specifications Summary
NRCS and Tri-Basin NRD
October 6, 2008

Listed (front and back) are known flow meters that may be installed in the Tri-Basin NRD. This sheet summarizes, to the best of our knowledge, the manufacturer's installation spacing specifications only for proper installation of their respective flow meters. The spacing specifications relate to both vertical and horizontal installations. Manufacturer specifications will be followed for complete installations, operations, maintenance, safety, etc. If anyone wishes to install different flow meters from those listed below, the flow meters will need to meet the +/-2% accuracy requirements as provided by the manufacturer, installation will follow manufacturer specifications, and a copy of the manufacturer's specifications needs to be provided to your local NRCS office or the Tri-Basin NRD office.

**** NOTE: Flow meters cost-shared through the Tri-Basin NRD are required to read in Acre-Inches and cannot have a resettable totalizer.***
***** NOTE: The NRCS and Tri-Basin NRD do not endorse these or any other flow meters.***

McCrometer propeller meter - from Great Plains Meter, Inc.'s "McCrometer Meter Installation Recommendations" sheet dated 1/1/2007:

- Upstream with flow-straightening device (FS100). This device is not your typical set of straightening vanes.: Non-jetting & Jetting flows – **1½ pipe diameters** or more of unobstructed straight pipe run **ahead of the propeller.**
- Upstream with straightening vanes: Non-jetting flows - **5 pipe diameters** or more of unobstructed straight pipe run **ahead of the propeller.**
- Upstream without straightening vanes: Non-jetting flows - **10 pipe diameters** or more of unobstructed straight pipe run **ahead of the propeller.**
- Upstream with straightening vanes: Jetting flows - **10 pipe diameters** or more of unobstructed straight pipe run **ahead of the propeller.**
- Upstream without straightening vanes: Jetting flows - **20 pipe diameters** or more of unobstructed straight pipe run **ahead of the propeller.**
- Downstream: **2 pipe diameters** or more of unobstructed straight pipe run **behind the propeller** or **1 pipe diameter behind the ell**.

> --- When installing a **reverse propeller meter**, all upstream distance specifications are the same as described above. Downstream distance is **2 pipe diameters** or more of unobstructed straight pipe run **behind the propeller**.

Sparling propeller meter – from Sparling Instruments, Inc. Handout superseding the Propeller Flow meters manual copyrighted 2002, dated 04/02. New brochure with pictures will be published in the near future:

- Upstream with straightening vanes: Non-jetting flows – **5 pipe diameters** or more of unobstructed straight pipe run **ahead of the propeller**.
- Upstream without straightening vanes: Non-jetting flows – **10 pipe diameters** or more of unobstructed straight pipe run **ahead of the propeller**.
- Upstream with straightening vanes: Jetting flows – **10 pipe diameters** or more of unobstructed straight pipe run **ahead of the propeller**.
- Upstream without straightening vanes: Jetting flows – **20 pipe diameters** or more of unobstructed straight pipe run **ahead of the propeller**.
- Downstream: **1 pipe diameter** or more of unobstructed straight pipe run **behind the propeller** except where a throttling valve, butterfly valve, or similar valve is placed downstream of the meter. Then **2 pipe diameters** or more of unobstructed straight pipe is required **behind the propellor**.

Siemens MAG8000 Electromagnetic meter – from installation guides dated July 15, 2005 (downstream of check valve and directly to well/pump discharge):

- Upstream without straightening vanes: Non-jetting flows - **0 pipe diameters** or more of unobstructed straight pipe run **ahead of the sensors**.
- Upstream without straightening vanes: Jetting flows - **3 pipe diameters** or more of unobstructed straight pipe run **ahead of the sensors**.
- Downstream: **0 pipe diameters** or more of unobstructed straight pipe run **behind the sensors.**

USDA is an equal opportunity provider, employer, and lender.

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SeaMetrics AG2000 Electromagnetic meter – from letter dated August 25, 2006 indicating test results under various conditions:

- Upstream without straightening vanes: Non-jetting & Jetting flows - **0 pipe diameters** or more of unobstructed straight pipe run **ahead of the sensors** and **behind the sensors**. It is recommended to use the traditional spacing of 2 pipe diameters ahead of the meter and 1 pipe diameter behind the meter.

Senninger Ag Rotor, Rotor-X, or Magmeter - from flow sensors manual date marked 08 FN 08.

AG Rotor:

- Upstream, Non-jetting & Jetting flows without straightening vanes: a minimum of **5 pipe diameters** or more of unobstructed straight pipe run **ahead of the sensor.** 10 pipe diameters is recommended.

Rotor-X or Magmeter:

- Upstream, Non-jetting & Jetting flows without straightening vanes: **10 pipe diameters** or more of unobstructed straight pipe run **ahead of the sensor.**

--- Downstream for all three Senninger meters listed above: **2 pipe diameters** or more of unobstructed straight pipe run **behind the sensor.**

Fluidyne/Hydro-Flow vortex meter - from page 5 of the vortex installation and operation manual from EMCO and the "Hydro-Flow Model 2200" installation and operation manual (dated 3/00):

- Upstream with straightening vanes: Non-jetting flows - **5 pipe diameters** or more of unobstructed straight pipe run **ahead of the meter** (3 pipe diameters ahead of the vanes & 2 pipe diameters between the vanes and the meter)**.**
- Upstream without straightening vanes: Non-jetting flows - **10 pipe diameters** or more of unobstructed straight pipe run **ahead of the meter.**
- Upstream with straightening vanes: Jetting flows - **13 pipe diameters** or more of unobstructed straight pipe run **ahead of the meter** (7 pipe diameters ahead of the vanes & 6 pipe diameters between the vanes and the meter)**.**
- Upstream without straightening vanes: Jetting flows - **30 pipe diameters** or more of unobstructed straight pipe run **ahead of the meter.**
- Downstream with straightening vanes: Non-jetting & Jetting flows - **4 pipe diameters** or more of unobstructed straight pipe run **behind the meter.**
- Downstream without straightening vanes: Non-jetting & Jetting flows - **5 pipe diameters** or more of unobstructed straight pipe run **behind the meter.**

--- The specifications above should cover most installation situations. Refer to the vortex meters installation and operation manual for additional specifications for various pipe scenarios.

Other Related Information

Definitions:

- ***Non-jetting flow***: Swirls and minor turbulence in pipe flows caused by pump discharges, pipe elbows, etc.
- ***Jetting flow***: The difference in velocity pipe flow caused by check valves, pressure regulating valves, butterfly valves, etc.
- ***Cooling coils***: Cannot be used for calculating straight-run distance.
- ***Cooling jackets***: Can be used for calculating straight-run distance with unobstructed centers.

Tri-Basin Flowmeter Installation Certification

Updated 03/23/21

Owner:__________________________Operator:____________________________Well Reg. #:___________

Legal Description: _____1/4 Section: _____ Township: _____ Range: _____

Meter Brand: ___________________ Model #: ____________________ Serial #: ____________________

Indicator Reading: _____________ *(Must read in acre inches – Must have non-resettable totalizer)*

Meter Size: 4” 6” 8” 10” 12” Other: _____

Meter Mounting: Horizontal: _____ Vertical: _____ Incline: _____

Straightening Vanes Installed: Yes _____ No _____

Pipe Hump or other restriction installed downstream: Yes _____ No _____

Full Pipe Flow Present: Yes _____ No _____

Nearest Upstream Source of Turbulence: ____________________

(Ex. check valve, cooling coil, elbow, miscellaneous projections inside pipe, etc.)

