



DETERMINING ACTUAL ANNUAL WATER USE OF SPRINKLER IRRIGATION SYSTEMS

Knowing the actual annual water use of an irrigation system will help to develop an effective irrigation schedule that meets the climate, crop and soil requirements. Some irrigation licences may state a water withdrawal rate; therefore, the actual annual water use must not exceed the licensed amount. The annual water use is based on peak flow rate and annual crop water requirement which vary depending on:

1. crop type
2. soil type
3. rooting depth
4. irrigation system efficiency
5. climate and field elevation that determine peak ET rates (farms at the bottom of the valleys have higher peak ET rates than those in the same area but at a higher elevation)

Step 1 Actual Peak Flow Rate

The actual system flow rate can be determined using meters, water purveyor restrictions, pump information or sprinkler nozzle output.

A **water meter** installed on the irrigation system can be used to determine the system flow rate by measuring the amount of water that passes through the meter during a given time period.

Water purveyors supplying irrigation water often allocate a flow rate of the farm based on acreage. Most often, these flow rates are regulated using flow control valves. Contact your water purveyor to find out how much water you are allowed to take if you are on municipal system or an irrigation district.

The **pump curve** can be used to estimate the irrigation system flow rate by using the impellor diameter, the number of revolutions per minute (rpm) of the pump, and the system operating pressure. This method is most reliable for pumps that have a steeper pump curve. Contact your pump supplier for pump curve information. It is a good idea to confirm the pump flow rate determined from a pump curve with one of the other methodologies whenever possible.

A **sprinkler system output flow rate** can be determined by:

1. measuring the sprinkler flow rate using a pail and stop watch
2. averaging the flow
3. multiplying this number by the number of sprinklers operating.

Alternately, the sprinkler system flow rate can be estimated using the tables in Chapters 3 and 4 of the [B.C. Sprinkler Irrigation Manual](#).

Step 2 Calculated Annual Water Use

The calculated annual water use is determined using an estimated value of crop water requirements (Table 1) and irrigation system efficiency factors (Table 2). The estimated annual crop water requirement values are based on data collected over the last 40 years. It is accepted that some years are wetter or drier than others and therefore annual water use varies. Regardless, farmers using a well or other water source should adhere to the calculated annual water requirement figures, and should have the annual withdrawal rate stay within the licensed amount.

Table 1 Estimated Annual Crop Water Requirements for B.C. Locations with Average (3 in or 7.5 cm) Maximum Soil Water Deficit

Location	Water		Location	Water		Location	Water	
	[in]	[mm]		[in]	[mm]		[in]	[mm]
Abbotsford	9	220	Golden	11	274	Oliver	24	622
Agassiz	4	109	Grand Forks	11	274	100 Mile House	17	439
Alexis Creek	11	274	Grandview Flats	18	457	Osoyoos	25	640
Armstrong	12	311	Grasmere	13	329	Oyster River	6	165
Ashcroft	25	640	Grindrod	7	183	Parksville	10	256
Aspen Grove	13	329	Hazelton	2	55	Pitt Meadows	6	146
Barriere	13	329	Hixon	6	165	Port Alberni	12	292
Baynes Lake	17	420	Hope	9	238	Prince George	10	256
Campbell River	10	256	Invermere	17	439	Princeton	18	457
Canal Flats	14	366	Kamloops	23	585	Quesnel	9	238
Castlegar	21	531	Kelowna	19	475	Radium	12	311
Cawston	25	640	Keremeos	23	585	Riske Creek	16	402
Chase	15	384	Kersley	9	238	Saanichton	10	256
Cherryville	14	348	Kettle Valley	18	457	Salmon Arm	13	329
Chilliwack	5	128	Kimberley	17	439	Smithers	9	220
Clinton	17	439	Ladner	8	201	Spillimacheen	14	348
Cloverdale	7	183	Langley	6	165	Sumas	6	165
Comox	12	292	Lillooet	19	494	Summerland	19	494
Creston	16	402	Lister	16	402	Terrace	9	220
Dawson Creek	7	183	Lumby	15	384	Vancouver	11	274
Douglas Lake	16	402	Lytton	25	640	Vanderhoof	8	201
Duncan	9	220	Malakwa	9	220	Vernon	16	402
Ellison	17	420	Merritt	21	531	Walhachin	20	512
Fort Fraser	8	201	Nanaimo	10	256	Westwold	20	512
Fort Steele	10	256	Natal	10	256	Williams Lake	13	329
Fort St. John	7	183	Notch Hill	14	366			

Note: An irrigation system efficiency needs to be applied to the figures to obtain the gross annual requirements.

