Small Acreage Irrigation Guide

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Water Rights and Irrigation Management

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INTRODUCTION

This guide provides information about water rights and irrigation for small acreage landowners. While the content is largely directed towards those engaged or interested in some form of agricultural production, it may also be useful for those simply interested in maintaining their yard and garden plot. This guide addresses many important questions about water rights and water use for landowners and for those thinking of purchasing land. Questions include: do I have water, can I get it, how much can I get, how do I determine how much to order, when can I get it, how do I get it, what will it cost, and what factors affect how much water ultimately ends up where I need it?

Crop water requirements and irrigation scheduling are discussed, and examples are provided to help the user with common calculations necessary for irrigation scheduling and ordering the necessary amount of water to meet crop needs. In addition, information is provided on irrigation systems that are appropriate for 5 acres or less, including pumps, pipelines, and water application options. In short, this guide is intended to help the water user get started with irrigation, and to help all landowners better understand water rights and the legal use of water.

CONSIDERATIONS FOR WATER USERS – FREQUENTLY ASKED (OR SHOULD BE ASKED) QUESTIONS:

1. **What is a 'water right'?**
   It is a property right in the form of a legal decree that allows for the beneficial use of a measurable amount of water and is subject to the historical date it was first recorded. In fact, some of the earliest recorded water rights in Colorado date to the 1860s. A water right is usually limited to a specific volume of water described in terms of acre-feet (ac-ft), acre-inches (ac-in), or cubic feet-per-second (cfs), and limited to a specific beneficial use, such as agriculture or domestic uses.

2. **Who owns the 'water right'?**
   A person does not 'own' the water. Rather, they have a legal 'right' to use a specified volume of water for a predetermined beneficial use. In some cases, individuals own this decreed right. However, it is more likely that individuals have a pro-rata interest (share) in a right that is managed by a mutual ditch company. While the ditch company manages the water supply and delivery, the shareholders own the water rights held by the ditch company (Jones and Cech, 2009). Therefore, the landowner would have 'shares' of water through their mutual ditch company.

3. **What is a ditch company?**
   Ditch companies as a group are typically referred to as a mutual ditch company and are similar to other corporations (ownership based on shares of stock), but organized to provide water to their shareholders on a pro-rata basis. Ownership in a mutual ditch company is evidenced by a stock certificate (Jones and Cech, 2009).

4. **What is a lateral ditch company?**
Lateral ditch companies differ from mutual ditch companies in that they do not own water rights. They tend to be smaller ditches that branch off from the larger ditches owned by mutual ditch companies. Their functions are to deliver water to the users along that lateral ditch and to maintain that ditch. They are separate legal entities from the mutual ditch company. It is very important to note that if your property is along a lateral ditch, then you need to be a shareholder in the mutual ditch company that delivers water to that lateral; otherwise you have no shares of water. Conversely, if you acquire shares of water in a mutual ditch company, but your property is along a lateral ditch, then you will also need to have shares in the lateral company in order to receive your water.

5. **What is a stock certificate in a ditch company?**
It specifies a predetermined amount of water (cfs, ac-ft, or ac-in) and is different for every ditch company. Within a ditch company, the amount of water allotted to a stock can vary by year, depending on the total available water supply that particular year. So, in a year of drought, the allocation of water for a particular ditch company may be less than it is during a year of average or abundant water supply.

6. **How is my water measured?**
Water is usually measured at the headgate of the ditch that delivers water to your property. Shareholders on the ditch, or a ditch rider, open the headgate an incremental amount that allows the desired flow for the intended use on your property. The amount of water you may get is determined by the need of the crop at that point in time or your pro-rata interest in the ditch company, whichever is less. It is accurately measured by the size of the opening of the headgate or by using a device, such as a measuring weir or flume.

7. **What is a ditch rider?**
A ditch rider is hired by the ditch company to maintain the ditch and open headgates as appropriate to divert water for water deliveries to shareholders in the ditch system. The ditch rider also calculates water volumes and oversees ditch operations. The ditch rider stays in close communication with the water commissioner (a.k.a. river commissioner) during the irrigation season to coordinate water

diversions and 'calls' on the river. Some of the smaller mutual ditch companies use a rotating ditch captain to coordinate ditch operation and maintenance activities (Waskom, et.al. 2011).

8. **What is a 'call'?**
If a decreed water user has an insufficient water supply, they can make a request to the district water commissioner that all upstream, 'junior' users curtail their use. This is known as placing a 'call'. For a 'call' to be valid, the shorted user must have a genuine need for water for purposes permitted by their decree, and there must be no downstream 'call' senior to their own. If the 'call' is valid, the commissioner will communicate the date of the 'call' (the date of the recorded water right of the caller) to water users upstream of the party making the 'call'. All upstream users that are junior to that priority date are then required to curtail water use until the calling user's water need is satisfied (Jones and Cech, 2009).

