PRO Green EXPO

Colorado Convention Center

Denver, CO | February 5 – 8

Irrigation Boot Camp Intro Session

Bill Carey & Lyle Fair

Colorado Convention Center

Denver, CO | February 5 – 8

Irrigation

Boot Camp Lite

Introduction

Plan Reading- 20 minutes

- Scale
- Symbols
- Legends

Concepts & Physical Attributes of Water- 45 minutes

- Water/Head Pressure
- GPM (Gallons per Minute)
- Inches per Hour

Break- 15 minutes

Plants & Soil- 45 minutes

- Categories (Low/Medium/High water usage)
- Soil Types and Irrigation Selection
- Irrigation System Options and Limitations
- Weather & ET (Smart) Controllers

Delivery Methods (Systems)- 45 minutes

- Drip & Micro-Spray
- Pop-up Sprays & Rotors
- Sub-surface
- Flood / Terracing

Programming Controllers- 30 minutes

Gallons per hour -or- Inches per hour

Precipitation Rate

LANDSCAPE TRAINING MANUAL FOR IRRIGATION TECHNICIANS

NATIONAL ASSOCIATION OF LANDSCAPE PROFESSIONALS

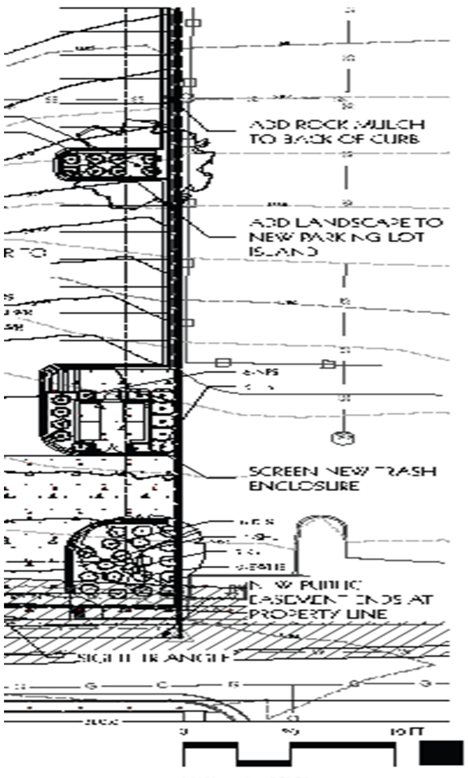
IRRIGATION

Hunter

TRAINING MANUAL SPONSOR

Plan Reading

- Title Block
- North Arrow
- Legend
- Specifications
- Drawing Scale
- Measuring Area



GENERAL NOTE:

PRIOR TO ANY USE OF THE NEWLY MODIFIED PARKING AND PEDESTRIAN ENHANCEMENT FACILITIES IDENTIFIED ON THIS SKETCH PLAN, THE LANDSCAPE [illegible] CITY OR AN IMPROVEMENT GUARANTEE SHALL BE PROVIDED TO THE CITY OF [illegible]

COLORADO CENTER FOR THE BLIND

SKETCH PLAN - CASE N SP17-0017

TOWNSHIP 5 SOUTH, RANGE 68 WEST OF THE 6TH PRINCIPAL MERIDIAN

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Architecture, Planning

Development Consulting

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REVISED:	
per staff comments	[illegible]
per staff comments	4-25-18
[illegible]	[illegible]

SHEET NO.

L1

LANDSCAPE PLAN

Overview

A landscape plan provides a lot of valuable information. It may show the original landscape layout or proposed changes to a current landscape, including plant locations or relocations, materials to be used and location of items like private electric or gas lines, domestic water supply lines, sewer lines, sprinkler lines, irrigation mainlines, isolation valves and backflow preventers, or relevant and existing fixtures, drainage, and/or topography on the site.

Reading and interpreting landscape plans enables you to:

- Understand the overall intentions of the landscape designer, i.e., what the final result will be.
- Identify the types and locations of materials that are specified by the design in the landscape plan.
- Estimate the quantity of materials needed to complete construction according to the design.
- Understand and estimate the maintenance needs according to the design.
- Avoid damaging private site utilities that a utility location service may not locate as part of their service.

This chapter describes the most common elements of landscape plans and how to estimate, calculate and measure installation materials or areas to be maintained.

Common Elements of Landscape Plans

There are several different types of landscape plans, including grading plans, planting plans, irrigation plans, etc. Though each type of plan has its unique drawing conventions, there are some elements that are common to nearly all landscape plans, such as, title block, specifications, north arrow, drawing scale and legend.

Title block

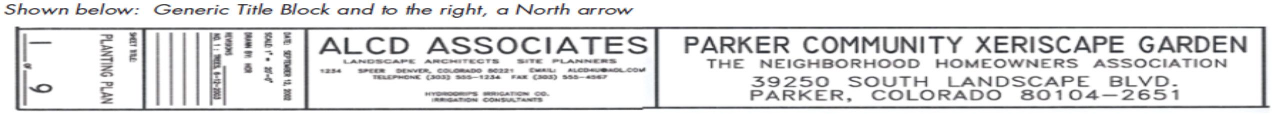
A title block is a collection of information about the landscape project and the drawing. It is typically contained in a box or rectangle along the bottom or side of a drawing on each page of a plan. Some or all of the following information is placed in the title block:

- Project name
- Client's name
- Sheet number
- Date
- Project location
- Designer's name
- Consultant's name
- Sheet title
- Drawing scale (sometimes)
- Landscape architect's seal (in some cases)

North arrow

A north arrow is a graphic symbol on the plan with an arrow or indicator that points north. The arrow's purpose is to orient a plan to the site so there is no confusion as to where the various aspects of construction or maintenance are to take place. North arrows are drawn many different ways. See one example below.

Shown below: Generic Title Block and to the right, a North arrow



Legend

Landscape designers use symbols on the plan to represent various different elements in the landscape. These elements can include physical objects, such as plants, pipes, sprinklers, etc., or imaginary objects, such as property boundaries and contour lines. A drawing legend shows the symbols used on a plan and indicates what they represent.

Specifications

Specifications are a list of instructions and requirements that the landscape contractor must follow when implementing a design. Specifications are intended to ensure that landscape construction is carried out to a satisfactory level of quality.

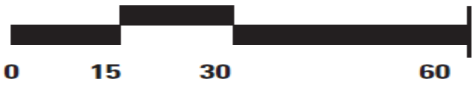
Specifications often include guidelines for:

- Product selection
- Excavation
- Planting techniques
- Grading and drainage
- Maintenance requirements
- Site preparation
- Mulching
- Cleanup
- Soil preparation

Drawing scale

Landscape plans are created to scale. This means there is a direct relationship between the distances on the drawing and the actual distances on the site. The drawing scale specifies this relationship.

For example, if a landscape plan has a drawing scale of 1″ = 20′, a walkway measured to be 1″ long on the plan is actually 20′ long on the site represented by the



Scale: 1" = 30'

The drawing scale is often shown with a scale bar like the one above. Scale bars are marked off in inches or fractions of an inch and labeled with the actual distance that each increment represents. Metric drawing scales use metric units. For example, the scale may read: 1cm = 15m.

plan. In metric units, if a landscape plan has a drawing scale of 1:100, a walkway measured to be 1 cm long on the plan is actually 100 cm or 1 metre long on the site represented by the plan.

There are several ways the drawing scale may be shown on a landscape plan. They include:

Equivalence

Example: "one inch equals fifty feet"

This means 1″ measured on the plan represents a distance of 50′ on the site.

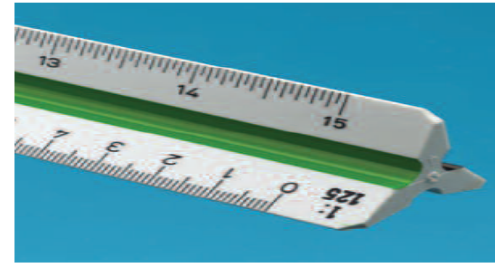
Ratio

Example: 1:600

A ratio shows the relationship between a measured distance on the plan and the actual distance on the site using the same units of measure. In this example, 1″ measured on the plan equals 600″ (50′) on the site. Metric scales always show ratios.

