Irrigation Systems for Establishing Riparian Vegetation

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Complexity	Environmental Value	Cost
Low Moderate High	Low Moderate High	Low Moderate High

OVERVIEW

Planners of stabilization or restoration projects should consider the benefits of irrigation systems to reduce the risk of plant material loss to drought (Figure 1). Reestablishment of vegetation lost to drought is very costly and, lacking good root establishment, the performance of the stabilization or restoration project may be compromised. Irrigation is typically required only in the first one or two growing seasons; thus, systems that can be removed and reused for other projects are desirable. Irrigation plans should be based on evaluating the site and the expected operating conditions. The soils and topography must be suitable for the type of irrigation selected. A sufficient quantity and quality of water should be available before any such siphon is considered.

IRRIGATION OPTIONS

Three principal types of irrigation systems are used for restoration and stabilization projects: trickle or drip systems, spray systems, and mobile systems. Flood systems (a fourth option) are generally more applicable to agricultural crops than streambank and riparian projects and are not covered in this note. Table 1 compares the merits and disadvantages of each system.

Trickle systems apply water directly to the root zone of plants by means of applicators (orifices, emitters, porous tubing, or perforated pipe) operated under low pressure. The applicators can be placed on or below the surface of the ground. Trickle systems are the most efficient way to water and maintain soil moisture within a specific range for good plant growth without excessive water loss, erosion, reduction in water quality, or salt accumulation.

Spray systems use sprinkler heads and pressure to distribute water over vegetation in a fashion that mimics rainfall. Spray systems can be further divided into underground, surface, and overhead systems depending on the location of the piping systems. Underground systems tend to be costly and are useful only in cases where permanence is required or where vandalism may present a problem.

Mobile irrigation systems can be the least expensive option for watering plants used in bioengineering or restoration projects. This option includes removable systems ranging from large long-range sprinklers used in conjunction with fire hoses to standard garden hoses and consumer-grade sprinklers supplied with low-head effluent pumps placed in the adjacent stream.

Figure 1. Supplemental irrigation may be required to ensure the success of riparian plantings and bioengineering projects

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Table 1. Comparison of Irrigation Systems

Trickle or Drip Irrigation	Underground Spray Systems	Surface/Overhead Spray Systems	Mobile Irrigation
Affordable	Expensive	Moderate cost	Inexpensive
Simple installation	Moderate installation	Simple installation	No installation
Unobtrusive	Unobtrusive	Unattractive	Unobtrusive
Vandal prone	Vandal proof	Vandal prone	Vandal proof
Convenient	Convenient	Convenient	Inconvenient
Temporary/movable	Permanent/immovable	Temporary/movable	Temporary/highly mobile
Not suitable for herbaceous	Suitable for all vegetation	Suitable for all vegetation	Suitable for all vegetation
Erosion resistant	Promotes erosion	Promotes erosion	Variable erosion
Moderate freeze resistant	Freeze resistant	Freeze susceptible	Freeze resistant
Low volume/pressure	High volume/pressure	High volume/pressure	Low volume/pressure

PLANNING

dictate many decisions regarding the design and layout of an irrigation system for a restoration or stabilization project. The size of the project, its location, and convenience factors will dictate the optimum source when more than one option is available. Generally, water sources include:

- Potable Water
- Surface Water
- Excavated Wells
- Drilled Wells
- Point Wells
- Cisterns

Quantity. To efficiently convey and distribute irrigation water to the point of application without causing excessive erosion or water losses, the project site must be suitable for irrigation. A sufficient quantity of water should be available to make irrigation practical for the vegetation to be grown and also must be adequate for the water application methods to be used. Water quantity considerations include:

- Water budget effects, especially volumes and rates of infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.
- Potential for a change in plant growth and transpiration because of changes in the volume of soil water.
- Effects on the water table in maintaining a suitable root zone for the desired vegetation.

Water Sources. Availability of water will

- Potential for irrigation of difficult soils and terrain through control of water within the root zone.

Quality. Generally speaking, the greatest water quality concerns associated with irrigation are not related to the value of the water for sustaining plant growth but, rather, to the impacts of excess irrigation water upon the receiving water bodies. Concerns include:

- Effects of nutrients and pesticides on surface and groundwater quality.
- Effects on the movement of dissolved substances below the root zone or to groundwater.
- Effects of water management on salinity of soils, soil water, or aquifers.
- Potential for development of saline seeps or other salinity problems resulting from increased infiltration near restrictive layers.

DESIGN

Code requirements governing the design and installation of irrigation systems exist in most locations. The extent and nature of the codes vary, but a permit is generally needed. In many western states, allocation of water rights can be a constraint as well. Be sure to check with local government agencies regarding water use restrictions. In urban environments, the three most common code requirements are 1) backflow protection (required only when potable water sources are used), 2) limitations on the types of materials used, and

3) investigation of underground utilities and trenching limitations. Codes are typically less stringent in rural areas.

Manufacturers of irrigation system supplies generally provide detailed design guidance. Design requirements for a standard trickle/drip system follow as an example.

