

EVALUATING YOUR PEAR IRRIGATION SYSTEM



Old, inefficient irrigation systems can contribute to low fruit quality and reduce grower profits. Evaluate the irrigation system in older blocks to identify challenges and potential solutions.

Common Challenges

Cork, small fruit, insufficient water availability for the block, plugging filters, uneven pressure on hills and slopes, over- and underwatering, irregular distribution across the block, and sandy soils with low water holding capacity are all common challenges in pear irrigation systems in north central Washington pear orchards (Table 1).

Table 1. Common pear irrigation system challenges and potential solutions.

Challenges	Potential solutions and tools
Cork, small fruit from insufficient irrigation.	Increase irrigation system capacity (larger flow rate to the field). Increase the irrigation frequency (shorter sets, return to zone sooner). Increase water holding capacity of soil with organic matter additions or mulch. Irrigation system upgrades.
Cork, excess spring suckering and growth when roots sit wet in spring.	Match initial irrigation in the spring to orchard water use using soil moisture monitoring and increased knowledge of tree needs. Improve water infiltration and soil structure with deep tillage at planting, organic matter additions, or bio-drilling cover crops.
Insufficient water availability.	Calculate water needs to identify potential ways to redistribute water. Consider changes to the mainlines to enable watering every other row. Consider automatic valve systems to facilitate irrigation in irregular sets for the hours needed with less labor. Increase water holding capacity with organic matter additions.
Filters plugging at canal intake. Pressure loss overnight.	Check for sticks blocking the intake. Consider self-cleaning filters. Use larger filters. Try to keep filters in the middle of the water intake, away from the top of the water surface and away from the bottom. Install flow meters to trigger cleaning.
Uneven pressure on hills.	Install flow control nozzles (pressure compensating) and flow control valves.
Match irrigation schedules with tree water needs.	Use weather-based irrigation scheduling models (such as Irrigation Scheduler Mobile). Use soil moisture sensors.
Cork and soilborne disease from overwatering.	Calculate irrigation needs. Use soil moisture sensors. Install automatic valves or variable speed pumps.
Secondary filters plugging.	Use larger filters. Is the screen unnecessarily fine? Improve primary filters.



Challenges	Potential solutions and tools
Irregular water distribution across the block.	Check for worn nozzles and replace. Replace nozzles with uniform size nozzles. Use flow control (pressure compensating) nozzles. Check flow rates. Switch to nozzle types that do not clog as readily. Improve filtration if nozzles are plugging. Periodically inject chlorine if algae is plugging nozzles.
Too long of an interval between irrigation sets because of the number of days required to water a block using the existing system.	Reduce nozzle size so a larger section of the orchard can be irrigated in a set. Reduce set times to apply less water, but more frequently. Change mainlines to allow irrigating every other row.
Sandy soils with low water holding capacity.	Increase water holding capacity of soil with organic matter additions or mulch. Install supplementary drip systems. Consider systems that allow for frequent pulses of irrigation with automatic valves, variable speed pumps, etc.
System inefficiencies.	Upgrade the intake line from canal for the correct number of shares. Fix intake delivery line if clogged. Make sure canal filter is working. Check for leaky mainlines. Check whether shared mainlines need better valves. Fix leaky valves. Replace worn or inconsistent sprinklers. Use flow control nozzles on hillsides.

Steps to Evaluating Your Irrigation System

To identify potential areas for improvement in an irrigation system, orchardists can answer the following questions using the tools outlined in the sections below.

- Is water application per set no more than the maximum amount the soil can hold?
- Does water application meet but not exceed tree water needs?
- Is the water application rate, flow, and pressure uniform throughout the block?
- Is water distribution under the tree uniform?

Irrigation System Measurements

To begin, gather information on your irrigation system and take a few simple measurements (Table 2).

1. Gather irrigation system description information

2. Measure sprinkler head flow rates

Use a measuring device like a five-gallon bucket. Direct the flow from your irrigation sprinkler into the bucket using a piece of hose (Figure 1). Allow the water to enter the bucket for exactly one minute. Pour the water from your bucket into a measuring container. Measure each sprinkler head twice and use the average. Measure the flow from at least six sprinkler heads distributed across your block to calculate an average flow rate. If

your block is on a hill, measure six heads at the top and six at the bottom of the hill. Note results in Table 3.

