Water Source Development for Forage Irrigation Systems

This guide is designed to help forage producers determine the feasibility of developing an irrigation system by evaluating water sources and exploring their capital costs.

Missouri water laws

Missouri is a riparian water law state, so landowners have a right to reasonably use water sources that are touching or underneath their land. Under this law, a landowner can withdraw as much water as needed as long as the withdrawals do not adversely impact the water use of other individual water users.

Water users who withdraw or divert 100,000 gallons per day, equivalent to 70 gallons per minute, all day, from streams, rivers, lake, wells, springs or other water sources are considered major water users. Missouri Water Law (Section 256.400–430 of the Revised Statutes of Missouri) requires that major water users register their water use annually with the Missouri Department of Natural Resources (DNR) [http://www.dnr.mo.gov/env/wrc/mwu-forms.htm](http://www.dnr.mo.gov/env/wrc/mwu-forms.htm). Users may be designated as major even if they only withdraw or divert the 100,000-gallon threshold on one day in a year.

The U.S. Army Corps of Engineers has jurisdiction over navigable waters, such as rivers and streams. Someone interested in directly pumping water or diverting water from a stream or river should contact the Army Corps of Engineers district office with jurisdiction for the proposed pumping location. The U.S. Army Corps of Engineers

- does not regulate temporary structures, such as a floating intake;
- does not require a permit if there is no construction in the channel and as long as no spoil or dredge material goes into the channel;
- does require that if a bank is altered, soil must be brought back and placed on the disturbed area or hauled off; and
- does require that the disturbed area be protected from erosion so that silt does not enter the channel.

Water sources

Three types of water sources exist for irrigation systems: surface water, ground water and public water. You will need to estimate the water quantity available from each source and determine if the given source will have the needed water available through the times when irrigation is needed in the growing season. Additionally, each option may have other issues you need to consider when deciding whether to use it as a water source for irrigation.

Surface water

Surface water includes sources such as streams, rivers, ponds and lakes.

Rivers and streams

If you are considering using rivers and streams, consult the local Army Corps of Engineers district office about the jurisdiction over the area from which the water will be pumped. These are some of the issues, topics or questions you must consider when pumping from a stream or river:

- Ensure that you have ownership of the land connected to the water source where the pumping site would be located.
- Estimate the volume of water that would be pumped from the river each year.
- Consider pumping to an intermediate water storage impoundment.

Written by
Joseph Zulovich, Extension Agricultural Engineer, Commercial Agriculture Program
Bob Broz, Extension Water Quality Specialist
Ryan Milhollin, Agricultural Economist, Commercial Agriculture Program

extension.missouri.edu > agriculture > equipment and facilities > water systems > g1696
Estimating pond capacity

1. Establish normal full pond water elevation.
2. Measure or calculate full pond surface area.
3. Estimate volume by multiplying surface area by 0.4 by maximum water depth measured at the dam.


Figure 2. How to estimate pond capacity.

Gallons of water in an acre-foot

\[
\text{27,200 gallons, approximately, in 1 acre-inch of water} \times \frac{12 \text{ inches}}{1 \text{ foot}} = 326,000 \text{ gallons per acre-foot}
\]

Figure 3. Acre-foot defined.

- An intermediate water storage impoundment may allow diverting river water when the river flow is such that a floating intake could be used so that no channel modifications would be needed. A floating intake would eliminate the need for a permit from the Corp of Engineers for channel modifications.
- Pumping when the flow in the river is above low flow should keep you from having any adverse effect on any other water use (Figure 1).
- Pumping will not adversely impact a downstream owner or fish living downstream from the pumping site.

Ponds and lakes

Ponds and lakes can be good, reliable sources for irrigation. Existing ponds and lakes on privately owned land can be used. Storage capacity for the pond needs to meet the irrigated forage crop requirements plus any water losses due to evaporation or seepage. Water impoundments should be large enough to store at least a one-year but preferably a two-year water supply. Ensure that the watershed area draining runoff is large enough to refill the impoundment within a normal year. A minimum of 10 acres’ drainage for every acre of pond surface is recommended. However, larger watershed areas per acre of water surface area may be required for cases when the pond is used to serve as a significant water supply.

Building a new pond or lake is an option for an irrigation water source. Site considerations include understanding the area adequacy for water drainage, minimum pond depth, drainage area protection, pond capacity estimation (Figure 2) and landscape evaluation. Select land where the topography achieves the largest volume of water per cubic yard of soil moved to minimize the cost of moving earth.

Estimating surface water storage requirements

1. Estimate the daily water usage in gallons per day.
2. Multiply the daily use by days of expected irrigation to determine an annual estimated water usage.
3. Divide the annual gallons per year by 325,828.8 (gallons per acre-foot) to obtain the annual water need into the volumetric measure of acre-feet of water.
4. Multiply the annual water need in acre-feet by 4 to obtain the estimated water impoundment storage capacity.

The constant 4 is derived as follows: A surface water system should be able to supply two years’ worth of water need without any significant runoff from the watershed due to dry weather. In Missouri, about half the water stored in a given impoundment is lost due to evaporation and seepage losses.

5. Multiply the total acre-feet of water storage by 2.4 to estimate the number of acres needed in the watershed to refill the water impoundments. The size of the watershed to refill the water impoundments should be large enough to refill all the water storage capacity in a normal year. In a normal year, about 5 to 6 inches of runoff can be expected from typical rural watersheds. The 2.4 constant is derived by dividing 12 by 5. The 5 is the depth in inches of runoff from an acre, and the 12 converts inches to feet.