Distance Upstream from propellers, sensors, etc: _______________

Nearest Downstream Source of Turbulence: ____________________

(Ex. Check valve, cooling coil, elbow, miscellaneous projections inside pipe, etc.)

Distance Downstream from propellers, sensors, etc: _______________

Check Valve, Butterfly Valve, Pressure Regulating Valve present:

Upstream Distance _____ Downstream Distance _____ None Present _____

As Built Drawing:

* See backside for planned drawing *

I hereby certify that the aforementioned flowmeter was installed in accordance with manufacturer’s specifications and includes a non-resettable totalizer that reads in acre inches.

Installation By: ___________________________________ **Date**: _______________

Return completed invoices and certifications to:

Minden NRCS Office
528 N Minden
Minden, NE 68959

Holdrege NRCS Office
PO Box 798
Holdrege, NE 68949

Elwood NRCS Office
PO Box 41
Elwood, NE 68937

Irrigation Water Management Record Sheet

2020 Growing Season

Water Use Report to be used to report irrigation information to Tri-Basin NRD (as required by the Republican River Compact and Tri- Basin NRD Rules and Regulations)

Field Name: ______________________

1. Water Source Information:

Registration # **Well Location** 1/4 of 1/4 **Section** W **County** **Basin**

Location of ALL Land Irrigated ______________________

List all legal locations that were watered this year by this well

Actual GPM **Power Source** ☐ **Power District** ☐ **Water Source** ☐

Part of Series No **Reg#'s of wells in series** ☐ **Check if well was used to supplement surface water this year?** ☐

2. Contact Information:

Contact ______________________ **Company** ______________________

______________________ **Phone** ____________ **Mobile** ____________

Well Owner ______________________ **Company** ______________________

3. Field Information:

Total Irrigated Acres watered by well ☐ **Pivot acres** ☐ **gravity acres** ☐ **drip tape acres** ☐

Acres Irrigated Corn ☐ **Acres Irrigated Beans** ☐ **Other Acres Irrigated** ☐ **Crop** ☐

Tillage Practice Used (Circle One) **No Till** **Strip Till** **Ridge Till** **Conventional Till** **Combination tillage**

(majority No Till)

Did you reuse runoff water this year? ☐ **Pivot Options** ☐ **Does gravity system have surge value?** ☐

NOTE: Total number of acres irrigated is not necessarily your certified acres for a parcel, but should include all certified irrigated acres that are watered with the above water source. If you have a groundwater transfer permit on this well the neighboring certified acres you irrigate should be included in your total irrigated acres and reported on this form.

continued on back

Irrigation Water Management Record Sheet

2020 Growing Season

Registration # ☐

Meter	Register	Meter Serial Number	Beginning Reading	Ending Reading	Multiplier	Total Volume Pumped	Total Irrigated Acres

Comments:

NOTE: The beginning reading should be the same as the ending reading from the previous year unless you changed or repaired your meter. Sometimes if meters are put into pipe piles the wind will cause the face to show a different number. If your beginning reading is different from the reading we had from the end of the previous season, please write in the number and explain why it is different.

Meter Notes:

Meter Notes Platte basin well, waters into Rep. basin.

Seasonal Water Application

Well Water _______________ (you may figure your usage or we can figure it in the office)

Surface Water _______________ (canal or runoff)

To figure how many inches you put on per acre

Ending reading - Beginning reading X multiplier = Total volume pumped

If meter reads in gallons - Total volume pumped divided by 27154 divided by the # of acres irrigated = inches per acre

If meter reads in acre inches - Total volume pumped divided by # of acres irrigated = inches per acre

REPORT DUE November 17, 2020 to Tri-Basin NRD @ 1723 North Burlington, Holdrege, NE 68949

I certify that the above information is an accurate accounting for the above referenced well during the 2020 growing season.

SIGNATURE : ________________________________ DATE: ________________

Irrigation Water Management Record Sheet

202X **Growing Season**

Water Use Report to be used to report irrigation information to Tri-Basin NRD (as required by the Republican River Compact and Tri- Basin NRD Rules and Regulations)

Field Name: East Pivot

*Sample *

1. Water Source Information:

Registration # G-000000 **Well Location** SE 1/4 of NW 1/4 **Section** 0 6 13 W **County** KEARNEY **Basin** LB

Location of ALL Land Irrigated ____

List all legal locations that were watered this year by this well

Actual GPM 850 **Power Source** Natural gas **Power District** ____ **Water Source** Groundwater

Part of Series No **Reg#'s of wells in series** ____ **Check if well was used to supplement surface water this year?** ☐

2. Contact Information:

Contact Joe Irrigator

Current Address, Town, NE 00000

Phone -- **Mobile** 000-000-0000

Well Owner Tom Well Owner **Company** ____

3. Field Information:

Total Irrigated Acres watered by well 130.60 **Pivot acres** 130.60 **gravity acres** 0.00 **drip tape acres** 0.00

Acres Irrigated Corn 60.60 **Acres Irrigated Beans** 30.00 **Other Acres Irrigated** 40.00 **Crop** Alfalfa

Tillage Practice Used (Circle One) [✓ **No Till**] **Strip Till** **Ridge Till** **Conventional Till** **Combination tillage**

(majority No Till)

Did you reuse runoff water this year? No **Pivot Options** end gun **Does gravity system have surge value?** N/A

NOTE: Total number of acres irrigated is not necessarily your certified acres for a parcel, but should include all certified irrigated acres that are watered with the above water source. If you have a groundwater transfer permit on this well the neighboring certified acres you irrigate should be included in your total irrigated acres and reported on this form.

continued on back

Irrigation Water Management Record Sheet **202X Growing Season**

Registration # G-000000

Meter	Register	Meter Serial Number	Beginning Reading	Ending Reading	Multiplier	Total Volume Pumped	Total Irrigated Acres
1	INCH	00-0000	0.000	1306.00	1.00	35,463,124 gal	130.60

Comments:

NOTE: The beginning reading should be the same as the ending reading from the previous year unless you changed or repaired your meter. Sometimes if meters are put into pipe piles the wind will cause the face to show a different number. If your beginning reading is different from the reading we had from the end of the previous season, please write in the number and explain why it is different.

Meter Notes: **Meter Notes** McCrometer. Has cover

Seasonal Water Application

Well Water 10.0" (you may figure your usage or we can figure it in the office)

Surface Water ________________ (canal or runoff)

To figure how many inches you put on per acre

Ending reading - Beginning reading X multiplier = Total volume pumped

If meter reads in gallons - Total volume pumped divided by 27154 divided by the # of acres irrigated = inches per acre

If meter reads in acre inches - Total volume pumped divided by # of acres irrigated = inches per acre

REPORT DUE November 17, 202X to Tri-Basin NRD @ 1723 Burlington, Holdrege, NE 68949

I certify that the above information is an accurate accounting for the above referenced well during the

SIGNATURE : Joe Irrigator Signature DATE: XX/XX/XX

South Central Nebraska Irrigation Tips

Water Use

In./Day	Corn	Root Depth In Feet
0.04	emergence	0.5
0.14	6 leaf	1.0
0.24	12 leaf	2.0
0.28	early tassel	2.5
0.30	silking	3.0
0.26	blister	3.5
0.24	milk	3.5
0.20	begin dent	4.0