Architect's Scale

Engineer's Scale



Metric Scale

Scales for measuring plans

To estimate quantities from a landscape plan, you must be able to take accurate measurements from a drawing. This is greatly simplified by using a measuring device called a measuring scale, which should not be confused with a drawing scale described in the previous section. The most commonly used scales are approximately 12" (30 cm) long and look somewhat similar to a common ruler, but with a triangular profile. Each face of the scale is marked in two or more increments corresponding to a different drawing scale. The three most common scales are the architect's scale, engineer's scale and the metric scale. When using the correct measuring scale properly, distances on a plan can be read directly as distances on the site. (See *"How to read a scale"* on page 21).

Each is discussed below, followed by instructions on how to read a scale.

Architect's scale

Architect's scales are used to measure distances on plans drawn in architectural units. In architectural units, distances are read in feet, inches and fractions of an inch. Architectural units are often used in landscape plans for residential properties.

Architect's scales are marked in increments corresponding to the most commonly used architectural drawing scales ranging from 1/16" = 1' (one sixteenth of an inch equals one foot) to 3" = 1' (three inches equals one foot).

Engineer's scale

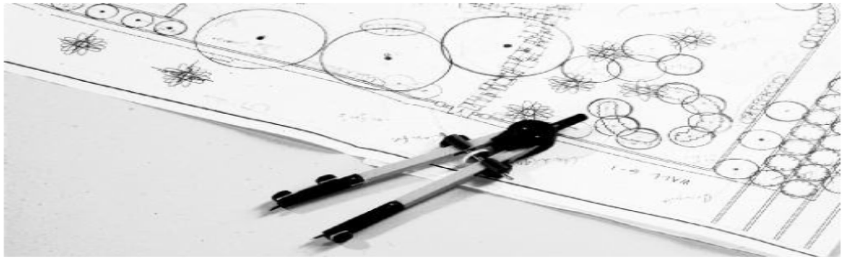
Engineer's scales are used to measure distances on plans drawn in decimal units. In decimal units, distances are read in feet and tenths of a foot. Decimal units are typically used in landscape plans for commercial properties.

Engineering scales are marked in divisions ranging from 10 units per inch to 60 units per inch. Each face of the engineer's scale can be used to read several different drawing scales. For example, the face marked in 20 units per inch can be used to read plans drawn at 1" = 2' (each mark equals 0.1'), 1" = 20' (each mark equals 1') or 1" = 200' (each mark equals 10'). With an engineer's scale, you can easily measure distances on plans with scales ranging from 1" = 1' to 1" = 600'.

Metric scale

Metric scales are used to measure distances on plans drawn in metric units of either metres or millimetres. Commonly used scales are 1:50, 1:75 and 1:100 for smaller projects.

Each face of the metric scale can be used to read several drawing scales. For example, the face marked 1:100 can be used for plans drawn to that scale, with each unit on the scale indicating one metre on the site. It can also be used for a 1:1000 drawing, with each unit on the scale indicating ten metres on the site.



Scaled drawings provide the basis for measurements.

Verify plan scale

Regardless of the scale you are using — engineer's, architect's or metric — be sure to use the correct scale, the one that matches the plan. Also, be sure that the plan was not enlarged or reduced, because this will cause the measurements to be incorrect. To verify whether the plan has been enlarged or reduced, use your scale ruler to measure the drawing scale on the plan.

Example

The plan scale states 1 inch equals 20 feet (1:20).

- When the measuring scale is placed on the plan's printed scale, the drawing scale, 1 inch equals 40 feet.
    - o This means that the plan has been reduced by half, causing the scale to double.
- Use the one inch equals 40 feet side of the measuring scale to obtain accurate measurements of the site.

How to use a scale

To use a scale, flip to find the face that matches the scale of the drawing you are working with.

1. Measure between two points on the drawing, as you would with a common ruler.
2. Read the distance from the scale. This is the actual distance. There is no need to perform calculations or conversions.

Read the top line of numbers on the scale from left to right and the bottom measurements from right to left (1/8" scale is read from left to right and the ¼" scale is read from right to left). Refer to the photos of the scale rulers on the previous page and to the example below explaining how to read scale.

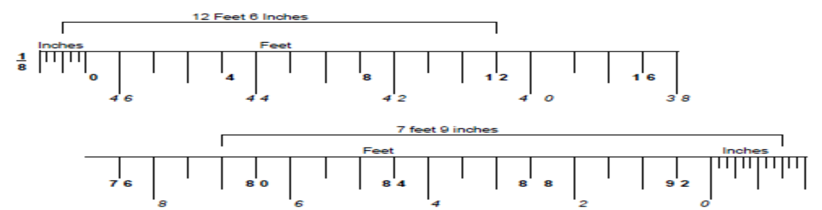
How to read an architect's scale

Often, the ruler will have two scales on it with the marks alternating one and then the other, odd to even. In the examples below, the 1/8" scale numbers are in **bold**, the ¼" scale numbers are *italic*.

Determine the scale to be used on your plan. Example: 1/8" = 1 foot (or ¼" = 1 foot).

Select the corresponding scale on the ruler. Each side will have four scales on it, so make sure you have the correct one. The scale will have several short marks to the left *(or right)* of a zero which represent divisions of a foot. Long marks to the right *(or left)* of a zero represent feet.

On the 1/8", the divisions are two inches each. On the ¼" scale, the divisions are one inch each. Confirm the readings illustrated below as 12' 6" and 7' 9".