Depth of Application. The net depth of application should be sufficient to replace the water used by the vegetation through transpiration during the peak use period or critical growth stage without depleting the soil moisture in the root zone of the vegetation below the minimum level established for optimum growth. The gross depth should be determined by dividing the net depth by the application efficiency provided by the manufacturer.

Capacity. The design capacity of trickle irrigation systems should be adequate to meet moisture demands during the peak use period of each plant to be irrigated in the design area. The capacity should include an allowance for reasonable water losses during application periods. The system should have the capacity to apply a stated amount of water to the design area in a specified net operating period. The design area may be less than 100 percent of the field area but not less than the mature vegetation root zone area.

Design application rate. The design rate of application should be within a range established by the minimum practical discharge rate of the applicators (orifices, emitters, porous tubing, perforated pipe) and the maximum rate consistent with the intake rate of the soil. The application rate should be expressed in gallons per hour per emitter or orifice or per foot of porous tubing or perforated pipe.

The discharge rate of orifices, emitters, porous tubing, or perforated pipe may be determined from the manufacturer's data relating to discharge and operating pressure. Emitters should be located to provide an overlap of the wetting pattern within the root zone.

Lateral lines. Lateral lines should be so designed that when operating at the design pressure, the discharge rate of any applicator served by the lateral will not exceed a variation of $\pm$ 15 percent of the design discharge rate.

Main lines. Main lines and submains should be designed to supply water to all lateral lines at a flow rate and pressure not less than the minimum design requirements of each lateral line. Adequate pressure must be provided to overcome friction losses in the pipelines and in all appurtenances, such as valves and filters. Mains and submains should be designed and installed according to local provisions or standards for irrigation pipelines.

Filters. A filtration system should be provided at the system inlet if a surface water source is selected. If available, recommendations of the emitter manufacturer should be used in selecting the filtration system. In the absence of the manufacturer's recommendations, the net opening diameter of the filter should be not larger than one-fourth the diameter of the emitter opening.

All injectors, such as fertilizer injectors, should be installed upstream of the system filter, except for systems having injectors equipped with separate filters. The filter system should permit flushing, cleaning, or replacement as required without introducing contaminants or foreign particles into the trickle system (Figure 2).

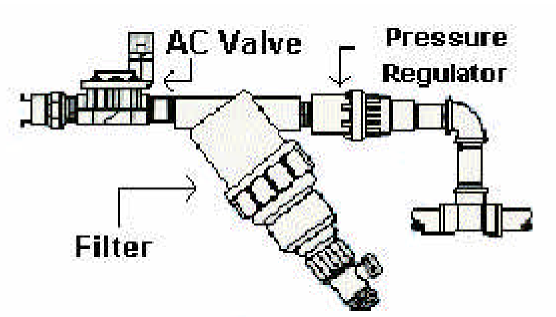

Figure 2. Filters are required for systems that utilize surface water sources and are recommended for all water sources

Table 2. Dripline Characteristics as a Function of Soil and Vegetation Type

	Emitter Spacing (in.)	Row Spacing (in.)	Emitter Flow (gph)	Burial Depth (in.)
MediumSand				
Trees/Shrubs/Groundcover	12	18	1	4
Grass	12	12	1	6
Loam				
Trees/Shrubs/Groundcover	18	18	1	6
Grass	12	18	1	6
Clay Loam				
Trees/Shrubs/Groundcover	18	24	1/2	6
Grass	18	18	1/2	6
Clay				
Trees/Shrubs/Groundcover	18	24	1/2	6
Grass	18	18	1/2	6

System Pressure. Landscape irrigation system performance is directly related to system pressure. Proper pressure results in water conservation, healthy plant material and system durability. Inappropriate pressure is a primary cause of poor irrigation performance and leads to poor water coverage of some zones and drought stress to vegetation. It is always better to have excessive pressure than inadequate pressure, since pressure regulation costs less than trying to overcome a low-pressure problem.

Many irrigation systems rely exclusively on delivered pressure. When this fluctuates, so will the coverage areas and precipitation rates of the sprinklers. A 10-percent pressure difference between laterals can cause a 5-percent difference in precipitation rates. Contract specifications should require a 15-percent maximum variation in pressure under operating conditions.

Excess system pressures are best managed through the use of pressure regulators. Using flow control for pressure control almost always results in uneven pressure and poor uniformity. Most valves come with a flow control knob or dial on top of the valve, which is tempting to use as a pressure regulator when the pressure is too great. Unfortunately, this device responds to changes in pressure and does not compensate for them. The best techniques to overcome inadequate pressure are:

- Increase pressure.
- Use shorter laterals or add a valve and split the lateral into two separate stations.
- Reduce the nozzle or orifice sizes on all heads on the zone by one nozzle size. This reduces the amount of water being applied overall, but it can improve uniformity.
- Adding new heads or laterals to an existing valve will affect pressure and may increase problems during the peak stress months. Additions to an existing system should consider both static and dynamic pressure, pipe size, sprinkler head type and flow, and distances between existing heads and laterals.