Table 2 lists the application efficiencies of various sprinkler irrigation systems that must be applied to the values in Table 1 to determine the calculated annual water use for the specific irrigation system being used.

Table 2 Application Efficiencies of Sprinkler Irrigation Systems		
Irrigation System Type		Typical Application Efficiency [%]
Sprinklers	Handmove	72
	Wheelmove	72
	Undertree Solid Set	75
	Overhead Solid Set	72
	Micro-sprinklers	80
Guns	Travelling	65
	Stationary	58
Centre Pivot	Sprinklers	72
	Spray Heads	72
	Drop Tubes	80

Step 3 Actual Annual Water Use

The actual annual water use by a sprinkler irrigation system can be determined using meter data, pumping information or irrigation system operation information.

A **water meter** provides accurate information on annual water use. Metered systems are usually on municipal or irrigation district water supplies. The meter reading can be converted into annual water use.

The **pump operating hours** may be determined from information on the hydro bill. The amount of energy used can be converted into operating hours and annual water use.

The **sprinkler system annual water use** can be estimated by using the system flow rate determined in Step 1, the irrigation interval, the number of irrigations per year and the irrigated area. Irrigation interval is the number of days between the start of an irrigation at any one setting and the start of the next irrigation at the same setting. It can be determined by dividing the length of the field by the distance the lateral is moved each day. The number of irrigations per year is the number of times the irrigation system has covered the field over the irrigation season. The irrigated area is the total field area that receives irrigation water.

Trickle systems are more efficient than most other irrigation systems. They also operated more frequently than other systems, usually every day or numerous times every week. The annual water use for each zone should be calculated separately, and then added together to determine the total annual use for the irrigation system.

Step 4 Compare Calculated and Actual Annual Water Use

If there is a water licence, do to Step 4(a), and then Step 4(b) to double-check. If groundwater is used or water is supplied by a purveyor (i.e., no water licence), follow Step 4(b) only.

4(a) To conduct a water licence check, the annual water use calculated in inches must be converted to acre-feet in order to be compared to the licensed volumes. The annual water use in acre-feet should not exceed the amount stated on the water licence.

4(b) Compare the calculated and actual annual water use. The actual value should not exceed the calculated value by 10%. If the farm obtains water from a surface water source under a water licence, the annual use allowed by the licence cannot be exceeded.

An example is shown on the next page on how to determine the actual annual water use for a sprinkler system. A blank worksheet is provided at the end for self-evaluation.

Example 1 Sprinkler Irrigation in Armstrong



Worksheet 1 Annual Water Use Check - SPRINKLER

Question: The total irrigated area for a farm in Armstrong is 170 acres. The 125-hp irrigation pump operates at a flow rate of 850 US gpm. The pump curve also indicates a flow rate of 850 US gpm. The irrigation system has 107 sprinklers with 1 1/64" x 3/32" nozzles operating at 52 psi. The electric bill indicates a hydro use of 140,337 KWh. It takes 15 days to cover the field. The field is irrigated four times during the year. Water withdrawal rate on the water licence is 262 acre-feet. Does the annual water use meet the licensed amount and/or the calculated annual irrigation water requirement for Armstrong?

Information:

Irrigated area	170	1	acres
Water withdrawal amount on water licence (if applicable)	262	2	ac-ft
Estimated annual crop water requirement from Table 1	12	3	in
Application efficiency from Table 2	72	4	%

Calculation:

Step 1. Determine actual system peak flow rate using one or more of the following methods:

Method 1. Water purveyor restriction or measured flow rate using a meter

Flow rate measured using a meter or provided by district US gpm

Method 2. Pump peak flow rate

Irrigation pump peak flow rate from pump curve US gpm

Method 3. Determine flow rate using sprinkler nozzles

Nozzle flow rate from supplier's tables	8.0	7	US gpm
No. of nozzles	107	8	nozzles

Equation 4.3

$$\begin{aligned}
 \text{Sprinkler System Output Flow Rate} &= \text{Nozzle Flow Rate} \times \text{No. of Nozzles} \\
 &= \left[\frac{8.0}{7} \text{ US gpm} \right] \times \left[\frac{107}{8} \text{ nozzles} \right] \\
 &= \left[\frac{856}{9} \right] \text{ US gpm}
 \end{aligned}$$

Note: The higher flow rate value is used.