9. **Can I apply water anywhere I want on my land?**
In most parts of Colorado, you can apply irrigation water only to land that has a documented irrigation history. Applying water to land that has not been historically irrigated is considered an 'expansion of use' and is prohibited by many ditch companies. There may be localized exceptions, so check with your ditch company or local District of the Colorado Division of Water Resources office to determine if this provision of Colorado water law applies to your land.

10. **How does one water right compare to another?**
In other words, who gets their water first? The state of Colorado operates using an appropriation system. In times of water shortage (like drought), those holding the earliest historically recorded water right have priority over those with a more recently recorded water right. For example, if you hold or have interest in a water right that was originally filed in 1869, you would get water before a neighbor that has a water right that was filed in 1902, regardless of location (your 'upstream' neighbor must let all water pass through their property so it gets to you if your water right is older). Using this same example, the 1869 right is known as a 'senior' right, while the 1902 right is referred to as a 'junior' right.

11. **How is water delivered to my land?**
Some individuals are located near a perennial stream or lake/reservoir and are permitted to draw water directly from that source. However, the vast majority of irrigators receive

water from a ditch that connects to a stream or reservoir, often many miles from their property.

12. **What if an irrigation ditch crosses my land? Can I use the water?**
    If you buy or own a parcel of property with a ditch either along or through the property, you are not automatically a shareholder in a ditch company or an owner of a water right. This means that you can't remove water from that ditch that runs through or along your property unless you either have a legal decree for a portion of that water, or are a shareholder in a ditch company that provides that water.

13. **How long will a mutual ditch or lateral run water?**
    Each ditch or lateral has a unique time frame of water flow that is dependent upon the water supply. Some run for 6 months, some for only 6 weeks. It is imperative to know the period of time that your ditch runs water – when it starts and when it goes dry each year. This will determine the kinds and amounts of crops that you can produce.

14. **Can I pump water into a storage tank or some other type of reservoir?**
    A water user in Colorado typically has 72 hours to apply any irrigation water that they order, unless they have a storage right. This applies to each time you irrigate.

15. **How do I order water?**
    Contact your ditch rider or ditch company and put in your order for water. Your ditch rider will fill your water order by opening and closing headgates to allow the permitted water to flow. Keep in mind that if water is limited, the more senior water rights will get their water before you, even if you put in your order first.

16. **When should I order water?**
    The typical recommendation is to order water 48 hours before you want to apply it on your crop. It is best to talk to your ditch rider to find out how much lead time is needed when ordering water at your location.

17. **How much water should I order?**
    If your target crop needs an inch of water for one irrigation, you might think that you only need to order an inch. However, you must take into account how far you are from the

headgate, the type of delivery system (earthen ditch, concrete-lined ditch, or pipeline), and the condition of that delivery system. As water flows towards your property, some will seep or soak away. If the ditch is not well maintained, and the water moves slower due to debris or vegetation, even more will seep or soak away before it reaches your property. Furthermore, some irrigation water applied to your crop (field) is lost to surface runoff and some to deep percolation (i.e., past the crop root zone or depth) and is not available to the plant. So, you have to order more water than you actually need to account for the seep, soak, and surface runoff. The total amount ordered counts against your total water right allocation, even though you don't receive all that you order. Examples follow in the guide that will help you calculate how much water to order. Additional information regarding irrigation efficiency can be found in Bauder, et al. 2011 and Howell, 2003.

18. **What is the minimum amount of water that I can order?**
It depends on the ditch company but it is usually 1 cfs for 24 hours, which equals 2 acre-feet. This amount is usually more than one small acreage landowner can effectively use at one time for their crop, so it can be important to collaborate with other small acreage neighbors. You share your water for this irrigation event, and then they share their water with you next time. Each of you ends up with 2 irrigations for your crop instead of one, thus stretching out the water supply for both of you. Often, several neighbors can partner in this fashion.

19. **What if my water right is not sufficient to meet my needs? Do I have other options?**
You do. You can lease water from other users who have more water in their right than they need, or you can lease water from ditch companies that have excess water. You can also take advantage of 'free' water, which is excess water available in the ditch system or river when all other user demands are being met. This usually occurs in the spring when snowmelt and runoff are at their highest, and available water at that time exceeds the combined water rights for that system.