Table 2. Irrigation system information.

System information	
Number of days to irrigate the block	
Pounds per square inch (PSI) of pressure at the pump (or at point where mainline reaches block if gravity fed)	
Mainline size	
Filter type	
PSI at the lines	
Spacing between irrigation lines (ft)	
Spacing between irrigation heads in the row (ft)	
Sprinkler head type	
Nozzle type and size (often different sizes are different colors)	
Soil type ^a	
Water holding capacity to 36 in ^a	
Elevation at highest point	
Elevation at lowest point	
Sprinklers per acre	

^a To determine your soil type and predicted water holding capacity, use the Web Soil Survey at <https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>.

Table 3. Sprinkler flow rate (GPM).

	Sprinkler 1	Sprinkler 2	Sprinkler 3	Sprinkler 4	Sprinkler 5	Sprinkler 6	Average
Section 1 (top of hill)							
Section 2 (middle)							
Section 3 (bottom of hill)							
						Overall Average	



Figure 1. Graduate students diverting the flow from an irrigation sprinkler into a container for one minute in order to measure the flow rate. Photo credit: Troy Peters.

3. Measure pressure

Remove the sprinkler heads from six or more sprinklers and screw a pressure gauge into the riser (Figure 2). The gauge shows your water pressure in pounds per square inch (PSI) (Table 4).

4. Measurements for irrigation efficiency and distribution

Under-tree sprinkler system efficiency can range from 40 to 80% (based on measurements in seven Washington blocks) where efficiency is the percentage of the flow which reaches the soil. Drip irrigation generally provides almost 100% efficiency. To measure the irrigation efficiency of your irrigation system, place a series of measuring containers (small paint buckets work well) in a grid pattern where some buckets are in line with the tree row, some are in the middle of the grass strip, and others are halfway in between (Figure 3). Run the irrigation system for one full set (at least one hour). Measure the amount of water in each container (Table 5).

5. Calculate irrigation efficiency

Use the average amount of water caught in the catch cans (overall average Table 5), the spacing between the sprinklers, the

test run time, and the average sprinkler flow rate (Table 3) to calculate irrigation efficiency (Equation 2).



Figure 2. Installing a pressure gauge on a sprinkler riser in order to measure pressure at the sprinkler head. Photo credit: Troy Peters.



Figure 3. Place catch cans in a grid pattern with one line of cans in each tree row, one in the grass strip, and another two lines halfway between the middle of the grass strip and the tree row. Photo credit: Tianna DuPont.

Table 4. Sprinkler pressure (PSI).

	Sprinkler 1	Sprinkler 2	Sprinkler 3	Sprinkler 4	Sprinkler 5	Sprinkler 6	Average
Section 1 (top of hill)							
Section 2 (middle)							
Section 3 (bottom of hill)							

Table 5. Catch can measurements. Measure the volume in each container (fl oz per hr).

Lateral 1	Lateral 2			Average
Sprinkler 1			Sprinkler 3	
Sprinkler 2			Sprinkler 4	
			Overall Average	

Equation 1. Find the opening area of your catch cans (inch²).

$$3.14 \times \left(\frac{\text{diameter of can opening in inches}}{2} \right)^2 = \text{_____ in}^2 \text{ per can}$$

Equation 2. Use the spacing between the sprinklers to find the area that each sprinkler irrigates. Assume that any water leaving the area is equal to the amount of water coming into the area from neighboring sprinklers.

$$\text{_____ Spacing between rows of sprinklers (ft)} \times \text{_____ Spacing between sprinklers in the row (ft)} \\ = \text{_____ ft}^2 \text{ per sprinkler}$$

Equation 3. Use the average catch in each can (in fluid ounces from Table 5) and the opening area of your catch cans (Equation 1) to estimate the actual amount of irrigation water that reached the ground from system.

$$\frac{\text{_____ fl oz (Tb 5)}}{\text{per can}} \times \frac{1.805 \text{ in}^3}{1 \text{ fl oz}} \div \frac{\text{_____ in}^2 \text{ (Eq 1)}}{\text{per can}} = \text{_____ in reaching the ground}$$