In./Day	Soybeans	Root Depth In Feet
0.04	emergence	1.0
0.14	vegetative	2.0
0.22	full bloom	2.5
0.26	begin pod	3.0
0.30	full pod	3.0
0.24	bean fill	4.0

Useful Information

USDA Natural Resources Conservation Service
Holdrege: 308-995-6121 Ext. 3
Minden: 308-832-1895 Ext. 3
Elwood: 308-785-3307 Ext. 3

Tri-Basin Natural Resources District
308-995-6688 or Toll Free: 1-877-995-6688

Central Nebraska Public Power & Irrigation District
308-995-8601

UNL Cooperative Extension
Holdrege: 308-995-4222
Minden: 308-832-0645
Elwood: 308-785-2390

Nebraska Department of Natural Resources
402-471-2363

Diggers Hotline
1-800-642-8434

Available Water Capacity

Soil Texture	Available Water Inches/Foot.
Fine Sand or Loamy Sand	1.0 to 1.1
Sandy Loam	1.4
Loam or Silt Loam	2.0 to 2.5
Silty Clay Loam or Clay Loam	1.8

Scheduling Example

Silt loam soil AWC = 2.5 in./ft.
At silking, corn root depth = 3.0 ft.
ET estimate = 0.30 in./day
MB=50%
Est. soil moisture at 60% for 3.0 ft. rooting depth by hand-feel method or moisture block readings.
AWC x root depth x soil moisture= available water
2.5" x 3.0' x 60% = 4.5" available water
2.5" x 3.0' x 50%= 3.75" MB
.75" water left
.75"/0.30"ET = 2.5 days moisture left

Irrigation Definitions

Evapotranspiration (ET) - Crop water use, plus evaporation.

Available Water Capacity (AWC) - Water available to plants in the root zone.

Field Capacity- Soil profile is full will not hold more water.

Minimum Balance (MB) - Minimum soil moisture content managed for to avoid crop stress.

Permanent Wilting Point (PWP) - Soil's water content so low the plant cannot recover.

Deep Percolation (DP) - Excess water the soil can't hold. Gravity pulls excess water below point where plant roots can't get.

South Central Nebraska Irrigation Tips

Irrigator's Formula

1 acre-inch = 27,154 gallons

452 gpm/hour = 1 acre-inch/hour

1 acre-foot = 325,848 gallons

How many inches of water is a field receiving from irrigation? To find out, use this formula:

$$\frac{GPM \times TIME}{ACRES \times 452} = INCHES\ APPLIED$$

GPM is flow rate in gallon per minute.

➡

Example: 800 gpm well
130-acre field
72 hours

$$\frac{800 \times 72}{130 \times 452}$$ 0.98 inches or 1 inch

TIME is length of irrigation in hours.

ACRES is n umber of acres irrigated per field or set.

Last Irrigation

Normal water requirement for corn and soybeans between various stages of growth and maturity in

Growth Stage	Days to Maturity	Water Use in Inches
Corn		
Blister	45	10.5
Dough	34	7.5
Beginning Dent	24	5.0
Full Dent	13	2.5
Beginning Maturity	0	0.0
Soybeans		
Full Pod Development	37	9.0
Beginning Seed Fill	29	6 .5
Full Seed Fill	17	3.5
Beginning Maturity	0	0.0

Water Application Measurement

30-Inch Rows

Table 1: Acres in an irrigation set

Row Length Feet	Number of Rows per Set (30-Inch Rows) 10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
500	29	.43	.57	.72	.86	1.0	1.2	1.3	1.4	1.6	1.7	1.9	2.0	2.2	2.3	2.4
600	34	.52	.69	.86	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.2	2.4	2.6	2.8	2.9
700	40	.60	.80	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4
800	46	.69	.92	1.2	1.4	1.6	1.8	2.1	2.3	2.5	2.8	3.0	3.2	3.4	3.7	3.9
900	52	.77	1.0	1.3	1.6	1.8	2.1	2.3	2.6	2.8	3.1	3.4	3.6	3.9	4.1	4.4
1000	57	.86	1.2	1.4	1.7	2.0	2.3	2.6	2.8	3.1	3.4	3.7	4.0	4.3	4.6	4.9
1100	63	.95	1.3	1.6	1.9	2.2	2.5	2.8	3.2	3.5	3.8	4.1	4.4	4.7	5.1	5.4
1200	69	1.0	1.4	1.7	2.1	2.4	2.8	3.1	3.4	3.8	4.1	4.5	4.8	5.2	5.5	5.9
1300	75	1.1	1.5	1.9	2.2	2.6	3.0	3.4	3.7	4.1	4.5	4.9	5.2	5.6	6.0	6.3
1400	80	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.0	6.4	6.8
1500	86	1.3	1.7	2.2	2.6	3.0	3.4	3.9	4.3	4.7	5.2	5.6	6.0	6.5	6.9	7.3
1600	92	1.4	1.8	2.3	2.8	3.2	3.7	4.1	4.6	5.1	5.5	6.0	6.4	6.9	7.4	7.8
1700	1.0	1.5	2.0	2.4	2.9	3.4	3.9	4.4	4.9	5.4	5.9	6.3	6.8	7.3	7.8	8.3
1800	1.0	1.6	2.1	2.6	3.1	3.6	4.1	4.7	5.2	5.7	6.2	6.7	7.2	7.7	8.3	8.8
1900	1.1	1.6	2.2	2.8	3.3	3.8	4.4	4.9	5.5	6.0	6.5	7.1	7.6	8.5	8.7	9.3
2000	1.2	1.7	2.3	2.9	3.4	4.0	4.6	5.2	5.7	6.3	6.9	7.5	8.0	8.6	9.2	9.8
2100	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4	6.0	6.6	7.2	7.8	8.5	9.0	9.6	10.2
2200	1.3	1.9	2.5	3.2	3.8	4.4	5.1	5.7	6.3	6.9	7.6	8.2	8.8	9.5	10.1	10.7
2300	1.3	2.0	2.6	3.3	4.0	4.6	5.3	5.9	6.6	7.3	7.9	8.6	9.2	9.9	10.6	11.2
2400	1.4	2.1	2.8	3.4	4.1	4.8	5.5	6.2	6.9	7.6	8.3	9.0	9.6	10.3	11.0	11.7
2500	1.4	2.2	2.9	3.6	4.3	5.0	5.7	6.5	7.2	7.9	8.6	9.3	10.0	10.8	11.5	12.2
2600	1.5	2.2	3.0	3.7	4.5	5.2	6.0	6.7	7.5	8.2	8.9	9.7	10.4	11.2	11.9	12.7