Step 2. Determine calculated annual water requirement.

Equation 4.6

$$\begin{aligned}
 \text{Calculated Annual Water Requirement} &= \frac{\text{Estimated Annual Crop Water Requirement}}{\text{Application Efficiency}} \times 100\% \\
 &= \frac{\left[\frac{12}{3} \right] \text{ in}}{\left[\frac{72}{4} \right] \%} \times 100\% \\
 &= \left[\frac{17}{10} \right] \text{ in}
 \end{aligned}$$

Step 3. Determine actual annual water use using one or more of the following methods:

Method 1. Metered water use

Meter reading at start of year	-	11	US gal
Meter reading at end of year	-	12	US gal

Equation 4.8

$$\text{Annual Water Use} = \frac{\text{Meter Reading at End of Year} - \text{Meter Reading at Start of Year}}{27027 \times \text{Irrigated Area}}$$

$$= \frac{-12 \text{ US gal} - (-11 \text{ US gal})}{27027 \times 1 \text{ acres}}$$

$$= -13 \text{ in}$$

Method 2. Pump water use

Pump horsepower from supplier's table	125	14	hp
Energy consumption for entire year from hydro bill	140,337	15	KWh
Pump flow rate from pump curve	850	16	US gpm

Equation 4.9(a)

$$\text{Pump Power} = \text{Pump Horsepower} \times 0.746 \text{ KW/hp}$$

$$= 125 \text{ hp} \times 0.746 \text{ KW/hp}$$

$$= 93 \text{ KW}$$

Equation 4.9(b)

$$\text{Pump Operating Hours} = \frac{\text{KWh for Entire Year}}{\text{Pump Power}}$$

$$= \frac{140,337 \text{ KWh}}{93 \text{ KW}}$$

$$= 1,509 \text{ hr}$$

Equation 4.9(c)

$$\text{Annual Water Use} = \frac{\text{Pump Operating Hours} \times \text{Pump Flow Rate} \times 0.0022}{\text{Irrigated Area}}$$

$$= \frac{1,509 \text{ hr} \times 850 \text{ US gpm} \times 0.0022}{170 \text{ acres}}$$

$$= 16.6 \text{ in}$$

Method 3. Sprinkler system annual water use

Irrigation interval	15	20	days
Number of irrigations per year	4	21	

Equation 4.10

$$\text{Annual Water Use} = \frac{\text{System Flow Rate} \times \text{Irrigation Interval} \times \text{No. of Irrigations} \times 0.053}{\text{Irrigated Area}}$$

$$= \frac{856 \text{ US gpm} \times 15 \text{ days} \times 4 \times 0.053}{170 \text{ acres}}$$

$$= 16 \text{ in}$$

Answer:

If there is a water licence, go to Step 4(a), and do Step 4(b) to double-check.
If groundwater is used or water is supplied by a purveyor (no water licence), follow Step 4(b) only.

Step 4(a). Calculate the annual water use and compare it with the water licence withdrawal.

Equation 4.12

$$\begin{aligned} \text{Annual Water Use [ac-ft]} &= \frac{\text{Annual Water Use [in]} \times \text{Irrigated Area [acres]}}{12 \text{ [in/ft]}} \\ &= \frac{16.6 \quad 13, 19 \text{ or } 22 \text{ in} \times 170 \quad 1 \text{ acres}}{12 \text{ in/ft}} \\ &= 235 \quad 23 \text{ ac-ft} \end{aligned}$$

Is 235 23 ac-ft less than 262 2 ac-ft?

Yes

Water withdrawal not exceeded

No

Refer to the B.C. Irrigation Management Guide

Step 4(b). Calculate percent difference of annual water use. Use the metered water use if available because it is the most accurate method.