20. **Can I collect rainwater for future use?**
Most homeowners are now allowed to use rain barrels to collect rainwater in Colorado. A maximum for two rain barrels with a combined storage of 110 gallons are allowed at each household. Collected rainwater can be used to irrigate lawns, plants, or gardens. For more information on rainwater collection contact Colorado Division of Water Resources or read CSU Extension Fact Sheet No. 6.707 Rainwater Collection in Colorado. A recorded webinar on Residential Rainwater Harvesting in CO is available at https://www.youtube.com/watch?v=JqHAZ6QUJvA&feature=youtu.be

IRRIGATION SYSTEMS

When choosing an irrigation system, consider the needs of the target crops (Tables 3 & 4), the water availability (how much and how often you can get it), how the water gets to your land

(Table 1 – conveyance), and the soil type (Table 6 - different types have different abilities for absorbing and holding water). Irrigation conveyance refers to the type of system that delivers your water from the source to the point of use. The length, slope, substrate (earthen, concrete, or pipe), and presence of vegetation and other debris all affect how much and how quickly your water gets to your application system. The further you are from the source, combined with the presence of unmaintained vegetation or debris, and the type of ditch (earthen vs. concrete) means that you will lose more water to seep and soak before it gets to your property.

Each type of conveyance system has an associated efficiency that needs to be accounted for in your irrigation planning (Table 1). Once you have water at your property or field, there are three basic irrigation systems – flood, sprinkler, and trickle (i.e., drip and micro-sprinkle or spray) – that are applicable for use.

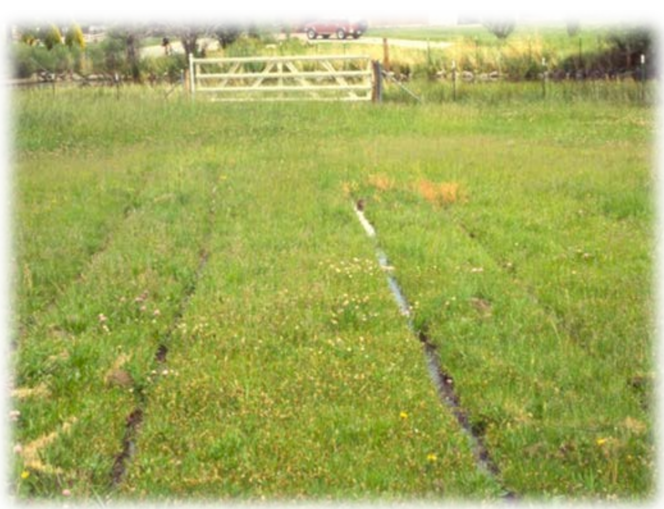
Table 1: Irrigation Conveyance Efficiencies

Conveyance Method	**Efficiency (%)**
Earthen Ditch	70 – 80
Concrete-lined Ditch	90 – 95
Pipeline	99 – 100

Source: USDA-NRCS NEH Part 23, Chapter 2, Irrigation water requirements.

Surface Irrigation

Surface irrigation options include **wild flood** (letting the water run across a field with no confinement mechanisms); **furrow** (a series of small shallow uniformly spaced channels used to guide water); **border** (confining water between two dikes); and **corrugation** (small V-shaped furrows used for close-growing crops such as grass).



Corrugated field for surface irrigation

One of the most common water application methods is to place a plastic or canvas dam in the **head ditch** (channel used to bring water to property) to back up the water, and then cut a notch in the ditch to let the water out. Each time the dam is moved and reset, it is called a **set**. A typical length of a set is 12-24 hours.Other variations include **head gates** (slide open gates), **siphon tubes** (siphon water over bank of irrigation ditch to transfer water to field), and **gated pipes** (series of pipes fastened together with uniformly spaced openings covered with adjustable gates that can be opened to let the desired amount of water out into the field).

Surface irrigation methods are more suitable to relatively flat land. It is difficult to obtain uniform water distribution on fields that are long, have an irregular surface, or have coarse soils (gravel or sand). Surface irrigation methods require very little energy (head) compared to sprinkler or drip, but labor is more intensive.

Sprinkler Irrigation

Sprinkler irrigation options include a **mini gun** (self-propelled travelling sprinkler mounted on a wheel and fed by a rubber hose); **portable hand line** (hand-moved sprinkler system); and **solid set** (stationary system where water supply pipelines are below the surface and sprinkler nozzles are elevated above the surface).

Sprinklers are more expensive than flood, but if designed, installed, and managed properly, can apply water more efficiently and uniformly. There is a potential to decrease the amount of water applied while maintaining or increasing crop yields.

Mini gun sprinkler system

Micro Irrigation

Drip irrigation systems can be **surface** or **subsurface**. Individual emitters are used to frequently apply water to the soil surface at a low flow rate and pressure. A continuous supply of water (perhaps from a tank, well, or reservoir) is needed for this system during operation. Water must be filtered or screened to protect emitters from clogging. An additional issue with drip irrigation is bacteria and other water quality issues that may require chemical injection to prolong the life of the system. Poor water quality can potentially plug emitters. Although the initial cost is high, it is a great option if the amount of water is limited or if the cost of water is high.

