USAF LANDSCAPE DESIGN GUIDE

AFCEE is the OPR for the USAF Landscape Design Guide
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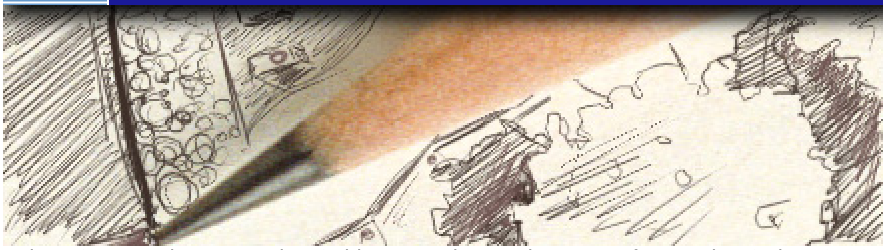

The USAF Landscape Design Guide meets the requirements of Executive Order 13148

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1.1 INTRODUCTION

1.1.1 OVERVIEW

The profession

Landscape architecture is a diverse profession. Besides traditional landscape design, tasks performed by landscape architects range from interior planting plan and wildlife habitat design to community planning and urban forestry. Landscape architecture considers elements from vegetation to street furniture. For the purpose of this guide, landscape architecture is defined as "the art and science of design for the human experience in the natural and man-made environment."

The professional

A professional landscape architect, qualified by education, experience, and often state registration, is concerned with arranging and preserving the environment to fulfill functional needs and quality of life desires of the user. The Air Force expects architectural and engineering firms, the Army Corps of Engineers, and the Naval Facilities Engineering Command to use qualified, professional landscape architects on Air Force projects. Landscape architect positions have been established at a number of commands and installations to provide planning, design, on-site construction assistance, and review expertise.

The design team

To achieve design excellence, the landscape architect must be an integral part of the design team. The training and education of a qualified landscape architect in planning, site analysis, site design, construction, and land management provides a unique perspective in project development and execution. Quality design is the conscientious application of each design profession in concert toward a common goal. Leave out any portion of the team and the entire effort suffers.

1.1.2 GOAL

Significant resources are required to the develop and maintain the Air Force installation. The continual need to minimize the outlay of funds on facilities and grounds while maintaining a high quality of life dictates a development process rooted in logic and efficiency. Although this goal is a challenge, it can be accomplished in part, through the establishment of a comprehensive landscape development program.

1.1.3 PURPOSE

The **Landscape Design Guide** is intended for the:

Landscape architect

As the standard for expectations and requirements for landscape development on Air Force installations to improve and enhance function and image

Planner

As a reference to the integral nature of landscape design in the facility development and planning process

Designer

As a definition of appropriate and desirable landscape development within the Air Force design process

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1.1.4 PHILOSOPHY

Quality landscape design contributes to attractive, safe, efficient, and maintainable installations. The designer must strive for sound, economical, functional, and aesthetic development. A well-designed installation will satisfy the user's needs, instill pride of ownership, and promote a unified visual image.

With continued emphasis on the environment, landscape development has gained increased significance in the everyday operation of the installation. Many environmental issues can be resolved through the application of landscape architecture principles.

The landscape architect typically addresses environmental issues such as storm water management, erosion control, wildlife habitat preservation, and restoration of damaged lands through proper design and implementation of water harvesting techniques, grading, wetlands design, and native species planting design.

With this in mind, the installation's landscape development program contributes to solving the problems of today and providing the foundation for the future by employing the tested solutions of yesterday and the innovative techniques of tomorrow.

1.1.5 GUIDE ORGANIZATION

The United States Air Force Landscape Design Guide is a comprehensive document composed of three integrated elements:

General Design Policy

This document presents the basic tenets of landscape architecture in context with the installation planning, design, and project implementation processes.

Implementation Guidance

Several significant tasks are integral to the implementation of a comprehensive landscape development program. In subsequent releases, the Landscape Design Guide will be supplemented with guidance on topics including landscape planning, landscape maintenance, site construction details, irrigation design, standard landscape construction specifications, landscape estimating, parking areas, and planting design.

Special Design Guidance

Many elements of landscape architecture are special and unique to the successful and efficient implementation of the landscape development program at the installation. Topics that will be individually addressed in the near future include xeriscape design, streetscapes, interior planting design, wetlands design, urban forestry, hydroseeding, golf course improvements, interpretive facilities, landscape lighting, static displays, and erosion control.

1.2 PLANNING PROCESS

1.2.1 COMPREHENSIVE PLANNING

The Air Force comprehensive planning process is comprised of phases that progress from the macro to the micro, beginning with land use and ending with a detailed site plan. This chapter provides a general overview of these phases as a precursor to the main focus of this guide: landscape development.

In the process of siting a facility, there are basically three planning phases:

- **1.2.2 LAND USE**
- **1.2.3 AREA DEVELOPMENT**
- **1.2.4 SITE PLAN**

Each phase involves analysis, assessment of alternatives, and a decision. The following is a brief summary of each planning phase as it evolves in the process of arriving at a facility siting solution.

1.2.2 LAND USE

The Land Use Plan divides the installation into functional areas and focuses attention on potential sites for a new facility. Land use areas generally encompass a group of facilities that have a common activity, service, or purpose. Since several land use areas on an installation may be compatible with a proposed facility, additional analysis is required to select the preferred area. Evaluation factors involved at this phase include:

- Functional relationship to existing facilities
- Proximity to user and customer
- Scope of the requirement and expansion potential
- Noise, environmental impact, safety, and security needs
- Existing infrastructure capacity
- Required site preparation

These are some examples of land use factors that must be evaluated and assessed. The Land Use Bulletin contains additional information regarding land use assessment and planning.

Figure 1-1: Land Use Plan Example

1.2.3 AREA DEVELOPMENT

Once the specific land use area has been determined, the next step is integrating the proposed facility into the surrounding environment of facilities, traffic, and circulation. Area development planning blends existing conditions and future facility requirements in the site selection process.

More detail is included in this planning process phase. The intent is to develop the site in context with existing adjacent facilities. The result is a plan that ties the area together. Some of the factors to evaluate in this phase include:

- Architectural theme of surrounding buildings
- Pedestrian and vehicular needs, volumes, destinations, and access
- Future facility requirements
- Parking configuration
- Street realignments and closures

More detail regarding this phase of the planning process can be found in the Comprehensive Planning Bulletin, Area Development Planning.

Figure 1-2: Area Development Plan Example

1.2.4 SITE PLAN

The site plan focuses primarily on the facility itself. The footprint of the building is refined with additional attention given to site amenities. The area covered by the site plan is generally smaller than either the Land Use Plan or Area Development Plan. Major site planning factors include:

- Topography
- Existing vegetation
- Existing nearby structures
- Existing natural features
- Entrances/service areas
- Orientation
- Walkways
- Parking details
- Lighting
- Drainage

- Pedestrian and vehicular circulation
- Irrigation
- Facility setback from street

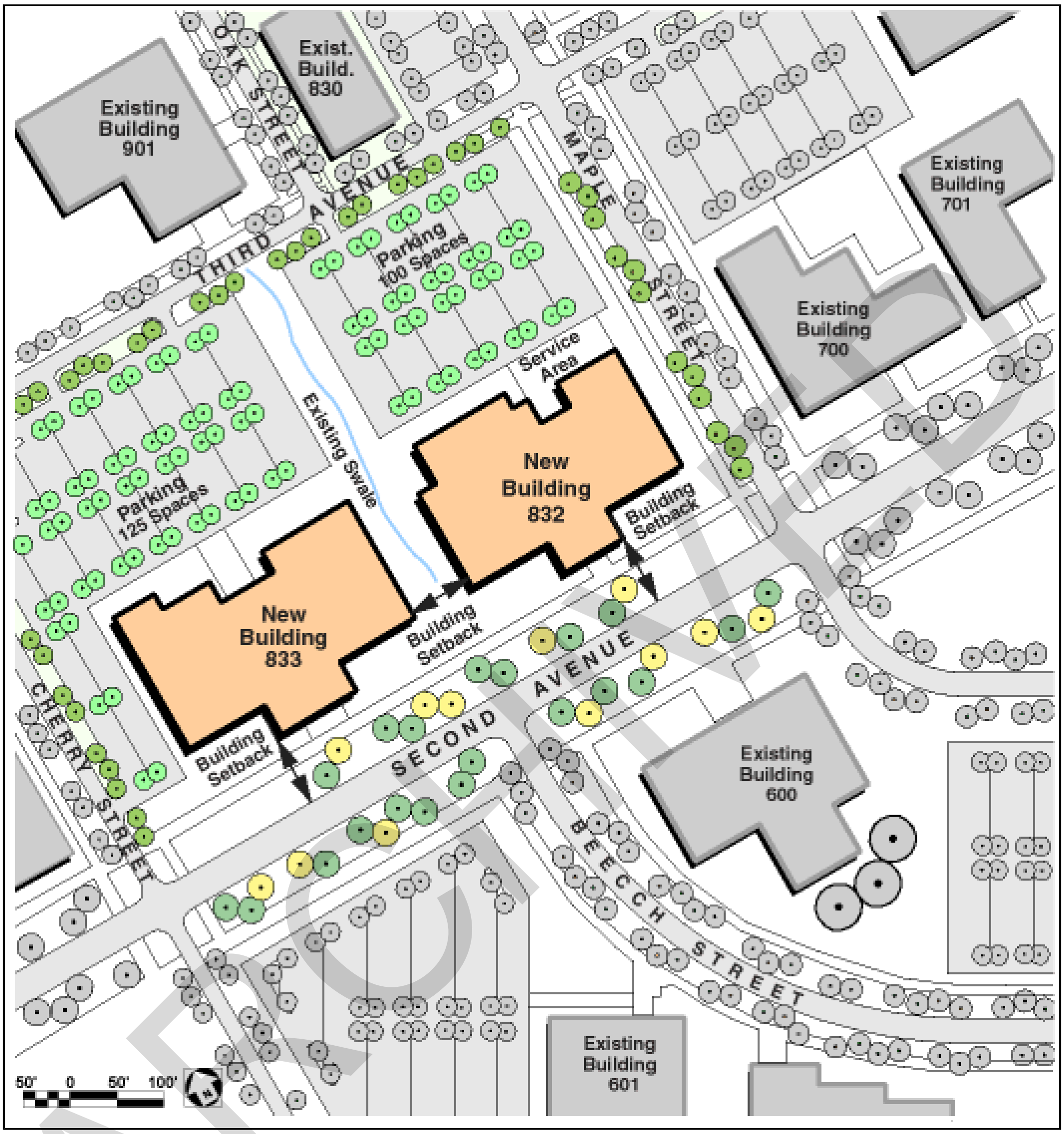

Figure 1-3: Site Plan Example

1.2.5 THE NEXT STEP

The remainder of this guide details the significance of landscape design in regards to function, image, and quality of life for achieving quality installations.

1.3 LANDSCAPE DESIGN

Landscape design is the creative arrangement of space to achieve harmony, utility, and beauty between man and nature. This is the phase of facility development process where landscape elements are integrated with or into the facility to complete the project.

Four factors influence landscape design:

- **1.3.1 PROCESS**
- **1.3.2 THEORY**
- **1.3.3 DESIGN ELEMENTS**
- **1.3.4 DESIGN GUIDELINES**

1.3.1 PROCESS

The design process synthesizes planning and analysis with project requirements. The design process results in a landscape design solution that is functional and pleasing within budget limitations. The following sections describe the main components of the design process:

- **Project Programming**
- **Site Analysis**
- **Concept Design**

Project Programming

The project program analyzes requirements, priorities, and user needs. Input is obtained from personnel who have an association with the project. For example, the user may require an on-site recreation area, a place for employees to gather for organizational functions, or additional screening to shield outdoor storage.

This information and feedback form the basis of the project program requirements and determine the various activities or functions that need to be addressed.

Site Analysis

The detailed site analysis focuses on site characteristics that help define the final design. Some of the evaluation factors at this stage include the following:

Evaluation factors

- **Views**

- Highlight good views
- Screen objectionable views

- **Existing conditions**
  - Preserve mature trees
  - Protect unique vegetation
  - Preserve natural and historic features
- **Soils**
  - Identify poor soils
  - Identify suitable soils
  - Identify wetlands
- **Topography**
  - Stabilize steep slopes
  - Integrate abrupt grade changes
- **Drainage**
  - Integrate runoff patterns
  - Locate potential ponding areas
- **Vehicular and pedestrian circulation**
  - Identify need for and location of ramps
  - Determine if screening of parking area is required
- **Noise**
  - Mitigate exposure
- **Security requirements**
  - Determine special needs

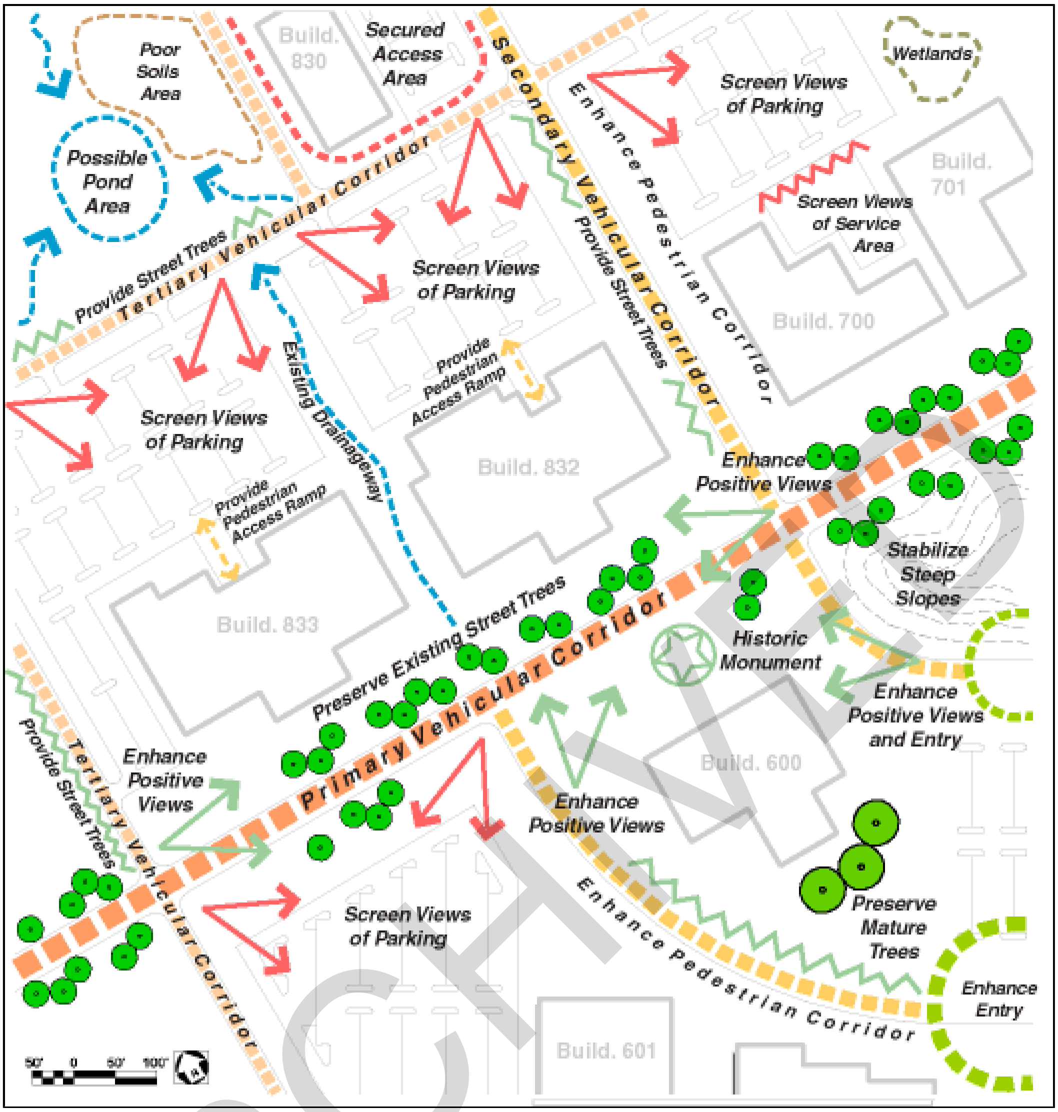

Figure 1-4: Site Analysis Example

Concept Design

Using the installation landscape theme, plant list, and analysis of the existing site conditions, the designer develops the concept design drawings. A concept design delineates the project elements in a highly graphic and detailed drawing. The designer has the responsibility to communicate the character and feel of the project to the user and commanders for final comment and approval. Realistically and naturally rendered, a well executed concept design drawing is the designer's best communication instrument. Once approval is obtained, the designer can develop the final design and construction documents.

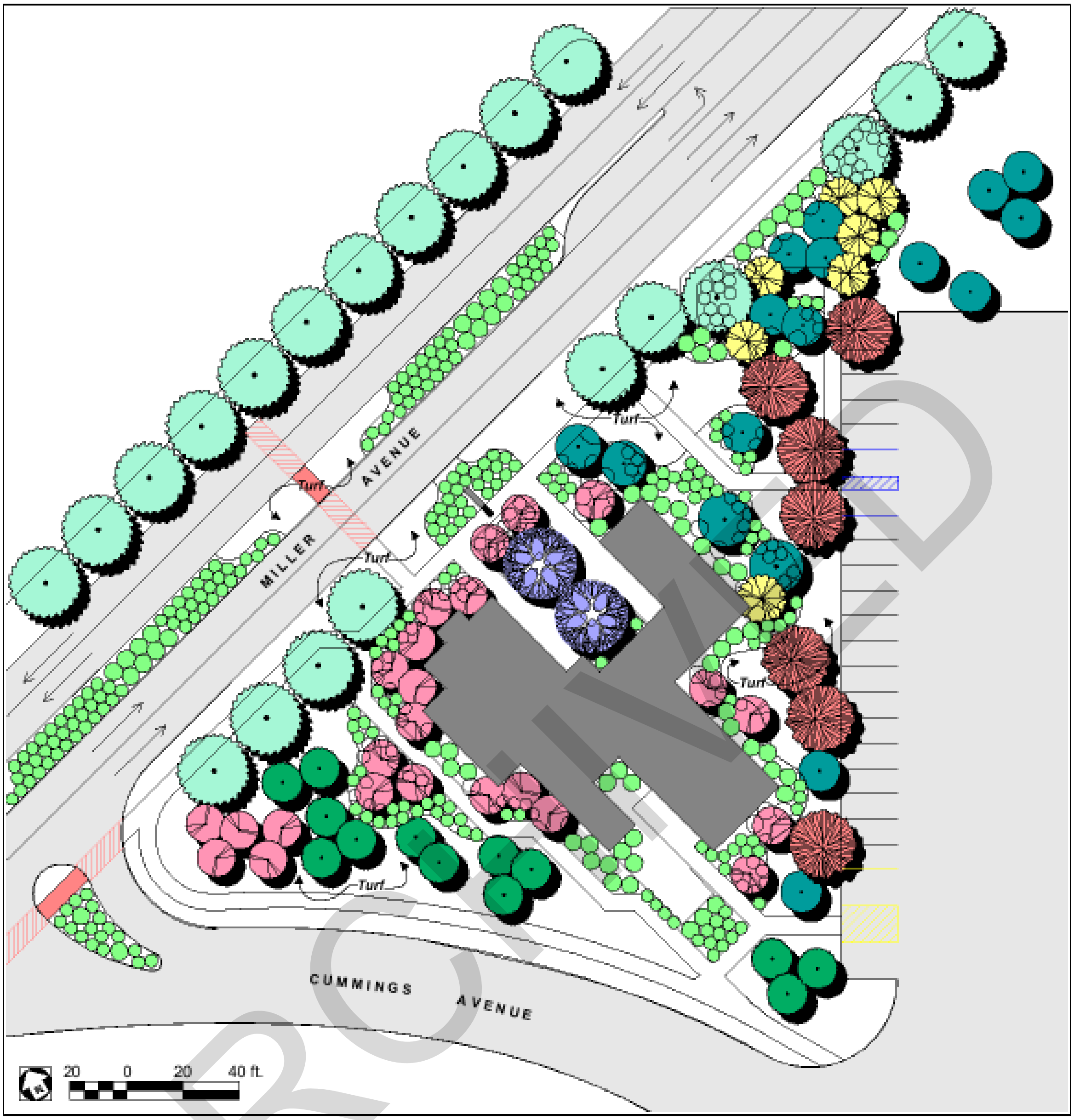

Figure 1-5: Concept Landscape Design Example

1.3.2 THEORY

The following artistic principles should be applied in developing a quality design solution:

Proportion and Scale

A visually pleasing and functional relationship should exist between the three dimensions of length, width, and height.

Balance

Accents should be carefully distributed in the design to provide an aesthetically pleasing integration of elements. Both formal and informal plantings and site amenities can achieve balance in the design solution.

Unity

Fitting together the component parts to form a pleasing whole results in unity.

Harmony

The aesthetic integration of diverse elements results in harmony. Within a design, harmony can be accomplished through the use of site amenities of a similar style and character as well as a communty of indigenous and compatible plant material.

Line

As part of the landscape design, the creation of lines should be pleasing and proportionate. Lines are expressed through paths, walls, fences, and planting masses. In a landscape composition, lines will direct the movement or sight to a particular area of interest.

Emphasis

Emphasis is directing attention to one object or portion of a composition. Vertical elements in open areas of installations can be dramatic and create interesting focal points.

Contrast

Contrast is the diversity of adjacent elements in terms of color, texture, or tone. The designer integrates plant material with distinctly different foliage color, texture, or form to highlight and draw attention.

Variety

Variety is created by introducing different forms or types of elements. Too little variety leads to monotony. Introducing too many elements can create a chaotic, unmanageable environment. A fine balance between extremes produces a pleasant sense of unity in a landscape design.

Repetition

Repetition is achieved by massing or grouping individual plants or site amenities. Repetitive elements in the landscape reflect or amplify architectural geometry and can improve the connection between indoor and outdoor space.

Form

The trunk, branches, and leaves together create the form of a tree and give definition to its shape. The different plant forms are: columnar, round, vase, weeping, pyramidal, oval, and irregular. Structures, landforms, and plant materials all contribute to the composite form of a landscape design.

