Water Conservation Guidelines:

A Guide for Facilities Managers

June 17, 2015

Quick Reference Essential Irrigation Operation

- ☐ **Turn on system, and observe irrigation system in operation. Repair as needed. Repeat throughout watering season.**
  - Check each valve in operation.
  - Clean filter(s).
  - Observe each head. Bring heads to upright, unobstructed position.
  - Check emitters in each drip zone.
- ☐ **Adjust heads to provide head to head coverage.**
  - Verify heads are matched in precipitation rate. They should be the same brand, type and have the same nozzle.
- ☐ **Adjust operating pressure to designed level.**
  - Check as-built plans for designed pressure.
  - Use pressure gauge on heads or a nearby quick coupling valve to determine pressure.
- ☐ **Seasonally adjust irrigation controller run times.**
  - Regularly observe weather conditions. Adjust controller run times to meet site needs.
- ☐ **Confirm existing sensor works properly.**
  - Replace batteries every year of operation.
  - Install new sensor if one does not exist or work properly.

Frost Susceptible Areas

- ☐ **Where required, shut down system for winter.**
  - Shut off main system valve.
  - Drain water from system.
  - Add frost protection to exposed equipment.
- ☐ **In the spring remove winterization measures.**
  - Close manual drains.
  - Remove frost protection.
  - Open main valves.

Water Conservation Guidelines: A Guide for Facility Managers

Introduction

As the demand rises for limited water supplies, it is critical to efficiently manage this resource. This document provides actions that will conserve water and reduce utility costs.

Remember, regardless of the recommended actions listed below; follow all local jurisdiction watering restrictions.

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Emergency Water Conditions Strategy

If emergency water restrictions are placed on an area, use these priorities and good judgment, to water landscapes. Always follow local ordinances in applying these priorities.

If needed, contractors or members could be used to hand water select priorities of a landscape.

<u>Priority 1 – Trees</u> Often trees are the most prominent, endearing, and valuable landscape feature. Watering should only be eliminated from them last. Water deeply and infrequently. Remember plants have a different water requirement so carefully evaluate their needs.

<u>Priority 2 – Shrubs and Groundcovers</u> Shrubs and groundcovers are a transition between lawn areas and buildings. Often they require less watering than lawns. Because of their relative cost to replace as well as their lower and less frequent watering requirement, shrubs should only be the second area of irrigation elimination.

<u>Priority 3 – Lawn</u> Lawns are beautiful, but they are heavy water users that can more readily be replaced than other planted elements if needed. Some lawns fare drought better than others, but this is the first landscape area from which to eliminate irrigation.

Remember, if the jurisdiction is only asking for a percentage decrease it is quite possible to sufficiently save when it comes to lawn. Generally, we water lawn too much. By conserving in lawn areas we may not have to lessen watering of the other priorities.

Landscape Considerations

In general, each landscape should be maintained to the following standards:

- Aerate lawns at least once annually.
- Use slow release fertilizers. Apply light applications only as needed to maintain health. A heavier application in the late fall is recommended.
- Keep lawns mowed at their proper height as referenced in the site management plans.
- Maintain 2” to 3” bark or rock mulch in planter beds.
- Spray for weeds and pests, prune and provide other needed landscape services as scheduled.
- Except when testing or in the rarest of cases, water should not be running during the day.

Who should be Part of Water Conservation Efforts?

The following is a list of who should help in water conservation efforts:

Facilities Management Group Personnel — Facilities manager and office staff can perform many of the water conservation tasks. However, they should rely on other resources such as Church service missionaries, interns (when authorized), and contractors. When using these other resources, the facilities management group should continue to monitor water conservation efforts.

Contractors — Many qualified irrigation and water management contractors have been hired to develop water management assessments and assist in water management efforts. When hiring contractors make sure they are aware of municipally directed water conservation mandates and appropriately adjust sprinkler run times.

Use contractors that are certified through groups such as the California Landscape Contractors Association (CLCA), Irrigation Association (IA), or Qualified Water Efficient Landscaper (QWEL) program. Water managers should be CLCA Water Managers, Certified Landscape Water Managers (CLWM), Certified Landscape Irrigation Auditors (CLIA) or have equivalent experience and certification. Maintenance personnel should be Certified Irrigation Contractors (CIC) or Certified Irrigation Technicians (CIT).

Members — Members should be involved as much as possible. See Handbook 1, Stake Presidents and Bishops [2010] 8.3.4 and the following Stake Building Specialists for Water Conservation letter.

However, before doing so, determine what level of capability they might have. If they don’t know how to repair sprinklers or adjust a sprinkler controller they could be used to make sure water is only running on schedule and spray heads are only spraying where they are intended to spray.

Church Headquarters Personnel — Church headquarters personnel can help in evaluating water conservation efforts and contractor capabilities, explaining contractor responsibilities, evaluating water consumption and other services. Direct technical questions to:

- First contact: David Wright, Meetinghouse Facilities Department Landscape Architect (wrightds@ldschurch.org)
- Second contact: Kevin Shields, Temples and Special Projects Landscape Architect (ShieldsKR@ldschurch.org).

Stake Building Specialists for Water Conservation letter June 25, 2002

THE CHURCH OF JESUS CHRIST OF LATTER-DAY SAINTS
THE QUORUM OF THE TWELVE APOSTLES
47 EAST SOUTH TEMPLE STREET, SALT LAKE CITY, UTAH 84150-1200

June 25, 2002

To: General Authorities and the following leaders in the United States and Canada: Area Authority Seventies; Stake, Mission, and District Presidents; Bishops and Branch Presidents

Dear Brethren:

Stake Building Specialists for Water Conservation

In an effort to implement water conservation measures, we ask each stake presidency to call a specialist for each meetinghouse and recreational property to assist the local facilities management (FM) group in the watering of lawns, trees, and shrubs. This could be an opportunity for the participation of prospective elders, less-active members, and responsible Aaronic Priesthood youth.

Under the direction of the stake physical facilities representative, the specialist should perform the responsibilities which are printed on the reverse side of this letter. The specialist should be assigned to monitor the lawn at each meetinghouse and adjust the irrigation system based on current weather conditions and watering needs.

Sincerely,

Boyd K. Packer
Acting President
Quorum of the Twelve

Meetinghouse Water Conservation Measures

Responsibilities of Stake Building Specialist for Water Conservation

1. Test and operate irrigation controls and other water fixtures according to training provided by the facilities manager.

2. Follow guidelines from the facilities manager on frequency and duration of watering periods.

3. Test landscape areas to determine certain watering needs.

4. Report problems and repair needs to the facilities manager.

This letter is being translated and will be distributed to units identified as French and Spanish units in the United States and Canada. Distribution in these languages will be complete within two weeks. Unit leaders may request original copies from the Salt Lake Mail Operations Center (ext. 21990). If leaders need it in languages not listed above, they may contact the Area Presidency who can forward requests to Scriptures and Production Coordination at Church headquarters (ext. 22933).

22939

See also Handbook 1, Stake Presidents and Bishops [2010] 8.3.4.

Recommended Water Conservation Actions

Overview

For each site do the following:

1. Identify all sprinkler systems at each site for which your facilities management group is responsible.
2. Gather all available documentation for the sprinkler systems at each site.
3. Determine if using irrigation maintenance contractors or landscape water managers is approved for your region.

   If so, determine if any irrigation maintenance contractors or landscape water managers are currently under contract in your region.
4. Gather all site-specific consumption statistics or water efficiency evaluations.
5. Determine if there are any conservation incentives available through municipalities or local water districts to help improve watering practices.
6. Determine if there are any water specialists assigned by the stakes or wards.

Once this information is gathered determine which sites have the most need for conservation. Using the action lists below develop a water conservation plan for each site.

The actions listed below are separated into two groups:

- Actions that evaluate performance.
- Actions that should be incorporated during sprinkler operations

Each list is organized from simple tasks to more aggressive tasks. Remember, not all of the actions are possible for all sites. Always follow local ordinances in applying these tasks.

Unless noted, each action should be performed on a regular basis by:

- The facilities management group including the manager or a member of his staff. This could also be a Church service missionary or intern assigned to the FM group.
- A professional contractor that the FM group hires to do specified work.
- Members from the wards and stakes with experience or interest and given specific tasks.

For more information about how to effectively use these individuals see Attachment 2 Water Conservation Personnel Descriptions.

Actions that Evaluate Performance

- ☐ Inspect the irrigation system in operation. Fix broken parts immediately. Turn off damaged zones until parts have been repaired.
- ☐ Use the "screwdriver test" to determine the water scheduling requirements.
- ☐ Investigate wet surface spots. Reduce watering schedules for these areas.
- ☐ Have contractor add heads in areas where landscape is too dry.
- ☐ Have contractor cap or eliminate unnecessary heads: i.e. heads spraying in shrub beds without plant material.
- ☐ Develop maintenance schedule for how often system should be checked.
- ☐ Perform "catch can tests" to determine how long it takes to apply ½ inch of water per zone.
- ☐ Through the FM group contract with an irrigation maintenance contractor.
- ☐ Purchase and install a rain and moisture shut-off device and sensors on all

controllers. Where existing sensors are in place, make sure batteries are replaced annually. Confirm component is operational. Device should be set to 1/8 inch of moisture for shut-off to occur.

- [ ] Through the FM group, and following existing church procurement protocol, contract with an approved contractor to install church approved smart controllers per standard details and specifications.

- [ ] Through the FM group, contract with a landscape water manager (LWM) to develop a water budget using ET requirements as provided in Appendix D and E.

  The LWM should be familiar with Landscape Irrigation Best Management Practices as developed by the Irrigation Association and the American Society of Irrigation Consultants http://www.irrigation.org/uploadedFiles/Standards/BMPDesign-Install-Manage.3-18-14(2).pdf.

Actions that Should Be Incorporated During Regular Sprinkler Operations

- [ ] Schedule zone run times to achieve aforementioned watering depths. Remember, <u>less frequent, deep watering is preferred.</u>

- [ ] Adjust watering times to accommodate site conditions. For example, shady areas will not need to be watered as often as sunny areas and hot slopes may require more water per application.

- [ ] Eliminate or minimize overspray and runoff onto un-irrigable surfaces. Water running across pavement or down gutters does not represent good water conservation.

- [ ] Eliminate watering during the hottest time of the day.

  Watering during the cooler hours minimizes evaporation. One exception would be when inspecting a system for operational status. Another exception would be to avoid fungal issues associated with humid regions. Some jurisdictions limit when watering can take place.

- [ ] Adjust schedules to allow soil to dry out between watering. Too dry can be damaging. Generally speaking, shrub areas can go longer between watering than lawn areas.

- [ ] Check and re-check system conditions per schedule developed above.

- [ ] Check water use.

