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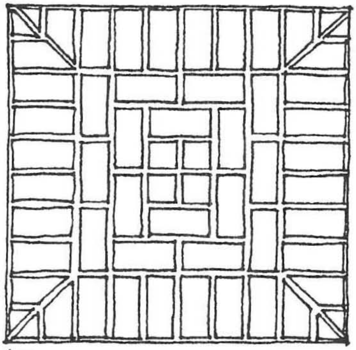

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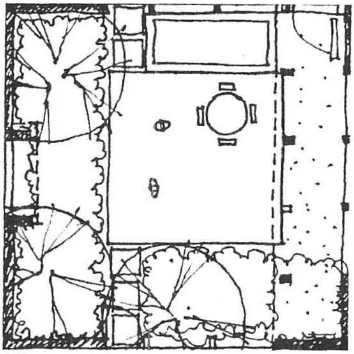

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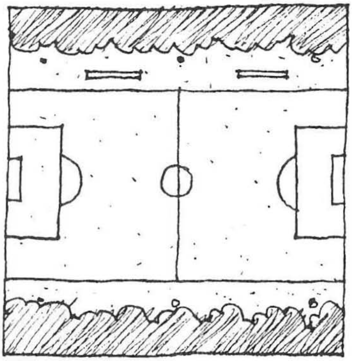

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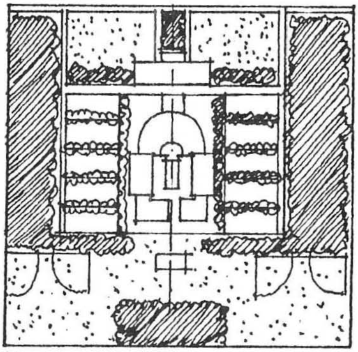

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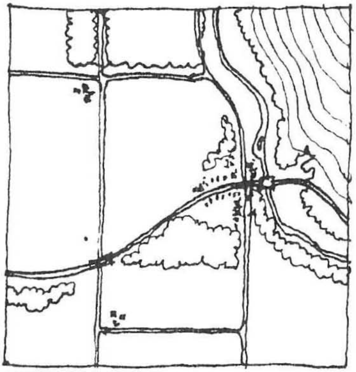

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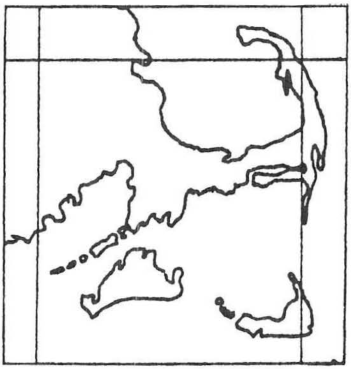

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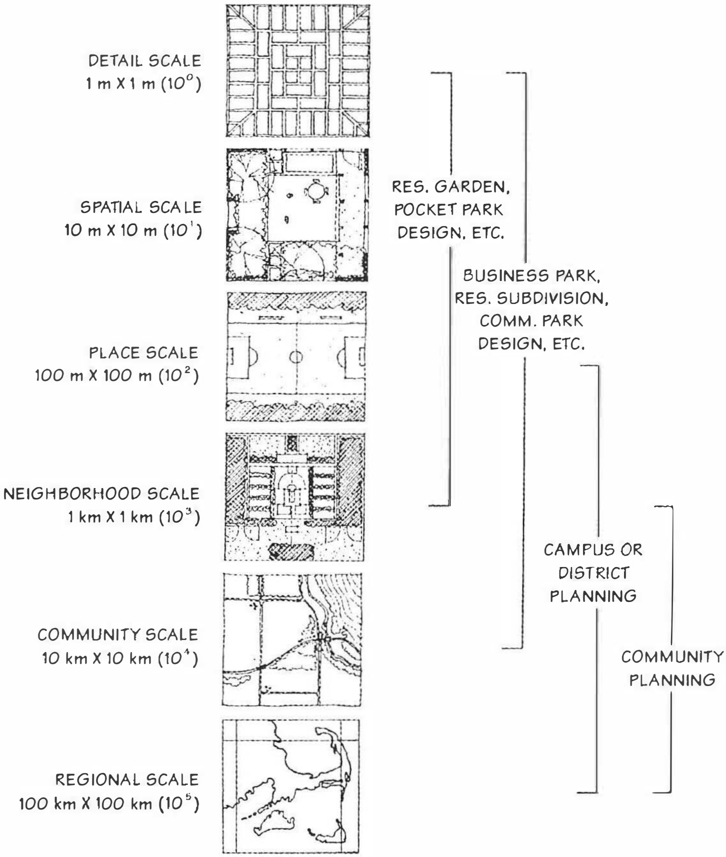


Figure 1.1. Typical primary scales of concern for common project types. Scales of concern for specific projects will depend on design objectives and project size, as well as ecological, cultural and economic context.

Field Sports

Field sports include any activities played, preferably, on soft turf surfaces. Where temporary bleachers are used, allow a width of 20-30 m (60-90 ft) between the sidelines and the playing fields.

- Figure 4.4 illustrates four drainage alternatives for fields (see Chapter 10: Grading for more information).
- Table 4.5 is a summary of the area requirements, dimensions, orientation, and drainage strategies for various field sports.

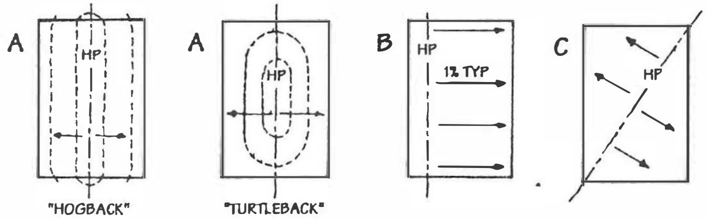


Figure 4.4. Drainage alternatives for fields.