Micro-sprinkler (spray) Irrigation

An above ground, spray-type trickle system is less likely to clog than drip and sub-surface drip systems. In spray irrigation, small sprinkler-like devices (often called micro-sprinklers) spray water as a mist (or short jets) over the land surface. Micro-sprinklers can be spaced to cover the entire land surface as with conventional sprinkler systems or a portion of the land surface like other trickle systems (i.e. drip). Discharge rates are usually less than 0.5 gpm (115 L/hr).

Table 2: Irrigation System Comparisons

Irrigation System	Application Efficiency*	Cost**(irrigation labor not included)	Advantages	Disadvantages
Wild Flood	15 – 40%	$0 – $20 (home made plastic or canvas dam)	• Low input cost • Low maintenance	• Low efficiency • Increased labor • Poor uniformity
Furrow • **Gated pipe** • **Corrugation**	40 – 80% 40 – 55% 50 – 80%	 $2 – $3/foot ------	• Control of delivery time and space	• High labor • Low efficiency
Sprinkler • **Mini gun** • **Portable hand lines** • **Solid set** • **Pod**	 55 – 75% 60 – 85% 60 – 85% 60 – 85%	 $2,500 - $8,000 (depends on hose size) ---- ---- $3,000 - $6,000/ac ($250 - $350 per pod plus supply line)	• High efficiency • Low labor • Suitable for most crops • Good choice for fields with varied soil & topography	• Higher cost • Higher operation & maintenance • Needs continuous supply of water • Requires pressurized water source
Surface Drip	70 – 95%	$1,000 – $2,000/acre	• Higher efficiency • Less time and labor • Reduced runoff • Reduced pumping costs • Typically used for vegetables, windbreaks, trees, vines, and shrubs	• High initial cost • Higher management time • Needs continuous supply of water • Filtration required

Source: Barta, et. al, 2004

*Application Efficiency refers to the percent of water delivered that ends up in the root zone of the crop. Efficiencies can be much lower due to poor design and management.

** Based on 2018 cost estimates

ESTIMATING WATER NEEDS

How much water does my crop need?
Water requirements for grass and other crops are determined by weather conditions and soil moisture available for plant uptake. **Irrigation scheduling** is the decision of when and how much water to apply to a field. Water requirements are typically described by the term **evapotranspiration** or **ET**, which is the combined water loss from the processes of evaporation and transpiration (plant water use). The cumulative amount of ET for a crop over an entire growing season is roughly equivalent to that crop's seasonal water requirement. ET losses in a given area can be accurately predicted from measurements of four local weather variables: air temperature, incoming shortwave solar radiation, air relative humidity, and horizontal wind speed. These weather variables differ significantly in Colorado due to latitude and elevation, which results in varying amounts of potential ET by grass and other crops.

Table 3: Estimated Consumptive Use or ET (inches/growing season/acre)

	Greeley	Lamar	Monte Vista	Fruita
Fruit trees	N/A	N/A	N/A	25.71
Alfalfa	31.58	39.06	23.58	36.22
Grass Hay/Pasture	26.63	34.16	19.85	31.44
Small Vegetables	17.70	18.85	6.79	18.06
Average Gross Precipitation	12.20	15.33	7.25	8.30
Average Effective Precipitation	7.32	11.00	3.93	3.98

Source: Colorado Irrigation Guide, 1988, USDA-NRCS.

Net irrigation requirement is the difference between crop consumptive use and effective precipitation. **Effective precipitation** is the amount of rainfall that actually infiltrates the soil and is available within the crop root zone. The **gross irrigation requirement** is the net irrigation requirement divided by irrigation system application efficiency. System efficiency makes a big difference.

***Example 1*:** **How much water do I need for a particular crop?**

Sarah lives in Greeley and has a 1-acre grass pasture irrigated by a portable sprinkler system. The average ET or consumptive use of grass pasture in Greeley is 26.63 inches/season (Table 2). *How many inches per season does Sarah need to water her pasture?*

1. Subtract the average effective precipitation from the ET to determine the net irrigation.
   26.63 inches/season/acre – 7.32 inches/season/acre = *19.31* inches/season/acre
2. The irrigation system efficiency must also be considered. To find the gross irrigation, divide the net irrigation by the irrigation application efficiency (Table 1).
   19.31 inches/season/acre / 0.70 (60 - 85% range from Table 1, we used 70%) = 27.59 inches/season/acre
3. To convert inches/acre to acre feet, divide by 12.
   Therefore, Sarah needs 27.59 inches/season/acre or 2.29 acre feet per season for the portable sprinkler system to water 1 acre of grass pasture in Greeley.

Once you have calculated an estimated gross irrigation water requirement, in order to find out if you have enough seasonal water for your crop, you must determine the flow rate of the water you will be receiving and the amount of time it will be available to you. Crops such as vegetables need water on a regular basis throughout their growing stages. So, if you have the right to "X" number of water shares that equal "X" amount of water, you can determine if you have adequate water for the target crop. You can rent additional water or sell excess water.