- [ ] Adjust sprinkler systems to apply ½ inch of water per application for lawn areas. Adjust per eco-region requirements.

- [ ] For shrub areas, increase watering duration to apply 3/4 inches to 1 inch of water per application or enough water to moisten soil at least 12 inches deep. Native and drought tolerant shrubs should be watered less frequently. Adjust per eco-region requirements.

- [ ] Utilize cycle and soak feature. Slopes, areas with dense soil types, and all spray zones should be considered.

  For example, if water begins to run off a hill or puddle in a flat area after 5 minutes of watering, set the controller on “Cycle and Soak” and set the “Cycle” to run that valve for 5 minutes. Then, set the “Soak” time for 30 minutes between cycles. The controller will now turn the water on 4 times for a total of 20 minutes during that watering period (20min./5min. = 4 cycles).

- [ ] The FM group or member should evaluate irrigation maintenance contractor’s work.

- [ ] Have contractor adjust schedules for each site so soil can dry out to a target level which by industry standard is 50% of field capacity.

- [ ] Have the contractor and FM group report water usage on a month-to-month basis to the regional facilities manager.

- [ ] On a regular basis evaluate the LWMs efforts and the water budget status.

Water Audit Techniques

A water audit of an irrigation system can help avoid overwatering by the FM group, contractor, or trained members. This document describes four water audit techniques.

A water audit can determine appropriate run times suited to a particular irrigation system. Run times are based on the sprinkler precipitation rates, distribution uniformity, and environmental conditions. The result of the intermediate and advanced audit techniques in this document provide zone specific precipitation rates for an irrigation system. These rates can be used in conjunction with the Basic Controller Adjustment and Advanced Controller Adjustment guidelines in Attachment 4 to determine the appropriate run times.

Screwdriver Test (Basic)

This test should be used periodically prior to water and then again after watering to determine how deep the water has penetrated. After watering a screwdriver should be able to be pushed into the soil to the point where the water has penetrated. Ideally, lawns are irrigated to a six-inch depth and shrub areas to a depth of twelve inches. However, recommended depths can vary according to soil and plant types.

Catch Can Water Audit (Intermediate)

This test measures an irrigation system's precipitation rate and distribution uniformity for individual zones. Audit kits are available at sprinkler supply stores, which provide calibrated catchment devices. Shallow metal cans, such as tuna fish cans, can be used in place of the kit.

1. Locate and mark all sprinkler heads by briefly turning on each zone prior to placing the catch cans. During this time identify and correct any problems such as broken heads, misaligned nozzles, or obstructions. **These should be corrected before continuing the audit.**
2. Place the catch cans in a grid-like pattern throughout the zone. Catch cans placed near the perimeter should be at least 12-24 inches from the edge. Maintain adequate distance from sprinkler heads to avoid altering spray patterns. If significant overspray occurs between two adjacent zones, distribute catch cans in both areas and run each zone for the same amount of time before measuring water depths. If wind exceeds 5 mph (unless such winds are common), the audit should be postponed.
3. Run the zone long enough to collect a measurable amount of water. Record the exact run time. As a guide, 5-10 minutes is sufficient for spray heads and 10-15 for rotary nozzles.
4. Measure and record the depth of water collected in each catch can by tenths of inches (this data can be used to determine distribution uniformity). Determine the average can water depth:

$$Average\ Can\ Water\ Depth = \frac{Sum\ of\ Cans\ Water\ Depth}{\#\ of\ Cans}$$

5. Determine the precipitation rate for the zone using the data from Steps 3 and 4:

$$Precipitation\ rate = \frac{Average\ Can\ Water\ Depth}{Run\ time} \times 60$$

6. The calculation from Step 5 provides the precipitation rate as inches/hour. Repeat previous steps for all zones in the system.

Distribution Uniformity (DU) (Advanced)

To determine the DU of a sprinkler zone, use the data from the Catch Can Irrigation Audit. Using the recorded amounts of water collected in each catch can, identify the average for the lowest quarter. Compare that result with the overall average can water depth:

$$DU = \frac{Lowest\ Quarter\ Average\ Can\ Water\ Depth}{Average\ Can\ Water\ Depth} \times 100$$

The DU should be at or above the “good” percentage. If the rating is lower, further inspection of the system may be necessary to determine the cause of poor uniformity.

	Excellent	Very Good	Good	Fair	Poor
Fixed Spray	75%	65%	55%	50%	40%
Rotor/Rotary Nozzle	80%	70%	65%	60%	50%

Drip Irrigation Audit

This audit will employ a process nearly identical to the Catch Can Irrigation Audit.

1. Place catch cans at various emitters along the lateral lines of a zone. The distribution of the catch cans will indicate precipitation rate and DU. The audit can be used on all emitter types by doing the following.
    - Bubbler: place inside the catch can
    - Spray: place inside the catch can
    - Dripper: place inside the catch can
    - Hose: place the catch can under the lateral line, if the can is not too tall to disrupt
2. Run the zone long enough to collect a measurable amount of water. Record the exact run time.
3. Measure and record the depth of water collected in each catch can by tenths of inches (this data can be used to determine the DU). Determine the average can water depth:

$$Average\ Can\ Water\ Depth = \frac{Sum\ of\ Cans\ Water\ Depth}{\#\ of\ Cans}$$

4. Determine the precipitation rate for the zone using the data from Steps 2 and 3:

$$Precipitation\ rate = \frac{Average\ Can\ Water\ Depth}{Run\ time} \times 60$$

5. The calculation from Step 4 provides the precipitation rate as inches/hour. Repeat previous step for all drip zones in the system.

Irrigation Controller Run Times

To effectively implement water conservation efforts the following guidelines should be used to adjust irrigation controllers. This section provides three levels of controller adjustment: basic, intermediate, and advanced. With each subsequent level, irrigation efficiency increases. Consequently, water conservation precision improves at the higher levels of controller adjustment.

- Basic Controller Adjustment focuses on applying ½" water per application using sprinkler precipitation rates. This low precision approach limits the amount of water applied, but does not consider environmental conditions.
- Intermediate Controller Adjustment provides the recommended minutes per week by sprinkler type. This provides intermediate precision as the recommendations are based on environmental conditions. However, the use of generic sprinkler precipitation rates creates limitations.
- Advanced Controller Adjustment also provides the recommended minutes per week but applies information obtained through an irrigation audit to average evapotranspiration (ET) rates. This provides the highest precision as it considers environmental factors and site specific sprinkler precipitation rates.

Regardless of the recommended actions within this attachment, the person programming the controller is responsible to follow all local jurisdiction watering restrictions. In addition, rainfall can have a significant effect on water requirements. Use a rain sensor to eliminate watering during rainstorms and adjust run times as required.

Basic Controller Adjustment

The recommended amount of water per irrigation application is ½". If sprinkler runoff occurs before reaching the desired application, use the cycle and soak method (irrigate zones in increments to allow water to percolate).

Average precipitation rates for various sprinkler types can be used to determine how to apply ½" of water. Preferably a water audit was conducted and the resultant sprinkler precipitation rates can be used in the formula. In the absence of such rates, the following list provides average sprinkler precipitation rates under the assumption that each zone consists of a single sprinkler type.

- Spray: 1.6 inches/hour
- Rotor: 0.7 inches/hour
- Rotary nozzle: 0.5 inches/hour

$$Rt = (Ar \div \mathrm{Pr})\ x\ 60$$

- *Rt* represents run time, provided as minutes/application
- *Ar* represents the desired application rate (most often ½" or 0.5")
- *Pr* represents the sprinkler precipitation rate
- *60* converts the equation from hours/application to minutes/application

Example:

A zone of rotor heads has a precipitation rate (*Pr*) of 0.7 inches/hour. The desired application rate (*Ar*) is .5". What is the appropriate run time (*Rt*)?

Solution:

$$Rt = (Ar \div \mathrm{Pr})\ x\ 60 \longrightarrow Rt = (.5 \div 0.7)\ x\ 60 \longrightarrow Rt = 42.9$$

The result is 42.9, which means the appropriate run time is 43 minutes per application.

Intermediate Controller Adjustment

To apply this controller adjustment, locate the appropriate table for a given property by its ecoregion location. Use the following recommended minutes per week tables. Divide the recommended minutes/week into reasonable times for each application and program the controller accordingly. Avoid daily watering as that encourages decreased rooting depth and improves turf resilience to drought conditions. Use the following formula to adjust the irrigation run times.

$$Ma = Mw \div Aw$$

- *Ma* represents minutes per application
- *Mw* represents the minutes per week
- *Aw* represents the applications per week

Example:

Program a zone of rotor heads for the month of July, watering three applications per week. The table below represents Montana's data for ecoregion 9.1 and can be found in the following tables.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
Montana[2,3]												
Spray	0	0	13	23	33	41	54	47	28	8	0	0
Rotor	0	0	29	53	75	93	122	108	64	19	0	0
Rotary Nozzle	0	0	41	74	105	131	171	152	90	26	0	0

Solution:

$$Ma = Mw \div Aw \longrightarrow Ma = 122 \div 3 \longrightarrow Ma = 40.67$$

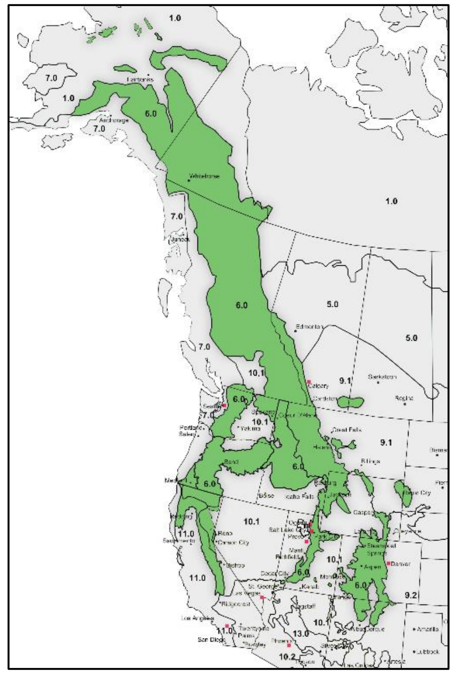
The result is 41 minutes per application, with 3 applications per week for the month of July.

Ecoregion 6.0: Western Mountains

The tables below provide the recommended irrigation run times measured in minutes per week. This is a useful reference but does not account for system specific precipitation rates, distribution uniformity, or soil types. Evapotranspiration averages and the following sprinkler precipitation rates determined the run times below:

Spray: 1.6 inches/hour
Rotor: 0.7 inches/hour
Rotary Nozzle: 0.5 inches/hour

Weather, climatic conditions, and local restrictions supersede the recommendations provided in the tables. Adjust run times as required to respond to these additional variables.