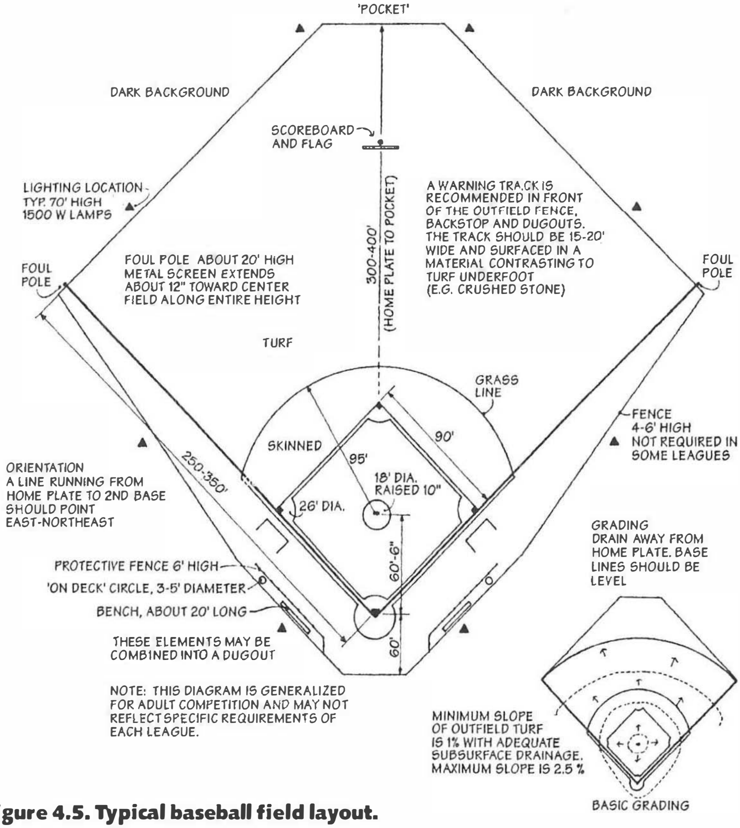


Figure 4.5. Typical baseball field layout.

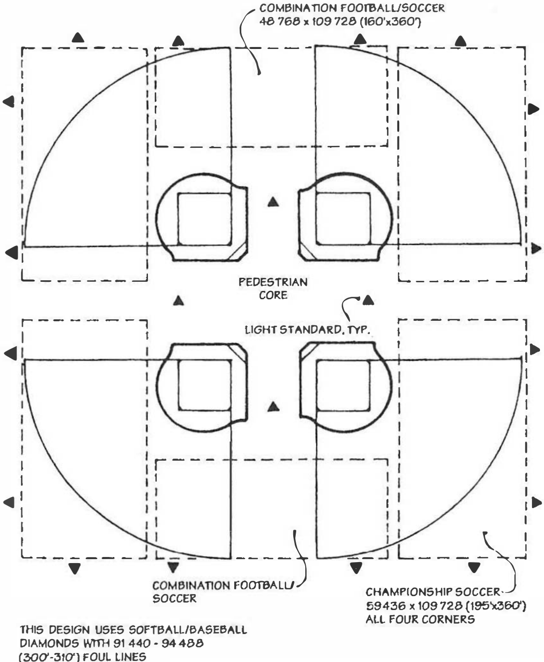


Figure 4.6. Schematic sports complex.

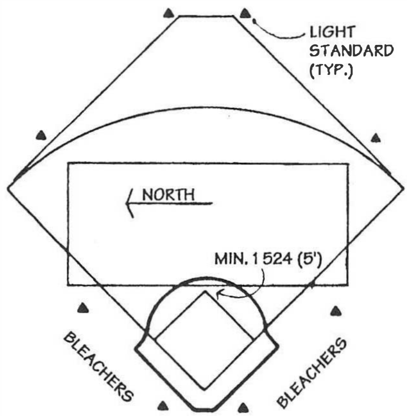
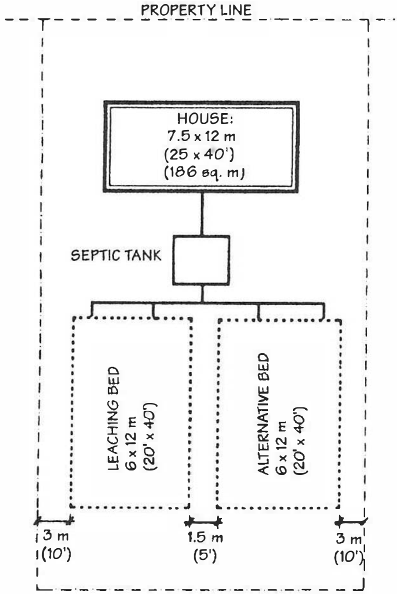


Figure 4.7. Baseball/ football complex.

- Figures 4.5 through 4.7 show the layout requirements for softball and baseball fields and how they can be combined with football and soccer fields to create multipurpose sports complexes. Multipurpose complexes have many advantages associated with reducing the total land required to accommodate many activities. Advantages include the common use of parking, support facilities, irrigation, and lighting systems. Disadvantages include possible scheduling conflicts, the need for portable outfield fences and goals, and the increased traffic, noise, and glare associated with high-density recreation.



NOTE: 3 BEDROOMS @ 490 L (130 gal) PER BEDROOM PER DAY
OR
6 PEOPLE @ 250 L (65 gal) PER CAPITA PER DAY @ 20.3 L (.5 gal) PER SQUARE METER PER DAY = 74 SQUARE METERS PER LEACHING BED

Figure 6.10. Typical on-site septic system layout.