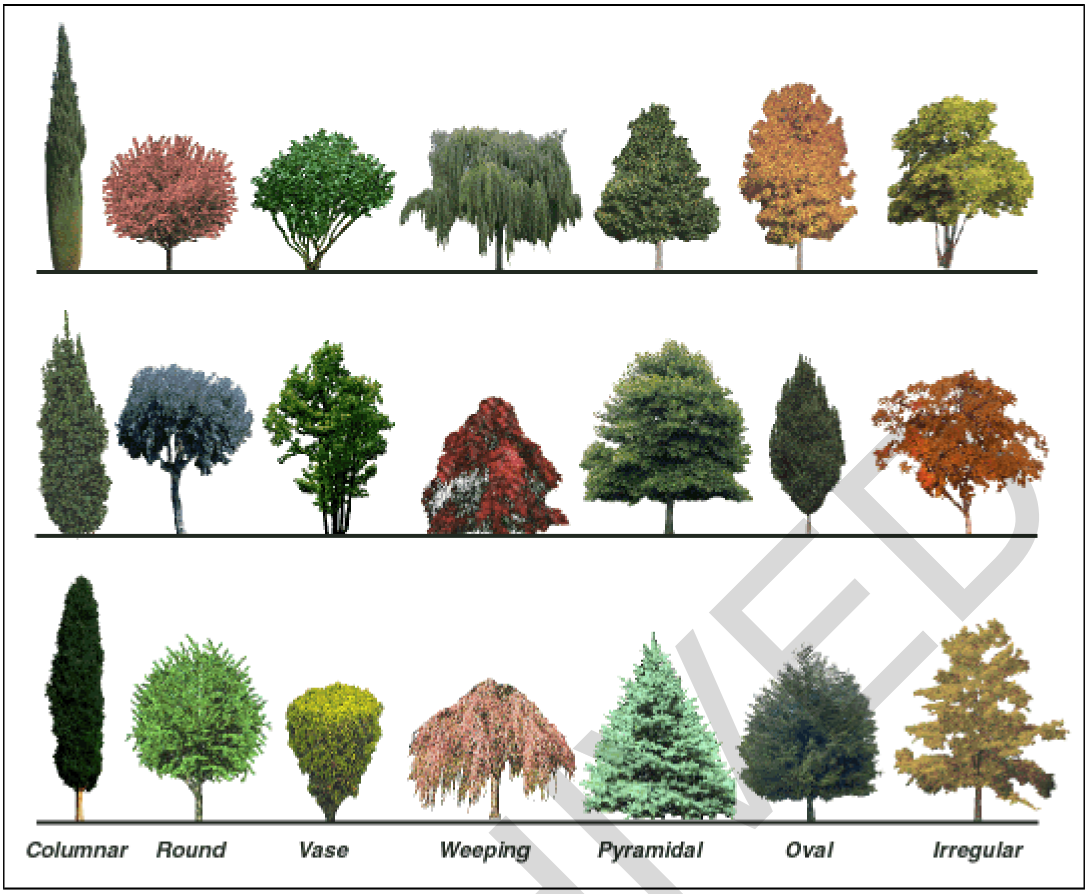

Figure 1-6: Tree Shape and Form

Texture

Seen close up, texture is defined by the size, surface, and spacing of small detailed components that create diverse and varied patterns of light and shade when seen from afar.

Color

A harmonious design in terms of color is most easily obtained by providing a dominance in one color. Color is introduced through the selection of plant materials and site amenities.

1.3.3 DESIGN ELEMENTS

- **Plants**
- **Inert Materials**
- **Landforms**
- **Site Amenities**
- **Circulation**
- **Water Features**

Plants

Plants can be categorized as:

- Trees
- Shrubs
- Groundcovers
- Vines
- Annuals
- Perennials
- Grasses

Evergreen plants keep their leaves throughout the year. Deciduous plants shed all or most of their leaves at one time of the year.

Figure 1-7a: Trees Provide Shade and Reduce Glare

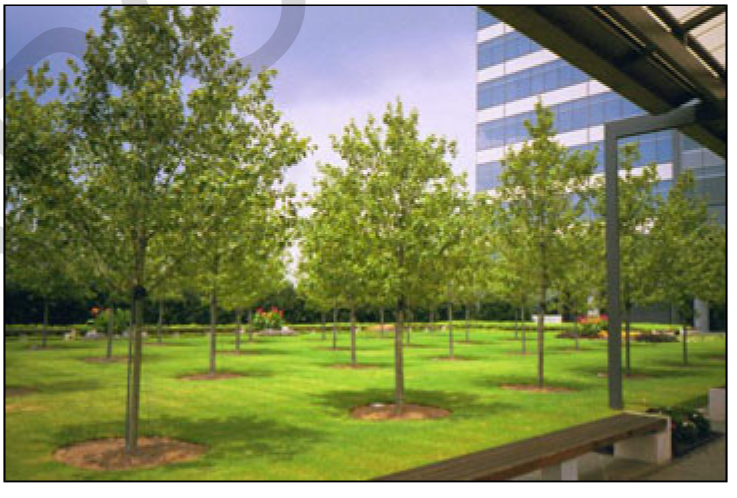

Figure 1-7b: Trees Used to Define Space

Figure 1-7c: Trees Used as a Screen and Background

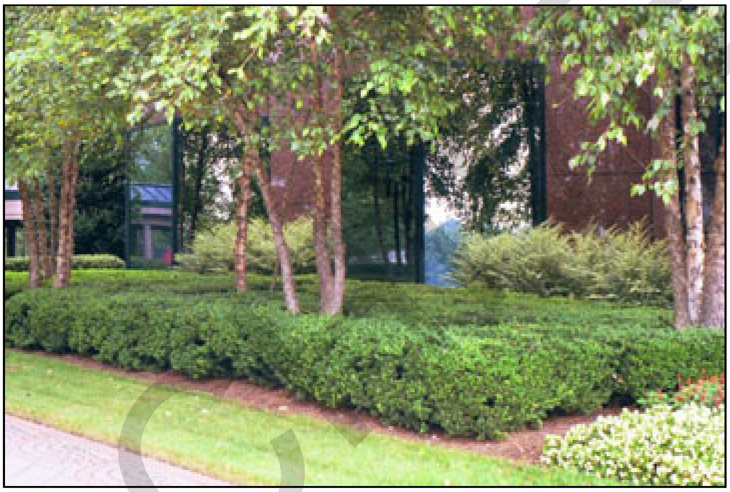

Figure 1-7d: Shrubs Used to Define Groundplane

Figure 1-7e: Shrubs Used as Foundation Planting

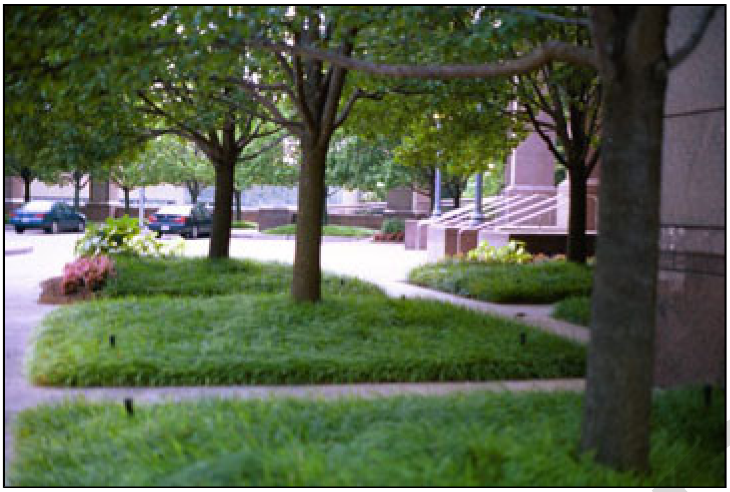

figure 1-7f: Groundcover Used to Define Pedestrian Circulation

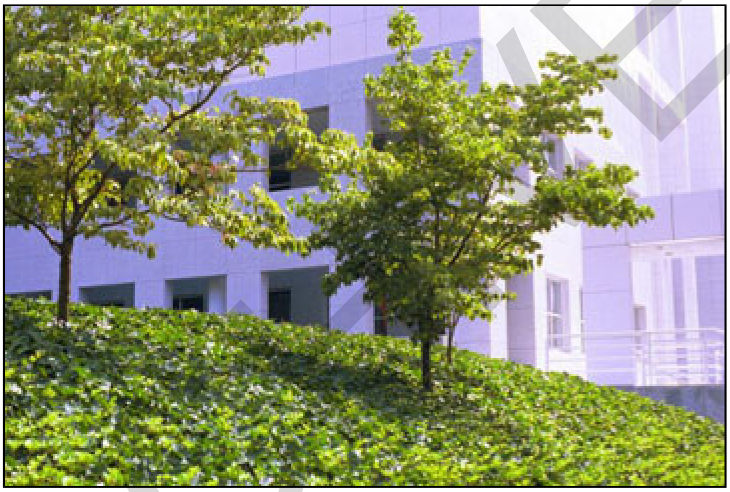

Figure 1-7g: Groundcover Used to Protect a Slope

Figure 1-7h: Groundcover Used in an Area Difficult to Maintain

Figure 1-7i: Annuals and Perennials Used to Accent Entry

Figure 1-7j: Ornamental Grasses Used as Accent in Foundation Planting

<u>Functional uses of plants</u>

Besides adding seasonal variety and beauty, plants can achieve the following functions through appropriate design application:

Wind Control

Plants can modify wind speed on the ground for distances up to thirty times their height. Dense masses of large evergreen trees planted to intercept prevailing winter and summer winds can influence energy efficiency of facilities and increase the livability of outside spaces.

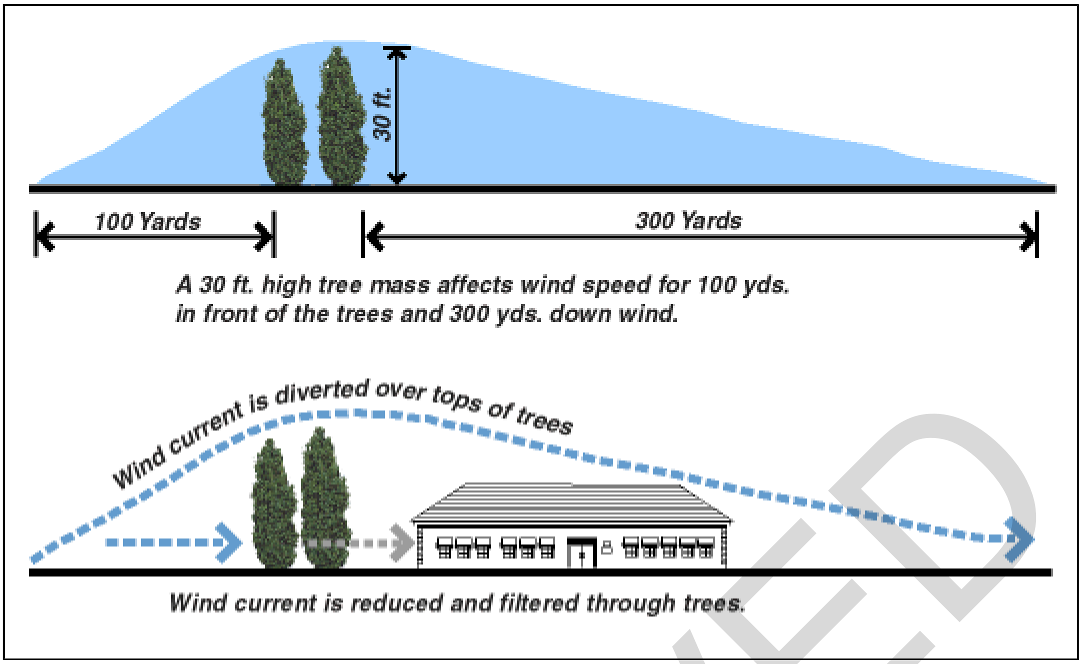

Figure 1-8: Trees Affect Wind Currents

Temperature Modification

Throughout many regions of the United States, direct radiation from the sun creates uncomfortably high temperatures during the summer season. Locating densely foliated trees and shrubs to the southwest and west of facilities can reduce heat gain.

In most regions, warmth from the sun is desirable during the winter. Deciduous trees planted to the south, east, and west of facilities will provide summer shade but will not block winter sun.

Noise Abatement

Trees, shrubs, groundcovers, and turf buffer noise. That is, plants diffract and break up sound waves, changing their direction and reducing their intensity when sufficiently massed. To be truly effective in controlling noise, plants should be used in concert with masonry walls or similar noise buffering structures.

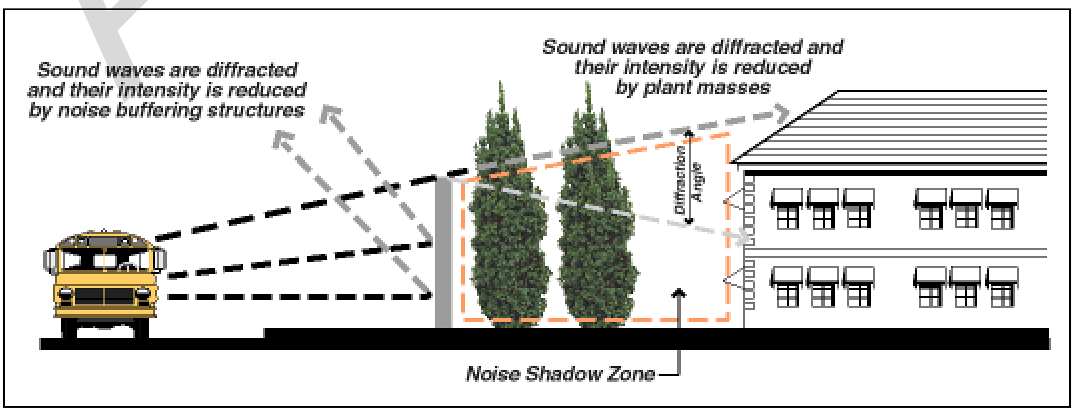

Figure 1-9: Plants Can Reduce Noise

Glare Control

Trees, shrubs, and other vegetation can effectively reduce glare and reflection when placed between the light source and the observer.

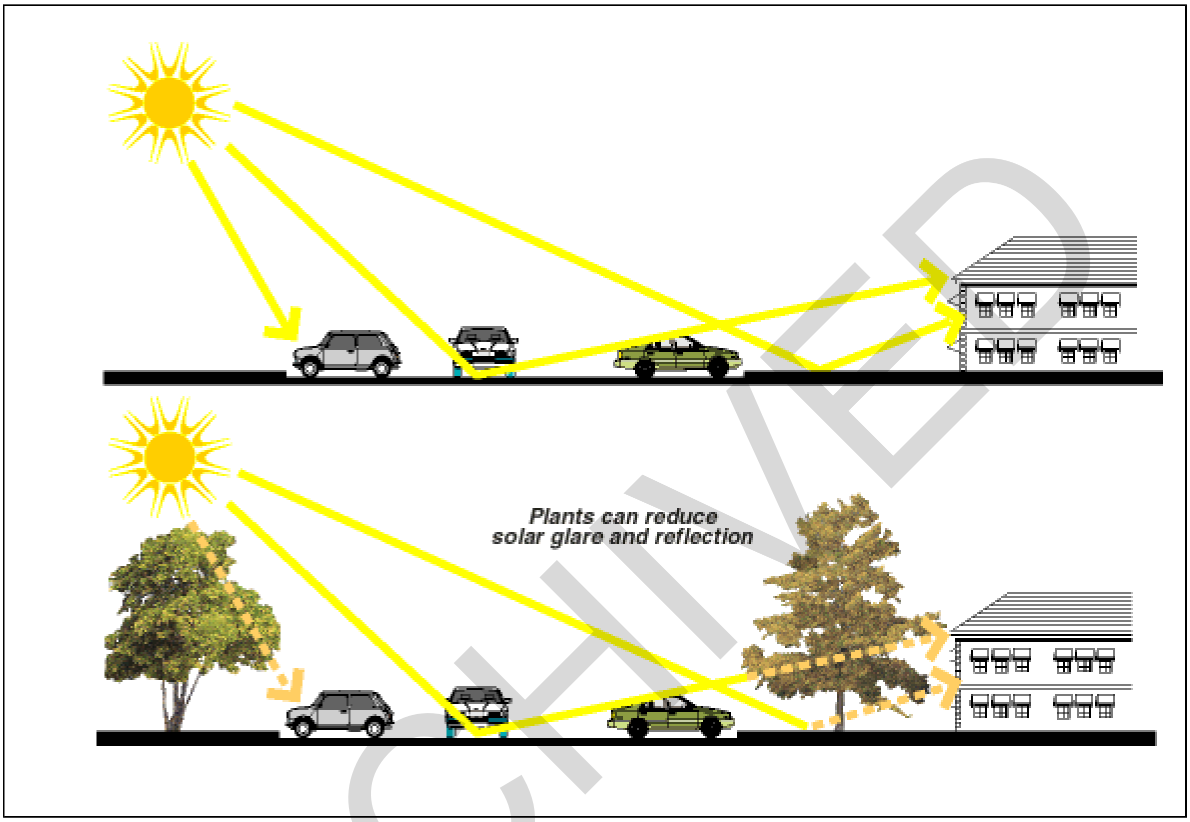

Figure 1-10: Trees Can Reduce the Effect of Solar Glare and Reflection

Surface Erosion Control

Wind and water can erode valuable top soil. Plants, especially grasses, can prevent or control erosion by stabilizing the soil through their root structure. Exposed soil on cut banks and steep slopes should be immediately planted with grasses and/or native low-growing shrubs and spreading groundcovers.

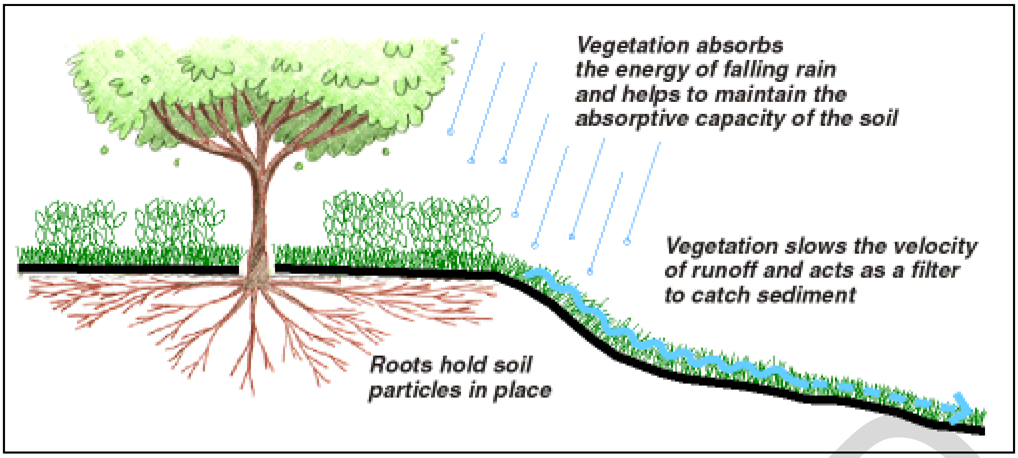

Figure 1-11: Plants Can Be Used to Control Erosion

Architectural

Just as walls, ceilings, and floors define interior spaces within a building, plants can effectively define exterior spaces. Following are some of the architectural uses of plants:

- Enframe and provide background for a building or view
- Soften corners, angles, bare walls, and hard architectural lines
- Accent entry areas and serve as focal points
- Provide a transition between the vertical walls of a building and the horizontal ground plane
- Provide screening for privacy and area separation
- Function as a barrier to vehicular or pedestrian traffic

Figure 1-12a: Trees Used to Frame View of Building Entry

Figure 1-12b: Trees Used to Soften Building Surface and Edges

Figure 1-12c: Groundcover Used to Soften Wall Surface

Figure 1-12d: Shrubs and Groundcovers Used to Accent Entry

Figure 1-12e: Trees Used to Accent Building Entry

Figure 1-12f: Shrubs and Groundcover Used to Transition From Vertical Building Walls to Horizontal Groundplane

Figure 1-12g: Trees Used to Screen Parking Structure

Figure 1-12h: Shrubs Used to Screen Parking Area

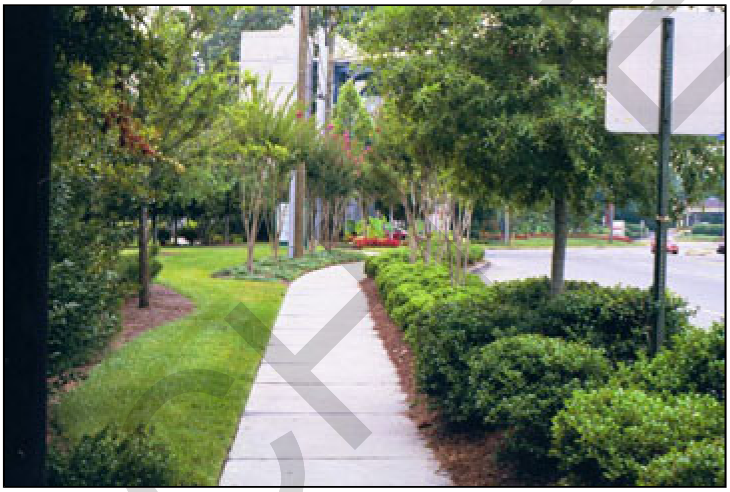

Figure 1-12i: Shrubs and Trees Used Between Pedestrian and Vehicular Traffic

Visual Effect

Plants not only contribute to the aesthetics of a space or area, they also serve a function within the landscape. Plants can be used to accomplish a desired effect or for a specific purpose. The following are some utilitarian ways plants can be used in the landscape:

- **Streetscape**
- **Foundation**
- **Barrier**
- **Screen**
- **Accent**
- **Wetlands**
- **Surface erosion control**
- **Parking area**
- **Wildlife**

Streetscape

Trees planted along a street can reduce glare, define transportation network hierarchies, and soften the man-made environment while dramatically increasing overall aesthetic quality. An ideal street tree possesses the following characteristics:

- 30 to 45 feet in height
- Forms a canopy
- Relatively free of debris
- Highly tolerant to pollution, diseases, and pests
- Deeply rooted and drought tolerant

Shrubs, groundcovers, and vines can accent, screen, define space, or provide barriers to circulation. A well-designed mix of plants can add interest along an installation's streets while enhancing aesthetics.