How do I know how much ditch water to order so the desired amount arrives at my property?
Determine how much water your target crop needs by learning about your specific crop's water requirements (Table 4). Additional information on crop water needs and irrigation scheduling can be found in Andales et al. (2011a). Crops use varying amounts of water depending on their growth cycle and the time of year. The website CoAgMet can help you determine the average ET of the target crop during the time the water will be used (www.coagmet.colostate.edu). Further information on using CoAgMet data and producing crop ET reports can be found in Andales et al. (2011b). Examples of ET for several regional locations in Colorado can be found in Table 3.

Table 4: Estimated Average Weekly Water Consumption

Crop	Water Use (inches/week)*
Fruit trees	1 – 4
Alfalfa	1 – 2.5
Grass hay/pasture	1-2
Small vegetables	1 – 2

*For accurate crop water use by region in Colorado, visit CoAgMet www.coagmet.colostate.edu

How do I know when to irrigate?

Irrigation scheduling is the decision of when and how much water to apply to a field. Table 4 contains estimates of average weekly water demand for select crops, but irrigation timing and amounts are best determined by root zone soil moisture (the amount of moisture in the soil at a particular depth where most water uptake occurs). This irrigation management root depth can be estimated by crop type (Table 5). Soil moisture content can be assessed using several methods, such as the Feel Method, tensiometers, and other sensors (Chávez et al., 2011). Typically, irrigation should occur before the soil reaches 50% available water holding capacity. Plant appearance is NOT an accurate method of determining soil moisture content.

In all soils other than sands, a rough check on soil moisture can be done using the **Soil Ball Method**. Dig a hole and remove a handful of soil from 6 to 12 inches deep. Squeeze the soil into a ball. Then 'bounce' the ball in the palm of your hand. If it remains in a stable shape, the soil has more than 50 percent of its available water. If it crumbles, it needs irrigation.

For a list of equipment needed and advantages and disadvantages of different methods of measuring soil moisture, read CSU Fact Sheet No. 4.708 Irrigation Scheduling (*http://extension.colostate.edu/docs/pubs/crops/04708.pdf*).

For detailed information on how to estimate soil moisture by feel, read the USDA-NRCS publication, **Estimating Soil Moisture by Feel and Appearance** available at https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_051845.pdf

Example of estimating soil moisture by feel and appearance

How long should I irrigate?

Water within the crop root zone is the source of water for crop evapotranspiration. An irrigator can estimate the amount of water applied at a desired depth by knowing the soil water holding capacity. **Soil water holding capacity** is determined by the soil texture, which can range from clay (finest) to sand (coarsest).

In general, irrigate clay soils for longer periods with lower application rates, and sandy or rocky soils for shorter periods because finer soil particles (like clay) hold more water than coarse soil particles (like sand) and clay soils have a lower intake rate. It takes approximately 1 inch of water to refill one foot of clay or loam soil. It only takes a half inch of water to recharge a foot of sandy soil. The length of time the irrigation system runs will determine how much water is applied. There is no point in filling the soil profile with water to a depth that crop roots cannot reach. Use Tables 5 and 6 to determine rooting depth of your crop and the water holding capacity of your soil. If you don't know the soil texture, visit the Web Soil Survey at http://websoilsurvey.nrcs.usda.gov/ to find more information.

***Example 2*:** **How much water do I need to order?**

Beth gets irrigation water from an earthen ditch. She irrigates her 2-acre grass pasture with wild flood. Her pasture requires about 1 inch of effective water per week. But Beth needs more than 1 inch of water because the delivery system (earthen ditch) and application system (wild flood), are only about 70% and 40% efficient, respectively. *If she wants to apply the effective water required for the week (1 in) over the course of one day, how much water will she need to order?*

1. 1 inch/(.70 x .40) = 3.6 inches total water needed per acre

2. We know 1 inch = 1 acre-inch/acre, so 3.6 in = 3.6 ac-in/ac.
   Then convert to volume: 3.6 ac-in/ac x (1ft/12 in) x 2 acres = *0.6 acre-feet(ac-ft) of water needed.*

3. *Mo*st ditch water is ordered by cfs (cubic feet per second).
   We know that 1 cfs = 23.76 ac-in/day, or 1.98 ac-ft/day, so

   $$0.6 \text{ ac-ft/day} \times \frac{1 \text{ cfs}}{1.98 \text{ac}-\text{ft/day}} = \mathit{0.303\ cfs}$$

Therefore, to meet her grass pasture's weekly needs using wild flood, Beth needs to order a constant 0.303 cfs for a full day or 0.6 acre-foot (7.2 ac-in) over the course of one day.