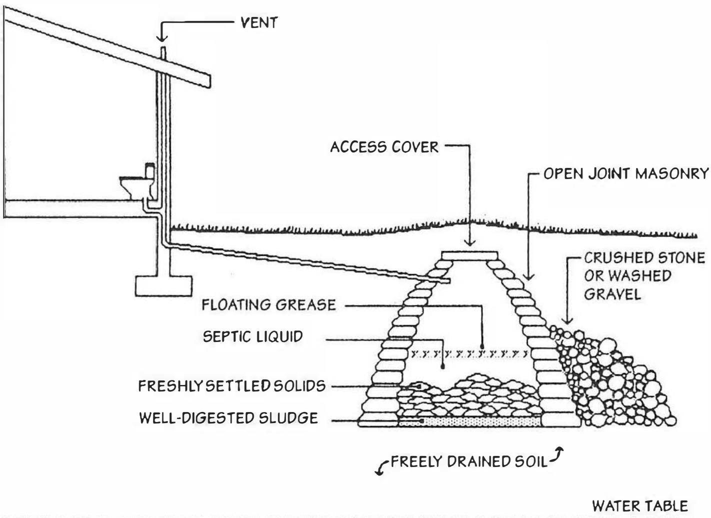
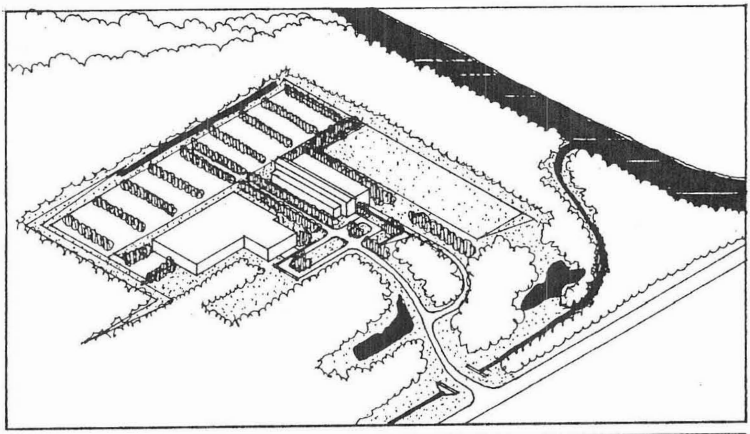
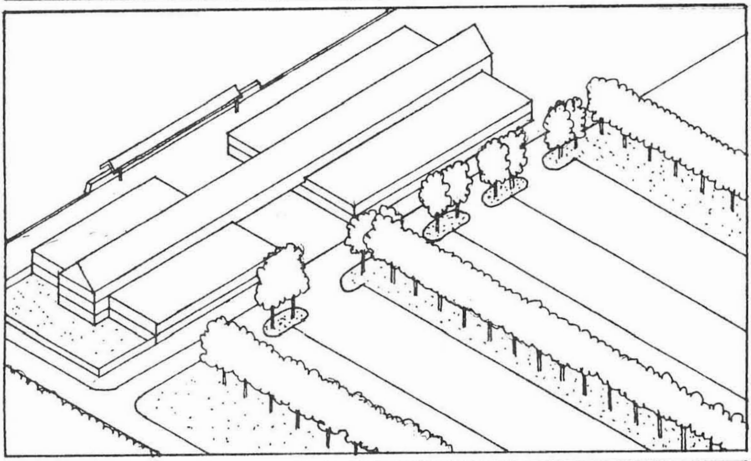
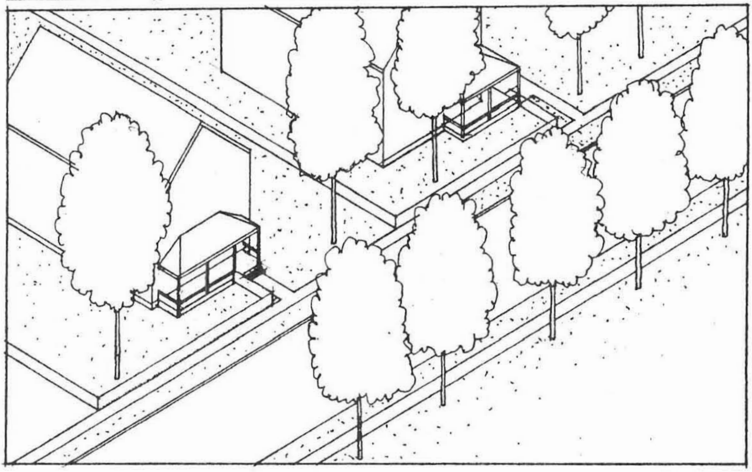


Figure 6.11. Typical cesspool design.







Planned Multiuse Developments

Planned multiuse developments integrate the array of urban uses, including employment-based office and industrial activities, commercial services, community and recreational facilities and housing. These developments should have the following characteristics.

- A comprehensive plan for the development, detailing full build-out intentions and integration with the surrounding community.
- Serve as a focal point for transportation networks, including mass transit.
- On-site essential services for businesses, employees, and residents, to minimize transportation needs, and encourage a pedestrian-oriented environment.
- A range of housing opportunities.
- Sensitivity and compatibility with the surrounding community.
- Design standards, including architectural and landscape design controls, and use requirements.
- Effective operational management to maintain park function and design.