Figure 1-13a: Formal Streetscape

Figure 1-13b: Informal Streetscape

Figure 1-14: Streetscape Corridor Plan Example

Foundation

Foundation plantings help anchor a building visually to the groundplane by providing a transition or connection between the vertical and horizontal planes. Foundation planting can range from formal arrangement of shrubs to a blend of trees, shrubs, groundcovers, annuals, and perennials that soften the intersection of the building and the ground.

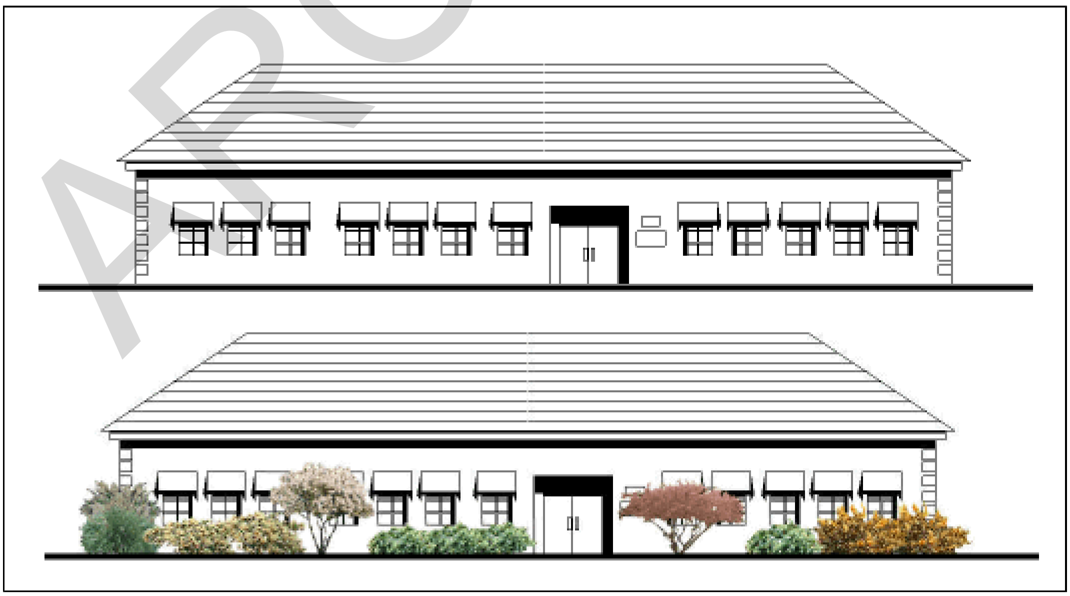

Figure 1-15: Plants Used to Enhance Building at Foundation

Barrier

Barriers control or divert vehicular and pedestrian movement. Massing of plant material can be effective in controlling access to certain areas.

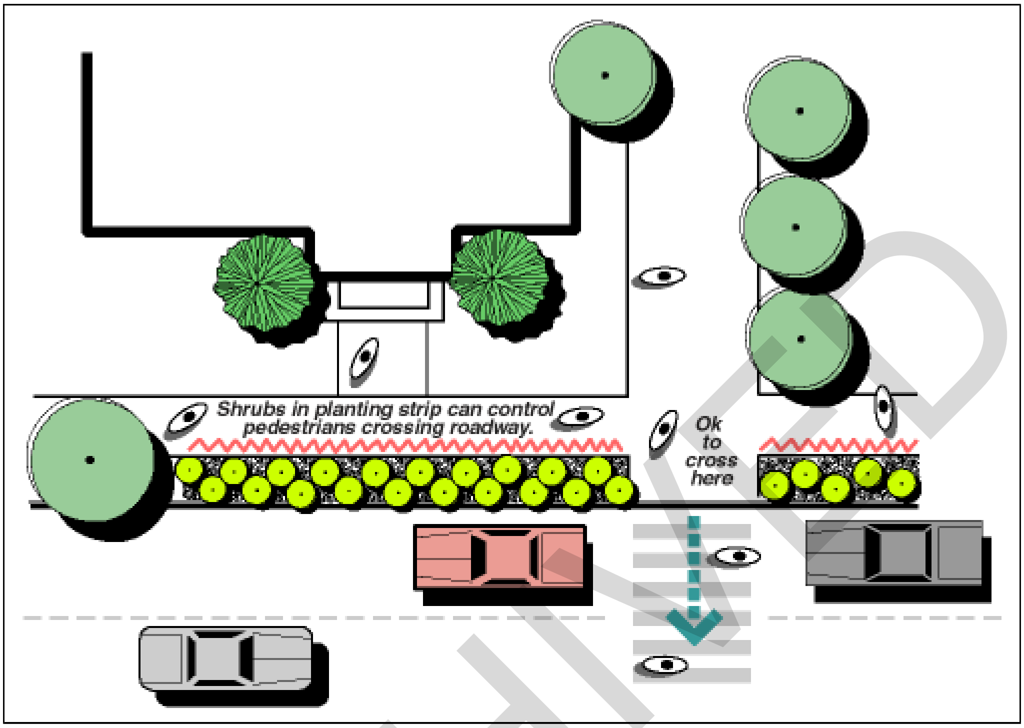

Figure 1-16a: Plants Can Be Used as Barrier

Figure 1-16b: Shrubs Used as Barrier

Screen

Plant material can be used to shield or screen undesirable features such as mechanical equipment, substations, pump stations, transformers, dumpsters, service areas, docks, and electrical switch gear. Densely foliated evergreen shrubs are most effective as screens.

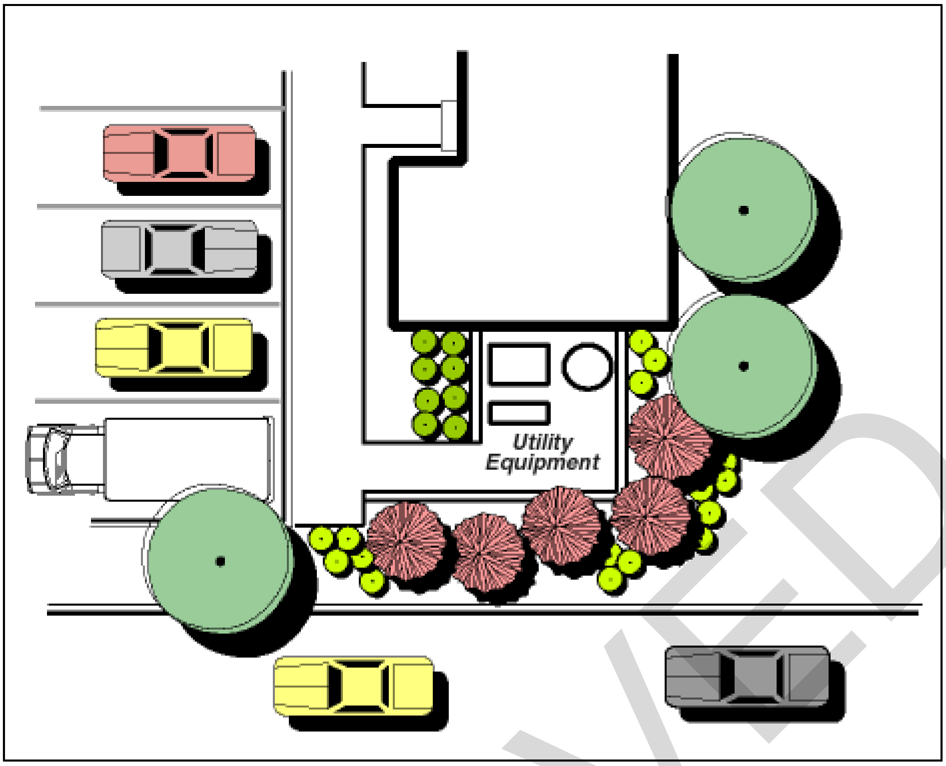

Figure 1-17a: Plants Can Be Used to Screen Utility Areas

Figure 1-17b: Shrubs Used to Screen Utility Structure

Accent

An accent plant demonstrates a sharp contrast or emphasis through its form, flower, or character. Accents draw attention, add visual diversity, and enliven the composition of a landscape plan.

Figure 1-18a: Accent Tree at Building Entrance

Figure 1-18b: Color Accent with Annuals and Perennials

Figure 1-18c: Color Accent with Flowering Trees

Wetlands

The wetlands ecosystem can be a very biologically-productive area. Wetland plants thrive in constant or intermittent soil moisture. Ideally, these plants contribute to the shelter or sustenance of the native wildlife while adding to the natural beauty of the area.

Surface Erosion Control

Ideal plants for erosion control are fast-growing, self-rooting native groundcovers with exceptionally shallow and fibrous root systems. Hydroseeding with a combination of quickly established grasses and desirable long-term groundcover varieties can effectively control erosion. Even shallow slopes can be eroded when exposed to high volumes of water due to extended runoff from major storms. Designers should address the entire site for erosion potential and mitigate appropriately.

Parking Area

Plants used in parking areas need to be hardy varieties that can thrive in confined growing areas and are able to withstand drought, reflected heat, and are pollution tolerant. They should be relatively clean and free of potential nuisances such as fruit, berries, sap, or pitch.

Wildlife

Landscape development for wildlife requires the designer to consider the four basic needs of wildlife: food, water, shelter, and space. In addition, consider function and diversity when choosing plant materials for enhancing or creating wildlife habitats.

Inert Materials

Inert materials are inorganic, naturally occurring elements that add interest and character. Examples of inert materials are boulders, river run stone, decomposed granite, and cobbles.

Carefully choose inert materials that will be widely installed over an installation. Their impact is comparable to, and as important as, choosing colors for buildings. Large expanses of inert materials can have a significant visual impact which can be positive or negative. The designer needs to select standards for inert materials to ensure compatibility and unity. Some of the uses for inert materials are:

- Landscape element
- Surface erosion control
- Accent
- Rip-rap

Landscape Element

When a variety of stone or decomposed granite is used in some areas as a substitute for grasses or groundcovers, extreme care must be exercised to ensure visual quality of the final product. The designer must select materials that contribute to the desired landscape theme as well as complement the architecture and overall character of the installation.

Surface Erosion Control

Lining a ditch, swale, or wash with stones, interrupting or slowing runoff with boulders, or just covering the soil with inert materials to prevent windblown dust are a few of the uses of inert materials for surface erosion control.

Accent

Boulders are a naturally occurring element near many installations. The designer may use boulders in high visibility locations to improve the visual quality and character of the landscape composition.

Rip-rap

Cut banks, steep slopes, and stream or river banks sometime need stabilization to prevent damage during peak runoff periods. Rip-rap, medium to large and usually angular stones, can be used to protect these areas. Plant material can be integrated to minimize the visual impact and increase erosion control.

Landforms

Landforms are natural or man-made topographic features in the landscape. The following types of landforms are often used in landscape design:

- **Berm**
- **Swale**
- **Terrace**
- **Wash/ditch/arroyo**

Berm

A berm is a low, gently rising and rolling, man-made landform with concave and convex slopes used to screen, emphasize or feature plant material, or add interest to the groundplane. Berms can be constructed on the periphery of parking areas to provide screening. When berms will be turfed, the designer must consider mowing operations and irrigation efficiency when deciding slope, height, and plant layout.

Berms can be used in large, flat open areas to help define a space, direct movement, or to direct or intercept runoff. Berm slopes need to be soft and gentle and carefully integrated into the overall grading plan of a project. Excess soil from building foundation excavation operations may be used to create berms.

Figure 1-19a: Screen Parking Facilities with Plants and Landform

Figure 1-19b: Shrubs, Trees, and Berm Used to Screen Parking Area

Swale

A swale is a low-lying, usually grassy, linear depression that is used to divert and carry water through or away from a site. Most projects require swales. As an integral part of the design, swales should be located, graded, and planted as part of the overall landscape design.

Terrace

A terrace is a natural or man-made, relatively flat area. Terraces are used when the natural slope of a site is severe and a usable level area is required. Terraces can be used for a variety of activities and allow the designer the opportunity to balance cut and fill, sometimes reducing the overall cost of the project. Retaining walls are often constructed to create terraces and offer the designer additional opportunities to implement a successful design solution on difficult, steeply sloped sites.

Wash/ditch/arroyo

Washes, ditches, and arroyos are linear and usually steep-sided water drainage courses that collect or conduct runoff. Although these landforms are usually a necessity rather than an aesthetic design element, the designer can affect their location, bank slopes, and planting to help integrate them into the landscape design composition.

Site Amenities

Site amenities are any landscape structure or permanent structural site element such as benches, gazebos, ramadas, bollards, drinking fountains, area lighting, landscape lighting, retaining walls, decorative water features, bus shelters, trash containers, and fences.

Site amenities should be compatible with the architectural theme of the installation. Early delineation of installation standards for these elements by the design team will prevent mixing different varieties and styles, jeopardizing visual quality of the installation.

Circulation

Circulation is the pattern and flow of pedestrian, bicycle, and vehicle traffic. Streets and sidewalks are parts of landscape design as they connect the functional areas or facilities on the installation. The guide will examine the following topics:

- **Walkways, Trails, and Bike Paths**
- **Streets**
- **Intersections**
- **Parking**

Walkways, Trails, and Bike Paths

A comprehensive environmentally-conscious landscape design can encourage the use of alternate forms of transportation. An integrated pedestrian and bicycle circulation system can reduce the use of the automobile. A pedestrian walkway system should provide the following:

- Be logically connected from start to finish
- Be handicap accessible and separated from vehicular traffic
- Be of sufficient width, and have intermittent shade with properly located seating areas

The standard walkway is four feet wide. This should be adequate in most cases. Bike paths should be wide enough to accommodate two bikes passing. Lighting should be considered for the safety and convenience commonly traveled routes.

Streets

The use of street trees is an effective way to visually soften, complement, and define the road system hierarchy. Large trees provide a canopy and give emphasis to the major corridors.

Trees are the main component of a streetscape corridor plan. Two styles of tree planting are commonly used: formal and informal.

Formal

Formally planted street trees generally are equally spaced, equally sized, on both sides, and follow the alignment of the street. This style is ideal along a street with limited planting space. On most Air Force installations, formal tree planting should be considered for the main roadways, primary housing area streets, unique pedestrian or bicycle paths, historical areas, or entry to a headquarters or command facility.

A formal street tree arrangement conveys a disciplined, organized, and ceremonial image with strong directional emphasis. The drawback to the formal style occurs when a mature tree dies or is removed from the symmetrical alignment. Finding a replacement of the appropriate size is extremely difficult or impossible.

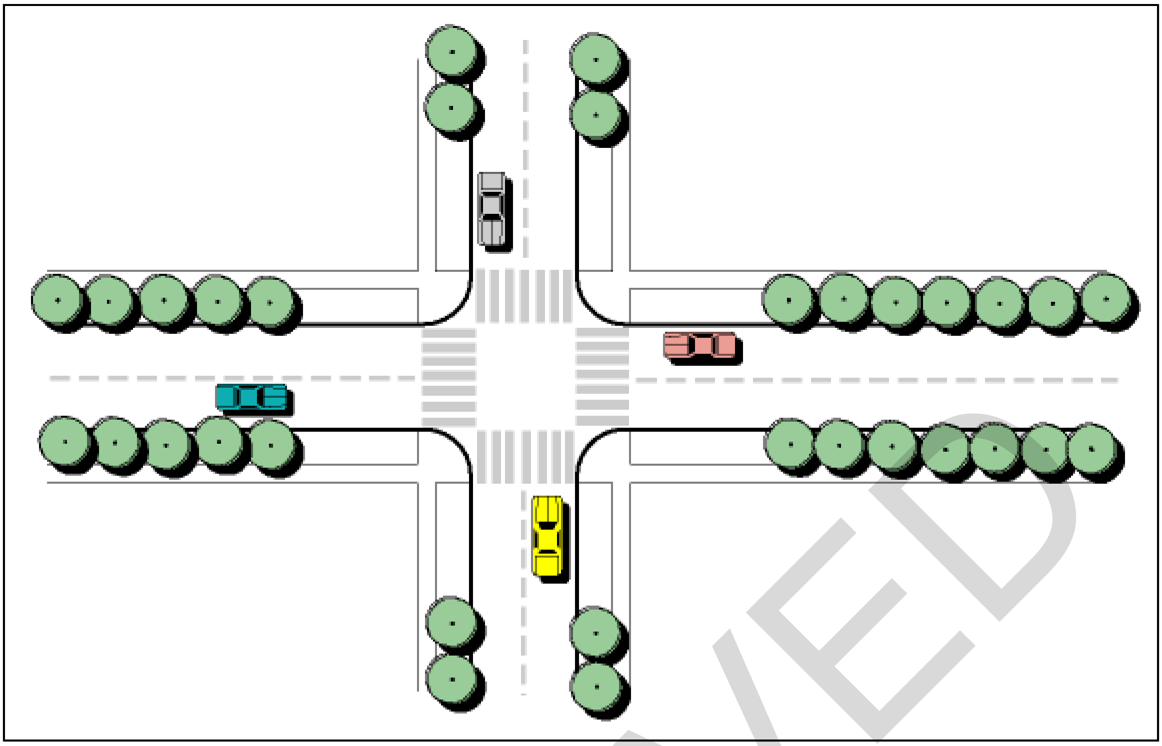

Figure 1-20a: Formal Streetscape Tree Planting

Figure 1-20b: Formal Streetscape Tree Planting

Informal

An informal style of street tree planting involves a mix of varieties randomly spaced within the streetscape corridor. The landscape design tends to be more natural and plant masses frame views adjacent to the street.

If a tree has to be removed, the impact is not as great as in a formal arrangement. Also, multiple species preclude potential disaster to the design if insect or disease damage occur to a specific species.

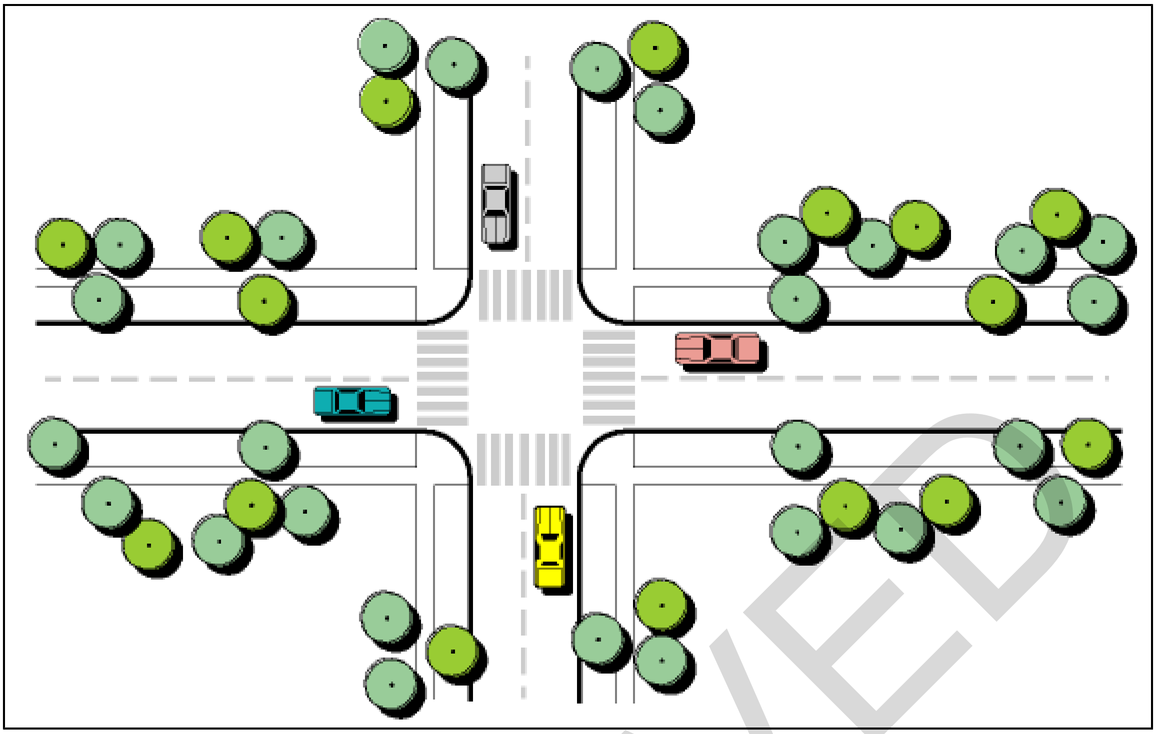

Figure 1-21a: Informal Streetscape Tree Planting

Figure 1-21b: Informal Streetscape Tree Planting

Intersections

Intersections benefit aesthetically from the addition of planting. At intersections where buildings dominate the landscape, plant masses can screen and soften the image. Special paving materials can be utilized in crosswalks to increase both safety and aesthetics.

Site distance triangles should be utilized to enhance safety for pedestrians and vehicle operators. Generally, what this means is that no planting or other site improvements between two and seven feet tall that will inhibit vehicle operator views of opposing traffic should occupy the triangular space 30 feet in each direction from the intersection corner.

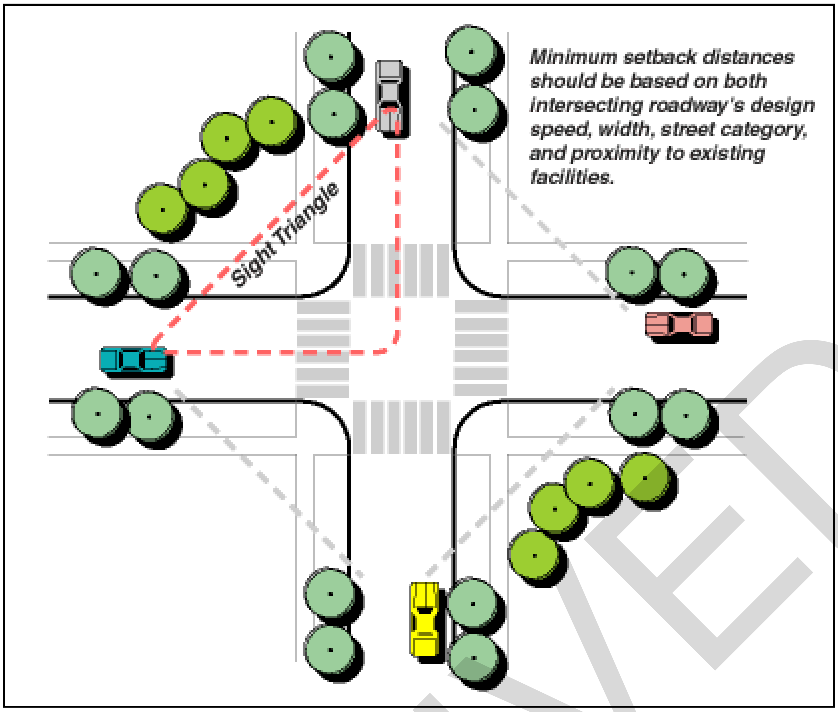

Figure 1-22: Maintain Visibility at Intersections

Parking

Parking areas are a dominant visual element on an installation. Landscape treatments can improve the visual appearance in a number of ways:

- Medians at the ends of parking rows, or full length, formally planted and curbed medians reduce the massive appearance of parking areas and vehicles and provide shade
- Landscape materials can be used to screen parking areas from view along major circulation routes or near high visibility facilities. Berms and informal evergreen shrub plantings are effective solutions year round

Landscape treatment of parking areas should always consider mowing and snow removal requirements to avoid the potential of increased long term maintenance.