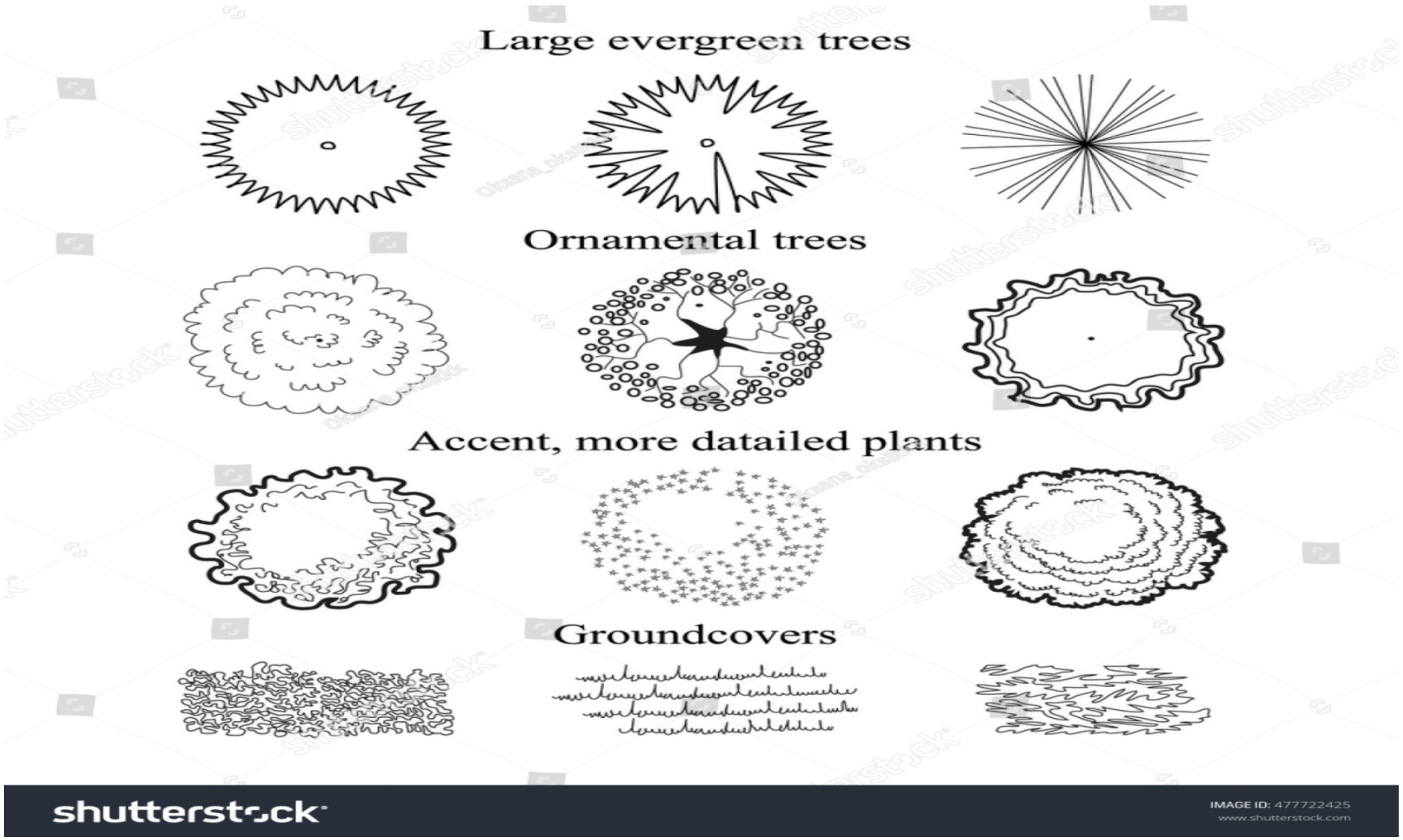


Architect's scale (Note: The architect's scale, as shown above, is not to scale. Its purpose is to illustrate how to read a scale.)

Scales are intended to be used as follows:

Line up the zero mark with the beginning of the section you want to measure. The nearest mark the line passes is the foot measurement. Then slide the ruler to the right (or left) and count the number of inches.

Landscape Legend



IRRIGATION SCHEDULE

MANUFACTURER	MODEL NO.	DESCRIPTION	DETAIL NO.
RAIN BIRD	1806-SAM-PRS WITH MATCHED PRECIPITATION RATE SERIES NOZZLE	POPUP SPRAY HEAD	8
RAIN BIRD	1806-SAM-PRS WITH MATCHED PRECIPITATION RATE SST & CORNER NOZZLE	POPUP SPRAY HEAD	8
RAIN BIRD	1812 SAM PRS WITH MATCHED PRECIPITATION RATE SERIES NOZZLE	HI-POP SPRAY HEAD	9
RAIN BIRD	1812 SAM-PRS WITH MATCHED PRECIPITATION RATE SST &CORNER NOZZLE	HI-POP SPRAY HEAD	9
RAIN BIRD	5006-PC/FC-SAM-R WITH # NOZZLE	GEAR DRIVEN ROTOR	10
RAIN BIRD	5012-PC-FC-SAM-R WITH # NOZZLE	HI-POP GEAR DRIVEN ROTOR	11
RAIN BIRD	PEB SERIES	ELECTRIC CONTROL VALVE	12 & 13
RAIN BIRD	44-LRC	QUICK COUPLING VALVE	14
RAIN BIRD	ESP-LXD (WITH ONE ESP-LXD-SM75 MODULE & LXMMPED) - 125 STATION	ELECTRIC CONTROLLER	3 & 4
RAIN BIRD	WR2-RFC	WEATHER SENSOR DEVICE	5
FEBCO	825YA	RP BACKFLOW PREVENTER	1
STRONG BOX	SBBC-15AL	BACKFLOW PREVENTER ENCLOSURE	2
OLDCASTLE / CARSON	REFER TO SPECIFICATIONS AND DETAILS	VALVE BOXES	VARIOUS
MATCO	201X	MANUAL DRAIN VALVE	15
	LINE SIZE - 2½" AND SMALLER	GATE VALVE	16
RAIN BIRD	PESB (1")	MASTER CONTROL VALVE	7 & 13
RAIN BIRD	FS100P (1")	FLOW SENSOR	6 & 13
	CLASS 200 BE - 2½" & SMALLER	PVC MAINLINE	17
	CLASS 200 BE	PVC LATERAL	17
	CLASS 160	PVC SLEEVING	18
TORO	BLUE STRIPE	POLY DRIP TUBING -¾" MIN. WIDTH	20 - 22
RAIN BIRD	XCZ-100-PRF	DRIP VALVE ASSEMBLY	20 & 13
		DRIP LINE BLOW-OUT STUB	21
RAIN BIRD	XERI-BUG	DRIP EMITTERS	22
RAIN BIRD	FD-101TURF	VALVE DECODER	6, 12, 13 & 20
RAIN BIRD	SD-201TURF	SENSOR DECODER	6
PAIGE	P7072D	2-WIRE DECODER CABLE	6, 12, 13 & 20
RAIN BIRD	LSP1TURF	SURGE PROTECTION	19
		WATER METER	BY OTHERS

CONTROLLER & STATION NO.
CONTROL VALVE SIZE

A (controller)
NUMBER OF SPARE WIRES - 2 CONTROL AND 1 SPARE
WIRES TO WHICH CONTROLLER - SEE CONSTRUCTION NOTES

Area calculations

Area is the measure of the surface within a closed boundary. In landscape applications, area calculations can be used for numerous situations, such as determining the number of ground cover plants needed to fill a planting bed, the quantity of sod needed to cover a new lawn area or the amount of product needed to treat an area with fertilizer or weed control compounds.

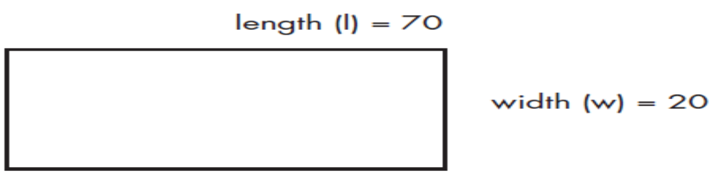
If measurements are being used to order materials, it may be necessary to add a waste factor, for example for sod installation. (See the chapter “Turf Installation”).

Area calculations are usually expressed in square units, such as square inches, square feet, square yards or square metres. Sometimes, square units are shown with the superscript “2,” an exponent, such as m^2 (square metres) or ft^2 (square feet).

This section lists formulas used to calculate the area (the value A) for a number of common shapes.

Example calculations — Area

Rectangle

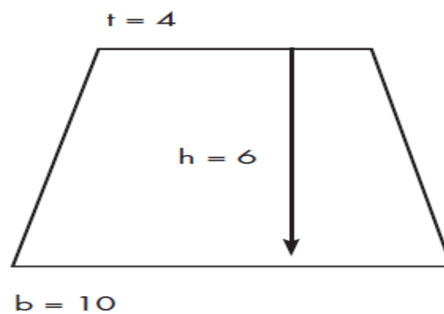


Rectangle Area = l x w

$A = 70 \times 20$

$A = 1400$

Trapezoid



Trapezoid Area = ½ (b + t) h

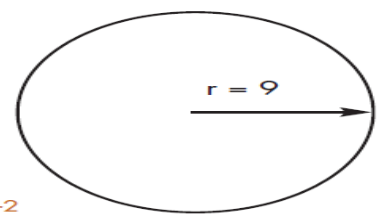
$A = \frac{(10 + 4)\,6}{2}$

$A = \frac{(14)\,6}{2}$

$A = \frac{84}{2}$

$A = 42$

Circle



Circle Area = πr^2

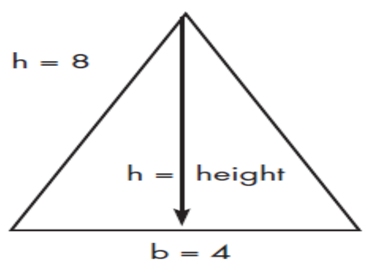
$A = 3.14 \times 9^2$

$A = 3.14\ (9 \times 9)$

$A = 3.14 \times 81$

$A = 254.34$

Triangle



Triangle Area = ½ (base x height)

$A = \frac{4 \times 8}{2}$

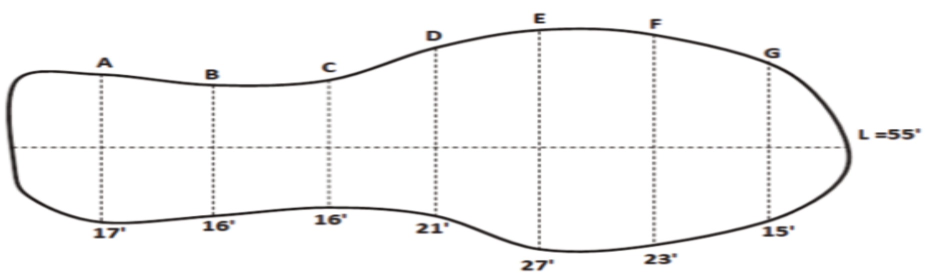
$A = \frac{32}{2}$

$A = 16$

Area calculations for irregular shapes

Calculating the area for shapes with irregular borders requires a different method than those described above. The results may not be as precise as for regularly shaped areas. To approximate the area of a shape with irregular borders, use the following procedure:

1. Measure a long (L) axis of the area.
2. Measure the width at right angles to the length. Make multiple measurements at equal distances.
3. Add all width measurements and divide by the number of measurements taken to get the average width.