Locational Requirements

Because most business parks that are developed today accommodate a mix of light-industrial, office, and research and development facilities, the selection of an appropriate site is dependent on a number of criteria, critical to the successful operation of these diverse facilities. Site selection and design should seek to optimize flexibility in terms of the needs of specific tenants, while ensuring that common fundamental needs are fulfilled. Considerations include:

1. Size of available parcels (should accommodate new development for a 10-15 year period if possible, based on local absorption rates).
2. Convenient access to major highways (often highway frontage is desirable for visibility).
3. Convenient access to airports and harbors, or adjacency to rail lines (depending on types of businesses expected).
4. Proximity of support services, including shopping malls, hotels, restaurants, daycare, and recreational facilities.
5. Availability and quality of local work force.
6. Proximity of university or research centers.
7. High quality of life within community, including affordable housing.
8. Access to utilities (water, sewer, gas, electricity, telecommunications).
9. Access to mass transit.
10. Minimum environmental limitations for building site development (assess suitability based on soils, wetlands, topography, critical natural resources, etc.)
11. Attractive physical landscape that will provide distinction to the proposed development.

COMMUNITY FACILITY STANDARDS

Table 7.4 lists standards for community facilities, based on residential development types and neighborhood population. Table 7.5 lists parking needs of various land uses.

TABLE 7.4. Land area requirements for community facilities.

	Neighborhood Population				
Type of development	1000 persons 275 families	2000 persons 550 families	3000 persons 825 families	4000 persons 1100 families	5000 persons 1375 families
ONE OR TWO-FAMILY DEVELOPMENTS*					
Area in component uses					
Acres in school site	1.20	1.20	1.50	1.80	2.20
Acres in playground	2.75	3.25	4.00	5.00	6.00
Acres in park	1.50	2.00	2.50	3.00	3.50
Acres in shopping center	0.80	1.20	2.20	2.60	3.00
Acres in general community facilities†	0.38	0.76	1.20	1.50	1.90
Aggregate area					
Acres: total	6.63	8.41	11.40	13.90	16.60
Acres per 1000 persons	6.63	4.20	3.80	3.47	3.32
Square feet per family	1050	670	600	550	530
MULTIFAMILY DEVELOPMENT‡					
Area in component uses					
Acres in school site	1.20	1.20	1.50	1.80	2.20
Acres in playground	2.75	3.25	4.00	5.00	6.00
Acres in park	2.00	3.00	4.00	5.00	6.00
Acres in shopping center	0.80	1.20	2.20	2.60	3.00
Acres in general community facilities†	0.38	0.76	1.20	1.50	1.90

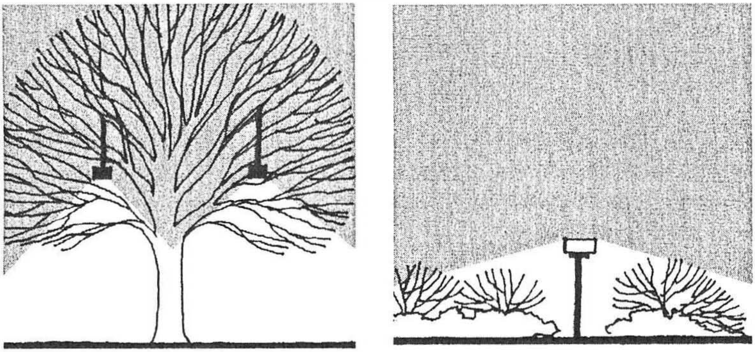


Figure 18.9. Spread lighting.

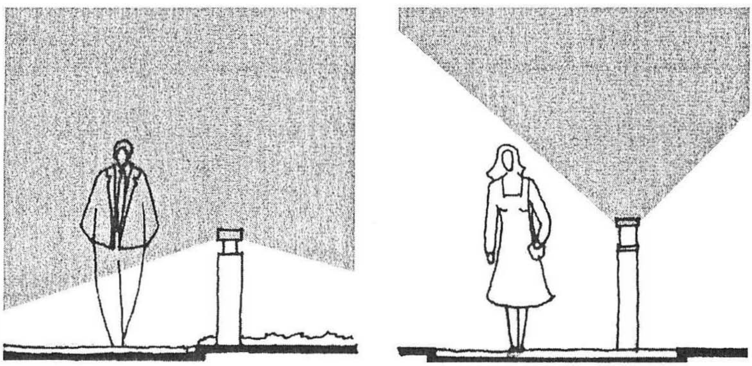


Figure 18.10. Path lighting.

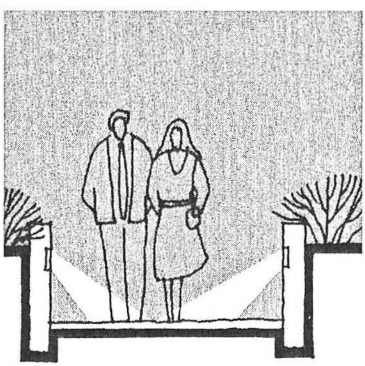


Figure 18.11. Wall lights.

Efficacy: A measure of how efficiently a lamp converts electric power (watts) into light energy (lumens) without regard to the effectiveness of its illumination. It should not be assumed that a lamp with high efficacy would give better illumination than a less efficient lamp.

Light depreciation: Lamp output (lumens) will depreciate over its effective life to 50-70% of original illumination. New installations are routinely designed to deliver 1.5 to 2 times as much illumination as needed, to avoid insufficient lighting over the anticipated life of the lamp.

Color: Two measures used to describe the color characteristics of lamps are (1) the apparent color and (2) the color rendering index. Apparent color refers to the warmth or coolness of the light source and the color rendering index is a measurement of the degree to which object colors are faithfully rendered. Figure 18.12 compares the apparent color of various light sources with the color rendering index.