Figure 1-23: Plantings Used in Parking Islands

Water Features

Decorative fountains, reflecting ponds, and other mechanical water features can add excitement and interest to the site. These features require continual maintenance to ensure proper operation and are high water users. Unless the budget allows, and the concept is supported, water features rarely become part of the project.

Use water features in those areas of the installation with the highest pedestrian exposure. These areas include plazas for large administration facilities, community center malls, or high visibility memorials.

Water cascading over surfaces with shallow pools is best. Avoid design solutions that require deep pools and large amounts of water.

Storm drainage requirements may dictate the use of retention ponds to control runoff. Such drainage structures can serve as positive features of the landscape. Care must be exercised to avoid attracting birds that may hinder or endanger the flying mission.

Figure 1-24a: Decorative Fountain Used in Pedestrian Area

Figure 1-24b: Informal reflecting pond

1.3.4 DESIGN GUIDELINES

The basic principles of quality landscape design apply to all projects. The following are a few of the guidelines to be employed:

1.3.4.1 General

- Use hardy, regionally native or naturalized plant materials when possible
- Create design solutions that minimize adverse impacts on the natural habitat
- Prevent pollution by reducing fertilizer and pesticide requirements: use integrated pest management techniques, recycle green waste, and minimize runoff throughout the design process
- Preserve and enhance existing natural landforms and vegetation
- Maximize low maintenance landscapes
- Maximize the use of water-efficient plant material
- Install standardized, water-efficient irrigation systems

- Employ foundation planting to visually anchor facilities to the groundplane
- Ensure planting plans respond to energy conservation concerns
- Screen undesirable elements

1.3.4.2 Specific

- Group trees to visually separate areas from heavy traffic or other functional uses
- Use mass plantings, berms, and architecturally compatible fencing as screens and buffers
- Combine massing of trees and shrubs with fencing and signage to create attractive and interesting entries
- Provide large turf areas near dormitory facilities to improve open field recreational opportunities
- Reduce building mass through use of foundation plantings and varying tree heights
- Use thornless and non-toxic plant material near children play areas
- Screen incompatible elements such as chain-link fenced service, storage, utility, loading, delivery, and mechanical areas from view with architectural walls or dense evergreens if exposed to public traffic or people-intensive uses
- Use site amenities that are durable, well constructed, and vandal-resistant
- Design irrigation systems to minimize opportunities for vandalism to key components such as controllers and backflow preventers

1.4 IMPLEMENTATION

This chapter describes the construction documents associated with the installation landscape program.

There are three main elements of the implementation phase: construction documents, post-construction project establishment procedures, and construction management.

1.4.1 CONSTRUCTION DOCUMENTS

Demolition Plan

Many projects will be built on sites with existing features or elements that are not part of the final design. These elements must be removed or demolished and are shown on the demolition plan.

Grading Plan

When project grading requirements are extensive, there may be a need for a grading plan. The grading plan is used to delineate elevations and drainage patterns. The final grading plan shows the site boundaries, existing landform contours with a benchmark to indicate the base for the elevations shown, existing site features, and proposed site structures.

Coordination with other design professionals on final elevations of structures, storm drains, and culverts is often necessary to ensure project success.

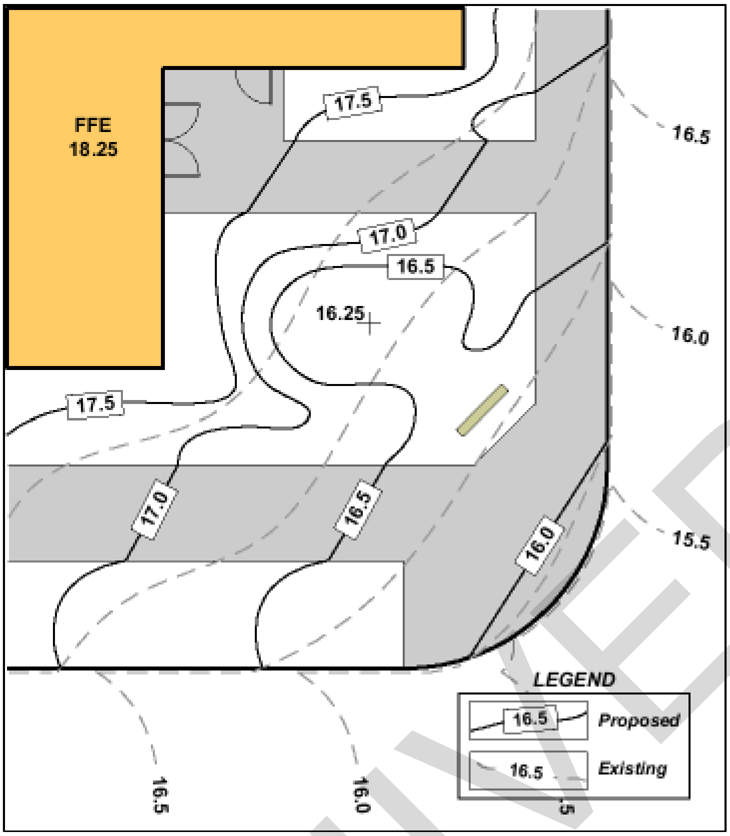

Figure 1-25: Grading Plan Example

Planting Plan

The planting plan is the essential element of the landscape construction package. The planting plan shows the location and types of proposed plant material in the project as noted in the plant schedule. The plant schedule contains the following information:

Planting Plan Elements

- Common and botanical names including specific
  - species if required
- Plant size
  - height
  - width
  - caliper
  - container grown (specify size)
  - balled and burlapped (field-dug)
  - bare-root
- Condition
  - standard (single trunk)
  - multi-trunk
  - foliated to ground
- Quantities
  - total number of each plant type and container size
- Notes or special requirements

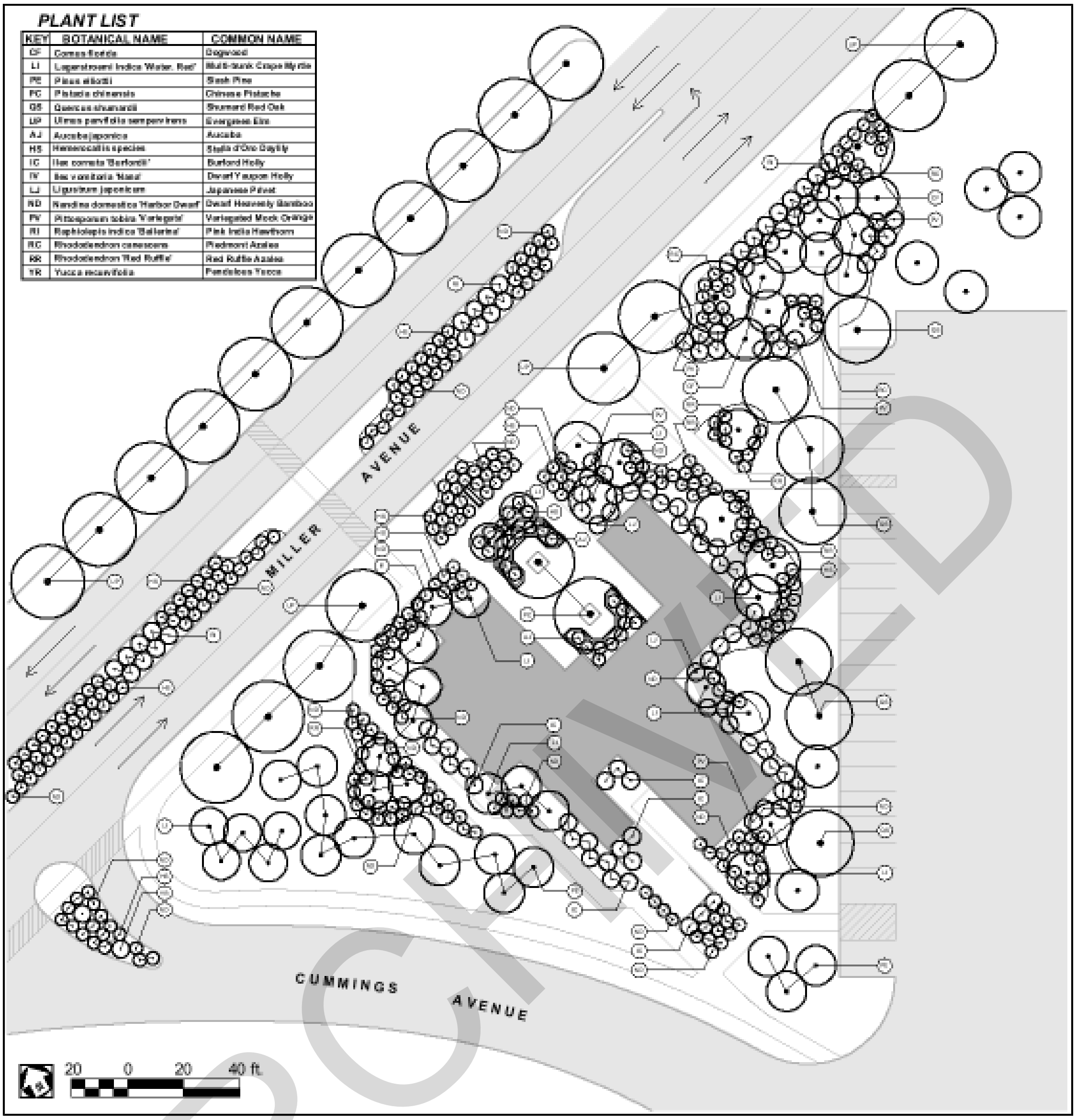

Figure 1-26: Planting Plan Example

Irrigation Plan

An irrigation plan is a schematic representation of the equipment and materials necessary to efficiently provide water to plant material and turfgrass. Standardized symbols should be used to depict irrigation elements. They should be listed and described in an irrigation schedule or legend as well as cross-referenced to the appropriate irrigation details.

Regional climatic conditions influence the requirement for an irrigation system. The designer must determine if the short-term construction costs and the long-term maintenance costs of the irrigation system are justified. If the planting plan is complex, or the project is highly visible and important to the perceived aesthetic quality of the installation, then an irrigation system should be part of the project. A properly designed irrigation plan identifies and locates the following irrigation features:

<u>Irrigation Plan Elements</u>

- Water source and point-of-connection
- Meter (if required)
- Emergency shutoff valve(s)
- Backflow device
- Pipelines
- Zonal isolation gate valves
- Turf, shrub, and/or drip valves
- Quick coupler valves
- Sprinkler heads
- Drip emitters
- Filters
- Pressure regulators
- Irrigation controller
- Electrical power source
- Moisture sensor
- System drain valves

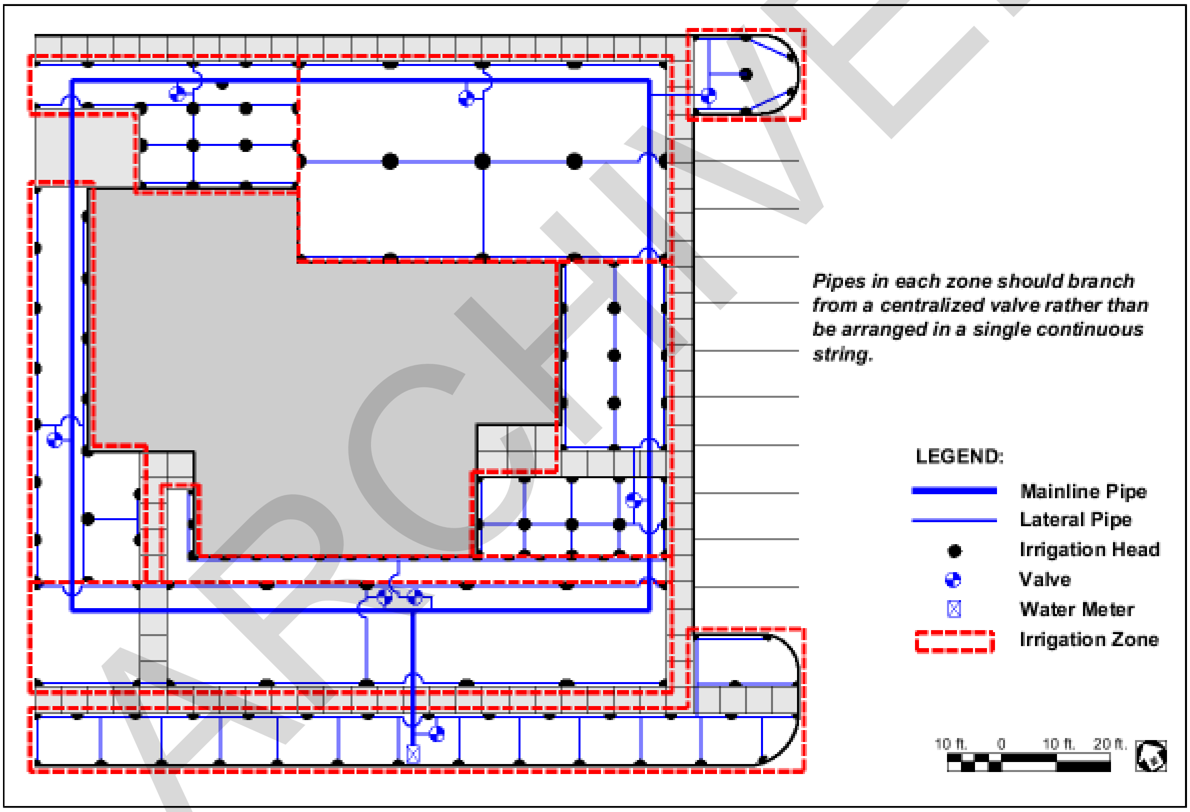

Figure 1-27: Irrigation Plan Example

Landscape Details

Landscape details provide specific information to assist the installer and the construction inspector in implementing a landscape project. Construction details for pavements, planting pits, retaining walls, footbridges, irrigation system components, berms, swales, benches, and fences are a few of the landscape elements that normally are detailed. Anything important enough to do right is important enough to detail.

Specifications

Specifications control the quality and direct the method of construction for a landscape project. Since specifications take precedence over all drawings and notes, they are crucial to the execution of a project. Specifications include technical data to support information contained in the drawings. A landscape project specification package should include precise construction methods, procedures, and quality control standards of work for all elements in the project. Plant material and irrigation system guarantees and warranties should be expressly stated to further ensure construction quality.

Cost Estimate

A cost estimate is a compilation of costs to complete a landscape project including materials, labor, overhead, and profit. Some installations use the AF Form 3052 for detailing project costs where others have moved to easily-updated computer spread sheet programs. If a cost estimate is not performed early in the design process, problems can arise as the project design nears completion.

An estimate should be performed at each phase of the design, from the initial budgeting at the programming phase to the final contract or construction package.

An equitable portion of the total project cost must be assigned to the landscape elements and site development. Listed below are typical landscape elements that require cost estimates:

Landscape Cost Estimate Elements

- Plant materials
- Inert materials (boulders, rip-rap, landscape element)
- Landscape grading operations (berm or swale construction)
- Planters
- Soil preparation
- Turf areas
- Irrigation systems
- Establishment operations
- Special paving, such as patterned concrete or colored pavers
- Decorative lighting, such as bollards or landscape lighting special to the project
- Other site amenities, such as benches, retaining walls, trash receptacles, and special signage

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1.4.2 ESTABLISHMENT

How a landscape project is established is important with respect to long-term results. Whether the project is constructed with in-house personnel or by contract, establishment procedures are the designer's quality guarantee.

Establishment specifications ensure proper installation of plant material, irrigation equipment, turf areas, and other project elements by requiring specific and constant attention to the project landscape elements immediately after installation. Since a large percentage of plant loss and irrigation system failure occurs in the first year, establishment specifications greatly increase long-term project success.

1.4.3 CONSTRUCTION MANAGEMENT

Designer and Inspector Interaction

Oversight by a landscape architect of a landscape project is all too often considered a luxury which cannot be accomplished due to lack of funds. The quality and ultimate success of the final product can be improved by involving the design professionals who best understand the project intent and requirements. Many decisions made during the construction of a project impact the intent of the design. By communicating the vital aspects of the design package to the contract manager as well as the contracting officer, the designer can ensure design continuity and success.

Many contractors will request the assistance of the designer in the layout of berms, plants, boulders, and walkways. This does not preclude the need for accurate and well-drawn plans, nor does it relieve the contractor of their contract responsibilities.

1.5 CONCLUSION

This guide assists MAJCOM and installation commanders, planners, and designers in the proper development of the land areas on Air Force installations. It establishes principles, procedures, and criteria for creating and maintaining a logical landscape development program at each installation and explores both time-proven and modern solutions in landscape design and implementation.

1.5.1 GETTING STARTED

1.5.2 LANDSCAPE ARCHITECT RESPONSIBILITIES

From budgeting, to site selection, to construction management, the landscape program should be monitored, supervised, and controlled by an individual trained in the profession. The landscape architect should provide the day-to-day direction required to implement most of the activities and requirements addressed in this guide. The following tasks are typical landscape architect responsibilities:

- Compile and update landscape planning documents
- Provide a comprehensive perspective on facility siting issues
- Perform conceptual site studies and plans
- Review A-E design submittals
- Provide design drawings, specifications, and details
- Monitor landscape construction projects
- Direct self-help landscape activities

1.5.3 ACTION ITEMS

Much of this guide can be easily implemented. Some concepts will take a measure of time, labor, and experience. Listed below are some actions to ensure success in landscape development:

- Adopt a landscape theme based on the regional character and historical and cultural significance of the installation
- Ensure contracted and in-house designers address landscape development in projects
- Develop and use an approved installation plant list
- Provide training and guidance to personnel performing grounds maintenance, irrigation, and pruning
- Monitor self-help work by requiring the following steps:

- Institute a review and approval procedure
- Stock the self-help store with approved plant and construction materials
- Use standard installation details
- Follow up and inspect landscape projects
- Provide public information on successful projects, good examples, award winners, and future opportunities

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1.5.4 REFERENCES

Suggested further reading:

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Time-saver Standards for Landscape Architecture, Charles W. Harris and Nicholas T. Dines, 1988, McGraw-Hill, Inc.

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2.1 INTRODUCTION

The image of an installation should be one of strength and quality. Its landscape can significantly influence the perceived quality as well as the overall morale and attitudes of the people who live and work there.

A positive image, achieved through visual compatibility and unity, is the result of a comprehensive landscape development planning program that brings together the natural and man-made environments.

2.1.1 DEFINITION

Landscape planning is the process of compiling basic information that can be utilized to guide the landscape design and development of the entire installation.

Landscape development planning is the comprehensive application of this information to develop the landscape planning and design documents of the installation as part of the Comprehensive Plan.

2.1.2 GOAL

The primary goal of landscape planning is to efficiently allocate landscape resources, protect the natural environment, and enhance the quality of life for the people who live and work in the Air Force community.

2.1.3 OBJECTIVE

The objective of landscape planning is to provide a framework that guides in-house, self-help, and contracted design efforts. It is a process that analyzes existing landscape resources and design requirements and creates a unified direction for future installation landscape development projects.

2.1.4 LANDSCAPE PLANNING ELEMENTS

Below are brief explanations of the landscape planning elements that will be covered in this guide:

Installation Plant List

Identifies readily available and proven plant material for use in facility landscape design. Selected plant materials should complement and reinforce the installation architectural theme.

Installation Inert Material List

Identifies the inert materials considered appropriate for use on the installation to create harmony and continuity in landscape design. Selected inert materials should also complement and reinforce the installation landscape and architectural themes.

Landscape Development Zoning Plan

Specifies the level of landscape treatment an area or facility should receive. Forms the basis for landscape programming, design, construction, and maintenance requirements. Directs intensity of treatment in concert with the landscape theme, plant list and inert material list.

Streetscape Corridor Plan

Identifies the level of landscape treatment installation roadways should receive. Includes such features as trees, sidewalks, bike paths, and screening. Utilizes landscape theme, plant list, inert material list, and landscape development zoning plan to assist in design of new and existing roadway improvement projects.

Existing Tree Inventory

Documents the location, size, and quality of the installation's urban forest resources. The database will assist in facility siting, site planning, maintenance scheduling, and landscape design.

2.1.5 LANDSCAPE DEVELOPMENT PLAN

Landscape planning elements are specific, informative, stand alone design and planning documents. Together, they form a sound and efficient basis for the comprehensive programming, design, and construction of the installation's landscape.

Guidelines for the actual preparation of the Landscape Development Plan can be obtained in the Comprehensive Plan master statement of work.

2.2 INSTALLATION PLANT LIST

2.2.1 INTRODUCTION

The installation plant list documents trees, shrubs, annuals, perennials, turfgrasses, and groundcovers to be used in landscape design projects. The plant list is the backbone of installation planting design. The installation plant list provides designers with a palette of desirable plant material that possess the following characteristics:

- **Hardy and relatively pest-free**
- **Regionally native or indigenous**
- **Minimal maintenance and irrigation**
- **Readily available**

2.2.2 SELECTION PROCESS

Hardy and relatively pest-free

Hardy plants endure the temperature extremes of a specific region. Most plants are categorized based on the lowest temperatures they can endure without significant damage. Marginal plants should be avoided or sparingly used to ensure maximum long term value and performance while minimizing maintenance and possible replacement.