Average width (W) = (A+B+C+D+E+F+G)/7
= (17+16+16+21+27+23+15)/7
= 135 ft/7 = 19.3 ft

Area = L x W
Area = 55 ft x 19.3 ft = 1061.5 sq ft

Concept & Physical Attributes of Water

- Water & Head Pressure
- Gallons per Minute
- Inches per hour

Hydraulics

Hydraulics is the science of liquids (water) in motion. This section reviews some of the properties and behaviors of water — basic hydraulics — that must be considered in the design of irrigation systems.

Water equivalents

Some important equivalents in measuring water include:

- 1 gal of water weighs 8.3 lbs
- 1 cu ft of water equals 7.48 gals
- 1 cu ft of water weighs 62.4 lbs, which is referred to as the specific weight of water
- 1 ml of water equals 1 cm^3 and weighs 1 g (gram)
- 1 litre of water weighs 1 kg
- 1 m^3 of water weighs 1000 kg

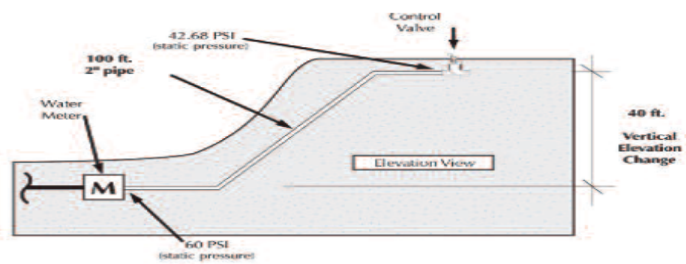
Water pressure

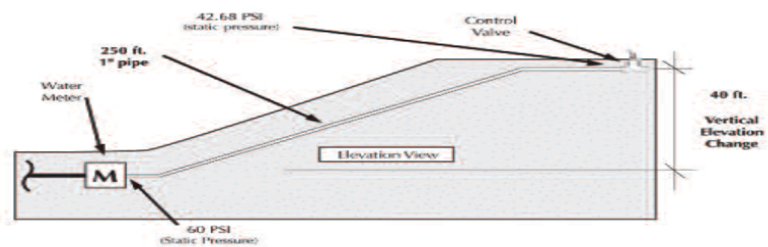
Water pressure is the force that water exerts over a given area. Water pressure is created either by the weight of water (such as in a water tower) or by the use of a pump. Sprinkler heads and other water-emitting devices are designed to operate within a certain pressure range. If water pressure is too low, sprinkler heads discharge large drops of water and may not apply uniform coverage to the area they are designed to irrigate. If water pressure is too high, the spray radius may be exceeded and the sprinkler heads may discharge a fine mist, which can increase water loss from wind drift and evaporation. Once again, the area does not receive uniform coverage of water.

If the supply system pressure is inadequate for proper performance and coverage, pressure regulators may be needed to lower pressure if it is too high or booster pumps may be needed to increase the system pressure.

Water pressure and elevation

Water pressure changes with elevation. This is known as feet of head (metres of head). A water tower provides an example of how water pressure is increased with elevation; the higher the tower, the greater the water pressure at the base. By knowing the conversion factors between pressure and elevation, the static (non-flowing) water pressure can be determined at the base of a tower or the bottom of a pipe at any elevation. For example, 1 ft of water exerts 0.433 psi at the bottom. If the elevation is 2 ft, the pressure is doubled to 0.866 psi (2 x 0.433) at the bottom. Refer to the diagrams below that show two sprinkler pipe configurations. Each has a different length of pipe, but both have the same vertical elevation change. The static pressure is the same for both.





The diagrams show that only vertical changes in elevation affect static pressure.

Conversions for water pressure

- 1 ft of water (1 foot of head) exerts 0.433 psi (pounds per square inch) at the bottom
- 2.31 ft of water exerts 1 psi at the bottom
- 1 psi equals 2.31 ft in elevation change
- 1 m of water exerts 9.79 kPa (kilopascals) at the bottom
- 1 kPa equals 0.102 m in elevation change

Sample Calculation — U.S. Standard/Imperial

To convert feet of head to pressure in pounds per square inch (psi), multiply feet by 0.433.

Note: Feet of head always refers to change in elevation.

Example:
What is the pressure (psi) at the base of 200 ft of water?

200 ft x 0.433 psi per foot = 86.6 psi at the base
To convert pressure in psi to feet of head, multiply the pressure by 2.31.

Example:
100 psi x 2.31 = 231 feet of head

Note: 2.31 is the inverse of 0.433, so multiplying by 2.31 is the same as dividing by 0.433 because 1/0.433 = 2.31.

Water Distribution & Gallons per Minute

Water Distribution

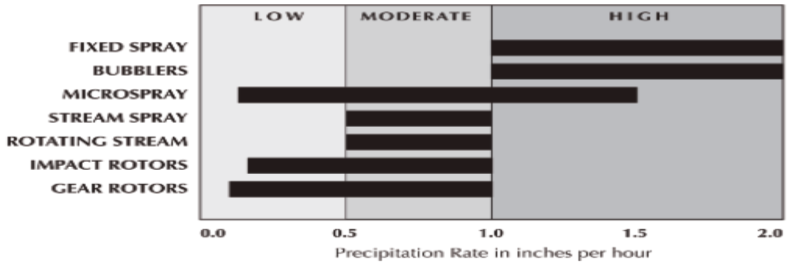
Water distribution refers to the amount of water delivered to each area. Uniform water distribution is an ideal situation in which each irrigated area receives the same amount of water. Distribution uniformity (DU) depends on proper distribution rates from the sprinkler heads and proper spacing of the sprinkler heads. This section discusses sprinkler precipitation rates, methods to calculate precipitation rates and ways to help achieve uniform coverage.

Sprinkler precipitation rates

In an irrigation system, precipitation rate, or PR, refers to the rate at which sprinkler heads apply water to the landscape area, and PR is measured in inches per hour (mm per hour), the same way that natural precipitation is measured. The precipitation rate should be as consistent as possible throughout a zone to avoid areas of overwatering or underwatering.

Different sprinkler types have different precipitation rates. For example, fixed spray sprinkler heads generally have a high PR, which is 1.0"/hr (25 mm/hr) and above. The PR for rotating stream sprays is medium or moderate (0.5" to 1.0"/hr (12.5 mm to 25 mm/hr). Rotor sprinkler heads have a moderate to low PR. Refer to the chart, which shows the general relationship between precipitation rates and sprinkler types.

TYPICAL PRECIPITATION RATE RANGES

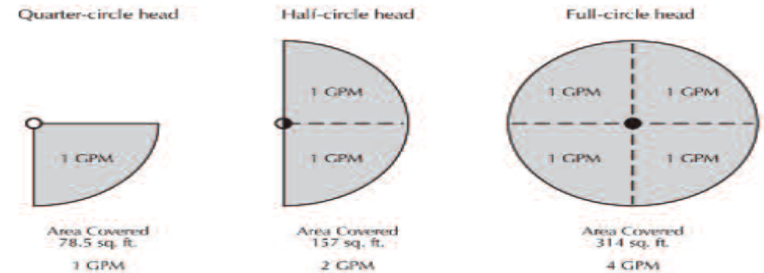


To ensure a uniform precipitation rate throughout a watering zone, follow these guidelines:

- Use sprinkler heads with the same precipitation rates (also known as matched precipitation rates). Matched precipitation rates mean that each sprinkler in a zone is providing about the same amount of water to a given area.
- Use only heads of the same type. In other words, avoid mixing rotor heads and pop-up spray heads on the same zone unless matched precipitation nozzles are used.
- When making repairs on a sprinkler system, if mixing heads from different manufacturers, be sure that precipitation rates are matched by installing comparable flow-rated nozzles.