Equation 4. Use the average sprinkler flow rate (in gallons per minute from Table 3), the area each sprinkler irrigates (from Equation 2 above), and the run time of the catch can test to estimate the amount of water that should have reached the ground if it were 100% efficient.

$$\frac{\text{gallons (Tb 3)}}{\text{min}} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \text{test run time (hr)} \times \frac{1 \text{ ft}^3}{7.54 \text{ gallons}} \times \frac{12 \text{ in}}{1 \text{ ft}} = \text{in}$$

_____ area for each sprinkler (ft²)(Eq2)

Equation 5. Irrigation efficiency is the actual amount of water that reached the ground (Equation 3) divided by the theoretical maximum amount of water that would have reached the ground (Equation 4).

$$\frac{\text{in actual reaching the ground (Eq 3)}}{\text{in that should have reached the ground (Eq 4)}} = \text{irrigation efficiency}$$

Is Water Application per Set No More than the Maximum Amount the Soil Can Hold?

Soil available water capacity (AWC) is the maximum amount of water that soil can store to be extracted by the plants. It is the water held between field capacity and the permanent wilting point. The total available water in the soil root zone for a specific crop is equal to the crop’s rooting depth multiplied by the available water holding capacity per unit depth of the soil (Table 6). Generally, irrigation managers choose a specific allowable depletion of water from the root zone between irrigations (management allowable depletion = MAD). For trees the MAD is most often chosen to be 50% of AWC. As an irrigation manager you can adjust the allowable depletion to be sure to avoid water stress. For example, you may determine that 30 to 40% depletion is more appropriate for your management system.

We usually assume 2 feet of root depth in young (less than 3 years old) or dwarf rootstock (e.g., M9.337 apple) orchards, and about 3 feet of root depth in older, vigorous rooted orchards (e.g., Bartlett seedling, Old Home Farmingdale 97). In very high quality soil or older trees you may assume rooting depths up to 3.5 or 4 feet. Root studies have determined that two-thirds of the root volume of large, old trees is in the top 2 feet of soil; roughly 80 percent of the roots are in the top 3 feet. Thus, even for large trees it is generally recommended to assume no more than 3 feet of rooting depth.

To determine your soil type, [Web Soil Survey](#) is a useful tool (USDA NRCS 2019). You can also send a soil sample to your local lab for textural analysis.

Table 6. Plant available water (AW) per foot of soil (in) for common soil types.

Soil texture	Inches AW
Very coarse sands	0.4–0.75
Coarse sands, fine sands, loamy sands	0.75–1.25
Sandy loams, fine sandy loams	1.25–1.75
Very fine sandy loams, loams, silt loams	1.50–2.30
Clay loams, silty clay loams, sandy clay loams	1.75–2.50
Sandy clays, silty clays, clays	1.60–2.50

Equation 6. Maximum irrigation per set.

$$\frac{\text{in plant available water (Tb 6)}}{\text{ft soil}} \times \text{depth(ft)} \times \text{preferred MAD (suggested 30-50\%)} = \text{maximum depletion or irrigation per set in inches}$$

Does Water Application Meet Tree Water Needs?

Calculate the application rate (Equation 8) for your block and compare it to estimated tree water needs. To determine your application rate, multiply the average flow rate in GPM from your measurements in Table 3 by the sprinkler heads per acre and convert from gallons to acre inches. Below is a sample calculation where the grower measured the output from their sprinkler heads at 1.87 GPM per head and the irrigation efficiency at 0.58.