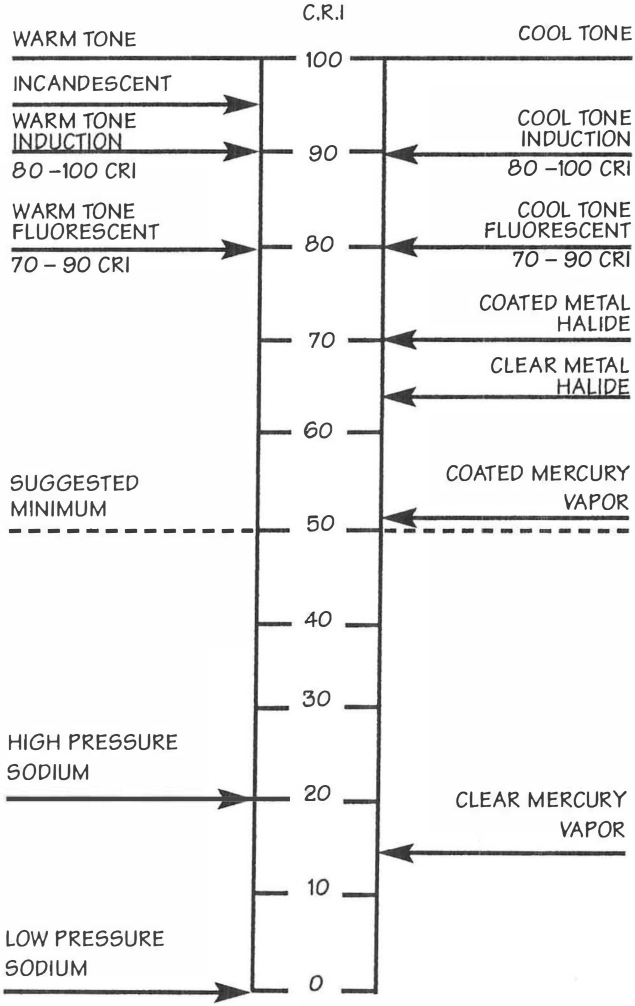


Figure 18.12. Color rendering index.

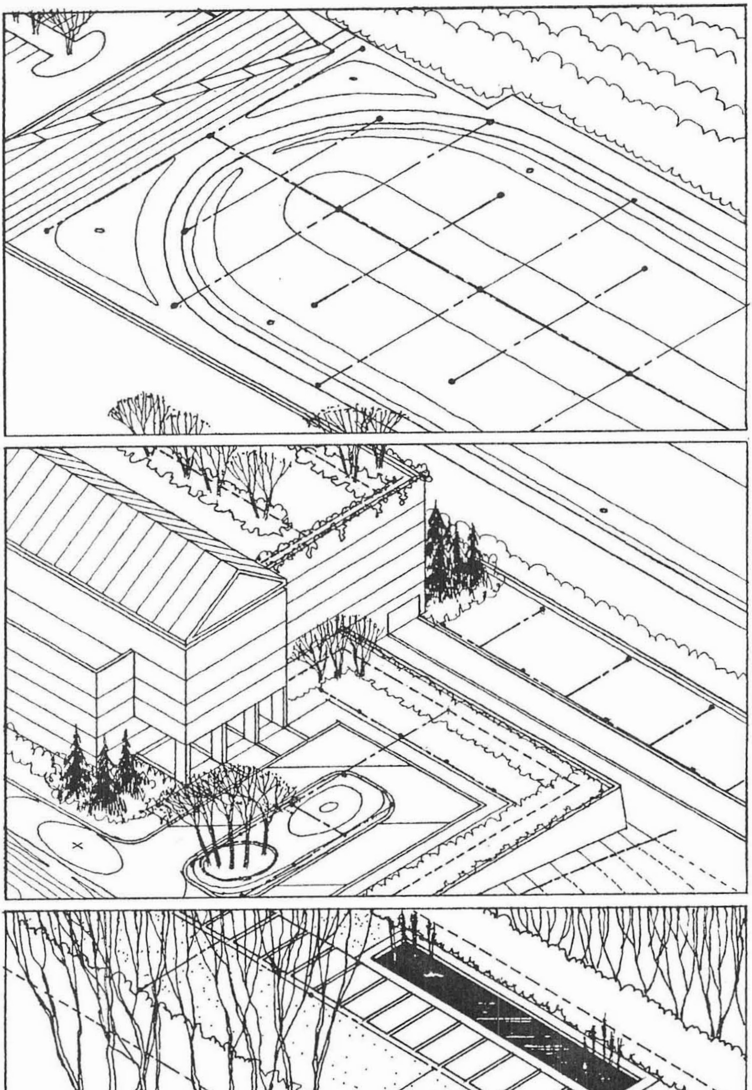


TABLE 19.3. Estimated species factor k_s used to determine landscape coefficient (K_L).

Vegetation Type	Low Water Req.	Average Water Req.	High Water Req.
Trees	0.2	0.5	0.9
Shrubs	0.2	0.5	0.7
Ground Covers	0.2	0.5	0.7
Mixed Trees, Shrubs and Ground Covers	0.2	0.5	0.9

Source: Adapted from Costello, Laurence R. et al. *Estimating Water Requirements of Landscape Plantings.* University of California Cooperative Extension, 1991.

TABLE 19.4. Estimated density factor k_d used to determine landscape coefficient (K_L).

Vegetation Type	Low Density	Average Density	High Density
Trees	0 5	1.0	1.3
Shrubs	0.5	1.0	1.1
Ground Covers	0.5	1.0	1.1
Mixed Trees, Shrubs and Ground Covers	0.6	1.1	1.3

Source: Adapted from Costello, Laurence R. et al. *Estimating Water Requirements of Landscape Plantings.* University of California Cooperative Extension, 1991.

TABLE 19.5. Estimated microclimate factor k_{mc} used to determine landscape coefficient (K_L).