Table 5: Irrigation Depths Based on Crop Root Zone Depths

Crop	Irrigation Management Depth (Feet)*
Fruit trees	2
Alfalfa	4
Vegetables	1 – 2
Pasture Grass	2
Turfgrass	1 or less

*Because plants take up water faster from upper roots, irrigation water management typically targets upper 60 to 80% of actual rooting depths.
Source: Midwest Plan Service, Sprinkler Irrigation Systems, Table 2-2 (1999)

Table 6: Soil Water Holding Capacity

Soil Texture	Water Available For Use Between Irrigations (50% of available water)	Intake Rate (inches/hour)*
Sand	0.5 inch/foot	1 – 3
Loam	1 inch/foot	0.3 – 0.8
Clay	1 inch/foot	0.01 – 0.2

*Intake rate can vary greatly with soil structure and stability.
Source: Fundamentals of Irrigation, USU Extension

***Example 3*: How long should I irrigate a specific crop?**

John wants to grow alfalfa in a loam soil. He is debating between using a sprinkler system which delivers 0.25 inches/hour and flood irrigation which delivers 0.5 inches/hour. *How long should he irrigate each time if he uses the sprinkler system and if he uses flood irrigation?*

1. First look up important information.
   Loam soil absorbs an average of 0.5 inches of water per hour (Table 6). Loam soil needs to be irrigated with 1 inch of water/foot (Table 6). The irrigation management depth for alfalfa is 4 feet deep (Table 5).
2. 1 inch of water per foot for loam soil x 4 feet deep = *4 inches* of water to be applied.
3. Next consider the irrigation system.
   Sprinkler: If the sprinkler system waters 0.25 inches/hour, it should run for *16 hours* to apply 4 inches (4 / 0.25 = 16).
   Flood: Since loam soils absorb 0.5 inches per hour, it should flood for *8 hours* (4 / 0.5 = 8).
   Therefore, if John uses the sprinkler system, he has to run it for 16 hours, but if he uses flood irrigation, he has to irrigate for 8 hours.

SMALL-SCALE WATER PUMPS

When should I consider using a small-scale pump?

Consider using a small-scale pump if you are looking to irrigate a small area of land, such as a front lawn or small garden. The water source must also be shallow (25 feet deep or less), such as a pond or ditch. Typically, the desire is to move water for distances of 0 to 200 or so feet, and sometimes up inclines. Details on how to choose a pump are located in the following section.

How do you choose a pump?

Remember that the power required (horsepower) is not the only important factor to consider when choosing a pump. There are four key elements to consider when choosing a pump:

1. head against which the flow is delivered,
2. required flow rate,
3. pressure,
4. and power required.

These combined elements help determine the efficiency of the pump. Every pump is designed for a different purpose, so in some instances high horse-powered pumps have higher efficiencies and in other instances low horse-powered pumps have higher efficiencies. To choose the most efficient pump for your purposes, you will have to consult the pump manufacturer so they can match a pump to your system using their pump curves and graphs.

Flow rate, pressure, and power required are always indicated by the pump manufacturer. Remember that your pump needs an **energy source**. Most pumps run on electricity or gas, however solar power panels are an option, especially since the system is small. Remember that the more horsepower your pump requires, the more energy you will have to supply and pay for.

Pumps

The most appropriate pumps to move water from a shallow water source to a small application area are the centrifugal, jet, and sump pumps. Before buying a pump, contact the pump manufacturer. The technicians will be able to tell you if the pump you selected will work for your desired application.

Centrifugal Pumps

Centrifugal pumps (Fig. 1), sometimes called sprinkler or lawn pumps, are best used when you want to move water from a shallow water source to a small system with high volume required. The shallow water source can be a pond, ditch, reservoir, etc. that is 25 feet deep or less. The small system can be a lawn sprinkler system with *many* sprinkler heads.

Jet Pumps

Jet pumps (Fig. 3) are best used when you want to move water from a shallow water source to a small system with low volume required. The shallow water source again can be a pond, ditch, reservoir, etc. that is 25 feet deep or less. The small system can be a lawn sprinkler system with *few* sprinkler heads.

Submersible Sump Pumps

Submersible (underwater) sump pumps (Fig. 2) are best used when you want to take water from a shallow water source to a single outlet with high volume. The shallow water source, can be a pond, ditch, reservoir, etc. that is 20 feet deep or less. The single outlet is typically a garden hose. The common use for the sump pump would be to water a small garden with a hose. (It's most common use however is to pump water out of flooded basements.)