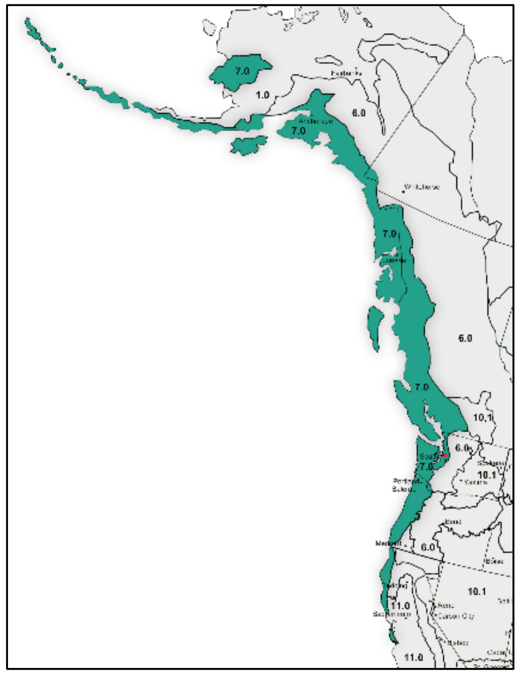
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
California[2, 4]												
Spray	5	8	13	19	41	59	71	63	45	14	7	4
Rotor	12	18	29	42	95	136	163	145	104	33	16	10
Rotary Nozzle	16	25	41	59	133	190	228	203	145	46	22	14
Colorado[1, 2]												
Spray	0	0	0	26	36	48	49	42	30	19	0	0
Rotor	0	0	0	60	83	109	112	96	68	43	0	0
Rotary Nozzle	0	0	0	84	116	153	157	134	95	61	0	0
Idaho[3]												
Spray	0	0	0	8	27	40	54	49	28	6	0	0
Rotor	0	0	0	19	61	92	124	112	63	15	0	0
Rotary Nozzle	0	0	0	27	86	129	173	157	88	20	0	0
Montana[2, 4]												
Spray	0	0	14	23	34	43	57	48	29	8	0	0
Rotor	0	0	31	52	77	98	131	110	66	19	0	0
Rotary Nozzle	0	0	44	73	108	137	183	154	93	27	0	0
Nevada[2, 4]												
Spray	0	6	11	25	38	52	61	53	38	17	6	0
Rotor	0	14	24	57	87	118	140	122	86	40	14	0
Rotary Nozzle	0	20	34	49	122	165	196	171	121	55	20	0
New Mexico[2, 4]												
Spray	0	8	23	36	48	60	55	44	36	23	8	0
Rotor	0	18	53	81	110	137	126	102	82	53	18	0
Rotary Nozzle	0	25	74	114	154	192	177	142	114	74	26	0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
Oregon[5]												
Spray	0	0	0	26	33	46	61	51	39	19	0	0
Rotor	0	0	0	61	76	106	140	116	90	44	0	0
Rotary Nozzle	0	0	0	85	106	148	197	163	125	62	0	0
South Dakota[6]												
Spray	0	0	0	26	33	46	61	51	39	19	0	0
Rotor	0	0	0	61	76	106	140	116	90	44	0	0
Rotary Nozzle	0	0	0	85	106	148	197	163	125	62	0	0
Utah[2, 4]												
Spray	0	0	0	29	43	58	63	53	37	18	0	0
Rotor	0	0	0	65	98	132	145	122	84	42	0	0
Rotary Nozzle	0	0	0	92	137	185	203	171	117	59	0	0
Washington[2, 4]												
Spray	0	0	0	15	30	40	53	46	26	8	0	0
Rotor	0	0	0	34	68	91	122	106	59	19	0	0
Rotary Nozzle	0	0	0	48	95	127	171	148	83	27	0	0
Wyoming[2, 4]												
Spray	0	0	0	20	31	45	55	48	30	9	0	0
Rotor	0	0	0	46	71	102	127	111	68	21	0	0
Rotary Nozzle	0	0	0	65	99	143	178	155	95	30	0	0

Sources:

1 www.ccc.atmos.colostate.edu/cgi-bin/monthly_coag.pl
2 www.weather.com
3 www.northernwater.org/WaterConservation/WeatherandETData.aspx
4 www.data.kimberly.uidaho.edu/ETIdaho
5 www.climate.usurf.usu.edu
6 http://ir.library.oregonstate.edu/jspui/bitstream/1957/18838/1/ec1638.pdf
7 www.climate.sdstate.edu/awdn/et/et.asp

Ecoregion 7.0: West Coast Forests



The tables below provide the recommended irrigation run times measured in minutes per week. This is a useful reference but does not account for system specific precipitation rates, distribution uniformity, or soil types. Evapotranspiration averages and the following sprinkler precipitation rates determined the run times below:

Spray: 1.6 inches/hour
Rotor: 0.7 inches/hour
Rotary Nozzle: 0.5 inches/hour

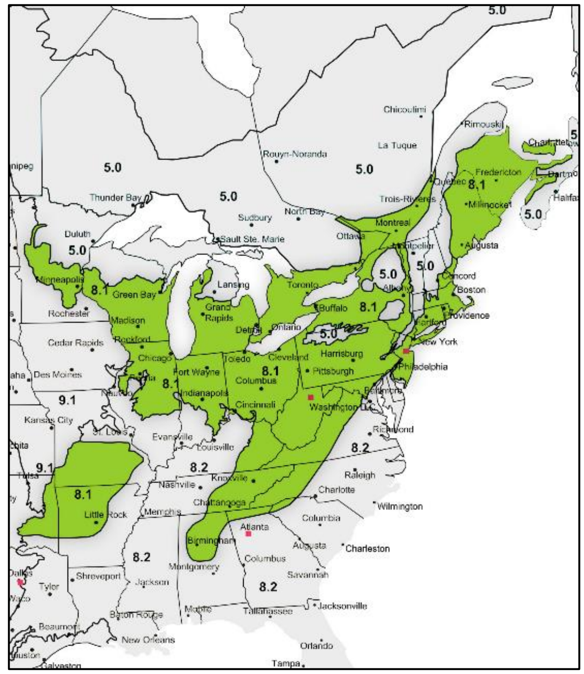
Weather, climatic conditions, and local restrictions supersede the recommendations provided in the tables. Adjust run times as required to respond to these additional variables.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
California[1, 2]												
Spray	6	8	12	16	32	40	41	38	31	12	7	5
Rotor	14	19	27	36	73	91	93	86	71	27	17	12
Rotary Nozzle	19	27	38	50	102	128	131	120	99	37	23	17
Oregon[1, 2]												
Spray	0	0	0	16	33	46	58	51	34	11	0	0
Rotor	0	0	0	37	75	105	133	116	78	25	0	0
Rotary Nozzle	0	0	0	52	105	147	186	162	109	35	0	0
Washington[1, 2]												
Spray	0	0	0	14	24	33	42	35	19	7	0	0
Rotor	0	0	0	31	55	75	96	81	44	17	0	0
Rotary Nozzle	0	0	0	44	76	104	135	113	62	24	0	0

Sources:

1 www.climate.usurf.usu.edu
2 www.weather.com

Ecoregion 8.1: Eastern Forests



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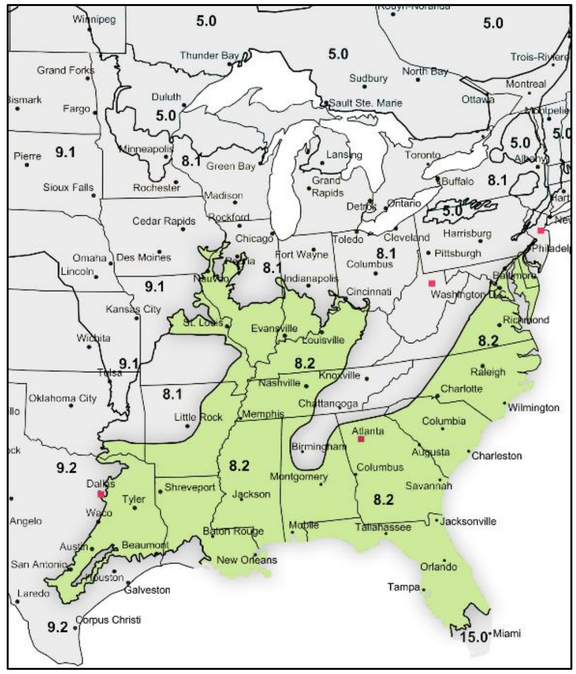
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
Oklahoma												
Spray	0	0	0	20	25	38	47	45	22	15	0	0
Rotor	0	0	0	46	56	86	107	103	50	34	0	0
Rotary Nozzle	0	0	0	65	79	120	150	144	70	47	0	0

Sources:
1 www.climate.usurf.usu.edu
2 www.weather.com

Ecoregion 8.2: Southeastern Forests



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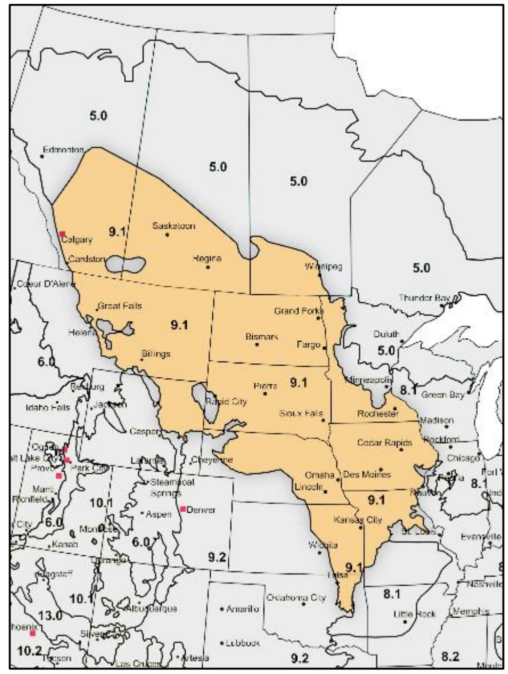
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
Oklahoma[1, 2]												
Spray	0	0	0	22	26	39	47	49	23	16	0	0
Rotor	0	0	0	50	59	88	108	111	53	36	0	0
Rotary Nozzle	0	0	0	70	82	124	152	155	74	50	0	0
Texas[1, 2]												
Spray	9	12	17	31	33	41	50	50	33	17	11	8
Rotor	20	27	38	72	75	95	113	114	76	39	25	19
Rotary Nozzle	28	38	54	100	105	132	159	160	106	54	35	27

Sources:
1 www.climate.usurf.usu.edu
2 www.weather.com

Ecoregion 9.1: Northern Plains



The tables below provide the recommended irrigation run times measured in minutes per week. This is a useful reference but does not account for system specific precipitation rates, distribution uniformity, or soil types. Evapotranspiration averages and the following sprinkler precipitation rates determined the run times below:

Spray: 1.6 inches/hour
Rotor: 0.7 inches/hour
Rotary Nozzle: 0.5 inches/hour

Weather, climatic conditions, and local restrictions supersede the recommendations provided in the tables. Adjust run times as required to respond to these additional variables.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
Kansas[1]												
Spray	0	0	13	23	33	41	54	47	28	8	0	0
Rotor	0	0	29	53	75	93	122	108	64	19	0	0
Rotary Nozzle	0	0	41	74	105	131	171	152	90	26	0	0
Montana[2,3]												
Spray	0	0	13	23	33	41	54	47	28	8	0	0
Rotor	0	0	29	53	75	93	122	108	64	19	0	0
Rotary Nozzle	0	0	41	74	105	131	171	152	90	26	0	0
North Dakota[3, 4]												
Spray	0	0	0	34	37	37	44	48	35	14	0	0
Rotor	0	0	0	78	84	84	102	110	80	32	0	0
Rotary Nozzle	0	0	0	110	117	118	142	154	112	45	0	0
Nebraska[3, 5]												
Spray	0	0	0	39	39	54	53	40	40	29	0	0
Rotor	0	0	0	90	89	123	120	91	92	66	0	0
Rotary Nozzle	0	0	0	126	124	172	168	127	128	93	0	0
Oklahoma												
Spray	0	0	0	27	29	32	48	41	25	0	0	0
Rotor	0	0	0	61	66	74	110	94	57	0	0	0
Rotary Nozzle	0	0	0	85	92	104	154	131	80	0	0	0
South Dakota												
Spray	0	0	0	27	35	42	55	49	35	18	0	0
Rotor	0	0	0	62	79	96	126	112	81	40	0	0
Rotary Nozzle	0	0	0	87	111	135	176	157	113	56	0	0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
Wyoming[2,3]												
Spray	0	0	0	24	33	48	59	53	33	15	0	0
Rotor	0	0	0	56	76	110	134	120	77	34	0	0
Rotary Nozzle	0	0	0	78	107	154	188	168	107	48	0	0

Sources:

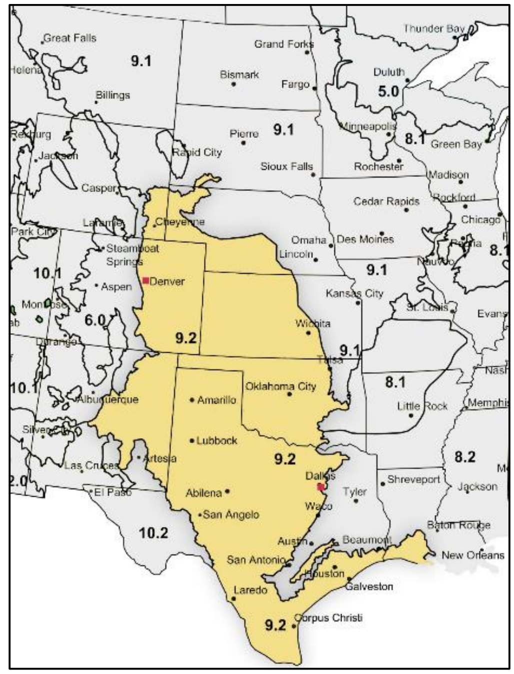
1 www.ksre.ksu.edu/wdl/climate/Climate%20Records%201.htm
2 www.climate.usurf.usu.edu
3 www.weather.com
4 http://ndawn.ndsu.nodak.edu/weather-data-monthly.html
5 www.ianrpubs.unl.edu/epublic/live/g2191/build/g2191.pdf
6 www.unce.unr.edu/publications/files/nr/2013/fs1338.pdf

Ecoregion 9.2: Southern Plains

The tables below provide the recommended irrigation run times measured in minutes per week. This is a useful reference but does not account for system specific precipitation rates, distribution uniformity, or soil types. Evapotranspiration averages and the following sprinkler precipitation rates determined the run times below:

Spray: 1.6 inches/hour
Rotor: 0.7 inches/hour
Rotary Nozzle: 0.5 inches/hour

Weather, climatic conditions, and local restrictions supersede the recommendations provided in the tables. Adjust run times as required to respond to these additional variables.

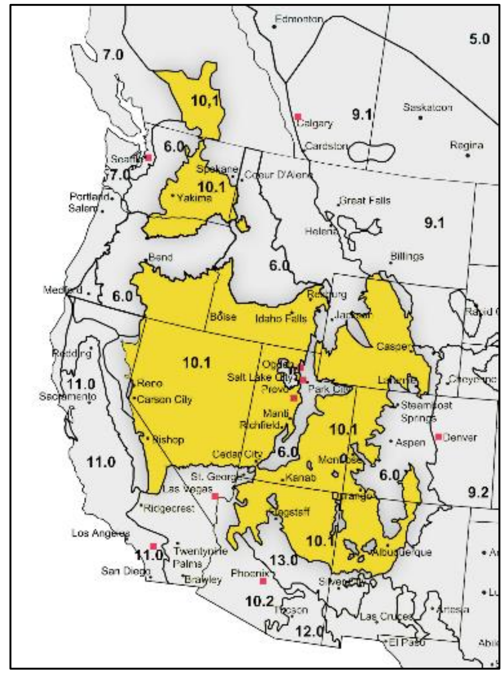


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
Colorado[1, 2]												
Spray	0	0	0	34	39	54	54	49	36	23	0	0
Rotor	0	0	0	77	90	123	123	112	83	52	0	0
Rotary Nozzle	0	0	0	107	125	172	172	157	116	73	0	0
Kansas[3]												
Spray	0	0	0	0	54	68	63	56	49	0	0	0
Rotor	0	0	0	0	123	156	144	128	112	0	0	0
Rotary Nozzle	0	0	0	0	172	218	201	179	157	0	0	0
Nebraska[4, 5]												
Spray	0	0	0	46	53	66	70	62	53	36	0	0
Rotor	0	0	0	106	120	151	161	143	120	82	0	0
Rotary Nozzle	0	0	0	148	168	211	225	200	168	115	0	0
New Mexico[5, 6]												
Spray	0	5	11	28	51	67	64	59	48	33	32	0
Rotor	0	11	24	65	117	153	147	135	110	77	72	0
Rotary Nozzle	0	15	34	90	164	214	206	189	153	107	101	0
Oklahoma[5, 7]												
Spray	0	0	0	20	17	23	34	30	15	0	0	0
Rotor	0	0	0	46	39	52	78	69	34	0	0	0
Rotary Nozzle	0	0	0	65	54	73	110	97	48	0	0	0
South Dakota												
Spray	0	0	11	25	34	44	54	51	34	11	0	0
Rotor	0	0	24	56	77	99	124	116	77	25	0	0
Rotary Nozzle	0	0	34	79	108	139	174	162	108	35	0	0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
Texas												
Spray	9	12	26	39	42	44	51	44	33	17	11	8
Rotor	21	28	61	88	97	101	116	101	76	39	26	19
Rotary Nozzle	29	39	85	123	135	141	163	142	107	54	36	27
Wyoming												
Spray	0	0	0	26	36	51	58	51	35	18	0	0
Rotor	0	0	0	60	82	116	132	117	79	42	0	0
Rotary Nozzle	0	0	0	83	114	162	185	164	111	59	0	0

Sources:
1 ccc.atmos.colostate.edu
2 northernwater.org
3 ksre.ksu.edu
4 ianrpubs.unl.edu
5 weather.com
6 aces.nmsu.edu
7 pods.dasnr.okstate.edu
8 climate.usurf.usu.edu

Ecoregion 10.1: Northern Cold Desert



The tables below provide the recommended irrigation run times measured in minutes per week. This is a useful reference but does not account for system specific precipitation rates, distribution uniformity, or soil types. Evapotranspiration averages and the following sprinkler precipitation rates determined the run times below:

Spray: 1.6 inches/hour
Rotor: 0.7 inches/hour
Rotary Nozzle: 0.5 inches/hour

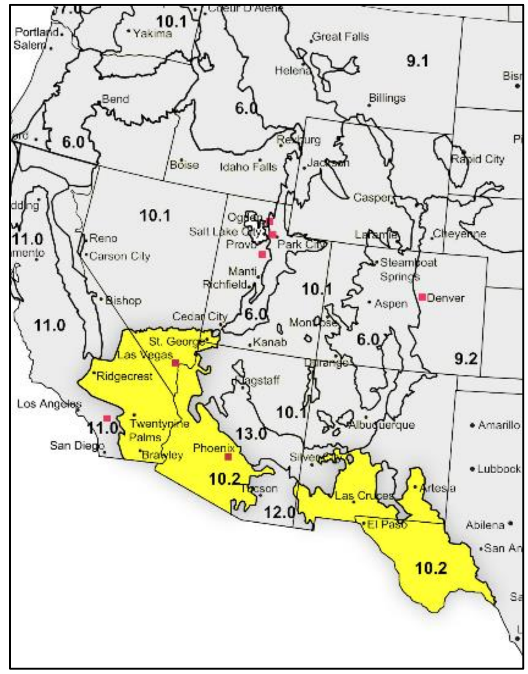
Weather, climatic conditions, and local restrictions supersede the recommendations provided in the tables. Adjust run times as required to respond to these additional variables.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
Arizona[1, 2]												
Spray	7	16	29	41	58	72	66	58	45	29	16	6
Rotor	16	36	65	95	132	164	152	132	102	66	37	14
Rotary Nozzle	22	51	91	132	185	230	212	185	143	92	52	19
California[1, 2]												
Spray	6	9	26	40	55	68	74	65	48	29	8	0
Rotor	14	20	59	91	125	156	170	150	111	65	19	0
Rotary Nozzle	19	28	83	128	175	218	238	209	155	91	27	0
Colorado[1, 2]												
Spray	0	0	0	31	47	62	65	55	36	19	0	0
Rotor	0	0	0	71	106	141	149	125	83	44	0	0
Rotary Nozzle	0	0	0	99	149	198	208	175	116	62	0	0
Idaho[2, 3]												
Spray	0	0	0	19	38	54	65	57	37	15	0	0
Rotor	0	0	0	43	87	123	148	130	84	35	0	0
Rotary Nozzle	0	0	0	60	121	172	208	182	117	49	0	0
Nevada[1, 2]												
Spray	0	6	19	30	43	58	69	60	41	22	6	0
Rotor	0	14	44	68	99	133	157	136	93	49	14	0
Rotary Nozzle	0	20	62	95	139	186	219	190	130	69	20	0
New Mexico[4]												
Spray	0	0	0	19	40	59	59	48	36	22	7	0
Rotor	0	0	0	44	92	134	135	109	82	50	16	0
Rotary Nozzle	0	0	0	62	129	188	189	152	114	69	22	0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
Oregon[5]												
Spray	0	0	0	23	39	55	67	56	37	0	0	0
Rotor	0	0	0	52	90	126	154	128	84	0	0	0
Rotary Nozzle	0	0	0	73	125	176	215	179	117	0	0	0
Utah[1, 2]												
Spray	0	0	0	28	43	60	66	57	38	18	0	0
Rotor	0	0	0	64	97	137	152	129	87	42	0	0
Rotary Nozzle	0	0	0	90	136	192	212	181	122	59	0	0
Washington[1, 2]												
Spray	0	0	0	27	41	52	64	55	36	15	0	0
Rotor	0	0	0	62	94	119	147	126	82	33	0	0
Rotary Nozzle	0	0	0	67	132	166	205	177	115	47	0	0
Wyoming[1, 2]												
Spray	0	0	0	25	36	51	60	52	32	16	0	0
Rotor	0	0	0	57	83	116	137	118	74	36	0	0
Rotary Nozzle	0	0	0	80	117	162	192	166	103	50	0	0