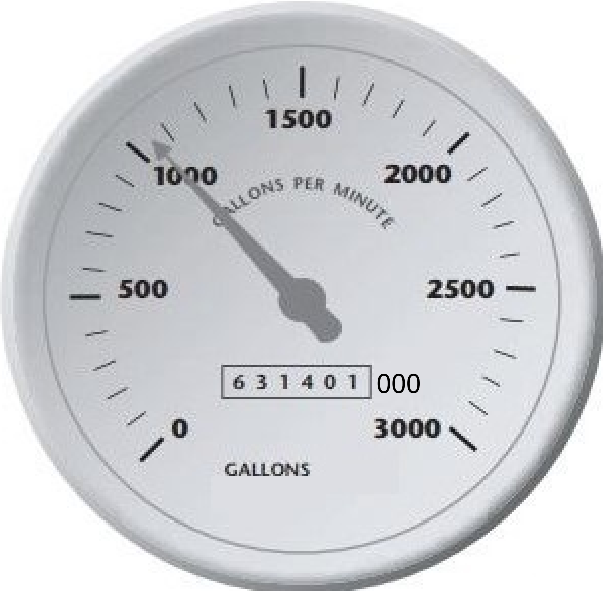
36-Inch Rows

Table 2: Acres in an irrigation set

Row Length Feet	Number of Rows per Set (36-inch rows) 10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85
500	.34	.52	.69	.87	1.0	1.2	1.4	1.6	1.7	1.9	2.1	2.2	2.4	2.6	2.8	2.9
600	.41	.62	.83	1.0	1.2	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.9	3.1	3.3	3.5
700	.50	.70	1.0	1.2	1.4	1.7	1.9	2.2	2.4	2.7	2.9	3.1	3.4	3.6	1.9	4.1
800	.55	.83	1.1	1.4	1.7	1.9	2.2	2.5	2.8	3.0	3.3	3.6	3.9	4.1	4.4	4.7
900	.62	.93	1.2	1.5	1.9	2.2	2.5	2.8	3.1	3.4	3.7	4.0	4.3	4.6	5.0	5.3
1000	.69	1.0	1.4	1.7	2.1	2.4	2.8	3.1	3.4	3.8	4.1	4.5	4.8	5.2	5.5	5.9
1100	.76	1.1	1.5	1.9	2.3	2.7	3.0	3.4	3.8	4.2	4.6	4.9	5.3	5.7	6.1	6.4
1200	.83	1.2	1.7	2.1	2.5	2.9	3.3	3.7	4.1	4.5	5.0	5.4	5.8	6.2	6.6	7.0
1300	.90	1.3	1.8	2.2	2.7	3.1	3.6	4.0	4.5	4.9	5.4	5.8	6.3	6.7	7.2	7.6
1400	1.0	1.5	1.9	2.4	2.9	3.4	3.9	4.3	4.8	5.3	5.8	6.3	6.8	7.2	7.7	8.2
1500	1.0	1.6	2.1	2.6	3.1	3.6	4.1	4.6	5.2	5.7	6.2	6.1	7.2	7.7	8.3	8.8
1600	1.1	1.7	2.2	2.8	3.3	3.9	4.4	5.0	5.5	6.1	6.6	7.2	7.7	8.3	8.8	9.4
1700	1.2	1.8	2.3	2.9	3.5	4.1	4.7	5.3	5.9	6.4	7.0	7.6	8.2	8.8	9.4	10.0
1800	1.2	1.9	2.5	3.1	3.7	4.4	5.0	5.6	6.2	6.8	7.4	8.1	8.7	9.3	9.9	10.5
1900	1.3	2.0	2.6	3.3	3.9	4.6	5.2	5.9	6.5	7.2	7.9	8.5	9.2	9.8	10.5	11.1
2000	1.4	2.1	2.8	3.4	4.1	4.8	5.5	6.2	6.9	7.6	8.3	9.0	9.6	10.3	11.0	11.7
2100	1.5	2.2	2.9	3.6	4.3	5.1	5.8	6.5	7.2	8.0	8.7	9.4	10.1	10.8	11.6	12.3
2200	1.5	2.3	3.0	3.8	4.5	5.3	6.1	6.8	7.6	8.3	9.1	9.9	10.6	11.4	12.1	13.0
2300	1.6	2.4	3.2	4.0	4.8	5.5	6.3	7.1	7.9	8.7	9.5	10.3	11.1	11.9	12.7	13.5
2400	1.7	2.5	3.3	4.1	5.0	5.8	6.6	7.4	8.3	9.1	9.9	10.7	11.6	12.4	13.2	14.0
2500	1.7	2.6	3.4	1.3	5.2	6.0	6.9	7.7	8.6	9.5	10.3	11.2	12.1	12.9	13.8	14.6
2600	1.8	2.7	3.6	4.5	5.4	6.3	7.2	8.1	9.0	9.9	10.7	11.6	12.5	13.4	14.3	15.2

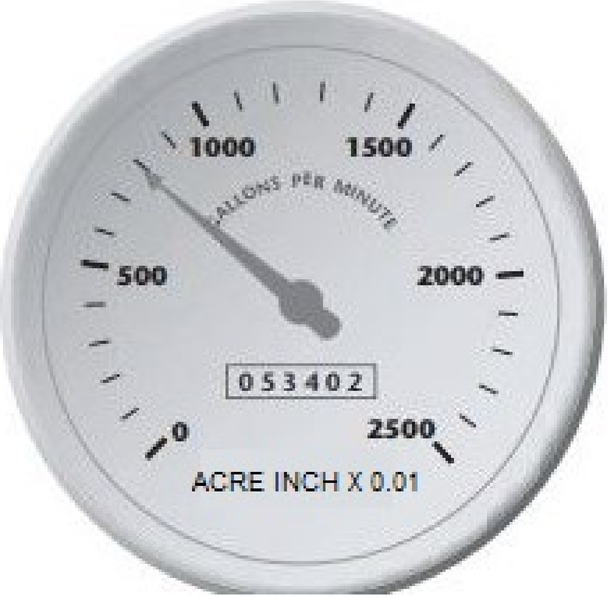
8" Dial Face with Gallon Totalizer x 100
Add 2 zeros to the 6-digit dial face reading.
Total Gallons = 89,057,200

6" Dial Face with Gallon Totalizer x 100
Add 2 zeros to the 6-digit dial face reading.
Total Gallons = 83,540,200



10" Dial Face with 3 fixed zeros
Include these zeros in your reading.
Total Gallons = 631,401,000

8" Dial Face with Acre Feet Totalizer x .001
and GPM Flow Rate Indicator. Place a Decimal
Point 3 places to the left. Acre Feet = 974.602



8" Dial Face with Acre Inches Totalizer x .01
and GPM Flow Rate Indicator. Place a Decimal
Point 2 places to the left. Acre Inches = 534.02

Dial Face with Cubic Feet Per Second flow
Rate and Acre Feet Totalizer. Place a Decimal
Point 3 places to the left. Acre Feet = 835.402

WATER EQUIVALENTS TABLE

1 acre-foot of water... 325,851 gallons (12" of water over 1 acre)
1 acre-inch of water..27,154 gallons (1" of water over 1 acre)
800 gallons per minute ....3.54 acre-feet or 42.42 acre-inches per day
450 gallons per minute= 1 cubic foot per second = 2 acre-feet per day = 24 acre-inches per day

WATER CALCULATIONS

To convert gallons totalizer readings to acre-feet

divide gallons used by 325,851

Example: .... present meter reading	89,057,200	gallons
subtract previous reading	48,563,000	gallons
gallons used =	40, 494,200	gallons
acre-feet used = gallons used ÷ 325,851 =	124.27	acre feet

To convert gallons totalizer readings to acre-inches

divide gallons used by 27,154

Example:........... present meter reading	41,012,800	gallons
subtract previous reading	31,444,300	gallons
gallons used =	9,568,500	gallons
acre-inches used = gallons used ÷ 27,154 =	532.38	acre-inches

To convert acre-fee t totalizer readings to gallons

multiply acre-feet used by 325,851

Example: ....present meter reading	278.760	acre-feet
subtract previous reading	267.334	acre-feet
acre-feet used =	11.426	acre-feet
gallons used = acre-feet used x 325.851 =	3,723,173.53	gallons

To convert acre-inch totalizer reading to gallons

multiply acre-inches used by 27,154

Example: .... present meter reading	160.530	acre-inches
subtract previous reading	99.560	acre-inches
acre-feet used =	60.970	acre-inches
gallons used = acre-inches used x 27,154 =	1,655,579.38	gallons

To check accuracy of the flow rate indicator:

Record the time it takes for several complete revolutions of the far righ t odometer wheel. Divide the gallons recorded by the time in seconds and then multiply by 60 to get Gallons Per Minute. Your calculations should give you the same rate as the meter needle shows.