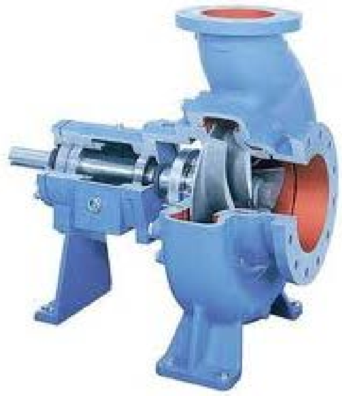


Figure 1: Centrifugal Pump; www.directindustry.com

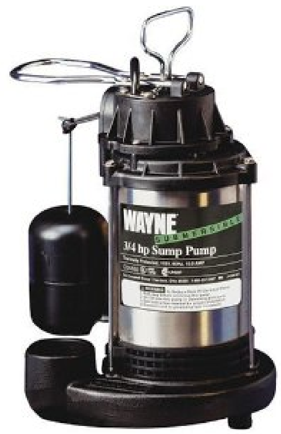


Figure 2: Submersible Sump Pump; www.waynepumps.com

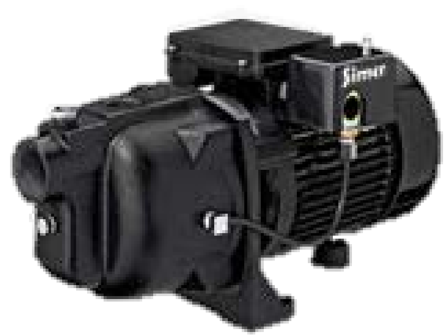


Figure 3: Jet Pump; www.simerpumps.com

Table 7: Pumping Across Horizontal Distances (0-20 feet change in elevation)

Pump Type*	Common Use	Distance (ft)	Pump Pressure (PSI)	Pump Flow Rate (GPM)	Pump Power (HP)
Centrifugal/ Sprinkler/ Lawn Pump	Move water from one source to many sprinkler heads along one line (low pressure, high volume)	0 – 100	30 – 50	15 – 45	1– 1.5
		100 – 200	30 – 50	25 – 55	1 – 1.5
		200+	30 – 50	35 – 60	1.5 – 2
(Shallow Well) Jet Pump	Move water from one source to very few sprinkler heads along one line (high pressure, low volume)	0 – 100	30 – 60	5 – 10	0.25 – 0.5
		100 – 200	30 – 60	10 – 20	0.5 – 0.75
		200+	30 – 65	10 – 25	0.5 – 1.5
Submersible Sump Pump	Drops into water and attaches straight to garden hose (low pressure, high volume)	0 – 150	30 – 60	25 – 80	0.25 – 1

* All pumps considered are for shallow depth (25 feet or less) water sources.

Pumping Up Inclines

When dealing with hills, or any other inclines over which you would like to pump water, there are a variety of options. The main options involve using jet pumps or booster pumps.

1. Jet pumps can be used if you are using a shallow water source, but want to pump the water up 70 feet or so.
2. Generally, adding a booster pump (Fig. 4) is the easiest way if you have hills greater than 70 feet in elevation.

Adding a **booster pump** simply allows you to provide the extra pressure you need to get up the incline. This pump would be in addition to whatever pump you chose given your needs.

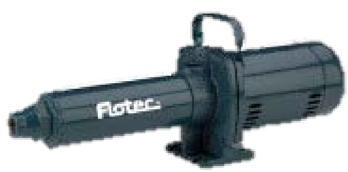


Figure 4: Booster Pump; www.flotecpump.com

Operation & Maintenance of Pumps

Be sure to consult the pump manufacturer about the proper operation and maintenance of your pump. A few general guidelines are:

1. Do not let trash get into your pump! You should make sure the intake pipe to your pump has a screen that does not allow trash through it, or it will reach the pump and the pump will die.
2. **Check valves** eliminate the need for priming. If you do not wish to prime your pump for every use, it is a good idea to have a check valve or foot valve installed. They are inexpensive.
3. **Pressure relief valves** protect your pump. If you do not purchase a pump that automatically shuts off when a maximum pressure is reached, buy a pressure relief valve to release the buildup pressure thereby protecting your pump. The valves are inexpensive.
4. Flush out your system! Flush out your system with debris-free water every so often.
5. Install a **pressure gauge**. You might want to install a pressure gauge to periodically check the pressure within your system. This is highly recommended if you opt out of buying a pressure relief valve. The gauges are also inexpensive.
6. Know that it is normal for pump performance to decrease over time. Pay attention to the water pressure: after some years it will get to the place where the pressure is too low for your purposes. If you can catch it early, it is more likely you will just have to buy a part for it, rather than running the pump until it dies, forcing you to buy a whole new pump.

Pump Pricing Estimates

There are a few things which typically affect pump price:

1. Horsepower: Generally, as you increase in horsepower, the price of the pump increases, and the energy needed to run the pump increases.
2. Electronic features: The more electronic features you desire, the more expensive the pump gets.
3. Material: Stainless steel is more expensive than cast iron or plastic.

SMALL-SCALE SPRINKLER SYSTEMS

How do I choose a small acreage sprinkler system?

There are a few key factors to consider when choosing a sprinkler system:

1. **Flow rate** - the amount of water (gallons per minute) that goes through the system and is delivered to the application area.
2. **Pressure** - the pounds per square inch your system needs to move water through it. You need to make sure your system can withstand the amount of pressure coming through it. As a reference, most garden hoses run at 35 to 65 psi.
3. **Mobility** - the ease with which you can move your system from place to place.
4. **Application area** - the area you want to irrigate.