Note: It is important to understand how the arc of a sprinkler, the sprinkler flow rate and the precipitation rate are related. Sprinklers with matched precipitation rates may have different flow rates. For example, to achieve matched precipitation rates in an irrigation area that has both quarter circle and half circle arcs, the flow rate (in gpm or L/m) of the half-circle head must be double that of the quarter-circle head. Refer to the diagram on this page.

MATCHED PRECIPITATION RATE HEADS



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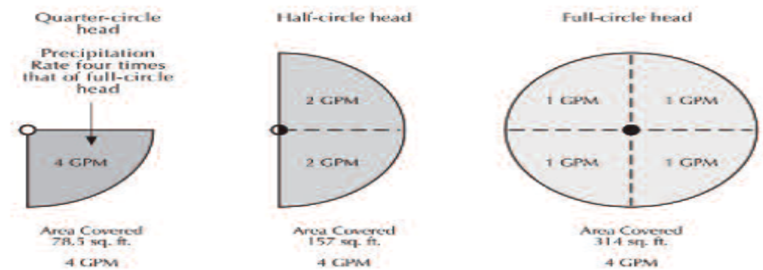
SPRINKLER HEADS THAT DO NOT HAVE MATCHED PRECIPITATION RATES



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Fixed spray heads have a high precipitation rate.

Rotating stream sprays have a medium PR.

Rotor heads have a low to moderate precipitation rate.

Hunter Industries

Precipitation Rate

Calculating precipitation rates for an area

Precipitation rate (PR) is measured in inches (mm) of water applied per hour to the irrigated area. The basic formula used to calculate the PR for irrigation systems is shown below, along with some variations for different sprinkler patterns.

Method 1 — Total Area Method

Sample Calculation — U.S./Imperial Formula

$$PR = \frac{96.25 \times \text{Total gpm}}{\text{total area in square ft}}$$

Where 96.25 is the constant that converts gallons per minute per square foot to inches per hour.

Method 1 — Sample Problems

U.S./Imperial

Calculate the precipitation rate (PR) for an irrigated area measuring 60 ft x 15 ft, containing the following sprinkler heads:

6 half circle (1.0 gpm nozzles)
4 quarter circle (0.5 gpm nozzles)

1. Total gpm = (6 x 1.0 gpm) + (4 x 0.5 gpm)
   = 8.0 GPM
2. Total Area = 60 x 15 = 900 sq ft
3. $PR = \frac{96.25 \times 8.0 \text{ gpm}}{900 \text{ sq ft}}$
   PR = 0.86 in/hr

Note: The total flow rate (gpm) for the area is calculated by adding the gpm for each head in the area.

Precipitation rate and infiltration rate

Infiltration rate is the rate at which water enters the soil. Sandy soils have a higher infiltration rate than clay soils. See the chapter, "Water Management," for more details.

The precipitation rate should not be greater than the infiltration rate. Otherwise, runoff will occur. Some strategies to avoid runoff on clay soils, which have a low infiltration rate, include:

- Using sprinkler heads with a low precipitation rate.
- Using the "cycle and soak" feature on the controller, if available, or set sprinklers to water multiple times in each zone.
  - Break up the total watering time for each zone into several segments or cycles by operating a zone for a short time, allowing the water to soak in, and then repeat the watering and soaking cycle. An example of a cycle and soak schedule is: water 3 times a day; water 4 minutes each cycle; wait 1 hour between watering cycles (soaking period).

Break- 15 minutes

Plants & Soils

- Categories (Low/Medium/High water usage)
- Soil Types and Irrigation Selection
- Irrigation System Options and Limitations
- Weather & ET (Smart) Controllers

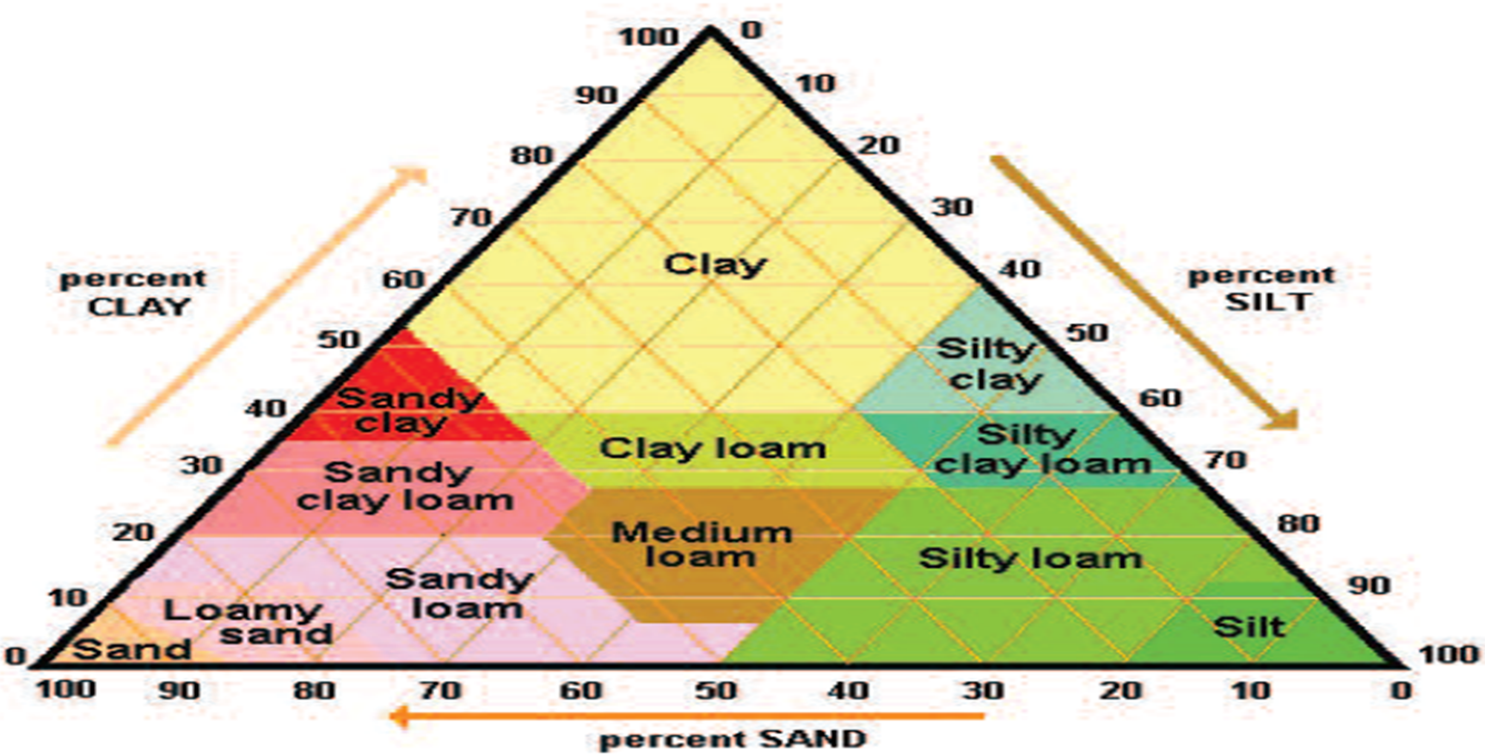
Relationship Between Soil and Water

When developing an irrigation schedule, soil properties must be considered since different soils take in and drain water at different rates.