Figure 4. How to estimate surface water storage requirements.

Soil is important as areas that have a lot of rock or sand make getting a good seal challenging and expensive. Dams should have about 30 percent clay in their structure and hauling in additional clay adds considerably to the construction cost. Generally, the Natural Resources Conservation Service (NRCS) recommendation for minimum pond depth in Missouri is 6 to 8 feet, depending on location. Two recommended reading materials on ponds are the NRCS handbook Ponds — Planning, Design, Construction and MU Extension publication G1555, Reducing Pond Seepage.

The cost of building ponds and lakes averaged $2.68 per cubic yard of soil moved in Missouri in 2012. But note that the costs ranged from $1.50 to $5 per cubic yard, which shows that costs vary greatly depending on variables such as location and soils.

Surface water storage requirements are expressed in the volumetric measure of acre-feet of water, with one acre-foot equal to about 326,000 gallons (Figure 3). A method of estimating the total size of surface water storage system required is presented in Figure 4 along with a method of estimating the number of watershed acres that should be available to refill the surface water storage. The estimated storage requirement can be provided by one or more water impoundment structures. The watershed acres must be such that all the available runoff from the watershed can be captured and stored in the water impoundment structures.
In Missouri, a majority of the water currently used for irrigation comes from groundwater sources. When the U.S. Department of Agriculture 2007 Census of Agriculture was taken, Missouri had a total of 12,869 irrigation wells in operation serving 1,415 farms. The Missouri Department of Natural Resources, Division of Geology and Land Survey, Wellhead Protection Section is the regulatory agency in charge of irrigation wells in Missouri. It is the clearinghouse for all well construction rules. It also maintains a Missouri database of licensed private well drillers and pump installers that should be used when drilling or repairing a well.

The Missouri DNR also provides two good tools for making water well decisions. It has established a network of groundwater observation wells located throughout Missouri, available online at [http://dnr.mo.gov/asp/wrc/gwells/search.asp](http://dnr.mo.gov/asp/wrc/gwells/search.asp). Groundwater observation wells are a good way to visualize the real-time depth and availability of water in an area. Additionally, the Well Information Management System (WIMS) has a database of all wells drilled in Missouri after November 1987, online at [http://dnr.mo.gov/mowells](http://dnr.mo.gov/mowells), which can give you an indication of what to expect when putting in a local well.

Understanding the geology of the state will give you an idea of how much groundwater is available (Figure 5). Special areas in Missouri may require that you either case or grout deeper depending on the area and geologic conditions. Requirements for well construction are based on yield, use of well and the region where the well is located.

Well system capacity needs to be large enough to supply the daily water need. An intermediate storage system can be used to store water if the well cannot supply the peak demand of water needed through direct pumping. Maximum pump size needs to be slightly smaller than maximum well yield capability.

The average cost of a 500-foot well, complete with pumping system, is about $10,615 under normal conditions.
in 2013 (Table 1). The final cost of any well installation can be affected by variables such as an increased drilling depth ($6.50 per foot), casing needed in steel ($16 per foot) vs. PVC pipe ($6 per foot), and a PVC liner ($6 per foot) needed outside of steel casing due to geological conditions. Contact your local NRCS and Soil and Water Conservation District (SWCD) offices to see what they have on record as average cost for a well in your area.

Public water
Public water supplies tend to be an expensive option for forage irrigation. The Missouri Rural Water Association conducts an annual survey to detail trends in local water rates in Missouri. Based on its 2012 survey, the cost of 5,000 gallons of water for a private system was $24.29, ranging from $7 to $69.50 across Missouri. This cost would be equivalent to $131 per acre-inch of water on average in Missouri, making it prohibitively expensive for irrigating forage. Many public water supplies may be limited on available water and may put a limit on water use for uses other than domestic use. During times of critical water supply shortages, public water supplies will request and sometimes require reductions for domestic use.

Intermediate water storage
Intermediate water storage structures have been used to extend low yield water supplies [low gallons per minute (gpm) yielding supplies] to provide the required water during periods of high usage (high gpm use periods). For example, if a small irrigation system needs 60 gpm for five hours a day and the well yields only 10 gpm, an intermediate water storage holding at least 15,000 gallons [(60 gpm – 10 gpm) × 5 hours a day × 60 minutes an hour] can allow the 10 gpm well to serve as a water supply for the 60-gpm irrigation system. The well pump would pump water into the intermediate storage, and the irrigation system pump would pump water from the storage. The storage must be full at the start of irrigation, and the well will continue to pump water into the storage after irrigation is complete to refill the storage for the next day’s irrigation event.

Another function of the intermediate water storage would be to provide a readily available source of water if flow from the primary water supply is interrupted. This volume of water storage will provide a minimum time frame to correct a water interruption problem or to arrange for the delivery of water by other means. Required intermediate storage volumes may need to equal the anticipated water usage over a 48 to 72 hour period. The availability of service personnel and repair parts required to keep the water system operational will be a major factor in determining the intermediate storage volume requirement.

References

Contacts
Missouri Department of Natural Resources, Division of Geology and Land Survey, Wellhead Protection Section http://www.dnr.mo.gov/geology/geosl/wellbd

This material is based upon work supported by the USDA/NIFA under Award Number 2012-49200-20032.
Funding for this project was provided by the North Central Risk Management Education Center and USDA National Institute of Food and Agriculture.

ALSO FROM MU EXTENSION PUBLICATIONS
G302 2012 Custom Rates for Farm Services in Missouri
G1555 Reducing Pond Seepage
extension.missouri.edu  800-292-0969