Sources:
1 climate.usurf.usu.edu
2 weather.com
3 data.kimberly.uidaho.edu
4 aces.nmsu.edu
5 ir.library.oregonstate.edu

Ecoregion 10.2: Southern Warm Desert



The tables below provide the recommended irrigation run times measured in minutes per week. This is a useful reference but does not account for system specific precipitation rates, distribution uniformity, or soil types. Evapotranspiration averages and the following sprinkler precipitation rates determined the run times below:

Spray: 1.6 inches/hour
Rotor: 0.7 inches/hour
Rotary Nozzle: 0.5 inches/hour

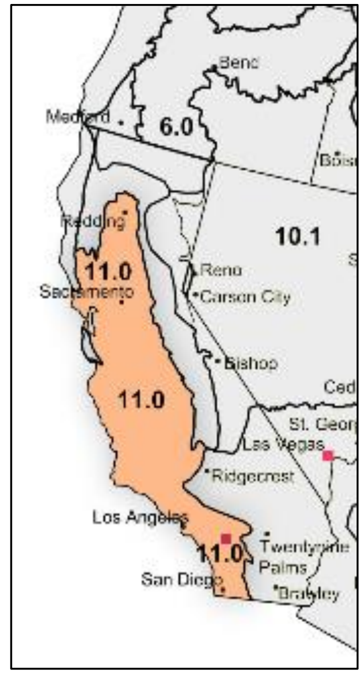
Weather, climatic conditions, and local restrictions supersede the recommendations provided in the tables. Adjust run times as required to respond to these additional variables.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
Arizona[1, 2]												
Spray	18	24	37	53	68	79	74	65	55	39	24	16
Rotor	42	54	85	122	156	181	167	148	126	89	56	37
Rotary Nozzle	58	76	119	171	218	254	236	207	176	125	78	52
California[1, 2]												
Spray	12	17	30	45	58	70	72	65	51	33	19	11
Rotor	28	38	69	103	133	159	165	149	116	76	44	26
Rotary Nozzle	39	53	97	144	186	223	231	208	163	107	61	36
Nevada[1, 2]												
Spray	13	18	32	48	64	77	77	68	53	34	19	0
Rotor	30	41	74	110	146	175	177	156	122	77	44	0
Rotary Nozzle	42	58	103	154	204	245	247	218	171	108	61	0
New Mexico[3]												
Spray	0	5	12	40	56	63	60	49	39	30	26	0
Rotor	0	12	29	92	128	144	137	111	89	68	60	0
Rotary Nozzle	0	17	40	128	179	202	191	155	124	95	64	0
Texas[1, 2]												
Spray	19	26	39	53	61	65	57	51	42	32	23	16
Rotor	43	59	89	120	139	148	131	117	96	74	52	37
Rotary Nozzle	600	82	124	168	195	207	184	164	134	103	73	52
Utah[1, 2]												
Spray	0	0	25	41	60	73	74	63	48	28	0	0
Rotor	0	0	56	95	136	167	169	145	110	65	0	0
Rotary Nozzle	0	0	79	133	191	234	236	203	154	90	0	0

Sources:
1 climate.usurf.usu.edu
2 weather.com

3 aces.nmsu.edu

Ecoregion 11.0: Mediterranean California



The tables below provide the recommended irrigation run times measured in minutes per week. This is a useful reference but does not account for system specific precipitation rates, distribution uniformity, or soil types. Evapotranspiration averages and the following sprinkler precipitation rates determined the run times below:

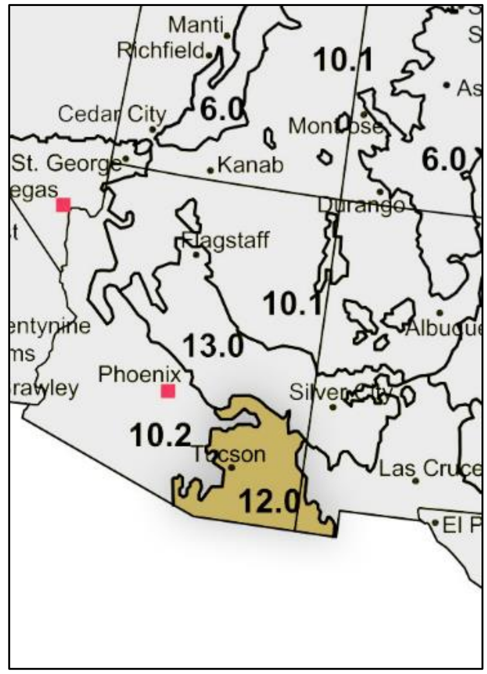
Spray: 1.6 inches/hour
Rotor: 0.7 inches/hour
Rotary Nozzle: 0.5 inches/hour

Weather, climatic conditions, and local restrictions supersede the recommendations provided in the tables. Adjust run times as required to respond to these additional variables.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
California[1, 2]												
Spray	8	11	15	35	49	59	64	59	47	27	10	7
Rotor	18	24	35	80	111	134	147	135	107	62	22	16
Rotary Nozzle	25	34	49	112	155	187	205	188	150	87	31	23

Sources:
1 www.climate.usurf.usu.edu
2 www.weather.com

Ecoregion 12.0: Southern Highlands



The tables below provide the recommended irrigation run times measured in minutes per week. This is a useful reference but does not account for system specific precipitation rates, distribution uniformity, or soil types. Evapotranspiration averages and the following sprinkler precipitation rates determined the run times below:

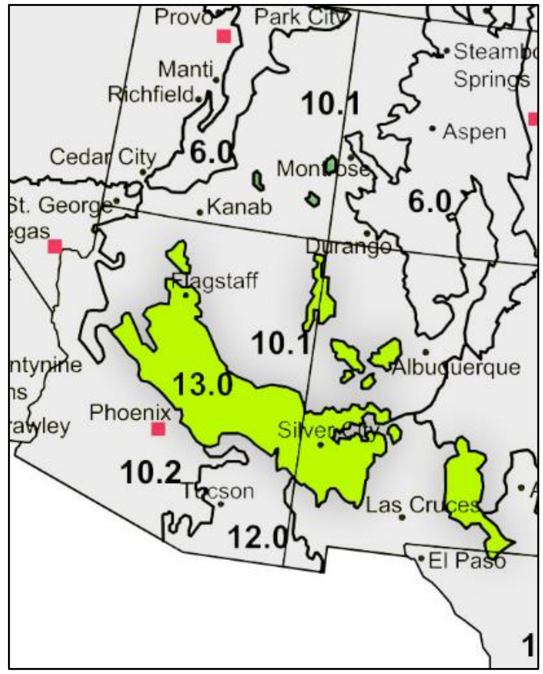
Spray: 1.6 inches/hour
Rotor: 0.7 inches/hour
Rotary Nozzle: 0.5 inches/hour

Weather, climatic conditions, and local restrictions supersede the recommendations provided in the tables. Adjust run times as required to respond to these additional variables.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
Arizona[1, 2]												
Spray	17	23	37	53	66	76	60	51	48	35	23	14
Rotor	38	54	85	120	152	174	137	117	109	81	52	32
Rotary Nozzle	53	75	119	169	212	243	191	164	152	113	73	45
New Mexico[1, 2]												
Spray	10	24	37	52	65	74	59	52	47	34	22	9
Rotor	23	55	85	119	149	168	136	119	106	78	50	21
Rotary Nozzle	32	77	119	167	208	236	190	167	149	109	71	29

Sources:
1 climate.usurf.usu.edu
2 weather.com

Ecoregion 13.0: Southwest Mountains



The tables below provide the recommended irrigation run times measured in minutes per week. This is a useful reference but does not account for system specific precipitation rates, distribution uniformity, or soil types. Evapotranspiration averages and the following sprinkler precipitation rates determined the run times below:

Spray: 1.6 inches/hour
Rotor: 0.7 inches/hour
Rotary Nozzle: 0.5 inches/hour

Weather, climatic conditions, and local restrictions supersede the recommendations provided in the tables. Adjust run times as required to respond to these additional variables.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Minutes/Week						
Arizona[1, 2]												
Spray	0	14	25	38	51	64	59	50	40	26	15	0
Rotor	0	32	56	86	117	145	135	115	92	60	35	0
Rotary Nozzle	0	45	79	120	164	203	190	161	129	84	49	0
New Mexico[1, 2]												
Spray	0	15	26	39	51	63	49	38	34	24	15	0
Rotor	0	35	60	90	116	143	112	88	77	55	33	0
Rotary Nozzle	0	49	83	126	162	200	157	123	108	77	47	0

Sources:
1 www.climate.usurf.usu.edu
2 www.weather.com

Advanced Controller Adjustment

This section requires slightly more calculation, but yields greater accuracy than either of the previous adjustments. Matching ET data to an actual irrigation system's precipitation rate and distribution uniformity generates higher efficiency and precision.

ET rates are provided by local weather stations and university extension offices. ET refers to water lost through evaporation and plant transpiration. It provides baseline water requirements for various vegetation types. In these guidelines, the ET rates are based upon turf requirements.