Pest free plants are rare. Many plants can withstand natural influxes of common garden pests. Plant growers are constantly improving and developing species that are especially tolerant to disease and pests. Resistance to major diseases should be considered in choosing plants for the installation plant list.

Regionally native or indigenous

Regionally native plants are generally conditioned to the climate and soil of a particular region. These plants tend to be drought tolerant and hardy. Use of native plants is highly desirable and should be a primary consideration when selecting plants for the installation's plant list.

Plants that have been successfully introduced into a region are considered indigenous. These plants have proven their durability through years of use. Many of these plants have naturalized and have become widely used. Some plants may become invasive and displace desirable natives. Characteristics of indigenous plants should be carefully examined prior to including them on the installation plant list.

Minimal maintenance and irrigation

Maintenance and irrigation is costly. Plants that can thrive without supplemental water after establishment are highly desirable. Certain plants exhibit characteristics that create a need for maintenance and attention. For example, Century plant, a saw-tooth bladed agave, grows to immense size only to bloom in a few years and die. Mexican fan palms require specially trained personnel and equipment to remove palm fronds as the plant matures. Installations should consider all these fixed, long term costs during the plant selection process.

Readily available

Plants included on the installation plant list must be readily available. Check with local or regional nurseries to ensure plants will be available in sufficient quantities to satisfy future landscape project needs.

2.2.3 PLANT LIST INFORMATION

The installation plant list should include the following information for each plant:

- Genus, species and cultivar (if necessary)
- Common name
- Evergreen/deciduous
- Mature height and width
- Planting size
- Exposure (sun/shade tolerance)
- Irrigation requirements

2.2.4 USE CATEGORIES

Plant material selected for the installation plant list should be categorized according to the following uses as defined in the Landscape Design Guide:

- Streetscape
- Foundation
- Barrier
- Screen
- Accent
- Wetlands
- Erosion control
- Parking Areas
- Wildlife

BOTANICAL NAME	COMMON NAME	Evergreen\Deciduous	Mature height (feet)	Mature width (feet)	Planting size (gallon)	Exposure	Irrigation requirements	Streetscape	Foundation	Barrier	Screen	Accent	Wetlands	Erosion control	Parking area	Wildlife
TREES																
Acacia minuta	S.W. Sweet Acacia	E	30	30	15	F	L	■		■					■	■
Carnegia gigantea	Saguaro	E	40-80	6-18	6-8 ft.	F	N	■				■				■
Cercidium floridum	Blue Paloverde	D	30-40	30-40	5	F	L			■				■	■	■
Olneya tesota	Ironwood	E	25-40	30	15	F	L	■		■	■				■	■
Pinus eldarica	Afghan Pine	E	50-65	30	5	F	M	■	■		■				■	
Platanus wrightii	Arizona Sycamore	D	65	40-50	15	F	M-H	■						■	■	■
Prosopis chilensis	Chilean Mesquite	D	40	30-50	5	F	L	■						■	■	■
Quercus virginiana	Southern Live Oak	E	60	45	24	F	M	■	■		■				■	
Rhus lancea	African Sumac	E	35	40	15	F	M	■	■		■				■	
Washingtonia robusta	Mexican Fan Palm	E	80-120	15	5	P-F	M	■				■	■			
SHRUBS																
Agave vilmoriniana	Octopus Agave	E	5	6	1	F	N			■		■				
Caesalpinia pulcherrima	Red Bird of Paradise	D	8-10	6	1	P-F	L	■	■		■	■				■
Calliandra eriophylla	Fairy Duster	D	4	4	1	P-F	L	■	■						■	
Chaemerops humilis	Mediterranean Palm	E	8-12	8-12	15	S-F	L-M	■	■			■				
Dasylirion wheeleri	Desert Spoon	E	6-10	4-8	5	F	N	■		■		■			■	
Ferocactus spp.	Barrel Cactus	E	3-4	2-3	6-12 in.	F	N					■				
Fouquieria splendens	Ocotillo	D	12-20	8-20	8 cane	F	N	■		■		■			■	
Hesperaloe parviflora	Red Yucca	E	4-6	3-5	1	P-F	N	■	■			■		■	■	
Penstemon parryi	Parry's Penstemon	E	3	2-3	1	P-F	M					■				
Yucca elata	Soaptree	E	8-12	4-8	5	F	N	■				■				■
GROUNDCOVERS & VINES																
Dalea greggii	Trailing Indigobush	E	1-2	6-8	1	F	L							■	■	
Lantans montevidensis	Trailing Lantana	E	2-3	4-6	1	P-F	M	■	■			■				
Macfadyena unguis-cati	Cat's Claw	E	30	45	1	S-F	M		■		■					
Oenothera drummondii	Baja Primrose	E	2	3-4	1	P-F	M	■	■			■				
Rosa baksiae	Tombstone Rose	E	15	20	1	P-F	L	■	■		■	■				
Verbena peruviana	Verbena	E	1	4-6	1	P-F	L-M	■				■		■		

KEY: F=full sun P=part shade S=shade L=low M=medium H=high

Figure 2-1: Example Plant List

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2.3 INSTALLATION INERT MATERIAL LIST

2.3.1 INTRODUCTION

Gravel, decomposed granite, lava rock, or river run stone are used in the landscape with the intent of lowering maintenance and improving aesthetics. When properly incorporated, these materials work well to create an efficient, economical, and aesthetic design solution. The difficulty arises when these materials are installed without regard to long term maintenance requirements.

The following issues must be considered in the installation inert material list selection process:

- **Compatibility With Architectural Theme**
- **Readily Available**
- **Proper Installation And Maintenance**
- **Appropriate Use**

2.3.2 SELECTION PROCESS

Compatibility With Architectural Theme

Inert materials should be visually compatible with the installation architectural theme. Color, size, texture, and long-term aesthetic value or durability should be primary considerations of inert materials to be included on the installation approved list.

Readily Available

Materials included on the installation inert material list must be readily available. Native or locally occurring materials usually will contribute the most toward preserving the character or image of the final project. Check with local or regional suppliers to ensure materials will be available in sufficient quantities to satisfy future landscape project needs.

Proper Installation and Maintenance

Overuse, misuse, and poor installation techniques hinder the effectiveness of inert material use in the landscape. Mixing different types or colors of similar materials of the same texture generally is inappropriate and detracts from the design composition.

Appropriate Use

Designating inert materials for specific uses throughout the installation is important. For example, 3-8" river run stone may be appropriate for use as an accent in an area of 3/4" decomposed granite or as erosion control in a small swale. In contrast, installing it as the primary groundcover over hundreds of square feet may be expensive, overpowering, and difficult to maintain.

2.3.3 INERT MATERIAL LIST INFORMATION

The inert material list should include the following information for each material:

- Descriptive name
- Locally used trade name
- Size or range of sizes
- Color
- Installation depth

2.3.4 USES

Materials selected for the installation inert materials list will be categorized by the following uses as defined in the Landscape Design Guide:

- Landscape element
- Surface erosion control
- Accent
- Rip-rap

DESCRIPTIVE NAME	TRADE NAME	Size	Color	Depth	Landscape Element	Surface erosion control	Accent	Rip-rap
Decomposed Granite	Bob's Red	¾ in. minus	red	2 in.	■	■		
River Rock	Salt River Run	3-8 in.	various	one layer		■	■	■
Granite Boulder	Catalina Mountain Granite Boulder	8-27 cf	natural	as detailed			■	■

Figure 2-2: Example Inert Material List

2.4 LANDSCAPE DEVELOPMENT ZONING PLAN

2.4.1 INTRODUCTION

Landscape development zoning defines the level of landscape treatment a particular area or facility should receive. It is the basis for budgeting for future landscape development. The landscape development zoning plan graphically depicts these zones to assist installation landscape programming, design, construction, and maintenance.

2.4.2 LANDSCAPE DEVELOPMENT ZONES

There are three zones of landscape development; primary, secondary, and tertiary. Landscape development zones are created through analysis of facilities and surrounding areas. By looking at the areas in terms of visual and historical significance and importance, visitor frequency, proximity to major circulation routes and other criteria specific to the installation, the intensity of landscape development can be determined.

Primary Zone

The primary zone is an area that is highly significant to the perceived visual quality and image of the installation. Facilities listed below commonly occur in the primary development zone. These facilities warrant additional funds in landscape design, construction, and maintenance.

Primary zone facilities:

- Main gate(s)
- Command and headquarters buildings
- Primary administration offices
- Community Center
- Main roadways
- Visitor Center
- Significant static displays and parade grounds
- Billeting office
- Distinguished Visitor quarters
- Hospital
- Airfield entrance to Base Operations
- Clubs
- Base Operations facility
- Military Family Housing areas (MFH)
- Golf clubhouse and course

Secondary Zone

The secondary zone contains most of the remaining developed areas of an installation. Many facilities in this area are important in the daily lives of the Air Force community, but extensive landscape development is not essential due to lower visibility and maintenance budget requirements.

This zone is a transition between what is generally a highly developed primary zone and the functionally and simply developed tertiary zone. Consistent and proper project programming and design become paramount as the secondary zone can be significant in creating a positive visual image for the installation.

Secondary zone facilities:

- Base Civil Engineer facility
- Fitness Center
- Family Support Center
- Squadron Operations facilities
- Credit Unions and banks
- Bowling Center
- Fam Camp
- Shoppette
- Undeveloped areas or open space in MFH
- Moderate public visibility areas of perimeter fence

Tertiary Zone

The tertiary zone encompasses those areas that will require little to no long-term landscape development. Many of these areas are adjacent to the flightline, in or near clear zones, or serve as buffer areas around the installation. Most of the areas should be left natural. Maintenance requirements in the tertiary zone are minimal.

Tertiary zone facilities:

- POL Tank farm
- Munitions storage facilities
- Operations side of runway facilities
- Civil engineer storage and shops areas
- Forested areas outside of cantonment area
- Service roads
- Water treatment facilities
- Test cells
- Limited public visibility areas of perimeter fence
- Security areas

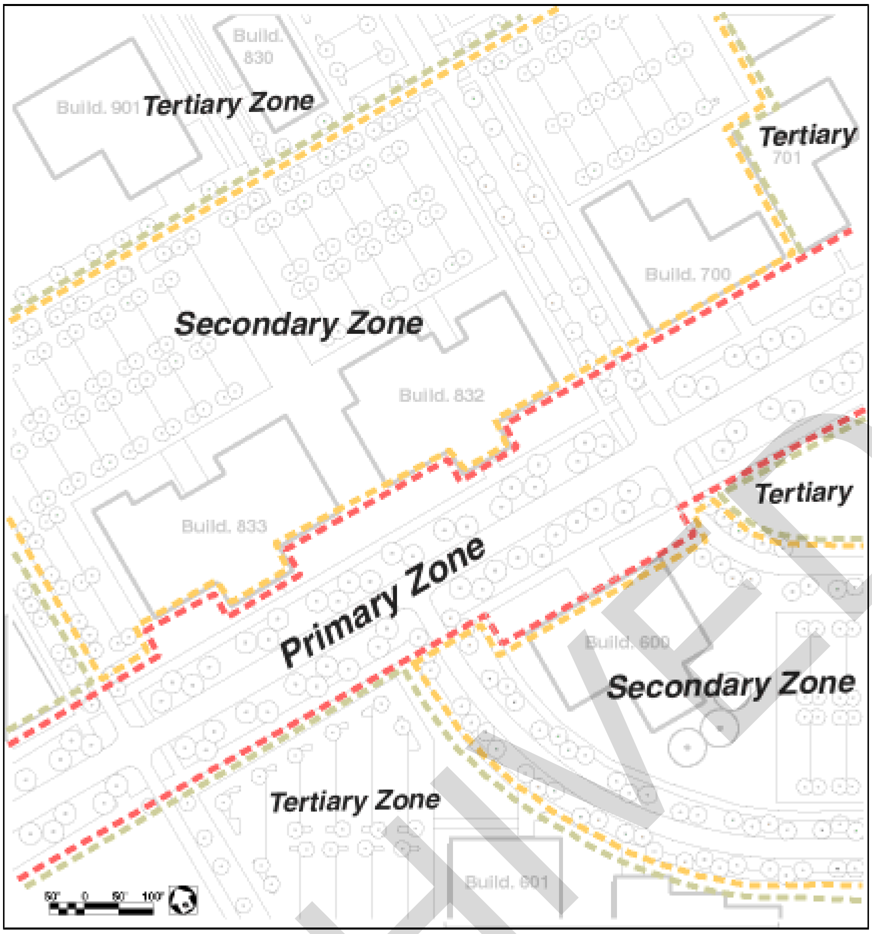

Figure 2-3: Landscape Development Zoning Plan

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2.5 STREETSCAPE CORRIDOR PLAN

2.5.1 INTRODUCTION

Generally, streets on Air Force installations include trees, shrubs, and site amenities such as lighting, screen walls, signage, sidewalks, flag displays, and bike paths. Properly developed, the landscape of an installation's streets is a subtle visual indicator of the hierarchy of the transportation network. It also contributes to the overall appearance and function of the installation.

The streetscape corridor plan directs proper landscape development of installation roadways to maximize utility, beauty, and safety. It will provide valuable insight to new or street project upgrades by documenting pedestrian, vehicular, utility, and aesthetic needs of the installation's streets.

2.5.2 DEFINITION

The streetscape corridor is defined as the area between buildings that are on opposite sides of a street. In cases where there are no buildings, the streetscape corridor will be delineated as the space 30-100 feet on either side of the center line of a street.

2.5.3 PROCESS

Developing the streetscape corridor plan is a three step process that includes documentation of the existing situation, determining needs, and establishing guidelines and plans for future development:

- **Analysis**
- **Needs Assessment**
- **Implementation**

Analysis

A detailed study of an installation's streetscape corridors is initiated to summarize the existing conditions. A comprehensive analysis should document the following existing streetscape elements:

- Vegetation
  - functional and visual quality
  - desirable and undesirable species and patterns
- Circulation
  - number, location, and safety of vehicular access points
  - location, condition, and continuity of walkways and bike paths

    - location and condition of bus stops, shelters, and pull offs
- Infrastructure
    - location of underground and overhead utilities
- Physical
    - location, condition, and functional quality of site amenities such as benches, lighting, and fencing
    - distance between existing buildings
- Safety
    - potential or existing safety hazards to vehicles, pedestrians, or property
- Visual
    - location, identification, and functional quality of screening elements (vegetation, berms, etc.)

Needs Assessment

After analysis of the installation streetscape corridors, designers can determine the aesthetic and functional needs of the installation roadways based on the development goals set by the installation's commanders and planners. The needs assessment phase of the streetscape corridor plan determines specific requirements to improve the utility, beauty, and safety of the installation roadways through landscape treatment.

The following issues should be addressed during the assessment of the collected information:

- Vegetation
    - High quality vegetation to preserve
    - Established desirable street tree patterns
    - Low quality vegetation that may be removed
- Circulation
    - Additional crosswalks and signage to enhance pedestrian safety
    - Additional walkways to ensure continuous and complete linkages between significant use areas such as between Military Family Housing areas and the Community Center
    - Bike paths
    - Bus stops and pull offs
- Infrastructure
    - Underground and overhead utility lines
    - Suggested sites for irrigation connections and controllers
- Physical
    - Site amenities such as benches, lighting, and fencing
    - Preferred distance between existing buildings and delineation of actual streetscape corridor
- Safety
    - Potential or existing safety hazards and mitigation solutions
- Visual
    - Screening requirements and potential design solutions

Implementation

The most important aspect of any plan is putting it into action. The final phase of the streetscape corridor plan is implementation. The information collected from the needs assessment phase should be used to develop and execute new or renovation street projects on the installation:

The streetscape corridor plan should:

- Assist in prioritizing projects
- Help establish budget requirements
- Standardize building setbacks
- Determine future pedestrian and bicycle transportation needs
- Delineate aesthetic requirements
- Delineate future walkway, bike path, and trail locations
- Set proper street tree planting offsets and determine varieties
- Direct safe intersection sight distance setbacks
- Recommend future utility locations
- Special planting details or instructions
- Identify need and locations for benches, lighting, and fencing

Figure 2-4: Streetscape Corridor Plan

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2.6 TREE INVENTORY

2.6.1 INTRODUCTION

Trees are the installation's most valuable landscape resource. The tree inventory documents the location, size, and quality of existing installation trees.

2.6.2 PURPOSE

A tree inventory will yield valuable information that can be utilized by the designer, community planner, natural resources planner, and grounds maintenance manager. Below are just a few of the potential uses for the tree inventory:

Inventory Uses:

- Assist facility siting by providing detailed locations of tree resources that must be protected and can be saved by integrating them into the siting process
- Starting point for landscape design site analysis and planting plan accomplishment by providing location, specie, and size of existing trees
- Information database for the establishment of an installation urban forestry management plan that will be the basis for tree maintenance scheduling and budgeting

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2.6.3 JUSTIFICATION

Trees are an important asset. They perform significant functions in many diverse categories including increased aesthetic value, energy conservation, natural resources, and engineering and environmental benefits.

Increased Aesthetic Value

Trees provide shade, create a canopy, add color and variety, and signal seasonal change. They can soften the appearance of buildings, concrete, and streets.

Energy Conservation

Several studies have shown that properly placed trees shade building walls and windows resulting in reduced utility consumption. They can also act as windbreaks, helping to further decrease energy consumption costs.

Natural Resources

Trees can provide food sources for numerous animals and birds. Endangered specie habitats can be created or improved by utilizing information from the tree inventory. Trees that support an endangered species common to the area can be increased or preserved to maintain an ideal environment.

Engineering and Environmental

Trees intercept rainfall and help control winds reducing erosion of valuable top soil. Trees filter many airborne pollutants including dust, absorb carbon dioxide, and release oxygen.

2.6.4 PROTECTION AND MANAGEMENT

Commanders and planners have recognized the benefits trees provide and realize the need to protect the investment with a comprehensive urban forest management program. The inventory draws attention to immediate problems such as disease, hazard potential of falling limbs, or dying trees. Most importantly, it can be used as the basis for designing a long-term management plan for efficient use of funds for tree maintenance and replacement.

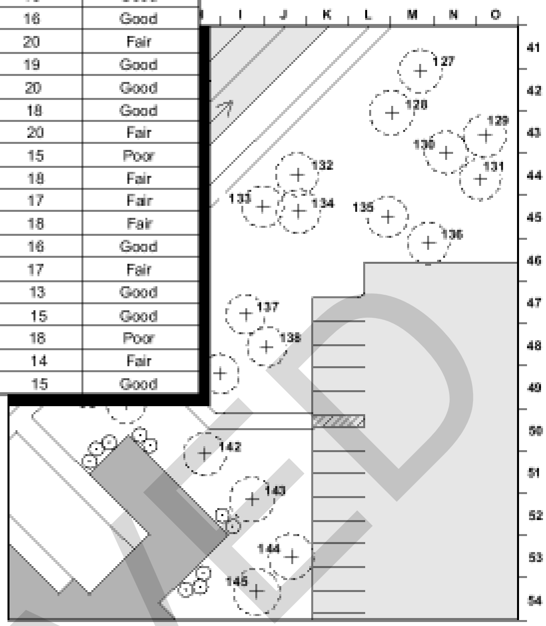
The following are examples of tree survey information generally collected:

- Botanical and common names
- Size
- Approximate age and life expectancy
- Condition
- Valuation
- Maintenance needs
- Tree location reference points
- Hazard potential

Much of the information above can be input into a computer aided drafting program (CAD) database or geographical information system (GIS). Several different programs are available. Most can be customized to create an integrated management strategy to effectively maintain the installation's valuable tree resources.

NUMBER	GRID LOCATION	COMMON NAME	BOTANICAL NAME	SIZE (in. DBH)	CONDITION
127	M-42	Lemon-Scented Gum	Ecalyptus citriodora	18	Good
128	M-42	Lemon-Scented Gum	Ecalyptus citriodora	18	Good
129	O-43	Lemon-Scented Gum	Ecalyptus citriodora	16	Good
130	M-44	Lemon-Scented Gum	Ecalyptus citriodora	20	Fair
131	O-44	Lemon-Scented Gum	Ecalyptus citriodora	19	Good
132	J-44	Lemon-Scented Gum	Ecalyptus citriodora	20	Good
133	J-45	Lemon-Scented Gum	Ecalyptus citriodora	18	Good
134	J-45	Lemon-Scented Gum	Ecalyptus citriodora	20	Fair
135	L-45	Brazilian Pepper	Schinus terebinthifolius	15	Poor
136	M-46	Brazilian Pepper	Schinus terebinthifolius	18	Fair
137	I-47	Brazilian Pepper	Schinus terebinthifolius	17	Fair
138	J-48	Brazilian Pepper	Schinus terebinthifolius	18	Fair
139	I-49	Jacaranda	Jacaranda mimosifolia	16	Good
140	E-49	Jacaranda	Jacaranda mimosifolia	17	Fair
141	F-49	Jacaranda	Jacaranda mimosifolia	13	Good
142	H-51	Jacaranda	Jacaranda mimosifolia	15	Good
143	I-52	Canyon Live Oak	Quercus chrysolepis	18	Poor
144	J-53	Canyon Live Oak	Quercus chrysolepis	14	Fair
145	I-54	Canyon Live Oak	Quercus chrysolepis	15	Good

TREE PLAN DATA BASE



TREE LOCATION PLAN

Figure 2-5: Existing Tree Plan

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2.7 CONCLUSION

This guide has provided descriptions and definitions of the elements necessary to compile an installation landscape development plan. The emphasis on increasing the quality of life on Air Force installations while decreasing funding for maintenance and construction continues to gain momentum. It is important that every installation ensure funding for landscape development is spent constructively and wisely.

2.7.1 ACTION ITEMS

Listed below are some of the necessary actions to create and implement a successful landscape planning program:

- Prepare and implement a Landscape Development Plan for the installation
- Require that all designers, design agents, and tenants comply with installation landscape development policy

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2.7.2 REFERENCES

Suggested further reading:

A Dictionary of Landscape Architecture, Baker H. Morrow, 1987, University of New Mexico Press

An Introduction to Landscape Architecture, Michael Laurie, 1975, American Elsevier Publishing Company, Inc.

Design on the Land, Norman T. Newton, 1971, The Belknap Press of Harvard University Press

Design with Nature, Ian L. McHarg, 1969, Doubleday & Company, Inc.