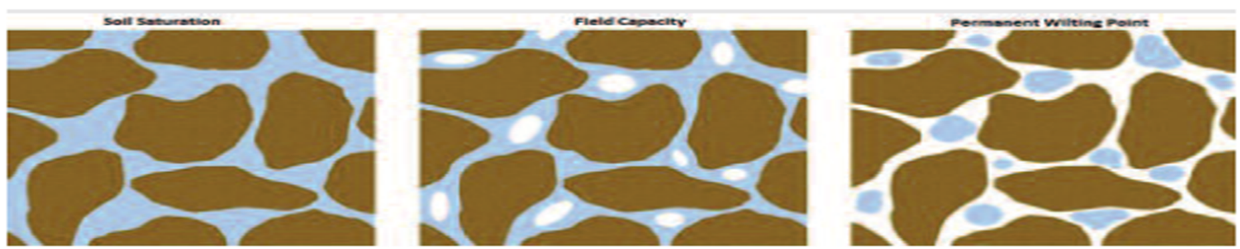
Soil properties

Soil is composed of sand, silt and clay particles. Sand particles are the largest and clay particles are the smallest. The percentage of each of these particles in soil determines the soil texture. Sandy clay, silty sand, clay loam and loam are some examples of different soil types. Based on the soil texture triangle, loam can vary. For example, it can be approximately 20% clay, 40% silt and 40% sand or about 25% clay, 40% silt and 35% sand. Sand, silt and clay are inorganic components of soil. When these inorganic components are combined with organic matter, this process creates soil structure. Soil structure can be improved by adding more organic matter. (See the chapter *"Plants and Planting"* for more information on soil texture and soil amendments.)

Spaces between soil particles can contain air and water. This is referred to as pore space. The most desirable condition for plant roots is a soil containing 50% pore space. Site construction or other activities that compact the soil diminish pore space.



Soil Texture Triangle: Clay percentages are read from left to right across the triangle. Silt is read from the upper right to lower left. Sand from lower right towards the upper left portion of the triangle.



This diagram shows how pore space varies with differing amounts of water. Soil particles are dark, air is white and water is blue. From left to right: soil saturation, field capacity, permanent wilting point.

Infiltration rate and field capacity

When water is applied to the soil surface, it moves downward filling pore spaces. Infiltration rate is the rate at which water moves into soil. Infiltration rate is important to irrigation scheduling because if water is applied to the surface faster than the infiltration rate, runoff occurs and water is wasted.

Furthermore, the rate at which soil absorbs water decreases as more water is applied. The point at which soil pore spaces are filled with water and the soil cannot absorb any more, is the saturation point. In saturated soil, roots of most plants cannot function or remain alive for very long because they do not get enough oxygen. In saturated soil, water displaces the air in the pore spaces. In this condition, with too much water and not enough oxygen, the plants are said to "drown."

Soil remains saturated until it is allowed to drain, which could take a day or more. Field capacity (FC) is the amount of water stored in the soil after it is allowed to drain, or move downward beyond the root zone, due to gravity. Field capacity and saturation point should not be confused.

Infiltration rate and field capacity vary with different soil textures. Clay soils have the lowest infiltration rate but retain water the longest. Clay soils should be irrigated at a low rate and require irrigation less frequently. To avoid runoff on clay soils, multiple start times in combination with shorter runtimes must be scheduled. Use the cycle and soak feature, if the controller has this feature. Water is applied until field capacity is approached and then watering is stopped. Once the water soaks in, the next cycle can begin, again for only a short run time. The "Irrigation Concepts" chapter provides a sample watering schedule for clay soils to avoid runoff.

Sandy soils have a higher infiltration rate and drain faster than clay soils. Sandy soils can be irrigated at a lower rate, but should be irrigated more frequently. Nutrients and chemicals can be washed away in fast draining sandy soils, which have poor cation exchange capacity (CEC). A cation is a positively charged element, including K^+ and H^+. CEC is an indication of a soil's ability to hold nutrients. See the "Plants and Planting" chapter for more information about soil types, including drainage and CEC.

Plant water Needs

- **Low Water Requirement Plants**
- Plants that require low levels of water are often called drought tolerant. Drought-tolerant plants can thrive in hot, dry conditions with very little water. They include both perennials and annuals. Most drought-tolerant plants only have to be hand-watered when they are planted and while they are establishing themselves. After that, they can be left to the natural cycle of the elements. Popular drought tolerant trees include the red cedar. live oak, crape myrtle, and the windmill and saw palmetto palm trees. All citrus trees are also drought tolerant. Many homeowners in areas prone to drought, such as parts of the southern United States, use shrubs and ground covering vines as part of their landscaping. These include Texas sage, orange jasmine and Chinese fountain grass. There are not many perennial drought-tolerant plants, but amaryllis is one that is very popular, along with the African iris. Popular drought-tolerant annuals include marigold, cosmos and the Dahlberg daisy.
- **Mid-Level Water Requirement Plants**
- Most plants land in this range when it comes to water requirements. These plants do not need to be watered every day, but they need to be watered when the soil has been dry for over a week or two. Sometimes these plants are classified as plants lying in the "occasional water zone". These include popular plants such as geraniums, most roses, wisteria, clematis and other vine plants, sunflowers, spring flowering bulbs, and most flowering perennial shrubs. Note that flowering annuals planted in containers will need watering at least once or twice a week, while annuals planted in the ground will need watering less often.
- **High Water Requirement Plants**
- Some plants require large amounts of water. These plants typically grow in marshy areas or bogs, or along the banks of rivers, streams and lakes. The soil for these plants should always be kept moist. Standing water is not a concern for these plants, so you don't have to worry about root rot. Perennials are especially good for wet areas because they don't have to be replanted year after year, which can be difficult in marshy areas. Popular perennials for wet soil include iris plants, cannas, bee balms, ferns, and bog salvia. Aquatic mint is a pleasant ground cover that likes wet soil. The red osier dogwood does very well in wet conditions. Most annual flowering plants also do well in constantly moist soil.

SPRINKLER RUN TIME SCHEDULE SPREAD OVER 7 DAYS

Water to Apply Each Week	Spray Sprinklers	PGJ Rotors	PGP® Rotors	I-20 Rotors
1"	40 min.	130 min.	150 min.	150 min.
2"	80 min.	260 min.	300 min.	300 min.

CITY OF AURORA				
Parks and Open Space Department				
2003 XERISCAPE PLANT LIST				
Trees and Evergreens				
		Garden Centers of Colorado Rating		
BOTANIC NAME	COMMON NAME	**X**	**XX**	**XXX**
Acer ginnala (all cultivars)	**Amur Maple**	■		
Acer grandidentatum	**Bigtooth Maple**			
Acer tataricum	**Tatarian Maple**		■	
Aesculus glabra	**Ohio Buckeye**		■	
Aesculus pavia	**Red Buckeye**		■	
Aescuclus hippocastanum	**Horsechestnut**		■	
Amelanchier sp.	**Serviceberry**	■		
Examples: Amelanchier alnifolia	*Saskatoon Serviceberry*	■		
Amelanchier alnifolia 'Regent'	*Regent Serviceberry*	■		
Amelanchier 'Autumn Brilliance'	*Autumn Brilliance Serviceberry*	■		
Amelanchier canadensis	*Shadblow Serviceberry*	■		
Catalpa speciosa	**Western Catalpa**	■		
Celtis occidentalis	**Hackberry**		■	
Cercis sp.	**Redbud**	■		
Crataegus sp.	**Hawthorn**			
Examples: Crataegus ambigua	*Russian Hawthorn*			
Crataegus arnoldiana	*Arnold's Hawthorn*			
Crataegus crus-galli	*Cockspur Hawthorn*			
Crataegus crus-galli var. inermis	*Thornless Cockspur Hawthorn*			
Crataegus douglasii	*River Hawthorn*			
Crataegus mollis	*Downy Hawthorn*			
Crataegus phaenopyrum	*Washington Hawthorn*		■	
Crataegus succulenta	*Fleshy Hawthorn*			
Crataegus virdia 'Winter King'	*Winter King Hawthorn*		■	
Examples: Gleditsia triacanthos inermis 'Imperial"	*Imperial Honeylocust*	■		
Gleditsia triacanthos inermis 'Shademaster'	*Shademaster Honeylocust*	■		
Gleditsia triacanthos inermis 'Skyline'	*Skyline Honeylocust*	■		
Gleditsia triacanthos 'Sunburst'	*Sunburst Honeylocust*	■		
Gymnocladus dioica	**Kentucky Coffeetree**		■	
Juglans nigra	**Black Walnut**			
Juniperus sp.	**Juniper (all types)**		■	
Koelreuteria paniculata	**Goldenrain Tree**	■		
Malus sp.	**Apple and Crabapple (all types)**	■		
Phellodendron amurense	**Amur Corktree**		■	
Pinus sp.	**Pine**			
Examples: Pinus aristata	*Bristlecone pine*			
Pinus cembroides edulis	*Pinyon Pine*			
Pinus flexilia	*Limber Pine*			
Pinus nigra	*Austrian Pine*			
Pinus ponderosa	*Ponderosa Pine*			
Pinus strobiformis	*Southwestern White Pine*			
Pinus sysivestris	*Scotch Pine*			