Use the tables below for these calculations. The equation on the left is the industry standard for calculating run times. The distinction between the two formulas is the crop coefficient, or *Kc* value. This value determines plant-specific water needs beyond ET recommendations. However, the *Kc* value for turf is already factored into the data provided in the tables as part of the ET recommendation. Consequently, the equation on the right will be used. Finally, conduct a Catch Can Water Audit (see *Attachment 3: Water Audit Techniques*) to obtain sprinkler precipitation rates and distribution uniformity.

$$Rt = \frac{60 \times ET \times Kc}{\text{Pr} \times IE}$$

- Rt represents run time, minutes
- ET represents evapotranspiration, inches
- Kc represents the crop coefficient (accounts for moisture need of varying vegetation types)
- IE represents application efficiency

$$Rt = \frac{ET \times 60}{Pr \times DU}$$

- *Rt* represents run time, minutes
- *ET* represents the number from the table (use the High, Low, or an average)
- *Pr* represents sprinkler precipitation rate
- *DU* represents the distribution uniformity

Example:

Determine the appropriate run time of a single zone in minutes per week and minutes per application. It is an exceptionally hot, dry June. The table below represents Nevada's data for ecoregion 10.1 and can be found in the tables below. The Catch Can Water Audit provided a sprinkler precipitation rate of 1.2 for this zone. The distribution uniformity is 75%. Local restrictions limit watering to 3 days per week.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Inches/Week						
Nevada[1, 2]												
High	0	.33	.61	.90	1.28	1.63	1.87	1.63	1.15	.66	.33	0
Low	0	0	.43	.68	1.04	1.47	1.79	1.54	1.02	.49	0	0

Solution:

$$Rt = \frac{ET \times 60}{Pr \times DU} \qquad Rt = \frac{1.63 \times 60}{1.2 \times .75} \qquad Rt = 108.67$$

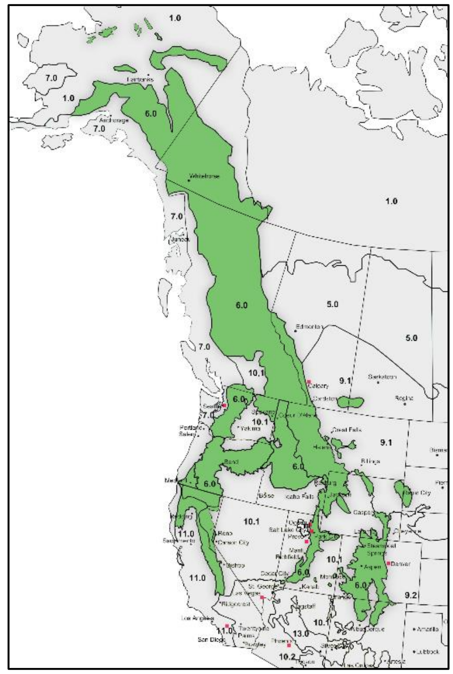
The appropriate minutes per week is 109 for this particular zone.

Use the formula from the *Intermediate Controller Adjustment* guidelines to determine the minutes per application.

$$Ma = Mw \div Aw \qquad Ma = 109 \div 3 \qquad Ma = 36.33$$

The final result is 36 minutes per application in this zone of the irrigation system, with 3 applications for the week.

Ecoregion 6.0: Western Mountains



The tables below represent the required irrigation as determined by local and historical evapotranspiration rates.

The two reference categories for weekly irrigation applications are high and low. The high category is based on the average evapotranspiration (ET) for the ecoregion and assumes zero precipitation. The low category also accounts for the average ET, but includes the expected annual precipitation for the area.

The numbers provided in the following tables indicate the amount of irrigation to apply in inches per week.

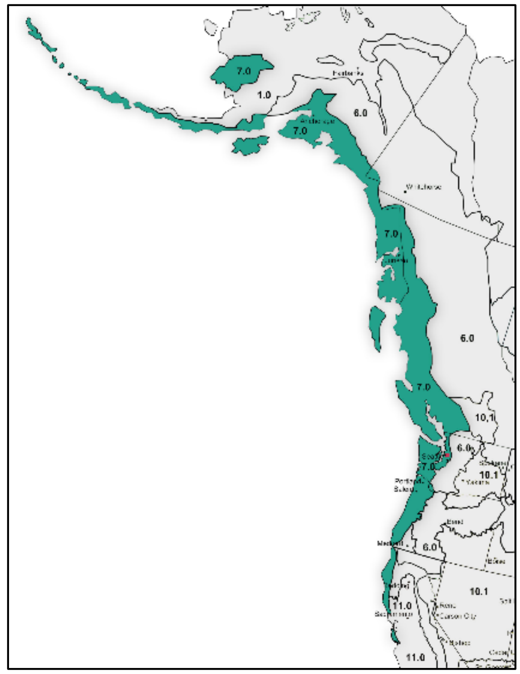
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Inches/Week						
California[2, 4]												
High	.27	.42	.68	.99	1.37	1.68	1.93	1.72	1.30	.76	.37	0
Low	0	0	0	.19	.84	1.49	1.87	1.66	1.12	0	0	0
Colorado[1, 2]												
High	0	0	0	.95	1.20	1.45	1.47	1.26	.99	.65	0	0
Low	0	0	0	.45	.73	1.10	1.15	.97	.60	.36	0	0
Idaho[3]												
High	0	0	0	.45	.98	1.33	1.58	1.42	.87	.34	0	0
Low	0	0	0	0	.45	.82	1.31	1.20	.60	0	0	0
Montana[2, 4]												
High	0	0	.47	.76	1.12	1.38	1.66	1.41	.91	.45	0	0
Low	0	0	.26	.46	.68	.90	1.40	1.16	.64	0	0	0
Nevada[2, 4]												
High	0	.34	.56	.81	1.14	1.45	1.67	1.47	1.08	.64	.34	0
Low	0	0	0	.51	.89	1.31	1.60	1.38	.93	.28	0	0
New Mexico[2, 4]												
High	0	.42	.71	1.05	1.42	1.75	1.73	1.50	1.16	.76	.43	0
Low	0	0	.52	.85	1.14	1.45	1.22	.87	.74	.48	0	0
Oregon[5]												
High	0	0	0	.65	1.11	1.45	1.72	1.43	.99	0	0	0
Low	0	0	0	.41	.85	1.27	1.61	1.34	.87	0	0	0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Inches/Week						
South Dakota[6]												
High	0	0	0	.93	1.22	1.54	1.87	1.54	1.21	.66	0	0
Low	0	0	0	.49	.55	.92	1.41	1.17	.89	.37	0	0
Utah[2, 4]												
High	0	0	0	.90	1.28	1.65	1.80	1.56	1.12	.65	0	0
Low	0	0	0	.63	1	1.43	1.59	1.28	.83	.33	0	0
Washington[2, 4]												
High	0	0	0	.80	1.13	1.32	1.54	1.35	.93	.45	0	0
Low	0	0	0	0	.46	.80	1.30	1.12	.45	0	0	0
Wyoming[2, 4]												
High	0	0	0	.72	1.08	1.41	1.64	1.43	.95	.50	0	0
Low	0	0	0	.36	.57	.96	1.32	1.15	.63	0	0	0

Sources:

1 www.ccc.atmos.colostate.edu/cgi-bin/monthly_coag.pl
2 www.weather.com
3 www.northernwater.org/WaterConservation/WeatherandETData.aspx
4 www.data.kimberly.uidaho.edu/ETIdaho
5 www.climate.usurf.usu.edu
6 http://ir.library.oregonstate.edu/jspui/bitstream/1957/18838/1/ec1638.pdf
7 www.climate.sdstate.edu/awdn/et/et.asp

Ecoregion 7.0: West Coast Forests



The tables below represent the required irrigation as determined by local and historical evapotranspiration rates.

The two reference categories for weekly irrigation applications are high and low. The high category is based on the average evapotranspiration (ET) for the ecoregion and assumes zero precipitation. The low category also accounts for the average ET, but includes the expected annual precipitation for the area.

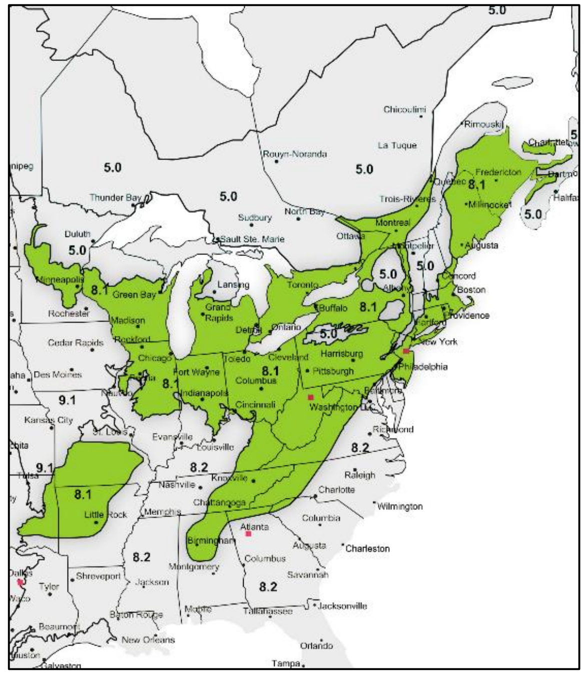
The numbers provided in the following tables indicate the amount of irrigation to apply in inches per week.

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
						Inches/Week						
California[1, 2]												
High	.32	.45	.64	.84	1.01	1.12	1.10	1.02	.87	.62	.39	.29
Low	0	0	0	.21	.69	1.01	1.08	.98	.78	.18	0	0
Oregon[1, 2]												
High	0	0	0	.86	1.18	1.39	1.61	1.42	1.06	.58	0	0
Low	0	0	0	0	.58	1.05	1.49	1.28	.75	0	0	0
Washington[1, 2]												
High	0	0	0	.73	1.00	1.14	1.27	1.11	.78	.39	0	0
Low	0	0	0	0	.28	.60	.97	.78	.25	0	0	0

Sources:

1 www.climate.usurf.usu.edu
2 www.weather.com

Ecoregion 8.1: Eastern Forests



The tables below represent the required irrigation as determined by local and historical evapotranspiration rates.

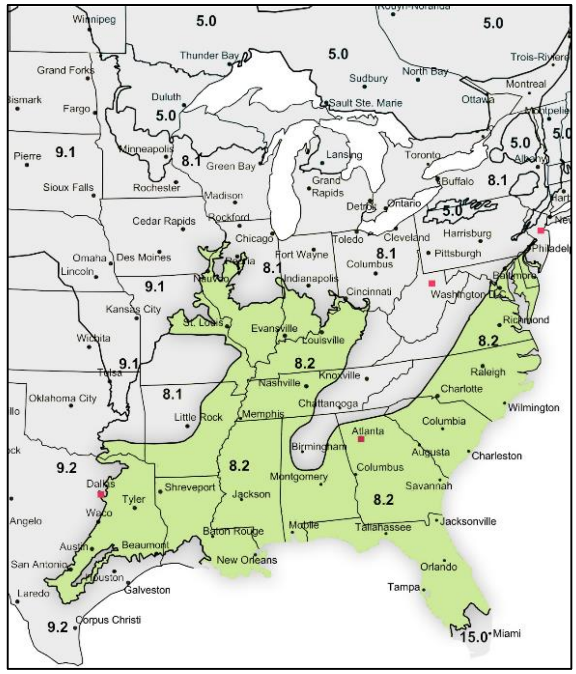
The two reference categories for weekly irrigation applications are high and low. The high category is based on the average evapotranspiration (ET) for the ecoregion and assumes zero precipitation. The low category also accounts for the average ET, but includes the expected annual precipitation for the area.