Graphic Standards for Landscape Architecture, R. L. Austin, T. R. Dunbar, J. K. Hulvershorn, and K. W. Todd, 1986, Van Nostrand Reinhold Company

Landscape Architecture, John Ormsbee Simonds, 1961, McGraw-Hill Book Company, Inc.

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Time-saver Standards for Landscape Architecture, Charles W. Harris and Nicholas T. Dines, 1988, McGraw-Hill, Inc.

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3 MAINTENANCE

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3.1 INTRODUCTION

Timely and proper maintenance is the cornerstone of a quality installation landscape. Proper landscape maintenance starts with quality design, material selection, and construction methods.

3.1.1 DEFINITION

Landscape maintenance is the regular care of plant material, site amenities, and other outdoor elements required to ensure an area functions and appears as it was designed. Time-proven and modern landscape maintenance procedures and practices, together with experienced inspectors and crew supervisors, are the keys to establishing a quality installation landscape.

Landscape maintenance includes trimming, fertilizing, mowing, pest control, and numerous other tasks necessary to ensure an appealing installation landscape. Proper landscape maintenance is often overlooked or taken for granted. Sound landscape maintenance guarantees design objectives are achieved as conceived by the designer.

3.1.2 GOAL

The goal of this guide is to provide an increased understanding of landscape maintenance practices and procedures required to ensure a healthy and pleasing installation environment. Each installation should develop and implement a comprehensive set of practical guidelines for maintaining the installation's grounds.

3.1.3 OBJECTIVE

The objective of this guide is to emphasize the importance of landscape maintenance and the role it plays in fulfilling the desires of commanders, planners, and designers.

3.1.4 LANDSCAPE MAINTENANCE ELEMENTS

Below are brief explanations of the landscape maintenance elements that will be covered in this guide:

Comprehensive Landscape Maintenance

Directs the type and frequency of landscape maintenance tasks for the entire installation based on general grounds maintenance categories and the composition of the native vegetation, climate, and soils.

Landscape Maintenance Tasks and Methods

Defines and explains basic landscape maintenance tasks and the various methods of accomplishment common to the care of installation grounds.

Landscape Maintenance Guidelines

Describes and directs the site specific application of landscape maintenance tasks for plant material, inert material, and other landscape amenities.

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3.2 COMPREHENSIVE LANDSCAPE MAINTENANCE

3.2.1 INTRODUCTION

Whether landscape maintenance is performed by in-house labor forces or by contractors, each installation should have a comprehensive plan to direct and control the quality of the work. This plan must be based on state-of-the-art field practices, comply with Air Force directives, and satisfy mission requirements while staying within the budget.

3.2.2 DEFINITION

Comprehensive landscape maintenance is comprised of the documents and maps that direct the type, frequency, and standard of landscape maintenance tasks and practices for the entire installation. There are two components of comprehensive installation landscape maintenance:

- **3.2.3 GROUNDS MAINTENANCE PLAN**
- **3.2.4 LAND MANAGEMENT PLAN**

3.2.3 GROUNDS MAINTENANCE PLAN

The Grounds Maintenance Plan directs the type and frequency of landscape maintenance tasks based on an area's category designation. Each installation will have maps delineating the grounds maintenance categories and a statement of work which will describe and define each task as it applies to each category.

Grounds Maintenance Categories

There are three levels or categories of grounds maintenance on the installation. These categories will be the basis for the quality and frequency of landscape maintenance performed on the installation. They are designated as the following:

Improved

Improved grounds usually consist of turfgrass areas and plant material requiring intensive maintenance. Grounds within this category are primarily in heavily developed areas of the installation including Military Family Housing.

Semi-Improved

Semi-improved grounds are areas where landscape maintenance is performed primarily for functional, operational, or aesthetic reasons. The semi-improved category may contain airfield safety zones, rifle ranges, and open spaces in developed areas.

Unimproved

The unimproved grounds category usually includes all other grounds on the installation and is largely made up of undeveloped areas. This category is comprised of the natural landscapes such as forests, wildlife areas, crop and grazing lands, lakes, ponds, and airfield areas outside the clear zone.

Little to no maintenance should be required, although some annual mowing or pruning may be part of the installation's grounds maintenance plan.

Task Definition and Frequency

The Grounds Maintenance Plan statement of work will determine the standard and frequency of specific landscape maintenance tasks as defined for each grounds maintenance category. Statements of work can be written based on requirements rather than frequencies. For example, turfgrass may require mowing anytime it exceeds four inches in height rather than weekly during a specific time of year. Many tasks are efficiently handled using requirements. Most statements of work will have a combination of both types.

Budget considerations will influence the way each maintenance task is handled. Balancing the need and desire for a certain level of maintenance quality and available funding should be undertaken as an installation team effort. The team should include commanders, planners, and a landscape architect.

3.2.4 LAND MANAGEMENT PLAN

The Land Management Plan has long been a vital component of the grounds maintenance program of an installation. According to Air Force policy, this document must be updated at least every five years. It contains general information on the physical, climatic, geologic, and vegetative characteristics of the installation.

Responsibility for preparing and updating this document varies greatly from installation to installation. Landscape architects should be consulted in the development of the Land Management Plan to ensure consistent implementation while meeting long-term landscape design, planning, and maintenance objectives.

The Land Management Plan can be used as a reference in design and landscape maintenance contracts. It can contain specific information such as the plant and inert material lists, standard landscape construction specifications and details, and soils maps.

3.3 LANDSCAPE MAINTENANCE TASKS AND METHODS

3.3.1 INTRODUCTION

Many landscape maintenance tasks are poorly defined and are performed without supervision. Well-defined maintenance guidelines are essential to conduct an efficient and effective program. Simple verbal or written directions can often alleviate many of the problems associated with an installation's landscape maintenance program. Since significant resources are expended in maintaining an attractive and safe installation landscape; tasks should be performed correctly.

3.3.2 DEFINITION

Landscape maintenance tasks are the recurring procedures and duties required to ensure a viable, functional, and beautiful installation grounds environment. Landscape maintenance methods are the standards and practices of the landscape industry used to accomplish these tasks.

The following tasks common to installation landscape maintenance will be defined and described:

3.3.3 LANDSCAPE MAINTENANCE TASKS

- **Aeration**
- **Fertilization**
- **Mowing**
- **Mulching**
- **Pest and Plant Disease Control**
- **Pruning**
- **Soil Amendments**
- **Trimming**
- **Weed Control**

Aeration

Aeration is the process of improving the gas and air exchange capabilities of soil being utilized for growing plant material. Compacted or water-logged soil conditions limit plant growth. Aeration reduces shallow rooting, improves nutrient infiltration, and increases overall plant vigor. Turfgrass is the most commonly aerated landscape element.

The most effective aerifiers are power hole-punching machinery that actually remove small cylinders of soil. New machines have been developed that employ high pressure water jets to aerate turfgrass on golf course greens and tees. Any aeration method that increases the permeability of compacted soils has merit and should be considered for use on the installation.

Fertilization

Fertilization is the supplemental application of nutrients required in the soil for healthy and sustained plant growth. There are 16 elements required for plant growth. Most soils contain traces of each.

The three major elements, nitrogen, phosphorus, and potassium are usually required in greater amounts. Numbers on fertilizer containers represent the three major plant nutrients: the first number is nitrogen (N), the second, phosphorus (P), and the third, potassium (K). For example, 10-8-6 shows nitrogen content of 10%, phosphorus content of 8%, and potassium content of 6%.

If a fertilizer's label says all or most of the nitrogen contained is in the nitrate or nitric form, it is a fast acting fertilizer and the nitrogen will be released quickly. If most of the nitrogen is ammoniac or organic, the nitrogen release will be slower but more sustained once the process begins. Phosphorus is absorbed through plant root tips. Acidic soils require increased phosphorus fertilizers. Potassium is described on the label in various ways: available or soluble potash, water soluble potash, or water soluble potash from muriate or tankage. Plants remove potassium from the soil in much the same way as phosphorus. The other thirteen trace minerals required for plant growth are usually readily available in most soils. Iron is the most common of these that may require replenishing.

There are three dry fertilizers commonly used: ammonium nitrate, 34-0-0; ammonium sulfate, 21-0-0; and ammonium phosphate, 16-20-0. They are readily available and safe for use on installations. Soil should be tested to determine exact fertilization requirements. Local extension agencies or nurseries can provide this service at little or no cost. These professionals will be able to provide detailed fertilization guidance based on the results of the soil analysis.

The most important aspect of fertilization is regularity. It is best not to fertilize unless it will be performed on a scheduled and recurring basis. Research has revealed irregular fertilization actually causes more harm than good. There is also the possibility of root burn if too much fertilizer is applied. Always water immediately after fertilizing any plant material. Continue regular irrigation to ensure the nutrients are diluted and disbursed throughout the root zone.

Fertilizer can be applied in many ways. Always follow recommended application rates. Hand-held crank units for shrubs, push rotary or drop spreaders for smaller turfgrass areas, and tractor pulled rotary spreaders for large turfgrass areas are a few common methods of fertilizer application.

Mowing

Proper mower and height of cut, sharp blades, and low moisture content are the main requisites for a successful mowing operation. In addition, not more than one-third of the grass should ever be removed in any one mowing operation.

Some turfgrass types require special mowers. Zoysia and Hybrid Bermuda grass should be mowed with reel type mowers only. Most grasses can be cut with standard rotary mowers. Heavy textured utility grasses can be mowed with flail type mowers.

Mulching

Mulching is the placement of organic material over a plant's root zone. Mulch keeps the soil near plant roots cool and moist longer than soil exposed to the sun and drying wind. Mulch provides insulation during winter, discourages weed germination, reduces soil erosion, impedes soil compaction, and protects plants from the damage caused by mowers and trimmers. Mulching should be accomplished annually as it decomposes, breaks down, and shifts. Depth should be 2-4 inches depending on plant type and geographical location.

Available materials for use as mulches include compost, ground or shredded bark chips, pine needles, leaves, straw, processed by-products such as grape and apple pomace, and cottonseed or rice hulls. Organic materials are preferred over inert such as rock or stone which reflect sunlight, retain heat, and may cause plant stress.

Pest and Disease Control

Pest and disease control is the logical process of minimizing or eliminating damaging insects, animals, and pathogens. Many pests are cyclic and their actual damage to the landscape is minimal. Some are thwarted through natural processes. Some pests, such as ground squirrels, termites, and particular varieties of blight should receive immediate attention and treatment. Always consult an entomologist on pest related problems.

Many states have adopted requirements and restrictions regarding pesticides as well as who can apply them. Many require licensed pest control specialists for the application of certain chemicals. Additional information is available from the Air Force Integrated Pest Management program manager. This program advocates economical and environmentally sound prevention or control of animal and pathogenic pests.

Application methods for the control of pests and plant diseases are numerous and include attachments to garden hoses, hand-held pump sprayers, tractor-mounted tank sprayers, foggers, and hand or machine broadcasted granules.

Pruning

Pruning is the selective removal of foliage or branches from plant material. It contributes to the quality, attractiveness, and longevity of installation trees and shrubs. Few landscape maintenance tasks are more important than pruning. Workers must be trained in the proper methods and then be supervised in the field by an experienced person.

Pruning should only be done to remove dead or diseased branches, reduce foliage density or crossing branches, or to improve the beauty of the plant through selective removal of a few branches. Proper pruning is not difficult. There is abundant information available on the correct way to prune. Ample training or instructional courses are also available and should be required prior to participation on a pruning crew.

Trees

Tree pruning is both an art and a science. Proper pruning is paramount to long term tree health and vitality and their aesthetic and energy conservation value. Many trees are incorrectly topped or pollarded, forever destroying their natural shape and size while greatly shortening their lives. It is better to leave a tree alone than to prune it improperly. Topping a tree removes the terminal bud and results in irregular and oddly-shaped trees. Pruning should restore a tree to a healthier condition and a more attractive shape, making it stronger and better able to withstand storms and disease.

Correct tree pruning is at least a two-person job. As a minimum, a tree pruning crew should include a highly-trained and experienced person to guide the cutter from the ground.

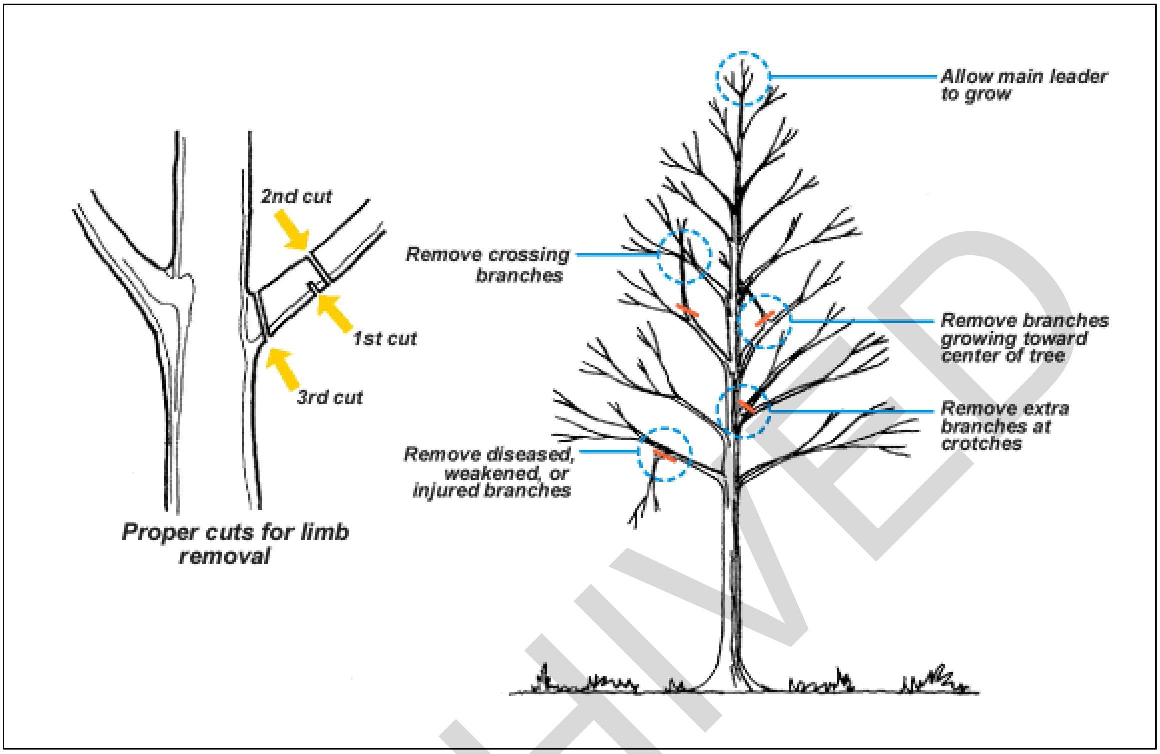

Figure 3-1: Tree Pruning Techniques

Shrubs

Overpruning of shrubs is common throughout the Air Force. Most of the shrubs receiving regular pruning probably don't need to be pruned at all. When they are pruned improperly or unnecessarily, the labor and associated costs are wasted, the plant suffers, and the aesthetic quality of the landscape declines.

Shrubs have distinct shapes; weeping, rounded, oval, upright, spreading, and irregular shaped. Allow shrubs to take on their natural shape, pruning only to reduce crowded foliage, crossed branches, an asymmetrical shape, or branches growing into the heart of the shrub.

Selective pruning restores a shrub to a healthy condition and an attractive shape. Allow plants intended for screening to grow naturally and do the job they were planted for. Trimming or pruning screening plants increases the maintenance activity and expends valuable resources.

Very few shrubs should ever be sheared, and then only the fine textured or small leafed varieties. Artificial shaping of shrubs should be minimized. If a shrub continually needs pruning due to safety or pedestrian clearance near a walkway, then removal should be considered. Generally, shrub pruning should result in soft, natural shapes and be performed a maximum of once or twice a year.

Pruning tools cover a large choice of available products. It is important to choose the correct tool for each operation. Tools range from hand-held pruners and bypass loppers to curved hand-held saws to power chain saws.

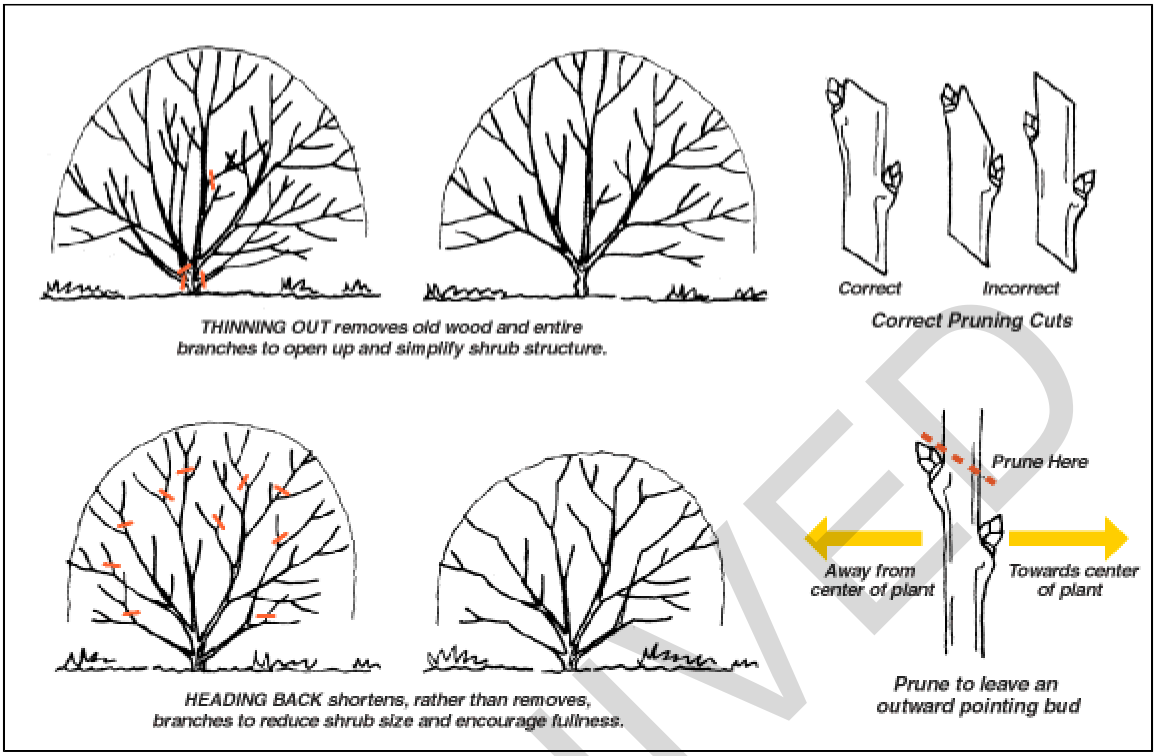

Figure 3-2: Shrub Pruning Techniques

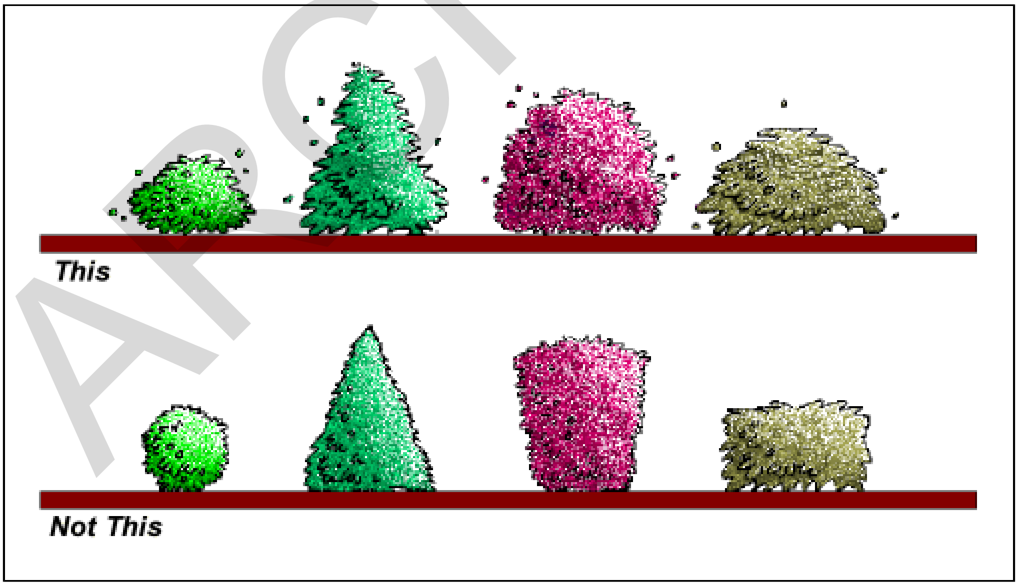

Figure 3-3: Maintain the Natural Form of Shrubs

Soil Amendments

Soil amendments are any materials added to the soil to improve or maintain it's texture, pH, or friability to encourage healthy plant growth. They are vital to the viability of all soils, especially those composed largely of sand or clay or those lacking sufficient organic matter.

Organic matter is the decaying remains of plants and animals. Because organic matter is a desirable component of all soils, and since organic materials are continually being decomposed by soil bacteria, even the best of soils benefit from periodic application of organic soil amendments. They can improve aeration and drainage in clay and compacted soils. In sandy soil, they help retain moisture and available plant nutrients.

Many soils require modification of the pH, or the acidity or alkalinity, to improve their ability to support plant material. Acidic soils have a low pH and often require the addition of lime, or calcium carbonate, as an amendment to raise the pH. Alkaline soils have a high pH and require the addition of gypsum, or calcium sulfate, as an amendment to lower the pH. They are often added to the drip or root zone as a long-term supplement to established plants. These amendments usually improve aeration and release many of the trace elements present in the soil that are unavailable to the plant.

The primary tools required to apply soil amendments vary greatly depending on the size of the plant or area being treated. Shovels, wheel barrows, front end loaders and tractor pulled spreaders are among the various methods of applying these materials.

Trimming

Trimming is the removal of excess or unwanted turfgrass or similar plant material on the edge of a turf area, walkway, or planter bed, and along fence lines and building foundations. These areas are generally trimmed at each mowing.

There are a variety of trimming tools available and selecting the proper one depends upon the area being trimmed, plant material involved, and desired final affect. Tools include gas or electric powered nylon-monofilament trimmers and gas powered bladed edgers. Monofilament trimmers allow for rapid and efficient removal of unmowable grass around steel edging, concrete mowing strips, sidewalks, foundations, and poles.