Vegetation Type	Low	Average	High
Trees	0.5	1.0	1.4
Shrubs	0.5	1.0	1.3
Ground Covers	0.5	1.0	1.2
Mixed Trees, Shrubs and Ground Covers	0.5	1.0	1.4

Source: Adapted from Costello, Laurence R. et al. *Estimating Water Requirements of Landscape Plantings.* University of California Cooperative Extension, 1991.

Water Requirement for Individual Plants

Water requirements for individual plants are measured in liters or gallons per day. First you must calculate the area of the plant's root zone, based on the area of the plant's canopy when it is mature.

$$\text{Canopy Area in square meters (sq. ft)} = 0.7854 \times \text{Diameter in meters (ft.)}^2$$

EXAMPLE (SI UNITS)

The mature canopy of a given tree is 6 meters.

$$\textit{Canopy Area} = 0.7854 \times 6^2$$
$$\textit{Canopy Area} = 28.27 \textit{ square meters}$$

To calculate the water requirement for an individual plant, you must know the mature canopy area, its K_L, the ET rate for the area and the application efficiency of the irrigation system.

$$\frac{\text{Water Requirements}}{\text{(liters or gallons per day)}} = \frac{0.623 \times \text{Canopy Area} \times K_L \times \text{ET}}{\text{Application Efficiency}}$$

EXAMPLE (SI UNITS)

The tree described in the previous example has average water requirements (0.5 species factor), is a sparsely planted specimen (0.5 density factor), located on the north side of a residential structure (0.5 microclimate factor). The site is located in a warm humid climate. Drip irrigation will be used.

$$\textit{Canopy Area} = 28.27 \textit{ square meters}$$
$$K_L = 0.5 \times 0.5 \times 0.5 = 0.13$$
$$ET = 5 \textit{ millimeters per day (from Table 19.1)}$$
$$\textit{Application Efficiency} = 0.90 \textit{ (from Table 19.1)}$$

$$\textit{Water Requirements} = \frac{0.623 \times 28.27 \times 0.13 \times 5}{0.90}$$
$$= 12.7 \textit{ liters per day}$$

SOURCES OF IRRIGATION WATER

Most projects use potable water provided by the local water district. Available volume and water pressure are key considerations when using this source. Table 19.6 lists the recommended available volumes of standard water meters. Pressure should be measured on site, as it will vary depending on a number of conditions, including time of day. Backflow

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TABLE 19.6. Maximum recommended capacities of standard water meters (US Units).

Meter Size (inches)	Available Water Volume (gallons per minute)
5/8"	20 gpm
3/4"	30 gpm
1"	50 gpm
1 1/2"	100 gpm
2"	160 gpm
3"	300 gpm
4"	500 gpm

Source: Landphair, Harlow C. and Fred Klatt. *Landscape Architecture Construction.* New York: Elsevier, 1988.

preventers are required to prevent contamination of potable supplies from irrigation systems.

A number of alternatives to irrigation sources are often available, and should be considered in an effort to conserve potable resources wherever possible. These alternatives include surface water, wells, recycled water and graywater.

Surface Water

Lakes, ponds, reservoirs, streams and rivers are a potential irrigation source, depending on riparian rights dictated by federal, state and local law. Pumping requirements, filtration of water, and seasonal changes in water availability must be considered with this option.

Wells

High water tables are good sources of irrigation water. Pumping requirements, water availability, and the relative purity of the water should be considered.

Recycled Water

Recycled water is liquid effluent that has been treated by a sewage plant and may be used for agricultural and landscape irrigation. It is commonly used for golf courses, college campuses, parks, and other large landscapes, particularly in regions with limited water supplies. Levels of nitrogen, phosphorous and potassium found in recycled water often reduce the amount of fertilizer required on these landscapes.

Graywater

Increasingly, regulatory agencies are providing for the use of graywater in irrigation systems, particularly in regions with limited water supplies. Graywater is untreated household wastewater that has not come into con-

TABLE 19.7. Estimated graywater flows from residential units.

Source	Volume in liters per day (gallons per day)
Showers, Bathtubs and Wash Basins	95 LPD (25 GPD) per occupant
Laundry	55 LPD (15 GPD) per Occupant

Source: Adapted from 1994 Uniform Plumbing Code.

TABLE 19.8. Minimum irrigation/leaching area for graywater.

Soil Type	Minimum Area per 100 Liters of Graywater Discharge per Day (Square Meters)	Minimum Area per 100 Gallons of Graywater Discharge per Day (Square Feet)
Coarse Sand or Gravel	0.5	20
Fine Sand	0.6	25
Sandy Loam	1.0	40
Sandy Clay	1.5	60
Clay with Considerable Sand or Gravel	2.2	90
Clay with Small Amounts of Sand or Gravel	3.0	120

Source: Adapted from 1994 Uniform Plumbing Code.

tact with toilet waste. It includes wastewater from bathtubs, showers, bathroom sinks, washing machines and laundry tubs. It does not typically include wastewater from kitchen sinks or dishwashers, or waste from manufacturing or processing. Most jurisdictions allow only subsurface irrigation with graywater, and some limit its use to single family residential dwellings. Table 19.7 lists estimated graywater flows from residential dwellings, and Table 19.8 lists minimum irrigation/leaching areas based on soil types. In some instances graywater may be a valuable supplement to conventional or low-volume drip irrigation.

DELIVERY SYSTEMS

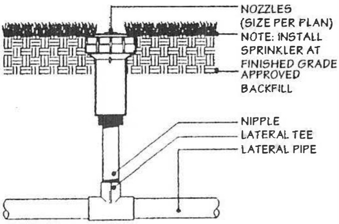
Most irrigation systems use a network of pipe, with controlled valves to regulate and direct the flow of water in the system. Pipe will be either polyvinyl chloride (PVC) or flexible polyethylene tubing.