To make calculations if your register rolls over:

Subtract end of previous year reading from 1000 acre-feet and add amount currently showing on meter. Example: End of 1992-920.328 AC FT & End of 1993-138.491 AC FT 1000 - 920.328 = 79.67 2 AC FT+ 138-491 AC FT= 218.163 ACRE FEET used 1993

Irrigation Formulas and Conversions

Danny H. Rogers
Extension Irrigation Engineer

Mahub Alam
Extension Irrigation Specialist

Water Measurement

1 cubic foot = 7.48 gallons = 62.4 pounds of water
1 acre-foot = 43,560 cubic feet = 325,851 gallons = 12 acre-inches
1 acre-foot covers 1 acre of land 1 foot deep; 1 acre-inch = 27,154
1 cubic meter = 1,000 liters = 264.18 gallons

$$1\ \frac{\text{acre-inch}}{\text{hour}} = 450 \text{ gallons per minute (GPM) or 1 cubic foot per second (cfs)}$$

1 gallon = 128 ounces = 3,785 milliliters
1 pound = 454 grams

Pressure

1 pound per square inch (psi) = 2.31 feet of water
A column of water 2.31 feet deep exerts a pressure of 1 psi
feet of head = psi x 2.31
Total Dynamic Head (TDH) includes: Pumping Lift, Elevation Change, Friction Loss, and Irrigation System Operating Pressure
TDH = Lift + Elevation + Friction + System Pressure

Area/Length

1 acre = 0.405 hectare (ha) = 43,560 feet^2
1 inch = 2.54 centimeters

Horsepower

Water Horsepower (WHP) — power required to lift a given quantity of water against a given total dynamic head.

$$WHP = \frac{Q \times H}{3{,}960}$$

where: Q = flow rate, GPM
H = total dynamic head, feet

Brake horsepower (BHP) — required power input at the pump.

$$BHP = \frac{WHP}{E}$$

where: E = pump efficiency

Power Unit Horsepower

Electric Units: approximate name plate horsepower = $\frac{BHP}{0.9}$

Internal combustion units:
Must derate 20% for continuous duty
5% for right-angle drive
3% for each 1,000 feet above sea level
1% for each 10° above 60°F

$$\text{Approximate Engine Horsepower Required} = \frac{BHP}{\underset{\text{cont. duty}}{0.80} \times \underset{\text{drive}}{0.95} \times \underset{\text{3,000' elevation}}{0.91} \times \underset{\text{100°F}}{0.96}}$$

Nebraska Performance Criteria (NPC)

Energy source	WHp-hours per unit of fuel
Diesel	12.5 WHp-hrs per gallon
Propane	6.89 WHp-hrs per gallon
Natural gas:	
925 BTU/ft^3	61.7 WHp-hrs per 1,000 ft^3 (MCF)
1,000 BTU/ft^3	66.7 WHp-hrs per 1,000 ft^3 (MCF)
Electric	0.885 WHp-hrs per kilowatt-hour

Water Application

$$\text{Average Application (inches)} = \frac{QT}{A}$$

where: Q =Flow Rate, Acre-Inches/Hour or GPM/450
T = Length of Application, Hours
A = Area Irrigated, Acres

Set Size (Acres) is computed by the formula:

$$\frac{\text{No. of Rows x Width of Row (Feet) x Length of Run (Feet)}}{43{,}560 \text{ Feet}^2\text{/Acre}}$$

Approximate Acreage Covered by Center Pivot

$$\text{Acres Covered} = \frac{(\text{Radius of wetted area, feet})^2 \times 3.14}{43{,}560}$$

For radius:
Without end guns — add 40 feet to length of machine
With end guns — add 75 feet to length of machine

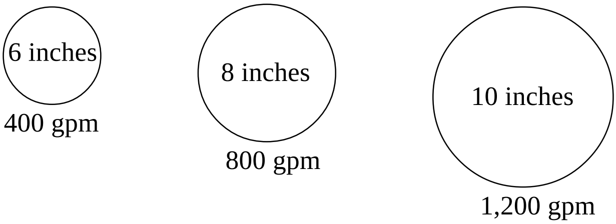
Irrigation Delivery Rate* per Acre (gpm/acre)

Net irrigation application (inches/day)	System efficiency (percent)					
	50	60	70	80	90	100
	gpm/acre					
0.10	3.77	3.14	2.69	2.36	2.10	1.89
0.15	5.66	4.71	4.04	3.54	3.14	2.83
0.20	7.54	6.29	5.39	4.71	4.19	3.77
0.25	9.43	7.86	6.73	5.89	5.24	4.71
0.30	11.31	9.43	8.08	7.07	6.29	5.66
0.35	13.20	11.00	9.43	8.25	7.33	6.60
0.40	15.09	12.57	10.78	9.43	8.38	7.54
0.45	16.97	14.14	12.12	10.61	9.43	8.49
0.50	18.86	15.71	13.47	11.79	10.48	9.43

Field delivery rate = gpm/acre x acres irrigated
Net irrigation = gross irrigation x system efficiency

Maximum Economical Pipe-flow Capacities

A rule of thumb for coupled and gated pipe:



Kansas State University Agricultural Experiment Station and Cooperative Extension Service

MF-2404 November 1999

Irrigation Water Management

Nebraska Conservation Planning Sheet No. 17

NRCS Natural Resources Conservation Service

reprinted November 2005

What is Irrigation Water Management?

Irrigation water management is managing the rate, amount, and timing of irrigation water according to crop needs and maintaining or improving the existing irrigation system. The frequency and amount of irrigation applications is managed to obtain the optimum yields, use the appropriate amount of irrigation water, and is based on soil moisture and crop water usage.

How it helps water and soil resources

In most cases, irrigation water management will reduce irrigation water losses due to runoff, deep percolation, evaporation, leaks, and allow for effective use of moisture from rainfall. Groundwater quality is improved by reducing nutrient and pesticide leaching. Each inch of water that is prevented from leaching below an irrigated corn crop's root zone can prevent the loss of about 5 lbs/acre of nitrate nitrogen contained in leached water. Surface water quality is improved by reducing runoff water, which may contain sediment, nutrients, and pesticides.

Where it can be utilized

Irrigation water management will work on all irrigated lands. Its use is important when the current irrigation system capacity is limited or when soil and water resources are being degraded. Net returns can be increased by reducing input costs, which include reduced pumping costs, and minimizing loss of soil, water, nutrients, and pesticides.

Where to get help

For assistance in improving irrigation water management, and in selecting an appropriate irrigation system on your farm, contact the Natural Resources Conservation Service, Cooperative Extension, or a private consultant.

Requirements of irrigation water management

In order to manage irrigation water properly it is critical that the irrigator has the ability to:

- Measure the amount of water delivered to the field and calculate the amount of water applied per irrigation.
- Measure the amount of rainfall.

Additional items that follow may allow the irrigator to manage irrigation water more efficiently:

- Determine the timing and amount of irrigation applications needed, based on soil moisture, crop water use, and stages of plant growth.
- Determine delivery losses due to leaks and take corrective action as necessary.
- Adjust application amounts and timing, in order to compensate for changes in field conditions.