One of the inherent problems is the potential damage to trunks and bark. Continued damage leads to girdling, which severely stunts growth and may even lead to the loss of the shrub or tree.

Weed Control

A weed is defined as any plant material growing where it is not wanted. Weed control is the process of controlling or eliminating unwanted plant material. Man-hours and funds can be reduced by using modern labor-saving methods and tools. Use of chemical herbicides is the most efficient weed control method, saving both time and money. Even with the advent of the modern monofilament trimming devices, the use of chemicals can greatly increase the efficiency of any landscape maintenance operation. Well-timed, regular applications of chemicals are most effective. However, use of chemicals has its own set of problems if not properly and safely used.

Soil sterilants should almost never be used in landscape maintenance operations. Security fence lines, railroad tracks, and POL tank farms are potential candidates, but the tendency of these chemicals to migrate and kill mature trees and shrubs by poisoning the soil usually limits their value and widespread use.

Weed Control methods

Chemicals

Chemical application can be accomplished using small screw-on applicator bottles on garden hoses, hand-held pump sprayers, rotary or drop spreaders, tractor-mounted tank sprayers, and hand or machine broadcasted granules.

Chemicals used for weed control vary greatly in their makeup, use, and purpose and include pre-emergent, contact, and systemic types. Pre-emergent herbicides attacks seeds during germination. Contact herbicides effectively "burn" weeds to death. Systemic herbicides are more effective as they work through the plants' physical structure and kill from within. There are two types of systemic chemicals commonly used in landscape maintenance:

Non-selective systemic

Non-selective systemic chemicals are applied to the foliage of unwanted plant material. The chemical works through the chlorophyll in plant leaves and bark and moves inside the plant to the roots. Although somewhat slow-acting, these chemicals will severely damage or kill almost anything they are sprayed on. An example is glyphosate-N, which is effective on Bermuda grass but usually requires multiple applications to remove stubborn, well-established stands.

Selective systemic

Selective systemic weed control chemicals are used to kill specific classes of plants . Plants are classified as either monocotyledons, which include palms and grasses, or dicotyledons, which include all broadleaf plants such as willows, oaks, dandelions, and privet. Chemicals can be selected to control broadleaf weeds in turfgrass or grasses in broadleaf ornamentals. These chemicals are effectively used to eliminate clover in Bermuda grass turf or to remove Bermuda grass from Asian jasmine groundcover. Some damage can occur to desirable plants during these operations. Strictly follow all label directions.

Pre-emergent

Pre-emergent weed control kills seeds during germination. The well-timed use of pre-emergent herbicides will eliminate the need for large scale systemic chemical or mechanical weed removal operations. These chemicals are extremely valuable when used to treat inert material areas. Depending on the climate, two to three annual applications may be required.

Mechanical

Mechanical weed control can be accomplished using shovels, hoes, spades, or by hand.

3.4 LANDSCAPE MAINTENANCE GUIDELINES

3.4.1 INTRODUCTION

Landscape maintenance guidelines are site specific directions for the care of plants and inert materials. They should be used by the grounds maintenance manager to efficiently care for the installation landscape. The numerous and varied plant types, natural and man-made landscape project components, and functional areas on installations require detailed and specific maintenance and care.

Utilization of the following guidelines will improve efficiency and reduce overall maintenance costs while creating a more aesthetically pleasing and environmentally sound installation landscape.

3.4.2 GUIDELINES

- **Plant Material**
- **Inert Material**
- **Walkways, Trails, and Bike Paths**
- **Water Features**

Plant Material

- Trees
- Shrubs
- Groundcovers
- Vines
- Turfgrass
- Annuals
- Perennials

Trees

Aeration

Some tree root zones can become compacted due to heavy pedestrian or vehicular traffic. These trees should be aerated at least once a year. Water, nutrients, and air can be provided to trees by using a deep root irrigator/feeder. This should be done at least every two years on mature trees. Apply at the drip-line at least every four feet entering the ground 12-18 inches.

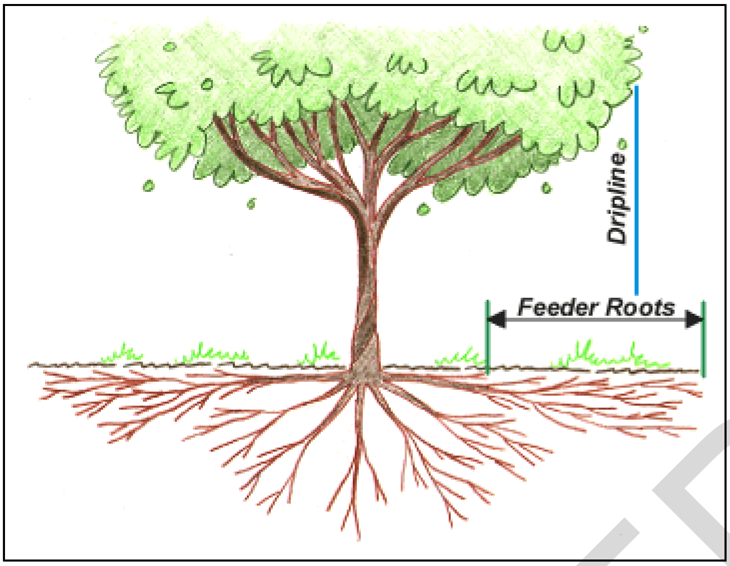

Figure 3-4: Tree Dripline and Feeder Roots

Fertilization

Trees generally require supplemental feeding annually. Use the following guide for specific tree-type fertilizer requirements.

- Evergreens thrive best with high nitrogen fertilizers, such as ammonium sulfate, 21-0-0.
- Deciduous trees, especially flowering ones, do best with a high phosphorous fertilizer such as ammonium phosphate, 16-21-0.
- Broad-leafed evergreens do best with balanced fertilizer such as 10-10-10.

Mulching

Use 2-4 inches of organic material at least 4 feet in diameter around the trunk. Add mulch as required.

Pruning

Prune to reduce foliage density, to remove crossing branches, to promote increased flowering, or to correct storm damage.

Staking

Remove all staking as soon as trees can support themselves. Timing varies by species and plant age, however, a general rule is 2-3 years after planting.

Soil Amendments

Depending on soil analysis results, add lime or gypsum as required and water thoroughly.

Shrubs

Fertilization

Most shrubs require supplemental feeding annually. Fertilizer requirements for specific shrub types follows:

- Evergreens thrive best with high nitrogen fertilizers such as ammonium sulfate, 21-0-0.
- Deciduous shrubs, especially flowering ones, require phosphorus.
- Broad-leafed evergreens do best with a balanced fertilizer such as 10-10-10.

Mulching

Mulch all shrub beds with 2-4 inches of organic material. Add mulch as needed to maintain the desired depth.

Pruning

Pruning only to remove dead or diseased branches or to improve shape and structure. Do not prune shrubs into unnatural geometric shapes.

Hedges are labor intensive. Formal, clipped hedges should be kept to an absolute minimum. Avoid gouging and clipping hedges too closely as it is unsightly and harms the plant.

Soil Amendments

Depending on soil analysis results, add lime or gypsum as required and water thoroughly.

Groundcovers

Fertilization

Most evergreen groundcovers require annual supplemental feeding in the early spring with a balanced fertilizer. Flowering groundcovers require more phosphorus and benefit from at least one application annually of ammonium phosphate.

Mulching

Mulch all groundcovers with 2-4 inches of organic material. Replenish as required.

Trimming

Groundcovers should only be trimmed when they overgrow their planter bed or to remove dead or damaged branches. As a general rule, do not mow groundcovers. Some species do respond to the rejuvenating effects of mowing. Check with local landscape maintenance professionals for information on specific practices of the region.

Soil Amendments

Depending on soil analysis results, add lime or gypsum as required and water thoroughly.

Vines

Fertilization

Most vines require annual supplemental feeding using a balanced 8-8-8 fertilizer formula.

Mulching

Mulch under and around all vines with 2-4 inches of organic material. Replenish as needed to maintain the desired depth.

Soil Amendments

Depending on soil analysis results, add lime or gypsum as required and water thoroughly.

Turfgrass

Aeration

Turfgrass areas in regions of clay, caliche, and highly compacted soils require regular aeration. Aeration should be accomplished in the early spring or before soils freeze in late autumn in colder climates.

Remove thatch buildup early in the growing season on Bermuda grass and St. Augustine as required.

Fertilization

Do not feed newly sodded, seeded, hydroseeded, or sprigged turfed areas. Allow the turfgrass to get established and mow at least three times before applying the first fertilizer treatment.

Turfgrasses require nitrogen and iron to maintain good health and color. Feed all turfgrasses just prior to the growing season. In areas where the growing season is over 250 days, apply additional fertilizer about two months prior to dormancy or onset of the first killing frost.

Mowing

Turfgrass mowing should be accomplished as required to maintain aesthetic appeal and vigor. Generally, warm-season grasses withstand closer mowing than cool-season grasses. Cool-season grasses mowed low are likely to sustain a decrease in root mass, become weakened, stress more readily, and become more susceptible to disease.

The following are recommended mowing heights for commonly used turfgrasses:

Cool-season grasses	Mowing height
Bluegrass	1 1/2-2 1/2 inches
Fescue, fine	1 1/2-2 1/2 inches

Fescue, tall	2-3 inches
Ryegrass, perennial	1-2 inches
Warm-season grasses	**Mowing height**
Bahiagrass	2 1/2-3 inches
Bermuda grass, common	2-2 1/2 inches
Bermudagrass, hybrid	1/2-1 inch
Buffalograss	1 1/2-2 inches
Centipedegrass	1-1 1/2 inches
St. Augustine	1 1/2-3 inches
Zoysia	1-2 inches

Soil Amendments

Apply organic soil amendment as top dressing every 2-4 years.

Trimming

Trim turfgrass at each mowing.

Annuals

Annuals are flowering, short-lived plants. They add color and variety to any area. Just as their name implies, annuals require removal and replacement with new plants every season. In warmer climates, there are a wide variety of winter and summer annuals that can provide year-round interest to the installation.

Fertilization

Annuals require monthly fertilizing during their specific growing season with ammonium phosphate.

Mulching

Mulch all annuals with 1-2 inches of organic material immediately after planting. Replenish as required.

Perennials

Perennials are a diverse assortment of plants. Typically, perennials have one blooming season each year. After blooming, the plant may continue to grow; it might die back and virtually disappear, or it may retain the same appearance throughout the year. Most perennials are grown for their flower color or interesting foliage.

Fertilization

Feed with a balanced fertilizer just prior to the growing season. Just after flowering has stopped, plants should receive another application to promote good growth in preparation for next year.

Mulching

Mulch all perennials with 2-4 inches of organic material.

Inert Material

Maintenance requirements for inert material in the landscape are focused on weed control. Regular and timely application of pre-emergent and non-selective systemic herbicides will keep inert material areas largely free of weeds. Periodic raking and litter removal also contribute to their attractiveness.

Walkways, Trails, and Bike Paths

Inert material

Apply pre-emergent herbicide 1-3 times annually.

Concrete and masonry

Sweep as required. Wash with high pressure hose at least four times annually.

Asphalt

Asphalt walks and paths may require repair of cracks, rejuvenation by spray sealing, or even replacement as they age. Consult with a civil engineer to determine the most efficient and appropriate method of maintenance.

Water Features

Mechanical equipment of fountains, pools, and ponds should be inspected regularly. Weekly check water quality for the presence of algae. Treat as recommended by local water feature experts.

3.5 CONCLUSION

This guide has provided descriptions and definitions of the elements necessary to maintain the installation's landscape. The emphasis on increasing the quality of life on Air Force installations while decreasing funding for maintenance continues to gain momentum. It is important that every installation ensure funding for landscape maintenance is spent constructively and wisely.

3.5.1 ACTION ITEMS

Listed below are some of the actions necessary to implement an efficient and logical landscape maintenance program:

- Ensure Grounds Maintenance Plan, Land Management Plan, and installation landscape development objectives are coordinated for consistency and long term compatibility
- Require project specific landscape maintenance guidance be provided for all new landscape projects on the installation
- Request landscape establishment specifications be provided for all new landscape projects on the installation
- Provide and require landscape maintenance training for all installation grounds personnel
- Assess existing shrub pruning methods and schedules and modify to establish new standard for the installation
- Compare the Grounds Maintenance categories map and the Landscape Development Zoning map to assess efficiency and compatibility of landscape maintenance practices and landscape development goals

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3.5.2 REFERENCES

Suggested further reading:

All About Pruning, Editor's of Ortho Books, 1989, Ortho Books Chevron Chemical Company

All About Trees, Editor's of Ortho Books, 1992, The Monsanto Company

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Arizona Weeds, An Illustrated Guide to, Kittie F. Parker, 1972, The University of Arizona Press

Gardening Techniques, Editor's of Ortho Books, 1984, Ortho Books Chevron Chemical Company

Home Gardener's Guide to Trees and Shrubs, The, John Burton Brimer, 1976, Hawthorn Books, Inc.

Landscaping Your Home, William R. Nelson, Jr., 1975, University of Illinois at Urbana-Champaign College of Agriculture Cooperative Extension Service Circular 1111

Lawncare, Henry F. and Jane M. Decker, 1988, Prentice-Hall, Inc.

Practical Guide to Home Landscaping, The Reader's Digest Association, 1972, The Reader's Digest Association

Right Plant, Right Place, Nicola Ferguson, 1984, Summit Books

Sunset Western Garden Book, Editors of Sunset Books and Sunset Magazine, Lane Publishing Company

Tree Maintenance, P. P. Pirone, 1972, Oxford University Press

Turfgrass Science and Culture, James B. Beard, 1973, Prentice-Hall, Inc.

Turf Managers' Handbook, Dr. W. H. Daniel, Dr. R. P. Freeborg, 1979, Harvest Publishing Company

Western Fertilizer Handbook, Soil Improvement Committee of the California Fertilizer Association, 1975, Interstate Printers & Publishers, Inc.

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4.1 INTRODUCTION

An efficient landscape development program is dependent on quality design and proper implementation. The most important aspect of any landscape construction project is the clear and concise communication of the design intent to the installer. This is accomplished through complete drawings, construction details, and specifications.

Landscape construction specifications define the type and quality of materials and equipment and specify the required construction standards and methods. In contracted work, specifications are the final word if there are contradictions between the various implementation documents such as drawings and details.

Since the landscape designer is usually unable to direct or coordinate the work on-site with the installer, the project specifications become increasingly important. A good set of specifications accurately represent the intent of the designer while being easily understood by the contractor, inspector, and procurement personnel.

4.1.1 PURPOSE

The purpose of this guide is to provide a common starting point for designers to accomplish quality landscape construction document packages.

4.1.2 GOAL

The goal of this guide is to create an efficient and standardized approach to the implementation of quality construction specifications for Air Force landscape development projects.

4.1.3 OBJECTIVE

The objective of this guide is to provide specifications that can be utilized at any installation with minimum modifications to deliver a quality finished landscape product.

4.1.4 GUIDE ORGANIZATION

The Landscape Construction Specifications Guide is composed of three sections:

Specification organization

Describes and explains the intent, style, format, and use of the master specifications provided in this guide.

Implementation

Details the steps necessary to implement the master landscape construction specifications provided in the Appendix at the installation.

Conclusion

Delineates actions that can be taken by the installation to improve the quality of their landscape construction specifications.

Appendix

Provides many of the common landscape construction specifications required to complete most contracted landscape implementation packages.

4.2 SPECIFICATION ORGANIZATION

4.2.1 INTRODUCTION

Specifications are highly organized design execution instruments. They should be written clearly and concisely, leaving little room for misinterpretation or misunderstanding. Since specifications supersede drawings and details in implementing a construction document package, they perform a valuable role in producing a quality landscape development product. A consistent format and clarity are probably the two most important traits of good specification writing.

4.2.2 FORMAT

A number of formats or styles are used for construction specifications. In order to effectively communicate the intent of the design, the specifications should follow a consistent format or organization of information. The landscape construction specifications provided in this guide follow the four-part format described below:

Part One - General

This section of the specifications discusses topics or concerns of the designer that are general in nature or refer to issues that are broader in scope. These topics include:

- summary of the work in the particular section
- handling of submittals
- salvaging and storage of materials
- references
- applicable publications
- plant and irrigation material warranties

Part Two - Products

The products section of the specifications is where the designer identifies all of the products required for the project. The quality standards and potential or preferred manufacturers are usually included in this section. The following topics are normally addressed in this section:

- concrete mixture ingredients
- fertilizers
- herbicides
- staking
- plant material
- turf and hydroseeding mixes

Part Three - Execution

The execution section of the specifications delineates the process and procedures of installing the products and materials presented in the project design drawings, details, and specifications. This section is the most significant as it specifies the actual method and sequence of construction. Items covered in the execution section include:

- planting
- irrigation equipment
- pouring concrete
- soil preparation
- turf sodding
- trenching

Part Four - Miscellaneous

This section contains design requirements that do not logically fit into the other sections. Schedules or instructions on specific tasks or other related activities expected of the contractor are included in this section:

- landscape establishment schedule
- procedures and schedule for submittals
- special tasks relating to project close-out

4.3 IMPLEMENTATION

4.3.1 USING MASTER SPECIFICATIONS

The master landscape specifications provided in this guide have been used for previous construction contracts. While they have been reviewed by Contracting Officers and proven successful in the field, they may require modification for each locale and project. They have been designed to be readily modified. The underlined blank spaces allow the preparer to fill in installation and project specific information.

4.3.2 IMPLEMENTATION

The following steps should be followed to successfully incorporate master landscape construction specifications in developing project :

- Use the floppy diskette and insert appropriate information
- Incorporate regional, climatic, or material modifications to all sections
- Submit specifications to the installation Contracting Officer and Construction Management offices for review
- Incorporate all suggested corrections or modifications to create new installation master file and store in design office file server or make multiple copies available to designers
- Create or reinforce office procedures for use and protection of the master specification files including procedures for extraction and use for specific projects that may require modification of the master
- Initiate and continue a program to update current files while adding newly created masters as required

4.4 CONCLUSION

4.4.1 ACTION ITEMS

Listed below are some actions that can be taken to enhance the construction implementation process at the installation:

- Obtain a computer copy of the master landscape specifications and incorporate into installation files
- Conduct a contractability and constructability review and modify the master specifications
- Initiate and enforce office procedures for the use and maintenance of the files
- Constantly refine and review the master specifications for accuracy and currency with available materials and technology

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4.4.2 REFERENCES

Suggested further reading:

A Dictionary of Landscape Architecture, Baker H. Morrow, 1987, University of New Mexico Press

Graphic Standards for Landscape Architecture, R. L. Austin, T. R. Dunbar, J. K. Hulvershorn, and K. W. Todd, 1986, Van Nostrand Reinhold Company

Time-saver Standards for Landscape Architecture, Charles W. Harris and Nicholas T. Dines, 1988, McGraw-Hill, Inc.

4.5 APPENDIX

MASTER LANDSCAPE CONSTRUCTION SPECIFICATIONS

CHECKLIST

The checklist can be used to facilitate the implementation of the master specifications. The designer can use the checklist in a number of ways:

- As a checklist for project cost estimating assistance early in the design process
- As a menu for communicating typing needs from administrative support
- As a labor- and paper-saving method for Contracting Office personnel on pre- approved and reviewed construction package documents
- As an assurance that the master specifications file is preserved to be utilized on future projects

The designer should check all of the specification sections that apply to a project. After review of the specifications, changes can be applied to another copy of the master to create a new, project-related specification. In this case, the designer would check the "use edited version" column on the checklist. If the master specification needs no changes, the designer would check "use master" column.

View the checklist in your browser.

Download a MS Word version of the checklist.

4.5 APPENDIX - CHECKLIST

MASTER LANDSCAPE CONSTRUCTION SPECIFICATIONS

CHECKLIST

Section #	Section Title	Use Master	Use Edited Version
01000	Project Information		
01010	Special Conditions		
01040	Project Coordination		
01095	Referenced Standards and Definitions		
01200	Project Meetings		
01300	Submittals		
01410	Quality Control		
01500	Temporary Facilities and Controls		
01600	Materials and Equipment		
01700	Contract Close-out		
02050	Demolition		
02224	Excavation, Trenching, and Backfilling for Irrigation Systems		
02623	Concrete Walkways		
02810	Irrigation System		
02811	Drip Irrigation System		
02950	Trees, Shrubs, and Groundcovers		
02951	Seeded Turf		
02952	Sodded Turf		
02960	Inert Material		
02970	Landscape Establishment		

5 COST ESTIMATING

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5.1 INTRODUCTION

One of the least understood, and most overlooked and improperly developed cost estimating component is the landscape. Landscape architects, planners, and programmers require accurate cost estimates to ensure scarce project dollars are factored into overall project costs. From project inception to bid acceptance, the accuracy of the current working estimate is vital to successful installation landscape development.

5.1.1 DEFINITION

Landscape cost estimating is the complete and accurate assessment of the costs associated with implementing the landscape component of a project. The costs associated with the materials, labor, and equipment required to implement the landscape design are included in the estimate.

5.1.2 GOAL

The primary goal of the Landscape Cost Estimating Guide is to define the components of a project to ensure appropriate and sufficient funding is available at each phase of the project.

5.1.3 OBJECTIVE

The objective of this guide is to provide a process framework in developing accurate and complete landscape project estimates.

5.1.4 LANDSCAPE COST ESTIMATING ELEMENTS

The following explains the landscape cost estimating elements that will be covered in this guide:

Cost Estimating Process

Describes the estimating process during the various sequences of a project and explains how to compile an accurate cost estimate for the landscape components.

Landscape Cost Components

Identifies and describes potential project components that comprise the landscape cost estimate line item. It provides a checklist of typical landscape components to ensure accuracy and completeness at each phase of a project.

Conclusion

Summarizes actions that can be taken by project managers, planners, and designers to conduct efficient landscape cost estimating at the installation.

5.2 COST ESTIMATING PROCESS

5.2.1 INTRODUCTION

Cost estimating is a logical and orderly process of determining the costs to implement the landscape requirements at each phase of a project.

5.2.2 PROJECT SEQUENCE

There are three basic steps of a project where cost estimates are required: programming, concept, and implementation.