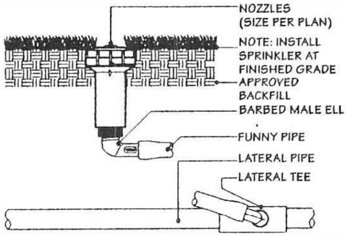
Pressure loss resulting from the delivery and distribution system must be calculated to ensure proper functioning of the system:

- Table 19.9 lists pressure loss from friction in commonly used PVC pipe.
- Table 19.10 estimates pressure loss through typical water meters. Meter manufacturers provide more precise data.

TABLE 19.9. Friction-loss table for pipe (PVC 1120-1220 class 160 in).*

		Loss per pipe length noted, psi §										
GPM†	Velocity‡	5	10	20	30	40	50	60	70	80	90	100
1/2-IN. PIPE, 0.720-IN-INSIDE DIAMETER												
1	0.8	0.01	0.02	0.04	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.20
2	1.6	0.04	0.07	0.15	0.22	0.30	0.37	0.44	0.52	0.59	0.67	0.74
3	2.4	0.08	0.16	0.31	0.47	0.62	0.78	0.94	1.09	1.25	1.40	1.56
4	3.2	0.13	0.27	0.54	0.80	1.07	1.34	1.61	1.88	2.14	2.41	2.68
5	4.0	0.20	0.40	0.81	1.21	1.62	2.02	2.42	2.83	3.23	3.64	4.04
6	4.8	0.29	0.58	1.15	1.73	2.30	2.88	3.46	4.03	4.61	5.18	5.76
7	5.6	0.38	0.77	1.53	2.30	3.06	3.83	4.60	5.36	6.13	6.89	7.66
8	6.4	0.49	0.98	1.96	2.93	3.91	4.89	5.87	6.85	7.82	8.80	9.78
3/4-IN. PIPE, 0.930-IN-INSIDE DIAMETER												
2	0.9	0.01	0.02	0.04	0.07	0.09	0.11	0.13	0.15	0.18	0.20	0.22
4	1.9	0.04	0.08	0.16	0.23	0.31	0.39	0.47	0.55	0.63	0.70	0.78
6	2.8	0.09	0.17	0.34	0.50	0.66	0.83	1.00	1.16	1.34	1.49	1.66
8	3.8	0.14	0.28	0.56	0.85	1.14	1.42	1.70	1.99	2.27	2.56	2.84
10	4.7	0.22	0.43	0.86	1.29	1.72	2.15	2.58	3.01	3.45	3.87	4.30
12	5.7	0.30	0.60	1.20	1.80	2.40	3.00	3.60	4.20	4.80	5.40	6.00
14	6.6	0.40	0.80	1.60	2.40	3.20	4.00	4.80	5.60	6.40	7.20	8.00





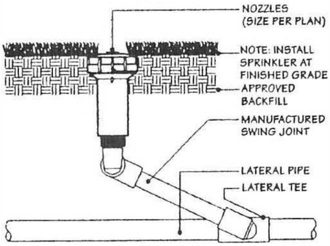


Figure 19.2. Typical pop-up spray heads.

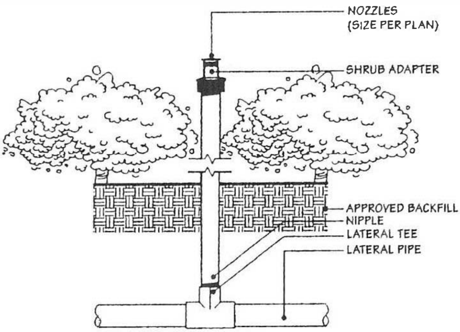


Figure 19.3. Typical shrub head.

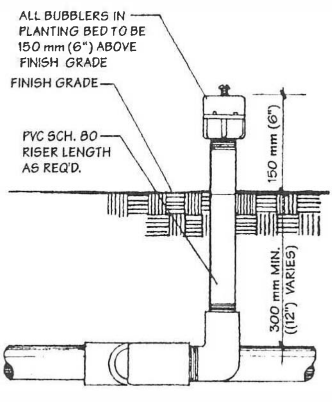


Figure 19.4. Typical bubbler head.

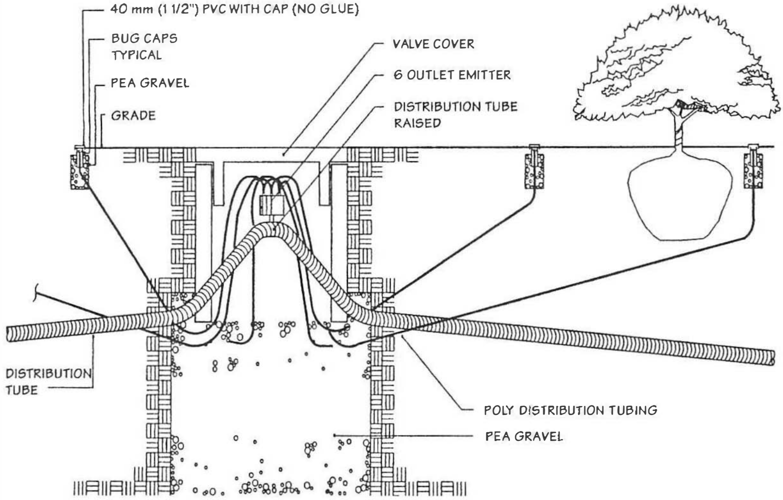


Figure 19.6. Multiple-outlet drip emitter installation.