Irrigation Scheduling

Irrigation scheduling techniques use a water balance accounting procedure. The amount of water stored in the crop's root zone is balanced before and after irrigation applications. Applications amount, rate, and timing are scheduled to replace soil moisture used by the crop, plus allowing some storage for rainfall.

- Methods of monitoring available soil moisture and uniform application can include; the soil "feel and appearance" method, moisture probes, tensiometers, moisture blocks, and other methods.
- Normally, no more than 50 percent of the soil moisture available to the crop should be depleted before being replenished.
- Determining the last irrigation is important in order to limit off-season nitrogen leaching, leave room in the root zone for off-season rainfall, and to obtain optimum test weight and crop yields.

Soil Moisture

For soils that do not have restrictive layers, and have an adequate supply of water throughout the root zone, 40 percent of the crop's water extraction occurs in the upper quarter of the root zone, 30 percent in the second quarter, 20 percent in the third quarter, and 10 percent in the bottom quarter. Under these conditions most corn varieties will extract 90 percent of water in the upper three feet of the root zone.

Table I. Approximate available water capacity for various soil types.

Soil Type	Available Water in the Upper 3 feet of the soil profile (inches)
Silty Clay and Clay	4.9
Silty Clay Loam or Clay Loam	6.9
Silt Loam over Silty Clay or Clay	5.2
Silt Loam	7.1
Loamy Sand	3.8
Fine Sand	2.5

Crops

- Evapotranspiration or "ET" (crop water usage) is the amount of water transpired by the crop and the amount evaporated from soil and plant surfaces.
- Corn can have average crop water use of less than 0.10 inches in May and September.
- Average peak crop water use in Nebraska for corn, sorghum, soybeans, alfalfa, and wheat is about 0.30 to 0.35 inch per day.

Table II. Seasonal crop water usage (ET) in Nebraska (inches/year).

Crop	West	Central	East
Corn	23-26	24-27	25-28
Soybeans	20-22	21-23	22-25
Dry Beans	15-16	NA	NA
Sorghum	18-20	19-22	20-23
Winter Wheat	16-18	16-18	16-18
Alfalfa	31-33	32-35	34-36
Sugar Beets	24-26	NA	NA

Furrow Irrigation Systems

- Length of irrigation runs and stream size should be based on soil intake characteristics.
- Maximum stream size should be based on:
  - ✓ Maximum non-erosive streams
  - ✓ Furrow capacity (spacing and depth)
- Optimum set times are based on row grade, intake rate, and length of run. For best uniformity, furrow set time should be based on an optimum cutoff ratio. Optimum cutoff ratios are as follows: 0.3 for course soils (sands), 0.5 for medium textured soils (silt loam), and 0.7 for fine textured soils (silty clay). When a tail water recovery system is in place, cutoff ratios should be less. Cutoff ratios are calculated by dividing the time required for water to advance to the end of the furrow by the total set time.
- Irrigating every other furrow can be a more flexible method and provide mid-season flexibility to adjust irrigation amounts due to changes in field conditions.
- Furrow irrigation management techniques that may improve efficiency from standard furrow irrigation include surge and tailwater recovery systems.
- Maintaining uniform row grade, eliminating low spots, and performing other needed maintenance is important for furrow systems to work properly.

Sprinkler Irrigation Systems

Sprinkler system design is based on the amount of irrigation water that can infiltrate the soil, surface storage provided by crop residue and tillage until water can be absorbed, and crop water needs.

- Low pressure sprinkler systems should only be used when the amount of irrigation water applied does not cause excessive runoff.
- Sprinkler system wheel track erosion should be adequately controlled.

For more information refer to the *Nebraska Irrigation Guide* available at Natural Resources Conservation Service offices, or refer to the University of Nebraska *NEBGuide* and *NEBFacts*.

Gross Irrigation Water Application

Gross Irrigation Water Application for:

____

Date:

____

County:

____

Location:

__________ Section ______ , T ____R ____

Item	Standard Furrow	Surge	Sprinkler
A. Water Supply (gpm)			
B. Furrow Length (feet)			■
C. Furrow Spacing (feet)			■
D. Rows per side x 2	■		■
E. Rows per set		■	■
F. Acres per set = B x C x D/43,560 (surge)	■		■
G. Acres per set = B x C x E/43,560 (standard furrow)		■	■
H. Set time/revolution time (hours)			
I. Acres under sprinkler	■	■	
Gross Application for Furrow Irrigation = A x 0.0022 x H/G =	________	________	inches
Gross Application for Surge Irrigation = A x 0.0022 x H/F =	________	________	inches
Gross Application for Sprinkler Irrigation = A x 0.0022 x H/I =	________	________	inches

IRRIGATION
MANAGEMENT
SERIES

IRRIGATION WATER MEASUREMENT AS A MANAGEMENT TOOL

Danny H. Rogers
Extension Agricultural Engineer

Gary Clark
Research Agricultural Engineer

Mahbub Alam
Extension Agricultural Engineer

Kansas State University
Agricultural Experiment Station and
Cooperative Extension Service
Manhattan, Kansas

In the defined use categories of municipal, industrial, stockwater, recreational, domestic, and irrigation, irrigated agriculture is the largest single water user in the state of Kansas. The approximately 3 million acres of irrigated land typically require 3 to 5 million acre-feet of water per year.

Most irrigation water is supplied by groundwater wells. However, declining groundwater levels in many of the major irrigated areas raise concern over the long-term availability of water. In other areas where either shallow recharging aquifers exist, or alluvial aquifers are used, irrigation may not cause long-term decline. However, irrigation use and increasing demand from other types of water use may cause occasional shortfalls with major environmental or economic impacts.

In either situation, irrigation managers need to make certain water use is within the limits of the irrigation allocation, and that no more is applied than needed for the crop. Implementation of best irrigation management practices is much more difficult without some means of water measurement. Water measurement can provide the basis for evaluations to optimize irrigation application. Water measurement data can help determine overall irrigation system efficiency, monitor system performance, detect well problems, monitor pumping plant performance, and simplify completion of the annual water use report.

While several water measurement methods are available, the most common method used in Kansas is an in-line propeller meter.

PROPELLER METERS

Propeller-type water meters use a multi-blade propeller positioned in the interior of the pipe water flow area (Figure 1). The rotational speed of the propeller is determined by the velocity (feet per second) of water flow which is then converted to volumetric flow rate (gallons per minute or gpm); or cubic feet per second (cfs); and volume (gallons, gal), cubic feet (cu-ft); or acre-feet (ac-ft), based on the pipe's diameter.

While all of the meters register the total volume, most modern designs register both flow rate and volume. A number of companies manufacture this type of meter in a variety of sizes and styles.

SELECTION

When selecting a water meter, be sure to check installation requirements with the conditions of your irrigation system and pipe supply network. If your situation does not meet all of the requirements, the meter should be calibrated after it is installed. The installed meter is commonly checked for accuracy using a non-intrusive sonic flow meter. It is also important to have spare parts and maintenance service locally available. While local service is usually the best option, convenience and speed are important.

Water meters vary in size, quality and design. Meter size should be determined by the size of the main pipe, the range of flow rates to be measured, and the head loss characteristics. Meter manufacturers should provide this information in a manner similar to the chart as shown in Figure 2. The meter must accommodate the expected range of flows, and the lowest anticipated flow should fit within the normal accuracy of the meter. It is also desirable to select a size that will not create excessive head loss.