Equation 4.5

$$\begin{aligned} \text{Percent Difference} &= \frac{\text{Actual Annual Water Use}}{\text{Calculated Annual Water Use}} \times 100\% \\ &= \frac{16.6 \quad 13, 19 \text{ or } 22 \text{ in}}{17 \quad 10 \text{ in}} \times 100\% \\ &= 98 \quad 24 \% \end{aligned}$$

Is 98 24 % less than 110%

Yes

annual water use not exceeded by more than 10%

No

Refer to the B.C. Irrigation Management Guide

Worksheet 1 Annual Water Use Check - SPRINKLER



Information:

Irrigated area	<input type="text" value="1"/>	acres
Water withdrawal amount on water licence (if applicable)	<input type="text" value="2"/>	ac-ft
Estimated annual crop water requirement from Table 1	<input type="text" value="3"/>	in
Application efficiency from Table 2	<input type="text" value="4"/>	%

Calculation:

Step 1. Determine actual system peak flow rate using one or more of the following methods:

Method 1. Water purveyor restriction or measured flow rate using a meter

Flow rate measured using a meter or provided by district US gpm

Method 2. Pump peak flow rate

Irrigation pump peak flow rate from pump curve US gpm

Method 3. Determine flow rate using sprinkler nozzles

Nozzle flow rate from supplier's tables US gpm
 No. of nozzles nozzles

Equation 4.3

$$\begin{aligned}
 \text{Sprinkler System Output Flow Rate} &= \text{Nozzle Flow Rate} \times \text{No. of Nozzles} \\
 &= \text{7 US gpm} \times \text{8 nozzles} \\
 &= \text{9 US gpm}
 \end{aligned}$$

Note: The higher flow rate value is used.

Step 2. Determine calculated annual water requirement.

Equation 4.6

$$\begin{aligned}
 \text{Calculated Annual Water Requirement} &= \frac{\text{Estimated Annual Crop Water Requirement}}{\text{Application Efficiency}} \times 100\% \\
 &= \frac{\text{3 in}}{\text{4 \%}} \times 100\% \\
 &= \text{10 in}
 \end{aligned}$$

Step 3. Determine actual annual water use using one or more of the following methods:

Method 1. Metered water use

Meter reading at start of year US gal
 Meter reading at end of year US gal

Equation 4.8

$$\begin{aligned}
 \text{Annual Water Use} &= \frac{\text{Meter Reading at End of Year} - \text{Meter Reading at Start of Year}}{27027 \times \text{Irrigated Area}} \\
 &= \frac{\text{12 US gal} - \text{11 US gal}}{27027 \times \text{1 acres}} \\
 &= \text{13 in}
 \end{aligned}$$

Method 2. Pump water use

Pump horsepower from supplier's table	<input type="text" value="14"/>	hp
Energy consumption for entire year from hydro bill	<input type="text" value="15"/>	KWh
Pump flow rate from pump curve	<input type="text" value="16"/>	US gpm

Equation 4.9(a)

Pump Power = Pump Horsepower x 0.746 KW/hp

= hp x 0.746 KW/hp

= KW

Equation 4.9(b)

Pump Operating Hours = $\frac{\text{KWh for Entire Year}}{\text{Pump Power}}$

= KWh

= KW

= hr

Equation 4.9(c)

Annual Water Use = $\frac{\text{Pump Operating Hours x Pump Flow Rate x 0.0022}}{\text{Irrigated Area}}$

= hr x US gpm x 0.0022
 acres

= in

Method 3. Sprinkler system annual water use

Irrigation interval	<input type="text" value="20"/>	days
Number of irrigations per year	<input type="text" value="21"/>	

Equation 4.10

Annual Water Use

= $\frac{\text{System Flow Rate x Irrigation Interval x No. of Irrigations x 0.053}}{\text{Irrigated Area}}$

= US gpm x days x x 0.053
 acres

= in

Answer:

If there is a water licence, go to Step 4(a), and do Step 4(b) to double-check. If groundwater is used or water is supplied by a purveyor (no water licence), follow Step 4(b) only.

Step 4(a). Calculate the annual water use and compare it with the water licence withdrawal.

Equation 4.12

Annual Water Use [ac-ft] = $\frac{\text{Annual Water Use [in] x Irrigated Area [acres]}{12 \text{ [in/ft]}}$

= in x acres
 12 in/ft

= ac-ft

Is ac-ft less than ac-ft?

Yes

Water withdrawal not exceeded

No

Refer to the B.C. Irrigation Management Guide

Step 4(b). Calculate percent difference of annual water use. Use the metered water use if available because it is the most accurate method.

Equation 4.5

$$\text{Percent Difference} = \frac{\text{Actual Annual Water Use}}{\text{Calculated Annual Water Use}} \times 100\%$$

$$= \frac{\text{13,19 or 22 in}}{\text{10 in}} \times 100\%$$

$$= \text{24} \%$$

Is **24** % less than 110% **Yes** annual water use not exceeded by more than 10%

No Refer to the B.C. Irrigation Management Guide

FOR FURTHER INFORMATION CONTACT

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