Mini Gun

Mini gun sprinkler systems (Fig. 5) are best used when you want to irrigate a small area by moving a portable sprinkler with a wide application area.

Mini gun systems come with a sprinkler attached to a water reel. The reel is connected to a hose which supplies it water. Because the reel is set on wheels, it is very easy to move. Once you have placed the reel, you pull out the sprinkler and then the reel pulls it back in automatically, irrigating as it goes. The reels are grazing animal - friendly.

Figure 5: Mini Gun Sprinkler; www.kifco.com

Solid Set

Solid set sprinkler systems come in two basic forms, portable and permanent. These systems may have a variety of sprinkler heads attached to them, depending on your needs. The solid set system is made up of sprinkler risers (vertical pipe) spaced evenly along the length of a horizontal pipe running on the ground. This system can be permanent or portable. These systems are labor intensive.

Portable solid set sprinkler system pipes can be removed from the field, eliminating the need to farm around sprinkler risers. Because the pipe is not permanently fixed in one location, these systems can be moved to different fields to follow the grazing or crop rotation.

Permanent solid set sprinkler system pipes, valves, and sprinklers are permanently installed in the field (Fig. 7), so it is easy to automate these systems compared to the portable ones. This means there is less irrigation labor required. Permanent solid set systems are not very common. The risers can be difficult to mow around and the permanent above-ground risers do not allow for flexibility in crops grown. The sprinkler risers need to be protected from grazing animals, so it is suggested that they be encased in PVC pipe.

Figure 7: Permanent Solid Set Sprinklers; www.nelsonirrigation.com

K-Line – 5 Pod 2 Acre Kit

K-Line sprinkler systems (Fig. 6) are highly mobile. If you are interested in irrigating more than a couple of acres, it is easy to expand by simply buying more of the K-Line sprinkler kits. The kits include the sprinklers, the tubing, and the rest of the system (without the pump). The sprinkler sits in a black pod which looks like a tire. The pods are connected along a line of hose, generally 5 pods to a hose. They are very easy to move and are grazing animal - friendly. They perform well on flat or hilly ground.

For less than 5 acres, the most appropriate irrigation systems are the mini gun and K-Line sprinkler systems. Be sure to consult the sprinkler manufacturer about the proper operation and maintenance of your sprinkler system.

Figure 6: K-Line Sprinklers; www.andrews-foster.com

Table 8: Sprinkler System Selection Matrix

Sprinkler System Type	Features	Application Area (acre)	Optimal Pressure (PSI)	Flow Rate (GPM)
Mini Gun	Portable. Grazing animal friendly. Easily automated. Can be used on irregularly shaped areas.	0.2 – 2*	45 – 150*	4 – 80*
Solid Set	Easily automated. More maintenance labor required. Expandable to more areas.	As desired	25 – 65	1 – 8 (per sprinkler head)
K-Line (5 pod 2 acre kit)	Portable. Expandable to more acres if more kits are purchased. Grazing animal friendly. Can be used on flat and hilly ground, as well as irregularly shaped areas.	2	40 – 50	12 – 24

*Depends on the mini gun model.

Table 9: Manufacturers Contact List

Manufacturer	Phone No.*	Website*	Products
Kifco	(800)452-7017	www.kifco.com	Mini gun sprinkler systems
Nelson Irrigation	(509)525-7660	www.nelsonirrigation.com	Solid set permanent sprinkler systems
K-Line Irrigation	(866)665-5463	www.k-linena.com	K-Line sprinkler systems

*Website and telephone information last updated Dec. 2018.

IMPROVING AN IRRIGATION SYSTEM

1. Improve your irrigation management by understanding plant water requirements and soil properties that influence irrigation amount and timing.
2. Improve irrigation uniformity. Look for signs that water is not being distributed uniformly – patches of stressed plants, water runoff from the field, and areas of ponding. Remedies for flood irrigation uniformity include corrugation and land leveling. Sprinkler irrigation uniformity can be corrected by adjusting sprinkler locations or nozzle type.
3. Improve irrigation system efficiency.

a. Many earthen delivery ditches are extremely permeable to water. Installation of plastic, concrete, steel ditch linings, or some type of delivery pipe can help conserve water.
b. Application of Linear Anionic Polyacrylamide (LA-PAM) to ditch water can reduce seepage losses in some cases. A review of LA-PAM effectiveness, application techniques, and environmental risks is available at pam.dri.edu/publicdocs.html.
c. Irrigation system efficiency can be measured with devices such as headgate flumes, weirs, and flow meters.
d. Improve your irrigation management. Many times water is over or under applied to meet crop water needs. Improving your scheduling can improve your water use efficiency and potentially increase yields or improve quality.

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