For example, an 8-inch meter needs a flow velocity of 1 ft/sec, or a flow rate of 150 gpm to reach its full level of accuracy. Furthermore, that same meter will have a friction head loss of 5 to 6 inches of water with a

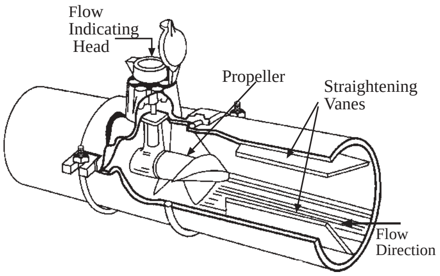
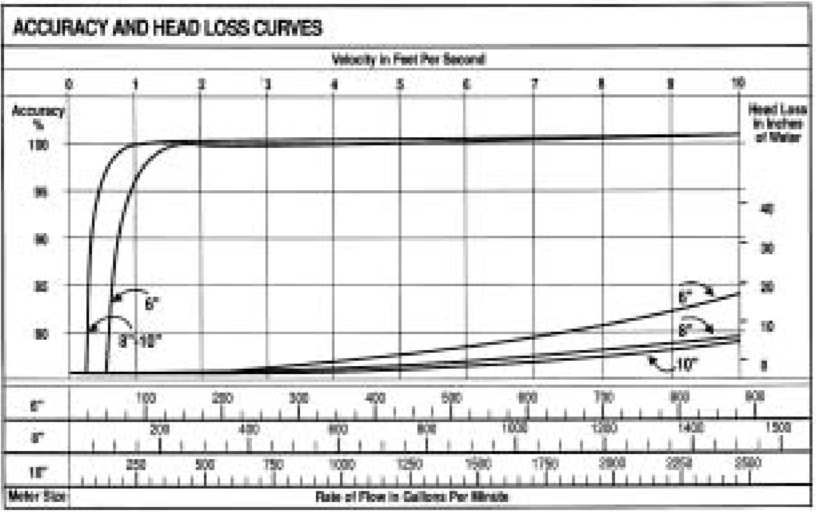


Figure 1.
Typical irrigation propeller meter. The large diameter propeller and straightening vanes are important for accurate measurement.

Figure 2.



flow rate of 1,200 gpm. Specific operating characteristics will vary with other meter designs.

Most meters use a magnetic drive between the propeller and the indicator head. This eliminates problems with sealing direct drive bearings, which sometimes bind because of sand or corrosion.

Propeller size usually ranges from 50 to 80 percent of pipe diameter. Small propellers are suitable when there is little variation in the flow. However, because larger propellers catch more of the total pipe flow, they provide more accuracy when wide fluctuations in flow occur within the pipeline.

The meter gear ratio must be selected to correspond with the inside diameter of the pipe in which the meter will be installed. All pipes with a certain listed "nominal" size do not necessarily have the same inside diameter. Because the inside diameter is used to determine flow rate from the propeller-indicated flow velocity, errors can occur with improper gear ratios. As an example, a meter geared for a 6-inch-diameter aluminum pipe, with a 5.884-inch inside diameter will be off by 6 percent if it is installed in a 6-inch-diameter seamless steel pipe with an inside diameter of 6.065 inches. Over the course of a season, a 6 percent measurement error can equate to 1.2 inches of water from a 20-inch application depth. This will influence records and your water management decisions.

INSTALLATION

The accuracy of the meter also depends on proper installation. Because different installation procedures are required for different meters, follow the guidelines provided by the manufacturer. Figure 3 shows correct and incorrect examples of water meter installation. Saddle meters are normally bolted onto the pipe, but some older styles were made to be welded in place. Meters mounted in straight pipe sections can be installed with dresser couplers or flanges, and some may be welded into the pipeline. Welding is not recommended unless there is a provision for removing the meter for service without having to cut the pipeline. For accuracy, the center line of the meter propeller must be positioned on the center line of the pipe. If the propeller is too high, off-center, or too low, improper flow velocity and flow rate readings will occur.

Propeller meters may be installed in any convenient position — vertical, horizontal or at an angle — but for accurate readings, the pipe must always be flowing full. If the pipe is not full, some arrangement — such as a restriction, bend or baffle plate — must be installed to ensure that full pipe flow occurs.

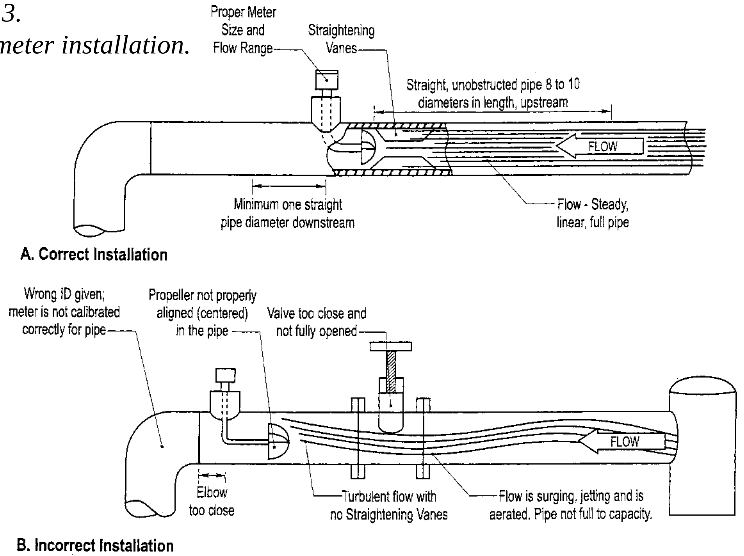
Spiraling flow or turbulence also affects meter accuracy. To minimize this problem, install the meter at least 10 pipe diameters downstream from any bend or obstruction, and at least five diameters upstream from such obstructions. However, follow the manufacturer's recommendations. For example, an 8-inch meter will need at least 80 inches of straight pipe between the meter propeller and the nearest upstream fitting or pump outlet.

If the minimum straight pipe cannot be provided, straightening vanes should be installed in the pipe ahead of the meter to reduce excessive turbulence. Many meters can be purchased as a flanged or vitalic (clamped) coupling pipe section that includes straightening vanes.

MAINTENANCE

Propeller meters, like all machines, require maintenance and care. Follow the manufacturer's recommendations for maintenance, including lubrication, periodic service, and frequent checks to make sure the meter is operating properly.

Figure 3.
Water meter installation.

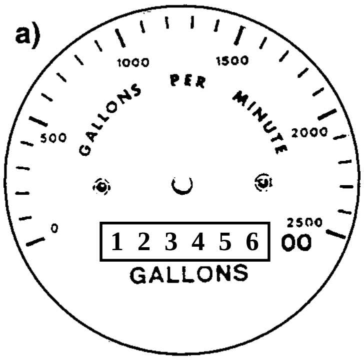


It is important that the propeller spins easily. If it seems to drag, check for the causes. Something may be caught on the shaft, or in the flow path to either bind the propeller or obstruct the pipe flow. Look for shaft wear and check bearings and gears.

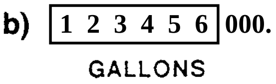
Every meter should have a periodic calibration check. This may be done in place, or the meter may be sent to a calibration facility. Some irrigation systems will pump sand or other suspended debris, causing corrosion and wear that can increase friction between moving parts and affect meter calibration. Again, improper calibration will result in measurement errors that will affect water management decisions and records.