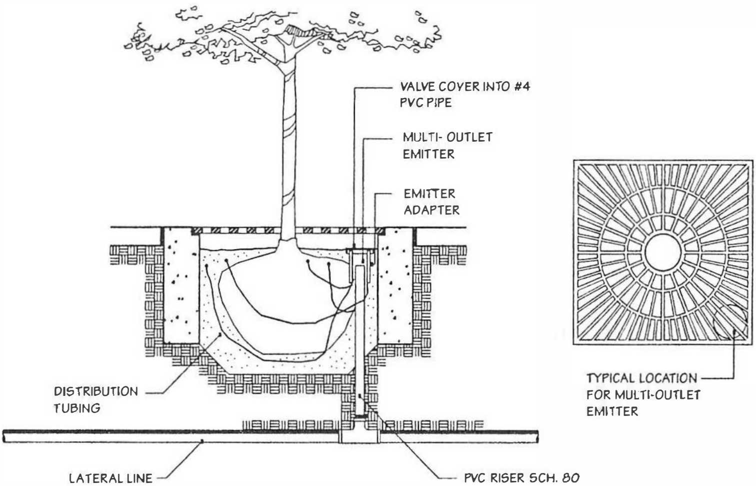
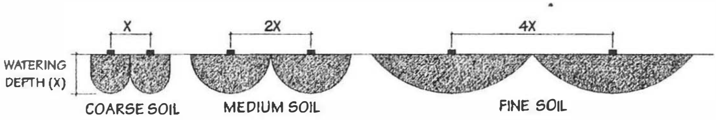


Figure 19.7. Drip emitter installation for trees with tree grates.

DEVICES

TABLE 19.12. Maximum emitter spacing.



	Soil Type		
Emitter Flow	**Coarse**	**Medium**	**Fine**
1.9 LPH (0.5 GPH)	300 mm (12")	700 mm (28")	1000 mm (40")
3.8 LPH (1.0 GPH)	600 mm (24")	1000 mm (40")	1250 mm (50")
7.6 LPH (2.0 GPH)	1000 mm (40")	1250 mm (50")	1650 mm (66")

Source: Adapted from *Low-Volume Landscape Irrigation Design Manual*, Donald B. Clark (ed.), Rainbird, Inc., 1994.

TABLE 19.13. Recommended emitter spacing.

Soil Type	Minimum Desired Watering Depth	Emitter Spacing
Coarse	150 mm (6")	Drip not Recommended
	300 mm (12")	300 mm (12")
	450 mm (18")	450 mm (18")
	600 mm (24")	600 mm (24")
Medium	150 mm (6")	300 mm (12")
	225 mm (9")	450 mm (18")
	300 mm (12")	600 mm (24")
	450 mm (18")	900 mm (36")
Fine	150 mm (6")	600 mm (24")
	225 mm (9")	900 mm (36")
	300 mm (12")	1200 mm (48")

Source: Adapted from *Low-Volume Landscape Irrigation Design Manual*, Donald B. Clark (ed.), Rainbird, Inc., 1994.

Low-Volume Drip Systems

Emitter Selection and Layout

Manufacturers provide a wide variety of emitters to meet the needs of any particular application, climate, or soil conditions. Consult proprietary data for specific information on the selection and layout of drip emitters. Figures 19.6 and 19.7 illustrate typical emitter installations.

The following should be considered in the layout of low volume systems:

- Lateral lengths of delivery systems should not exceed 60 m (200 ft).

- Flow rates should not exceed 750 L/h (200 GPH).
- Maximum working pressure should not exceed 275 kPa (40 psi).
- 15 mm (½ inch) PVC pipes or polyethylene tubing should be used.

For densely planted areas, soil infiltration rate and desired watering depth are important factors in layout of emitter devices. Table 19.12 illustrates the emitter spacing required to water to the same depth in different types of soil. Table 19.13 lists recommended spacing for watering to varying soil depths.

For individual plants, the minimum area to be wetted should be ½ the area of the plant's mature canopy. The number of emitters required is calculated by the formula:

$$\text{Number of emitters} = \frac{50\% \text{ canopy area in m}^2 \text{ (ft}^2\text{)}}{\text{Soil Area Wetted by Emitter in m}^2 \text{ (ft}^2\text{)}}$$

Figure 19.8 provides a graphical means to calculate the number of required emitters for individual plants, and the estimated duration of irrigation for various climates.

Container Plants

Table 19.14 recommends irrigation duration for plants in containers. Table 19.15 lists the frequency for watering container plants.

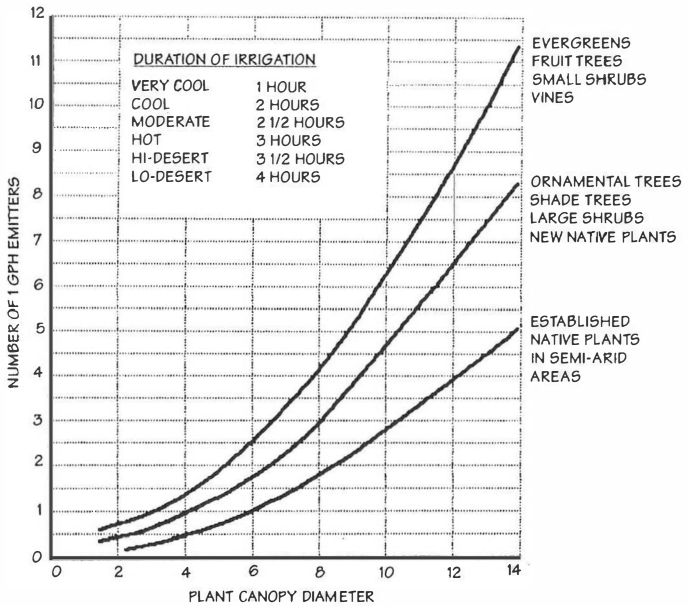


Figure 19.8. Simplified drip irrigation design chart (U.S. units).