Irrigation System Options

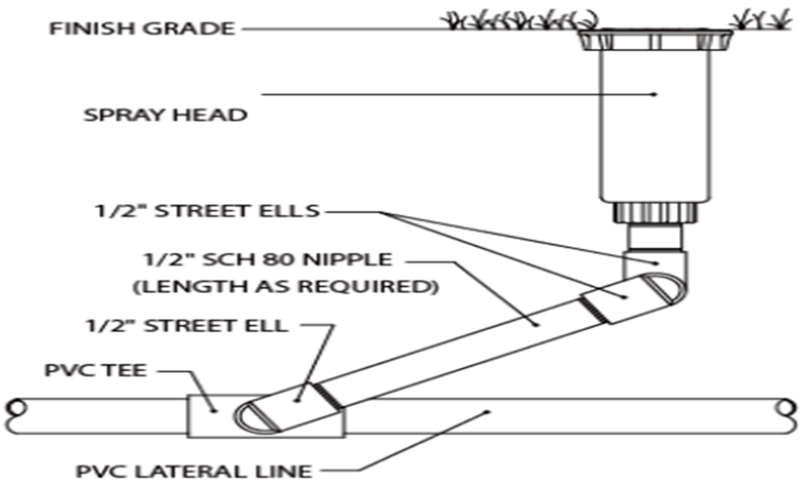
Sprinkler heads emit a spray of water on turf areas and planting beds. They attach to laterals using either a rigid PVC riser or swing pipe as specified by state or provincial code. Sprinkler heads are available in many varieties to match different site conditions, available water pressure, etc. The two main types of sprinkler heads that are described in this section are spray heads and rotors. (Refer to the detailed drawings that show proper sprinkler head installation).

Spray heads

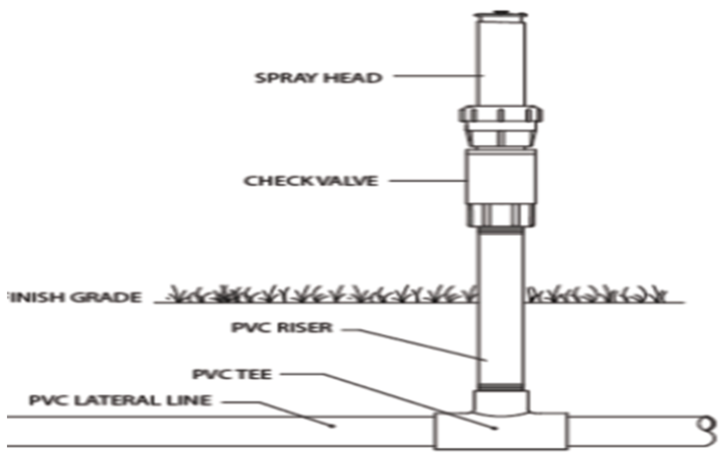
Spray heads discharge a continuous spray of water at distances typically ranging from 5 – 15' (1.5 – 5 m). The two main types of spray heads are risers and pop-ups.

Note: If an irrigation system is supplied with non-potable water, the caps on the heads must be purple. This color is a standard indicator of non-potable water.

Pop-up spray sprinkler detail



Pop-up spray heads are installed below the turf line or at grade. When the water is turned on, they pop up and spray. When the water is turned off, they retract. They are available in different spray patterns, including full-circle, half-circle, quarter-circle, fully adjustable and in special patterns for long, narrow strips. Pop-ups are commonly used in lawns and planting beds. Refer to the diagrams showing the details.

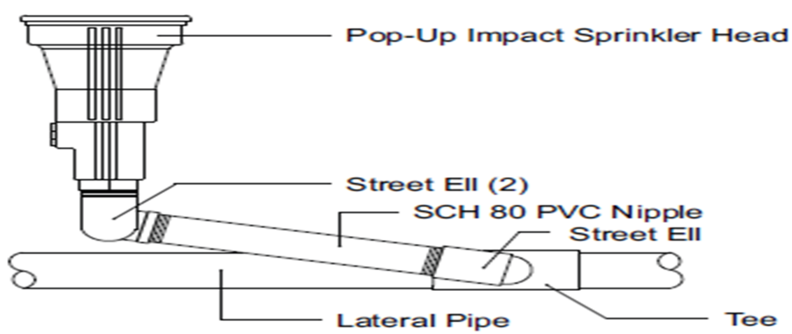


Rotors

Two basic types of rotors are impact rotors and gear-driven rotors. Rotors rotate in a full or partial circle. They have a larger spraying radius than risers or pop-ups and are best suited for large turf areas. Rotors tend to be more costly than spray heads, but fewer heads are needed to cover a given area. Rotors are available in pop-up models and in fixed versions for mounting on risers.

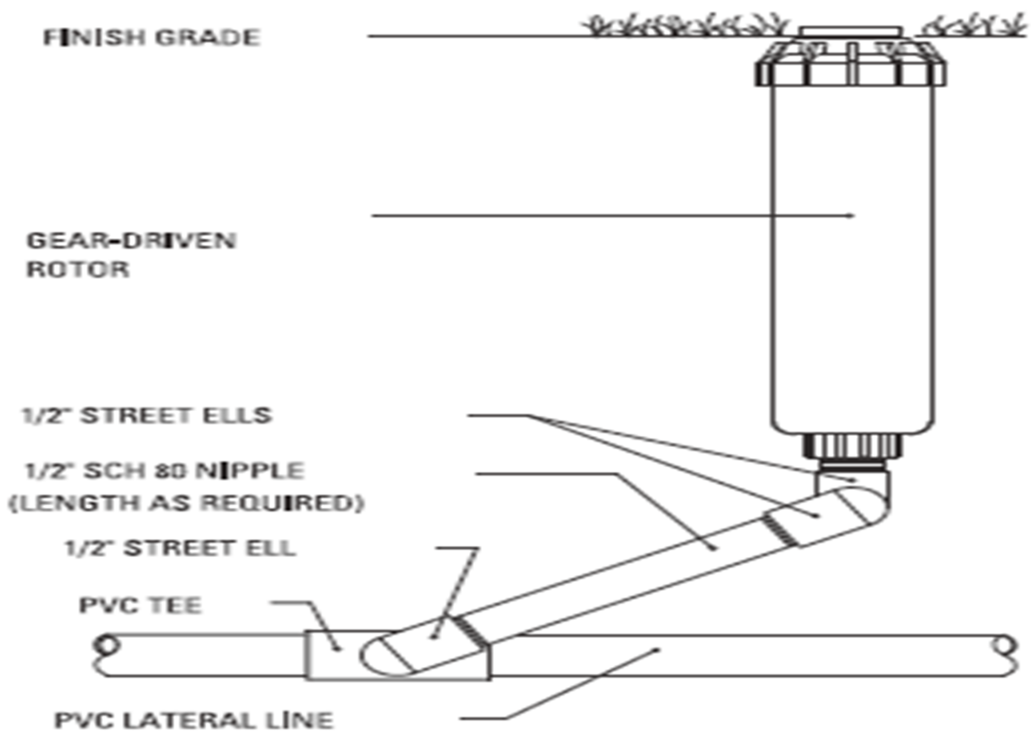
Impact rotors have a spring-loaded arm that swings sideways when contacted by water sprayed through the nozzle. When the arm swings, it impacts the sprinkler body, causing it to rotate a small amount. Each time it rotates, a new section of lawn receives water. Impact sprinklers can be adjusted to rotate in a full or partial circle. Impact rotors are easily recognized by the loud, distinct noise they make while operating.