The numbers provided in the following tables indicate the amount of irrigation to apply in inches per week.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Inches/Week						
Oklahoma												
High	0	0	0	1.08	1.31	1.54	1.63	1.55	1.17	.78	0	0
Low	0	0	0	0	0	.47	.88	.85	0	0	0	0

Sources:
1 www.climate.usurf.usu.edu
2 www.weather.com

Ecoregion 8.2: Southeastern Forests



The tables below represent the required irrigation as determined by local and historical evapotranspiration rates.

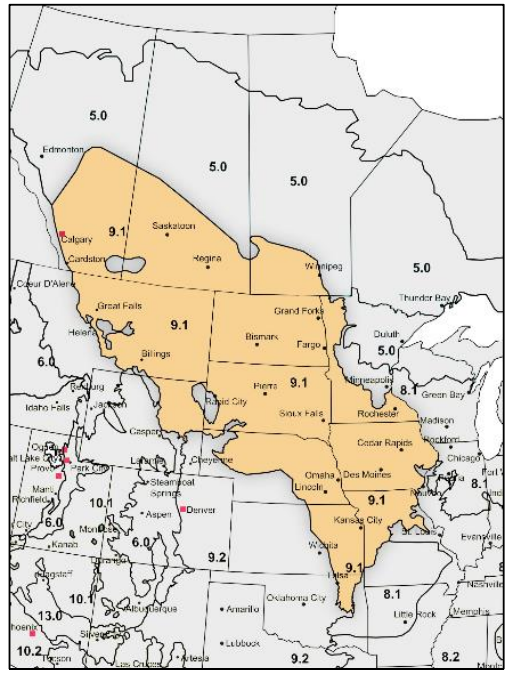
The two reference categories for weekly irrigation applications are high and low. The high category is based on the average evapotranspiration (ET) for the ecoregion and assumes zero precipitation. The low category also accounts for the average ET, but includes the expected annual precipitation for the area.

The numbers provided in the following tables indicate the amount of irrigation to apply in inches per week.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Inches/Week						
Oklahoma[1, 2]												
High	0	0	0	1.16	1.37	1.58	1.70	1.61	1.23	.84	0	0
Low	0	0	0	0	0	.49	.83	.98	0	0	0	0
Texas[1, 2]												
High	.46	.64	.90	1.20	1.41	1.61	1.66	1.59	1.26	.90	.59	.44
Low	0	0	0	.48	.34	.59	.98	1.07	.50	0	0	0

Sources:
1 www.climate.usurf.usu.edu
2 www.weather.com

Ecoregion 9.1: Northern Plains



The tables below represent the required irrigation as determined by local and historical evapotranspiration rates.

The two reference categories for weekly irrigation applications are high and low. The high category is based on the average evapotranspiration (ET) for the ecoregion and assumes zero precipitation. The low category also accounts for the average ET, but includes the expected annual precipitation for the area.

The numbers provided in the following tables indicate the amount of irrigation to apply in inches per week.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Inches/Week						
Kansas[1]												
High	0	0	0	1.36	1.52	1.65	1.64	1.49	1.24	.94	0	0
Low	0	0	0	1.20	1.31	1.36	1.43	1.29	1.09	.82	0	0
Montana[2,3]												
High	0	0	.43	.76	1.12	1.39	1.62	1.40	.90	.44	0	0
Low	0	0	.26	.48	.63	.79	1.23	1.13	.60	0	0	0
North Dakota[3, 4]												
High	0	0	0	1.01	1.03	1.03	1.36	1.47	1.07	.46	0	0
Low	0	0	0	.82	.92	.94	1.01	1.09	.79	.29	0	0
Nebraska[3, 5]												
High	0	0	0	1.41	1.60	1.94	1.83	1.50	1.42	1.04	0	0
Low	0	0	0	.69	.47	.93	.97	.62	.72	.51	0	0
Oklahoma												
High	0	0	0	1.10	1.20	1.42	1.63	1.47	1.05	0	0	0
Low	0	0	0	.33	.34	.30	.95	.72	.28	0	0	0
South Dakota												
High	0	0	0	.95	1.26	1.51	1.76	1.53	1.16	.65	0	0
Low	0	0	0	.51	.59	.73	1.17	1.08	.72	.29	0	0
Wyoming												
High	0	0	0	.83	1.18	1.53	1.75	1.52	1.04	.54	0	0
Low	0	0	0	.46	.60	1.04	1.38	1.28	.75	.25	0	0

Sources:
1 www.ksre.ksu.edu/wdl/climate/Climate%20Records%201.htm
2 www.climate.usurf.usu.edu
3 www.weather.com
4 http://ndawn.ndsu.nodak.edu/weather-data-monthly.html
5 www.ianrpubs.unl.edu/epublic/live/g2191/build/g2191.pdf

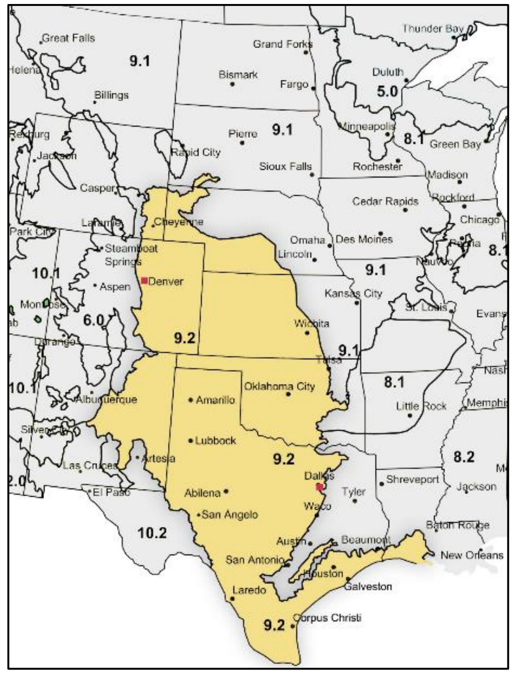
6 www.unce.unr.edu/publications/files/nr/2013/fs1338.pdf

Ecoregion 9.2: Southern Plains

The tables below represent the required irrigation as determined by local and historical evapotranspiration rates.

The two reference categories for weekly irrigation applications are high and low. The high category is based on the average evapotranspiration (ET) for the ecoregion and assumes zero precipitation. The low category also accounts for the average ET, but includes the expected annual precipitation for the area.

The numbers provided in the following tables indicate the amount of irrigation to apply in inches per week.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Inches/Week						
Colorado[1, 2]												
High	0	0	0	1.05	1.32	1.69	1.68	1.47	1.11	.67	0	0
Low	0	0	0	.74	.77	1.18	1.18	1.14	.82	.54	0	0
Kansas[3]												
High	0	0	0	0	1.73	2.14	2.12	1.82	1.48	0	0	0
Low	0	0	0	0	1.14	1.50	1.23	1.16	1.13	0	0	0
Nebraska[4, 5]												
High	0	0	0	1.47	1.73	2.14	2.16	1.9	1.56	1.12	0	0
Low	0	0	0	1	1.07	1.39	1.59	1.43	1.25	.80	0	0
New Mexico[5, 6]												
High	0	.25	.56	1.09	1.54	1.96	1.96	1.86	1.54	1.09	.84	0
Low	0	0	0	.42	1.19	1.61	1.47	1.30	1.02	.70	.84	0
Oklahoma[5, 7]												
High	0	.34	.56	.81	1.14	1.45	1.67	1.47	1.08	.64	.34	0
Low	0	0	0	.51	.89	1.31	1.60	1.38	.93	.28	0	0
South Dakota[5, 8]												
High	0	0	.56	.90	1.25	1.55	1.76	1.55	1.08	.58	0	0
Low	0	0	0	.41	.56	.77	1.14	1.15	.72	0	0	0
Texas[5, 8]												
High	.49	.65	.93	1.25	1.51	1.68	1.67	1.55	1.25	.90	.60	.45
Low	0	0	.48	.80	.75	.67	1.04	.82	.53	0	0	0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Inches/Week						
Wyoming[5, 8]												
High	0	0	0	.88	1.23	1.59	1.76	1.52	1.07	.60	0	0
Low	0	0	0	.51	.67	1.11	1.34	1.20	.77	.38	0	0

Sources:

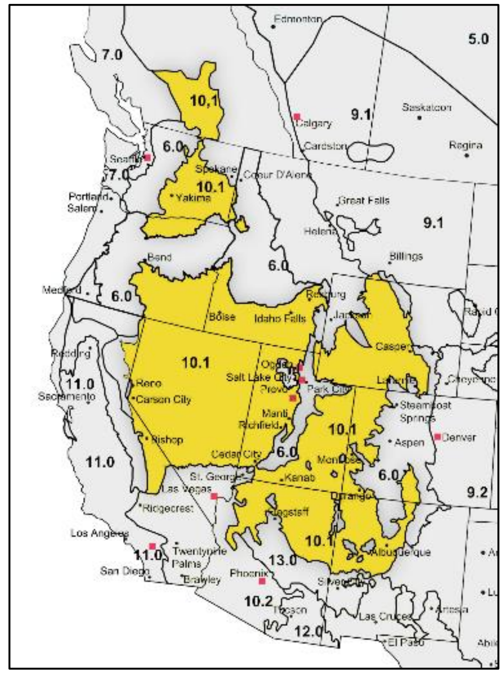
1 ccc.atmos.colostate.edu
2 northernwater.org
3 ksre.ksu.edu
4 ianrpubs.unl.edu
5 weather.com
6 aces.nmsu.edu
7 pods.dasnr.okstate.edu
8 climate.usurf.usu.edu

Ecoregion 10.1: Northern Cold Desert

The tables below represent the required irrigation as determined by local and historical evapotranspiration rates.

The two reference categories for weekly irrigation applications are high and low. The high category is based on the average evapotranspiration (ET) for the ecoregion and assumes zero precipitation. The low category also accounts for the average ET, but includes the expected annual precipitation for the area.