Special Considerations for Slopes. Driplines should be located parallel to the contour of slopes whenever possible. Because subsurface runoff occurs on sloped areas, consideration must be given to dripline density from the top to the bottom of the slope (slopes greater than 3 percent). The dripline on the top two-thirds of the slope should be spaced at the manufacturer's recommended spacings for the soil type and plant material in question and on the lower one-third, the driplines should be spaced 25 percent wider. The last dripline can also be eliminated on slopes exceeding 5 percent. For areas exceeding 10 ft in elevation change, zone the lower one-third of the slope separately from the upper two-thirds to help control drainage. Table 2 shows dripline characteristics as a function of soil and vegetation type.

When using non-pressure-compensating driplines, elevation differences of 5 ft or more require separate zoning or individual pressure regulators for each 6-ft difference on uniform slopes. When working with elevation differences of 5 ft or more within a zone, a pressure-compensating dripline should be used to equalize pressure differentials created by the elevation differences. Subsurface irrigation zones must have a vacuum relief valve at the highest point to eliminate the vacuum created by low line drainage that causes soil ingestion. This feature is especially crucial when the dripline laterals must be placed perpendicular to the contour of the slope. All dripline laterals must be connected within the elevated area with an air relief lateral.

Conservation Measures. A variety of measures can be applied to reduce water use, including:

- Controllers with multiple programs that allow the differential application of irrigation water to areas with different requirements.
- Rainguards that measure rainfall and stop operation of the irrigation controller if rainfall amounts are sufficient within a given time period.
- Moisture meters that measure soil moisture with a probe can indicate water need, and automated meters can prevent the system from operating when not needed.

CONSTRUCTION

Drip irrigation lines are generally installed subsurface and several trenching options are available. Table 3 provides advantages and disadvantages of the more common methods. Aboveground installation is used for temporary systems (1 to 2 growing seasons), with driplines placed on the ground surface and covered with mulch.

SOIL PREPARATION. As with all types of landscape irrigation systems, properly prepared soil is necessary to provide a consistently homogenous foundation for proper plant establishment, root growth and water distribution. Heavily compacted and layered soils should be ripped and tilled at a uniform 12-in. depth to improve the homogeneity of the soil.

When the soil texture, soil pH, and water quality are in doubt soil and water analyses can determine soil amendments and water treatment when necessary.

If possible, pre-irrigate the installation site when the soil is too dry to till and trench. This makes tilling and installation much easier and trouble free.

INSTALLATION STEPS. Installation should be in accordance with manufacturer's recommendations, but generally follows these steps:

1. Assemble and install filter, remote control valve, and pressure-regulating valve assembly(s).
2. Assemble and install supply header(s). Tape and/or plug all open connections to prevent debris contamination.
3. Assemble and install exhaust header(s). Tape or plug all open connections to prevent debris contamination.
4. Install dripline laterals. Tape or plug all open ends while installing the dripline to prevent debris contamination.
5. Install air vacuum relief valve(s) at the zone's highest point(s).
6. Thoroughly flush supply header(s) and connect dripline laterals while flushing.
7. Thoroughly flush dripline laterals and connect to exhaust header(s) or interconnecting laterals while flushing.
8. Thoroughly flush exhaust header(s) and install line-flushing valves.
9. Test system operation and performance.

OPERATION AND MAINTENANCE

Irrigation systems must be designed as an integral part of an overall plan of restoration or conservation land use. The capabilities and needs of the project sponsor will dictate

Table 3. Considerations for Trenching Methods.

Insertion Method	Advantages	Disadvantages
Hand trenching or backfilling	- Handles severe slopes and confined areas - Uniform depth	- Slow - Labor-intensive - Disrupts existing turf and ground
Oscillating or vibrating plow (cable or pipe pulling type)	- Fast in small to medium installations - Minimal ground disturbance - No need to backfill the trench	- Depth has to be monitored closely - Cannot be used on steeper slopes (20%) - Requires practice to set and operate adequately - Tends to "stretch" pipe
Trenching machine (Ground Hog, Kwik-Trench, E-Z Trench)	- Faster than hand trenching - May use the 1" blade for most installations - Uniform depth	- Slower, requires labor - Disrupts surface of existing turf - Backfill required
Tractor-mounted 3-point-hitch, insertion implement	- Fastest, up to four plow attachments with reels - A packer roller compacts soil over the pipe	- Only suitable for area large enough to maneuver a small tractor

their potential to adequately operate and maintain the irrigation system.

Irrigation systems need to be checked on a regular basis, especially during summer months. The system should be monitored to ensure that it is in good repair, has no leaks, and the sprinklers are adjusted to minimize misdirected spray. Low-volume spray heads should be used and watering stopped if puddling and runoff are observed. Watering should be accomplished before 9 a.m. when conditions are generally cooler and less windy.

APPLICABILITY AND LIMITATIONS

Techniques described in this technical note are generally applicable to stream restoration projects that include revegetation of the riparian zone or bioengineering treatments.

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> Fischenich, C. (1999). "Irrigation systems for establishing riparian vegetation," *EMRRP Technical Notes Collection* (ERDC TN-EMRRP-SR-12), U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes.army.mil/el/emrrp