Equation 7. Application rate example.

$$\frac{1.87 \text{ GPM}}{\text{sprinkler head}} \times \frac{50 \text{ sprinkler heads}}{\text{acre}} = \frac{93 \text{ GPM}}{\text{acre}} \times \frac{60 \text{ min}}{\text{hr}} = \frac{5554 \text{ GPH}}{\text{acre}} \times \frac{1 \text{ acre in}}{27,000 \text{ gallons}} = \frac{0.21 \text{ in}}{\text{hr}} \times 0.58 \text{ efficiency}$$

$$= \frac{0.12 \text{ in}}{\text{hr}} \times 12 \text{ hr set} = \frac{1.4 \text{ in}}{12 \text{ hr set}}$$

Equation 8. Application rate calculation.

$$\frac{\text{GPM (Tb 3)}}{\text{sprinkler head}} \times \frac{\text{sprinkler heads}}{\text{acre}} = \frac{\text{GPM}}{\text{acre}} \times \frac{60 \text{ min}}{\text{hr}} = \frac{\text{GPH}}{\text{acre}} \times \frac{1 \text{ acre in}}{27,000 \text{ gallons}}$$

$$= \frac{\text{in}}{\text{hr}} \times \text{efficiency (Eq 5)} = \frac{\text{in}}{\text{hr}} \times \text{hr set} = \frac{\text{in}}{\text{hr set}}$$

Compare the application of a set for the block to estimated tree water needs. The amount of water that trees need in a given week is calculated based on the evapotranspiration rate (ET). You can use data from AgWeatherNet (<https://weather.wsu.edu/>) to find pear ET in your area (ET for a given crop is noted as ET_c or ET_r) (Table 7). Log in and click on water use. Select your crop and a station near you. The water use model will predict tree water use over the prior week (Table 5). For general estimates, see Table 8.

Table 7. Estimated weekly water use from AgWeatherNet data for N Cashmere pears.

2017 Date	2017 Inches	2018 Date	2018 Inches
7-May	0.6	7-May	0.6
14-May	0.5	14-May	0.8
21-May	0.7	21-May	0.8
28-May	1.0	27-May	1
4-Jun	1.0	3-Jun	0.9
11-Jun	1.0	10-Jun	1.0
18-Jun	1.1	17-Jun	1.2
25-Jun	1.7	24-Jun	1.7
2-Jul	2.0	2-Jul	1.6
9-Jul	2.2	9-Jul	1.7
16-Jul	2.1	16-Jul	1.9
23-Jul	1.8	23-Jul	2
30-Jul	2.0	30-Jul	1.8
6-Aug	1.7	6-Aug	1.8
13-Aug	1.7	13-Aug	1.6

Source: AgWeatherNet (2023).

Table 8. Water use for pears with cover crop. Calculated based on ET_c for pears Cashmere, WA, from 2013 to 2022, where 2022 is used as a reference cool year and 2017 as a reference warm year.^a

	Cool year inches per week	Average inches per week	Warm year inches per week
early April	0.0	0.0	0.0
late April	0.0	0.1	0.0
early May	0.4	0.7	0.5
late May	0.7	0.9	1.0
early June	0.8	1.4	1.4
late June	1.6	1.9	2.2
early July	1.5	2.1	2.7
late July	1.9	2.1	2.4
early August	1.7	2.0	2.2
late August	1.5	1.7	2.1
early September	1.3	1.4	1.7

Source: AgWeatherNet (2023).

^a AgWeatherNet uses a crop coefficient for pears of 0.4 to 0.7 of reference (alfalfa) early season to 0.8 to 1.0 of reference mid season similar to crop coefficients from Girona et al. (2011) where annual averages range from 0.7 to 0.99 for July to August (Allen et al. 1998; Allen et al. 2005).

Another tool for estimating simple irrigation schedules during an average year for different areas of Washington State is available online at:

<http://irrigation.wsu.edu/Content/Calculators/Historic/SimpleSch ed.php>.

Are Flow and Pressure Even throughout the Block?

If pressure and flow are not even in your block, some trees or sections of the block will be receiving more water than in others. When irrigation rate is uneven you will be constantly over- or underwatering some trees.

Consider your pressure and flow measurements in Tables 3 and 4. A certain amount of pressure variation is normal (5–10 PSI). Flow variation over 10% is a signal that your irrigation system may need some upgrades.

There are multiple solutions to uneven flow and pressure depending on what is causing the problem. Consider flow control nozzles. Check for worn nozzles and replace. Replace nozzles with uniformly sized nozzles. Switch to nozzle types that do not clog as readily. Water more frequently so algae does not clog nozzles.

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Additional Information

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