Impact rotor sprinkler detail



Gear-driven rotors are turned by the water, which causes the gears to turn and then the head to rotate. They do not have the noise of impact sprinklers. Impact and gear-driven rotor heads may be attached to the piping using either a rigid PVC riser or swing pipe, as specified by state or provincial code.

Gear-driver rotor sprinkler detail



Low-Volume Irrigation

Low-volume or drip irrigation provides a watering system that applies water at a slow rate directly to the base of plants. Drip irrigation operates at low pressure and carries water through flexible polyethylene pipe or tubing. It can be discharged through emitters installed only where water is desired, or along the length of inline emitter tubing. This tubing can be placed either on the surface, covered with mulch, or buried underground.

Inline irrigation tubing and low-volume emitter.

Drip irrigation systems require lower water pressure than spray systems to work properly, so pressure regulators are usually required at the valve. Emitters used in drip systems can become easily clogged, so a water filtration (Y-strainer) must be incorporated into drip systems.

One of the advantages of drip irrigation is that it minimizes evaporation and runoff. Drip irrigation is an efficient way to water planting beds, as well as individual trees and shrubs. Drip irrigation is measured in gallons per hour (gph) or litres per hour (L/h) rather than gallons or litres per minute.

Drip Irrigation

Advantages

- Water is distributed only where needed
- Weed growth is reduced, since water is applied only to selected areas
- Runoff is reduced or eliminated if runtimes are properly scheduled on the controller
- Evaporation is reduced
- Low water pressure means leaks are less critical
- When properly designed, installed and managed, system benefits and payoffs include savings on water costs and maintenance costs for weed control, reduced "carbon footprint."

Disadvantages

- Sub-surface piping cannot be easily inspected for proper function
- Pressure regulation is required
- Filtration is required
- Surface systems are vulnerable to damage and vandalism
- May have higher upfront cost (installation) before payoffs are realized

Drip valve assembly with a valve, filter and pressure regulator

In-line tubing with built-in emitters

Microspray emitter

Multi-stream bubbler component

Controller Types & Programming

Electro-mechanical controllers

Electro-mechanical controllers have been in use for many years. They are driven by motors and gears and are considered dependable, but they have limited features and are relatively inflexible in their ability to set different watering rates for different watering zones.

Electronic (solid state) controllers

Electronic controllers are more complex and are controlled by microprocessors. They are also called solid state controllers. They have more sophisticated programming capabilities and allow for more flexible irrigation schedules.

Smart controllers

"Smart" controllers, as defined by the Irrigation Association, are controllers that automatically update the watering schedule to allow for changes in water needs throughout the year.

Courtesy of Hunter Industries

This ET system is an optional accessory for some controllers that measures environmental conditions, calculates the local ET and initiates a new watering schedule that replenishes only the water that is actually needed.

Programming controllers

Electro-mechanical controllers are programmed using a series of dials and switches. Electronic controllers are programmed through a keypad or a dial and keypad interface. Though different controllers have different methods of programming, they all require the following information to be entered:

- Current day and time
- What days to water
- What time of day each cycle should begin
- How long each zone should operate

When a controller is programmed, be sure to modify the program as evapotranspiration (ET) rates change, that is, as weather conditions change. This could be weekly, bi-weekly or monthly. It is usually not necessary to completely reprogram the controller to make adjustments in a program. For example, as weather conditions change — and therefore ET rates change — adjust the amount of time or number of days to irrigate. The easiest way to modify the base program is to adjust run days or run times.

Central control systems

Central control systems are sophisticated computer-based systems that operate controllers, sensors and other parts of irrigation systems from a central location. These high-tech systems provide an extremely efficient means of controlling large or complex irrigation installations.

A central control system has a central computer that can be placed in a remote location. This computer communicates (using various methods, such as hard wiring, radio, phone lines or the Internet) with an on-site control device that monitors and controls the various components of the irrigation system.

> Central control systems can be programmed off site.

Actions that affect an entire system, such as adjusting watering times for different seasons, can be programmed from a central control system. Some systems can interface with sensors that monitor wind, weather, rain and soil moisture. If environmental conditions exceed pre-defined limits, the central control system responds by adjusting watering schedules.

Multiple program controllers allow you to enter different programs for different groups of zones. For example, Program A can irrigate turf zones, Program B can irrigate low water use shrubs and Program C can irrigate trees.

When entering multiple programs, be careful not to overlap run times. If the run time of one program overlaps the start time of another program, the second program will most likely run at the end of the first program.

Environmental sensors

Environmental sensors are devices that interface with controllers, shutting down an irrigation system when water is not needed. Different sensors are available that can monitor rainfall, soil moisture, humidity, air flow (wind) and temperature. Sensors can be integrated into a complete irrigation management system using smart controllers.

Rain sensors are the most common type of sensors. These sensors have a collection device that gathers rainwater. When enough rainwater is collected, it disables the controller so the system can't operate. Some rain sensors are adjustable so that light showers will not shut down the system. When rainwater evaporates, the controller again operates as programmed.

Smart controllers estimate or measure depletion of available plant soil moisture in order to operate an irrigation system, replenishing water as needed while minimizing excess water use. Smart controllers use sensors and weather information to manage and adjust watering schedules. There are several methods by which smart controllers receive information needed to modify watering times. For example, information can be weather-based (using an on-site weather station or using nearby weather stations), based on soil moisture monitored in the root zone, or tied to historical weather data.

A properly programmed smart controller requires initial site-specific set-up that includes information such as soil type, plant type and slope. Then it will make irrigation schedule adjustments to run times and required cycles, based on changes in weather, soil moisture or other changing data, throughout the irrigation season without human intervention.

Programming

SPRINKLER RUN TIME SCHEDULE SPREAD OVER 7 DAYS

Water to Apply Each Week	Spray Sprinklers	PGJ Rotors	PGP®Rotors	I-20 Rotors
1"	40 min.	130 min.	150 min.	150 min.
2"	80 min.	260 min.	300 min.	300 min.

Zone No.	Plant Type	Zone Description	Prec. rate in/hr	Zone flow GPM	Peak inches per week	***Weekly zone run time hours***	***Daily zone run time minutes***	***Water usage gallons per week***	Design operating pressure psi
A1	Shrubs	Drip	0.50	4	1.00	***2.00***	***40.00***	***480***	30.00
A2	Shrubs	Drip	0.50	4	1.00	***2.00***	***40.00***	***480***	30.00
A3	Native	Rotors	0.57	17	1.00	***1.75***	***35.09***	***1,768***	50.00
A4	Turf	Pop-Up (15’)	1.83	18	1.80	***0.98***	***19.67***	***1,091***	30.00
A5	Turf	Pop-Up (8’)	1.83	7	1.80	***0.98***	***19.67***	***436***	30.00
A6	Turf	Pop-Up (15’)	1.83	26	1.80	***0.98***	***19.67***	***1,527***	30.00
A7	Turf	Pop-Up (10’)	1.75	20	1.80	***1.03***	***20.57***	***1,255***	30.00
A8	Turf	Pop-Up (12’)	2.01	31	1.80	***0.90***	***17.91***	***1,689***	30.00
A9	Turf	Pop-Up (8’)	1.83	11	1.80	***0.98***	***19.67***	***654***	30.00
A10	Native	Rotors I-20 (#6.0)	0.57	11	1.00	***1.75***	***35.09***	***1,179***	50.00
A11	Native	Rotors I-20 (#3.0SR)	0.78	36	1.00	***0.93***	***18.69***	***1,996***	50.00
A12	Shrubs	Drip	0.50	4	1.00	***2.00***	***40.00***	***480***	30.00
Total projected peak season water use per week (gallons)								***13,036***	
Total peak season hours per week - Controller 'A'						***16.65***			
Number of days/week						3			
Two (2) starts per day									

PRO Green EXPO
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Thank you!

Lyle Fair- 720-934-7480
Bill Carey