The pipe section containing the meter should be drained when not in use, especially over the winter when freezing conditions may cause damage. Meters that are removed during the off season should be drained and blocked to prevent the entry of dust, dirt, insects and rodents.

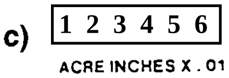
Figure 4.
Dial face configurations showing total readings.



Standard 8" meter dial face with gallon totalizer. Note: Two fixed zeros at right to be included in the reading.
Gallons = 12,345,600



Standard 10" meter dial face with gallon totalizer. Note: Three fixed zeros at right to be included in the reading. Three zeros may also be found on some 8" meters.
Gallons = 123,456,000



Standard 8" meter dial face with acre inch totalizer. Note: The multiplier .01 places a decimal point two places to the left. The odometer wheels also change color at the decimal point.
Acre Inches = 1234.56

Standard 8" meter dial face with acre feet totalizer. Note: The multiplier .001 places a decimal point three places to the left. The odometer wheels also change color at the decimal point.
Acre Feet = 123.456

METER INDICATING HEAD OPTIONS

Water measurement can be done with a variety of meter styles and measurement units. As previously stated, rates are usually in gallons per minute, but totals may be shown in gallons (gal), acre-feet (ac-ft), acre-inches (ac-in), or cubic feet (cu-ft). Figure 4 shows an example of a water meter dial face and a description of the readings. The choice of units is largely a personal preference, although it should be one with a counter total that would not turn over more than once during an irrigation season.

Volume and flow rate units can be measured in one type of unit and then converted to different units. Table 1 lists equivalent water measurement units that are useful for irrigation management. For example, the volume of water applied and the acres covered must be known in order to calculate the depth of water applied.

Another option most meters have is indicators of flow rate. Flow rates are normally in gallons per minute (gpm) or cubic feet per second (cfs). Flow rate can be determined for any meter equipped with a sweep hand (Figure 5a), or a flow rate indicator (Figure 5b). A stop watch must be used in conjunction with the sweep hand to determine flow rate. Figure 5b depicts a meter featuring all options: totalizer, sweep hand, and flow rate indicator.

Accurate water measurement figures allow the irrigator to adjust water applications to soil storage availability and crop requirement, thereby improving irrigation efficiency. Water measurement accuracy also allows the irrigator to monitor total applied water over the season, and to make adjustments to stay within water right the limits. Regular review of water measurement records can help identify system problems. For example, an irrigator could suspect an underground pipe failure if a higher than normal flow rate is detected. Water measurement for subsurface drip irrigation (SDI) can help identify if the emitters of the SDI system are plugging. This would be indicated by decreasing flow rates.

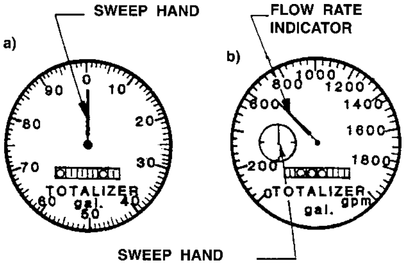


Figure 5.
Dial face configurations showing sweep hand and flow rate indicators.

Accurate water measurements can also help in early detection of well and pump problems, or how water level changes from declining ground water are affecting pumping performance and efficiency. Pumping plant efficiency can be better estimated when accurate water measurements are available. These are just a few examples of how accurate water measurements can help irrigators make sound irrigation management decisions.

EXAMPLE CALCULATIONS

Example 1: *A totalizer unit similar to Figure 4a indicates an ending reading of 12,345,600 gallons, and the beginning reading was 98,785,300 gallons. What was the total volume applied?*

Solution: In general, all that is required is subtracting the beginning meter reading from the ending. However, in this case that would result in a negative number. This means the totalizer unit has passed its maximum reading of 100,000,000 gallons and started over. So, add the maximum reading (100,000,000 gallons) to the ending reading, then subtract the beginning reading.

Ending reading:	112,345,600 gal.
Beginning reading:	<u>98,785,300 gal.</u>
Volume applied:	13,560,300 gal.

Example 2: *How many acre-inches were applied in Example 1?*

Solution: From Table 1:
one ac-in = 27,154 gal.

$$\frac{13{,}560{,}300 \text{ gal.}}{27{,}154 \text{ gal/ac-in}} = 499 \text{ ac-in}$$

Total volume applied

Example 3: *The volume of water from Example 2 was applied in three irrigations to a field with a row length of 1,000 feet, and was planted in 1,045 rows, 30- inches wide. What was the total applied depth and average gross irrigation depth for each of the three irrigation events?*

Solution: The area covered is:

$$\frac{1{,}000 \text{ ft x } 30 \text{ in/row x } 1{,}045 \text{ rows}}{12 \text{ in/ft x } 43{,}560 \text{ ft}^2\text{/acre}}$$

Area covered = 60 acres

$$\frac{499 \text{ ac-in}}{60 \text{ acres}} = 8.32 \text{ in.}$$

Total applied depth

$$\frac{8.32 \text{ in.}}{3 \text{ irrigations}} = 2.77 \text{ in./irr.}$$

Average irrigation depth

The calculated and measured information can also be compared to other known data. For example, an hour-meter reading from the pumping plant could be compared to the calculated hours of pumping using the flow rate indicator. If these values are similar, the operator would know that both devices are functioning properly.

Table 1.

EQUIVALENT MEASURES

Volume Units:
1 gal = 8.33 pounds
1 cubic foot = 7.48 gals
1 cubic foot = 0.02832 cubic meters
1 liter = 0.264 gallons
1 gal = 3.79 liters
1 cubic meter = 264.2 gals
1 ac-in = 3,630 cubic feet
1 ac-in= 27,154 gallons
1 ac-foot = 43,560 cubic feet
1 ac-foot = 325,381 gallons

Units of Flow:
1 cu ft per second = 449 gals per minute
1 cu ft per second for one hour =1 ac-in
1 cu ft per second = 0.02832 cu meter per sec
1 cu ft per second = 35.31 cu ft per second
1 ac-in/hr = 450 gpm
1 gal per minute = 0.00223 cu ft per sec
1 gal per minute = 0.00221 ac-inchs per hour
1 gal per minute = 0.06309 liters per sec
1 liter per second = 15.85 gal per minute

Example 4: *The flow rate indicator registers 500 gpm when the pump is operating. The hour-meter or the engine indicates 450 hours of operation. Are these instruments indicating similar results?*

Solution A: Example 1 showed 13,560,300 gallons were pumped.

$$\frac{13{,}560{,}300 \text{ gal.}}{450 \text{ hrs x } 60 \text{ min hr}} = 502 \text{ gpm}$$

This pumping rate compares favorably with rate indicator.

Solution B: Example 2 showed that the water volume was equal to 499 acre-inches. The well is producing 500 gpm.

$$\frac{500 \text{ gpm}}{450 \text{ gpm/ac-in}} = 1.11 \text{ ac-in/hr}$$

$$\frac{499 \text{ ac-in}}{1.11 \text{ ac-in/hour}} = 449 \text{ hours}$$

This compares favorably with the hour meter.

ABBREVIATIONS USED

gal. = gallons
ac-in. = acre-inch
in. = inch
hr. = hour
min. =minutes
sec. = second

OTHER RESOURCES

See the K-State Research and Extension Library at:
www.oznet.ksu.edu/library
Irrigation Web sites:
www.oznet.ksu.edu/mil
www.oznet.ksu.edu/irrigate
www.oznet.ksu.edu/sdi

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