The numbers provided in the following tables indicate the amount of irrigation to apply in inches per week.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Inches/Week						
Arizona[1, 2]												
High	.37	.52	.84	1.18	1.58	1.94	1.88	1.67	1.29	.85	.49	.32
Low	0	.33	.68	1.09	1.50	1.89	1.66	1.42	1.10	.69	.37	0
California[1, 2]												
High	.32	.47	.80	1.14	1.52	1.87	2.01	1.78	1.33	.82	.45	0
Low	0	0	.58	.99	1.39	1.77	1.95	1.71	1.25	.70	0	0
Colorado[1, 2]												
High	0	0	0	.96	1.35	1.74	1.86	1.59	1.14	.67	0	0
Low	0	0	0	.69	1.13	1.56	1.61	1.32	.80	.36	0	0
Idaho[2, 3]												
High	0	0	0	.68	1.21	1.57	1.79	1.58	1.07	.54	0	0
Low	0	0	0	.32	.81	1.30	1.67	1.45	.88	.27	0	0
Nevada[1, 2]												
High	0	.33	.61	.90	1.28	1.63	1.87	1.63	1.15	.66	.33	0
Low	0	0	.43	.68	1.04	1.47	1.79	1.54	1.02	.49	0	0
New Mexico[4]												
High	0	0	0	.81	1.30	1.75	1.72	1.44	1.10	.77	.37	0
Low	0	0	0	.23	.86	1.38	1.44	1.10	.81	.39	0	0
Oregon[5]												
High	0	0	.19	.70	1.18	1.55	1.84	1.54	1.04	0	0	0
Low	0	0	0	.51	.91	1.38	1.75	1.44	.92	0	0	0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Inches/Week						
Utah[1, 2]												
High	0	0	0	.94	1.32	1.70	1.85	1.61	1.15	.67	0	0
Low	0	0	0	.57	.95	1.49	1.69	1.41	.88	.30	0	0
Washington[1, 2]												
High	0	0	0	.85	1.23	1.49	1.77	1.52	1.02	.50	0	0
Low	0	0	0	.59	.97	1.28	1.66	1.42	.89	.28	0	0
Wyoming[1, 2]												
High	0	0	0	.76	1.11	1.47	1.68	1.45	.96	.50	0	0
Low	0	0	0	.58	.83	1.23	1.51	1.31	.75	.34	0	0

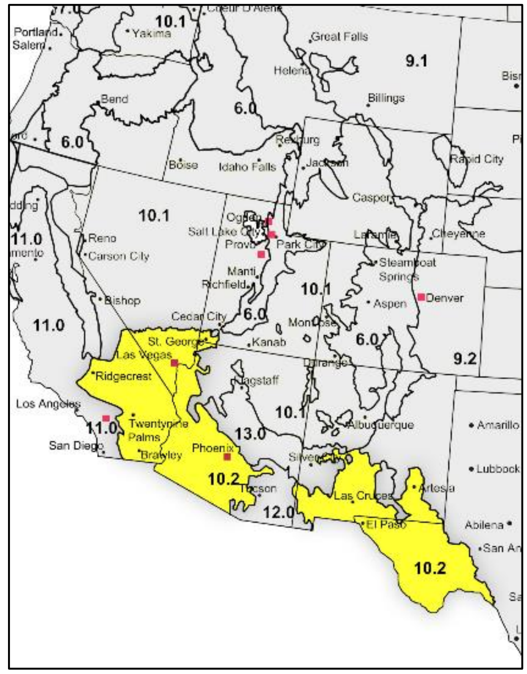
Sources:
1 climate.usurf.usu.edu
2 weather.com
3 data.kimberly.uidaho.edu
4 aces.nmsu.edu
5 ir.library.oregonstate.edu

Ecoregion 10.2: Southern Warm Desert

The tables below represent the required irrigation as determined by local and historical evapotranspiration rates.

The two reference categories for weekly irrigation applications are high and low. The high category is based on the average evapotranspiration (ET) for the ecoregion and assumes zero precipitation. The low category also accounts for the average ET, but includes the expected annual precipitation for the area.

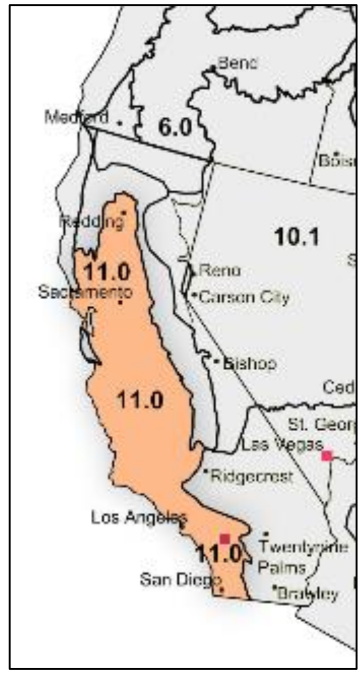
The numbers provided in the following tables indicate the amount of irrigation to apply in inches per week.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Inches/Week						
Arizona[1, 2]												
High	.57	.74	1.08	1.45	1.83	2.12	2.03	1.84	1.53	1.09	.70	.51
Low	.40	.53	.90	1.40	1.81	2.11	1.91	1.61	1.41	.99	.60	.36
California[1, 2]												
High	.44	.60	.90	1.23	1.56	1.86	1.95	1.78	1.39	.93	.56	.39
Low	0	.29	.72	1.18	1.54	1.85	1.89	1.69	1.32	.86	.45	0
Nevada[1, 2]												
High	.43	.60	.94	1.31	1.72	2.05	2.12	1.89	1.46	.95	.56	.38
Low	.27	.37	.78	1.25	1.68	2.03	2.00	1.74	1.39	.86	.46	0
New Mexico[3]												
High	0	.28	.67	1.26	1.65	1.86	1.72	1.47	1.19	.91	.70	0
Low	0	0	0	.88	1.33	1.51	1.47	1.12	.88	.67	.70	0
Texas[1, 2]												
High	.56	.75	1.08	1.47	1.76	1.93	1.78	1.64	1.33	1.01	.68	.51
Low	.43	.61	.99	1.33	1.49	1.52	1.28	1.09	.90	.71	.54	.36
Utah[1, 2]												
High	0	0	.85	1.21	1.64	1.98	2.06	1.81	1.38	.87	0	0
Low	0	0	.47	1	1.54	1.91	1.88	1.57	1.18	.64	0	0

Sources:
1 climate.usurf.usu.edu
2 weather.com
3 aces.nmsu.edu

Ecoregion 11.0: Mediterranean California



The tables below represent the required irrigation as determined by local and historical evapotranspiration rates.

The two reference categories for weekly irrigation applications are high and low. The high category is based on the average evapotranspiration (ET) for the ecoregion and assumes zero precipitation. The low category also accounts for the average ET, but includes the expected annual precipitation for the area.

The numbers provided in the following tables indicate the amount of irrigation to apply in inches per week.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Inches/Week						
California[1, 2]												
High	.42	.56	.82	1.10	1.37	1.58	1.71	1.58	1.28	.86	.52	.38
Low	0	0	0	.76	1.22	1.54	1.71	1.56	1.22	.59	0	0

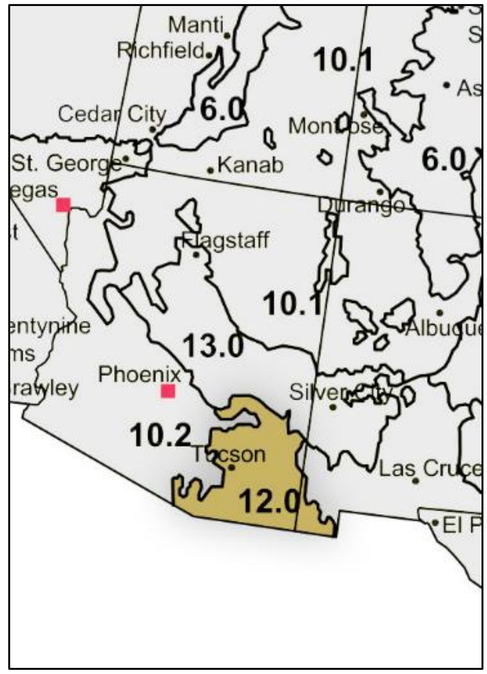
Sources:
1 www.climate.usurf.usu.edu
2 www.weather.com

Ecoregion 12.0: Southern Highlands

The tables below represent the required irrigation as determined by local and historical evapotranspiration rates.

The two reference categories for weekly irrigation applications are high and low. The high category is based on the average evapotranspiration (ET) for the ecoregion and assumes zero precipitation. The low category also accounts for the average ET, but includes the expected annual precipitation for the area.

The numbers provided in the following tables indicate the amount of irrigation to apply in inches per week.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Inches/Week						
Arizona[1, 2]												
High	.55	.73	1.06	1.44	1.80	2.09	1.89	1.67	1.43	1.06	.69	.50
Low	.34	.52	.92	1.37	1.74	1.96	1.30	1.07	1.11	.83	.53	.25
New Mexico[1, 2]												
High	.53	.72	1.04	1.42	1.76	2.03	1.83	1.63	1.39	1.03	.67	.48
Low	0	.57	.95	1.36	1.71	1.90	1.34	1.15	1.10	.80	.50	0

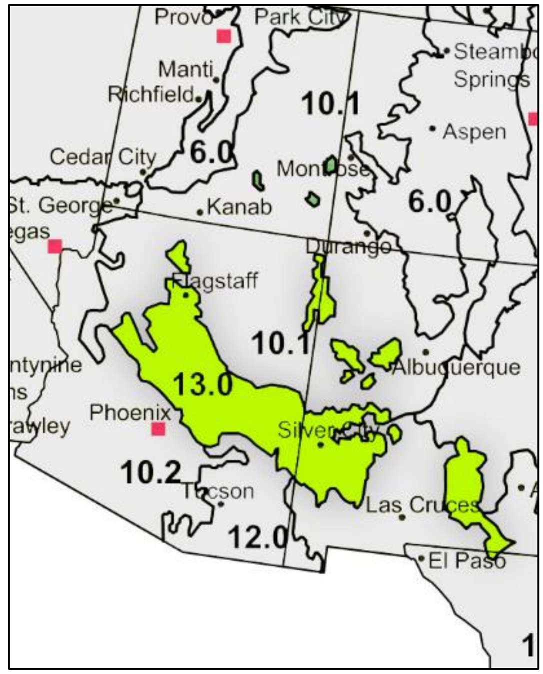
Sources:
1 climate.usurf.usu.edu
2 weather.com

Ecoregion 13.0: Southwest Mountains

The tables below represent the required irrigation as determined by local and historical evapotranspiration rates.

The two reference categories for weekly irrigation applications are high and low. The high category is based on the average evapotranspiration (ET) for the ecoregion and assumes zero precipitation. The low category also accounts for the average ET, but includes the expected annual precipitation for the area.

The numbers provided in the following tables indicate the amount of irrigation to apply in inches per week.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Inches/Week						
Arizona[1, 2]												
High	.34	.47	.73	1.05	1.40	1.72	1.69	1.47	1.17	.78	.47	.31
Low	0	.28	.58	.95	1.33	1.67	1.47	1.21	.98	.62	.34	0
New Mexico[1, 2]												
High	.39	.53	.78	1.11	1.44	1.75	1.63	1.40	1.14	.81	.51	.35
Low	0	.29	.61	1.00	1.27	1.59	.99	.64	.67	.48	.28	0

Sources:
1 www.climate.usurf.usu.edu
2 www.weather.com