- **Programming**
- **Concept**
- **Implementation**

Programming

Projects are generally submitted to satisfy mission requirements. This process usually starts with development of an AF Form 332, Work Request which requires an initial cost estimate for the entire project. If the project is approved by the installation Facility Board, a DD Form 1391 may also be required to secure the necessary funding to complete the project. Cost estimates are required at each phase. Many of the issues to consider during the programming phase that may affect the cost of the project landscape component include:

- User and mission requirements
- Quality of life needs and desires
- General characteristics of project siting
- Installation and area development planning goals
- General landscape development zone objectives
- Major site grading requirements
- Environmental impact

Although determining costs at this phase of the project is difficult, the accuracy of the landscape component estimate should be within 25-40% of the final working estimate. The chart below is a guide to lump sum cost estimating during project programming. The chart shows the portion of total project funds that should be allocated for a project by landscape development zone. These zones are described in the Landscape Planning Guide.

$ Cost of Entire	**Recommended % $ Cost for Landscape by**

Project	Development Zone		
	Primary	Secondary	Tertiary
< 25,000	10	4 - 7	1
25 - 150,000	7 - 10	2 - 4	.5
150,000 - 500,000	4 - 7	1 - 2	.25 - .5
500,000 - 2 mil	3 - 4	.5 - 1	.1 - .25
2 - 5 million	1 - 3	.3 - .5	.05 - .1
> 5 million	.5 - 1	.2 - .3	.05

Figure 5-1: Recommended Minimum Lump Sum Landscape Component Costs

For example, a $1.6 million project in the secondary landscape development zone would require a minimum of $8,000-16,000 allocated and programmed for the landscape component.

Concept

Upon completion of the concept design, the project scope and major elements of the final design solution become more refined. The cost estimate for the landscape components can be more readily delineated and itemized. Its accuracy should improve to within 15-25% of the final working estimate as a result. Issues to consider in compiling estimates at this stage of the process include:

- Sitework
- Screening
- Environmental mitigation
- Specific landscape development zone objectives
- General signage
- Plant material
- Landscape grading
- Irrigation system
- Site amenities

Implementation

At the implementation, or construction document step, the elements of the project are accurately itemized and quantified. The designer has determined the sizes, amounts, and locations of the required landscape elements. If properly calculated, the cost estimate for the landscape elements should be within 5-15% of the actual contract bid price. Most elements considered in the final landscape cost estimate are provided later in this chapter in the Landscape Cost Estimating Checklist.

5.2.3 ESTIMATING PROCESS

There are three steps in the estimating process. These steps should be accomplished sequentially to ensure thoroughness and accuracy.

- **Project review**

- Pricing
- Summation

Project Review

The first step in the estimating process is a thorough review of the project drawings, details, and specifications. Using the checklist, the following steps will help ensure a complete review of the project has been completed:

- Note all of the landscape component elements
- Check the various project documents to ensure all elements have been identified
- List all of the project elements on a cost estimating spreadsheet or AF Form 3052
- Determine quantities for each element by size, type, manufacturer, or other definitive means.

Pricing

The next step in the cost estimating process is to assign current and accurate costs to each element on the spreadsheet or AF Form 3052. The following should be considered during this step:

- Ensure that costs for each element include materials, labor, and other tasks or equipment related to its installation
- Carefully choose the construction method or equipment type and size most consistent with the scale of the job and specification requirements
- Strive to use prices for the most cost effective method and piece of equipment available unless site conditions dictate differently
- Ensure that material information correlates with the final drawings, details, and specifications

Another important factor in the pricing step is adjustments. The costs for landscape materials and labor may require adjustment for a variety of reasons:

- Local costs may differ greatly from national averages
- Procurement method;
    - Open bid, SABER, 8A small business set aside, and blanket purchase agreements each have characteristics that may affect cost
- Local bidding climate and economy
- Differences in unit labor costs due to project location or local labor rates
- Allowances for possible overtime or additional travel, shipping, or delivery expenses if the project is remote from a metropolitan area

Summation

The final step of the estimating process is calculating the total costs of the project. The following actions will complete the landscape cost estimate:

- Compute the total cost for the final quantity of each project element
- Add these subtotals to determine the landscape component cost estimate
- Double check calculations for accuracy
- Add appropriate overhead and profit for bottom line component cost if applicable

5.3 LANDSCAPE COST COMPONENTS

5.3.1 INTRODUCTION

A logical and practical approach to landscape cost estimating is to compile project costs according to the expected order of construction. The following landscape components generally occur in the following order:

- **Sitework**
- **Irrigation**
- **Site Amenities**
- **Planting**
- **Inert Material**
- **Establishment**

Sitework

Sitework includes all materials and tasks associated with preparing the project site.

- Demolition
- Grading
- Drainage
- Excavation
- Subgrade preparation
- Concrete work

Irrigation

The irrigation phase includes all project elements required to deliver supplemental water to plant material.

- Meters
- Valves
- Piping
- Spray heads
- Drip emitters
- Filters
- Pressure regulators
- Controllers
- Electrical connections

- Trenching and backfill

Site Amenities

The site amenities phase includes any permanent structure or site element that enhances the utility a project.

- Benches and seating
- Tables
- Drinking fountains
- Lighting
- Waste receptacles
- Tree grates
- Signage
- Gazebos and ramadas

Planting

The planting phase includes all material and tasks associated with preparation and installation of plants at the project site.

- Planter bed construction
- Trees
- Shrubs
- Groundcovers
- Turf
- Mulch
- Staking

Inert Material

The inert material phase includes all inorganic material that adds interest and character to a project.

- Decomposed granite
- Rip-rap
- Accent groundcover
- River rock
- Boulders

Establishment

The establishment category includes all of the specified tasks that will be the responsibility of the contractor after completion of the construction portion of the project

- Selective pruning
- Mowing
- Trimming
- Fertilization
- Planter bed cultivation
- Weed and pest control

5.3.2 CHECKLIST

The following checklist is provided to facilitate the landscape cost estimating process. It can and should be utilized by programmers and designers throughout the life of a project. The checklist can also be used:

- As a guide to checking the accuracy of estimates of projects designed by others
- As a reference for estimating future projects

The checklist is designed to increase cost estimating accuracy as the project progresses towards implementation. Each phase of the project has blanks for elements not listed. A summary of project costs is provided at the end of the checklist. Following are examples of how to use the checklist for each project sequence:

Programming

The checklist provides spaces for entry of single line item costs for the major phases of a project. The significant elements and sub-elemtents listed in each phase can be used to help determine these costs.

Concept

The checklist provides spaces for significant elements within each major project phase. The sub-elements listed under each significant element in each phase can be used to help determine more accurate costs.

Implementation

The checklist provides spaces for all sub-elements and elements within each major project phase. Detailed and accurate costs can be determined.

LANDSCAPE COST ESTIMATING CHECKLIST

1 of 4

ELEMENT	PROJECT PHASE		
	PROGRAMMING	CONCEPT	IMPLEMENTATION
SITEWORK			

Demolition			
- structures			
- pavements			
- plant material			
Site clearing			
- trees			
- shrubs			
- weeds			
- topsoil			
Excavation			
Grading			
- swales			
- berms			
- drainage			
Compaction			
Hauling			
Concrete			
- foundation			
- curbing			
- flatwork			
IRRIGATION			
Water source/point of connection			
Meter			
Backflow preventer			
Pipe			
- mains			
- laterals			
- fittings			
- emitter laterals			
Valves			
- emergency shut-off			
- solenoid turf			

- solenoid drip			
- system drain			
- wiring			
- boxes			
Spray heads			
- turf			
- shrub			
Drip emitters			
- emitter tubing			
- emitter end caps and boxes			

LANDSCAPE COST ESTIMATING CHECKLIST

2 of 4

ELEMENT	PROJECT PHASE		
	PROGRAMMING	CONCEPT	IMPLEMENTATION
Filters			
Pressure regulators			
Controllers			
Electrical power connection			
Electrical wire and couplings			
Moisture sensor			
Trenching			
Backfill			
SITE AMENITIES			
Pavers			
Benches			
Tables			
Retaining walls			
Gazebos			
Ramadas			
Bollards			

Drinking fountains			
Lighting			
- area			
- landscape			
- activity			
- signage			
Bicycle racks			
Bus shelters			
Trash receptacles			
Fencing			
Tree grates			
Signage			
BBQ grills			
Inert walkways			
- edging			
- foot bridge			
PLANTING			
Plant transplanting			
Steel edging			
Mow strips			
Planter preparation			
- topsoil			
- soil amendments			
- mulch			

LANDSCAPE COST ESTIMATING CHECKLIST

ELEMENT	PROJECT PHASE		
	PROGRAMMING	CONCEPT	IMPLEMENTATION
Shrubs			
Trees			
- staking			
Groundcovers			

Annuals/perennials			
Vines			
Turf			
- soil preparation			
- sod			
- seed			
- sprig			
- hydroseed			
Hydroseeding			
Organic mulch			
INERT MATERIAL			
Landscape element			
- groundcover			
- accent			
Surface erosion control			
- groundcover			
- accent			
Accent			
- river rock			
- boulders			
Rip Rap			
ESTABLISHMENT			
Weed control			
- contact systemic			
- pre-emergent			
Pest and disease control			
Mowing			
Trimming			

Pruning			
- trees			
- shrubs			
- groundcovers			
Sweeping			

LANDSCAPE COST ESTIMATING CHECKLIST

4 of 4

ELEMENT	PROJECT PHASE		
	PROGRAMMING	CONCEPT	IMPLEMENTATION
Irrigation			
Policing			
Fertilization			
- trees			
- shrubs			
- groundcovers			
- turf			
Raking inert material			
Planter bed cultivation			
SUMMARY			
SITEWORK			
IRRIGATION			
SITE AMENITIES			
PLANTING			
INERT MATERIAL			
ESTABLISHMENT			
TOTAL			

Figure 5-2: Landscape Cost Estimating Checklist

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5.4 CONCLUSION

5.4.1 ACTION ITEMS

Listed below are some actions associated with executing a thorough landscape cost estimating process at the installation:

- Use the Landscape Cost Estimating Checklist on all appropriate installation projects
- Apply the provided cost estimating process on all projects that include landscape development
- Include landscape component costs in every work request and programming document to ensure sufficient funding

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5.4.2 REFERENCES

Suggested further reading:

A Guide to Estimating Landscape Costs, Gary O. Robinette, 1983, Van Nostrand Reinhold

Kerr's Cost Data for Landscape Construction, Norman L. Dietrich, 1990, Van Nostrand Reinhold

Means Landscape Cost Data, Kornelis Smit, Editor, 1990, R. S. Means Company, Inc.

Means Landscape Estimating, Sylvia Hollman Fee, Editor, 1987, R. S. Means Company, Inc.

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6.1 INTRODUCTION

Designers must ensure project construction documents convey the necessary information to successfully implement the design. They are responsible for designing the project; the landscape contractor is responsible for the actual implementation, installation, and establishment of the design. Following installation, maintenance personnel are responsible for the various landscape elements of the project to maturity. Between the design, implementation, and establishment phases is a need for clear, understandable communication. Landscape construction details provide this link by establishing a clear understanding of the design and construction requirements.

An integral part of any project design is the landscape construction details. Details, along with specifications and plans, are ways designers communicate their design intent to the project contractor. Landscape details convey the precise way to implement elements of a landscape project.

6.1.1 PURPOSE

The purpose of the Landscape Construction Details Guide is to provide information on how to develop, incorporate, and execute landscape construction details.

6.1.2 GOAL

The goal of this guide is to help a Air Force personnel understand the importance of landscape architecture construction details and their application to design, installation, and establishment.

6.1.3 OBJECTIVE

The objective of this guide is to provide users with representative landscape design details for developing or reviewing landscape design projects and for creating a detail library.

6.1.4 GUIDE ORGANIZATION

Details

Discusses the relationship between landscape construction details, specifications, and notes, as well as information on the Tri-service CADD/GIS Technology Center standards for detail development.

Conclusion

Delineates the actions necessary by installation personnel to improve the quality and usability of their landscape construction details.

Appendix

Provides a representative graphic sampling of various details from landscape architecture construction components including sitework, irrigation, site amenities, plant material, and inert material.

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6.2 DETAILS

A design becomes beneficial and usable only when it is implemented. The designer must be familiar with proper construction and installation procedures to ensure the design fulfills intent. Even though specifications override details in executing a construction document, details are the method of visually conveying the designerís intent to contractors, installers, and quality assurance personnel. Details, therefore, must be clear, concise, and understandable in order to effectively bring a design concept to completion.

Anything important enough to do right is important enough to detail. For example, the designer may want to incorporate a brick raised planter/seating wall into a courtyard. The details prepared by the designer graphically show how the footing, reinforcing, brickwork, drainage, sealing treatment, soil layering, and planting should be accomplished. Details should eliminate doubt and confusion on how to bid or construct the project.

6.2.1 DETAIL SPECIFICS

Details are just one part of a project's construction documents package. The other parts include the demolition, grading, planting, and irrigation plans, as well as specifications and cost estimate. For a further discussion on construction documents see Chapter Four of the Landscape Design Guide.

Details provide the essential ingredients contractors need to construct a project. they visually show the various elements related to a landscape design for the purpose of ensuring proper implementation. Details must be complete and should clearly demonstrate acceptable construction standards. Details should clearly show types and sizes of all materials.

Details are generally depicted "not to scale" as they are a visual representation of the specific method of accomplishing the intent of the designer. There are variables in root ball or tree height, sprinkler size, or slope grade to consider. In addition, "to scale" allows details to be enlarged or reduced for inclusion with other project construction documents.

Detail dimensions depict the desired width, height, depth, spacing, or other guidance necessary to ensure correct and intended installation. Metric measurements are now the Air Force standard.

Details should be free from ambiguity. In order to secure uniform bidding and construction, sufficient information should be provided to achieve the design intent.

6.2.2 DETAIL RELATIONSHIPS

Details are just one part of a construction documents package. In addition, details have a unique relationship with the following:

Drawings

Drawings are a graphic means of defining and illustrating the project design. The designer usually creates drawings showing plan, profile, elevation, and sections to illustrate the design concept. Drawings need to be accurate. It is not practical to include all of the information determining the quality of materials, workmanship, and installation requirements on the drawings. Therefore, specifications, details, and notes are necessary. Together they form a complete landscape construction documents package.

Specifications

Landscape construction specifications define the type and quality of materials and equipment and specify the required construction standards necessary to ensure satisfactory design implementation. Details must be coordinated with specifications. It is important to remember in contracted work that specifications are the final word if there are contradictions between the other various project implementation documents. For a further discussion on specifications, see the Landscape Construction Specifications guide.

Notes

Notes add additional information and clarification to the project drawings. Notes should be concise, clear, simple, easily understood, and free from vagueness and misinterpretation. Some examples of notes would be:

- "Minimum curb radius shall be .5 meter."
- "Maximum grade slope shall be 4:1 unless shown."
- "Contractor shall spread 5 cm topsoil, blue-grass seed, and fertilizer on all disturbed soil surfaces."

6.2.3 TRI-SERVICE CADD/GIS DETAILS

The use of computer-aided design and drafting (CADD) systems within the Department of Defense (DOD) has increased design efficiency while reducing overall design cost. These improvements have been achieved by utilizing design-discipline specific CADD programs and the sharing of CADD-developed project information.

The Tri-Service CADD/GIS Technology Center recognized the increased production represented in the sharing and adaptation of design and construction details and initiated a project to collect and disseminate generic design details. Landscape construction details are currently being compiled and formatted into Tri-service standards and are available for download by logging onto the Tri-Service CADD/GIS Technology Center website at http://tsc.wes.army.mil

For more information, please call, e-mail, or write:

```
USAE Waterways Experiment Station
Tri-Service CADD/GIS Technology Center
```

Attn: CEWES-IM-DA/Spangler
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Phone: (601) 634-4582
E-Mail: spangls@ex1.wes.army.mil

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6.3 CONCLUSION

6.3.1 ACTION ITEMS

Listed below are some important reminders as well as actions that can be taken to develop, utilize, and accumulate landscape construction details:

- Anything important enough to do right is important enough to detail.
- Details should eliminate doubt and confusion on how to construct or implement a design.
- Details must be complete and should clearly, concisely, and understandably demonstrate desired as well as acceptable construction standards.
- Inventory and catalog all current installation details ensuring they are usable and representative of desired design intent into a master landscape construction detail computer file.
- Conduct a metric standards review and modify the master landscape construction detail file as necessary.
- Initiate and enforce office procedures for using and maintaining the master landscape construction detail file to ensure project consistency.
- Continually refine, review, and update the master landscape construction detail file for accuracy.
- Utilize the Tri-Service CADD/GIS Details Library.

6.3.2 REFERENCES

Suggested further reading:

Access For the Handicapped, Peter S. Hopf, AIA, and John A. Raeber, AIA, 1984, Van Nostrand Reinhold Company Inc.

CADD Details Library, Report 1, Architectural Details, Tri-Service CADD/GIS Technology Center, 1995, U.S. Army Engineer Waterways Experiment Station

Container Gardening Indoors and Out, Jack Kramer, 1971, Doubleday and Company, Inc.

Graphic Standards for Landscape Architecture, R.L. Austin, T.R. Dunbar, J.K. Hulvershorn, and K.W. Todd, 1986, Van Nostrand Reinhold Company, Inc.

Off the Board / Into the Ground, Gary O. Robinette, 1968, Kendall/Hunt Publishing Company

Planting Details, Gary O. Robinette and Richard Nehring, 1981, Van Nostrand Reinhold Company, Inc.

Site Design and Construction Detailing, Theodore D. Walker, 1986, PDA Publishers Corporation

Site Details, Gregory W. Jameson and Michael A. Versen, 1989, Van Nostrand Reinhold Company, Inc.

Site Planning and Design For the Elderly, Diane Y. Carstens, 1985, Van Nostrand Reinhold Company, Inc.

Time-Saver Standards for Landscape Architecture, Charles W. Harris and Nicholas T. Dines, 1988, McGraw-Hill Publishing Company

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6.4 APPENDIX

6.4.1 REPRESENTATIVE LANDSCAPE CONSTRUCTION DETAILS

The following details are just a sample of the hundreds available to designers. Their intent is to convey detail options, composition, and layout. Installation personnel should begin compiling a landscape architecture detail library based on installation and regional standards, policies, and practices. Blank pages are provided for compiling and organizing installation landscape details. Details can be created for any of the following:

Sitework

- Riprap Slope
- Drain Inlet
- Rail to Deck Connection
- French Drain

Includes all materials and tasks associated with preparing the project site such as demolition, grading, drainage, excavation, subgrade preparation, and concrete work.

Irrigation

- Turf Pop-up Spray Head Installation
- Turf Spray Head Installation
- Trenching Standards
- Quick Coupling Valve on Swing Joint Riser
- Valve and Controller Installation
- Backflow Preventer
- Double Check Valve Assembly Installation
- Drip System Assembly

Includes all project elements necessary to deliver supplemental water to plant material including meters, valves, piping, spray heads, drip emitters, filters, pressure regulators, controllers, electrical connections, trenching, and backfill.

Site Amenities

- Outdoor Table Seating
- Bench
- Bicycle Base
- Square Tree Grates

Include any permanent structure or site element enhancing the utility of a project such as benches and seating, tables, drinking fountains, lighting, waste receptacles, tree grates, signage, gazebos, and ramadas.

Planting

- Tree Planting and Vertical Staking
- Tree Planting and Guy Wiring
- Conifer Tree Planting
- Shrub Planting
- Groundcover Planting
- Vine Planting

Includes all material and tasks associated with preparation and installation of plants at a project site including planter bed construction, trees, shrubs, groundcovers, turf, mulch, and staking.

Inert Material

- Boulder
- Decomposed Granite

Includes all inorganic material adding interest and character to a project including decomposed granite, rip-rap, accent groundcover, river rock, and boulders.

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7.1 INTRODUCTION

Self help is a function within the Civil Engineering organization of the Air Force which makes available supplies, tools, and equipment which organizations and housing occupants can use in maintaining their facilities.

7.1.1 PURPOSE

The purpose of this chapter is to provide guidance to air force personnel in basic landscaping principals and standards for air force installations (more detailed information on a topic can be found in the specific chapters regarding that topic in this guideline). This includes the installation policy, appropriate planting materials for installations, checklists, promotional ideas, and references.

7.1.2 GOALS & OBJECTIVES

The goal for self help is to increase involvement and knowledge of the landscaped environment on installations by:

- providing the ability of personnel to become involved in the landscaping process;
- providing guidance, materials, tools, and information to interested personnel.

The objectives for self help that support achievement of this goal are to:

- standardize the processes required for base personnel to improve the landscaping on an installation;
- disseminate information and programs to personnel to increase interest in participation.

7.2 CLIMATE AS A LANDSCAPING FACTOR

The climate has a dramatic affect on the landscaping that surrounds us. The major climatic conditions that need to be considered are annual rainfall, seasonal temperature, quality and quantity of sun, and the prevailing winds. These factors have a tremendous impact on the plants and designs that will be successful in specific climatic regions.

Research is needed on the characteristics of the desired plant material prior to selection for a successful landscape installation. How much water does the plant require? Does it need full sun, partial shade, or full shade? Does the plant like a hot climate or is it freeze resistant? If needed can the plant withstand strong winds due to its root and body structure? A good starting point in answering these questions is using plants that are indigenous to the region (re: 7.4 Installation Approved Plant Material).

7.2.1 GEOGRAPHY AND ITS AFFECT ON LANDSCAPING

The geography can also have an impact on the design and on the proper selection of plants. The main geographical features that come into play are the type of soil, the terrain, and any existing water features. The soil characteristics that need to be thought about are its alkalinity and its classification.

Plants can be temperamental to the soil alkalinity or the pH level of the soil. Some soils are acidic (high pH), neutral, or basic (low pH) and the proper plant needs to be chosen that will thrive in the existing alkalinity of the soil. Putting additives into the soil can modify the alkalinity of the soil, but this is not a long-term solution and is not recommended. The classification of the soil can tell you how well the soil drains or holds water, if the root structure of a plant will have a firm foundation or could be uprooted easily. The classifications of soil vary from location to location but they typically range from sand, clay, silt, loam or a combination of these.

The terrain can be used as a feature in any landscape design. Existing rocks can enhance a design, or you can take advantage of a sloping terrain, or accentuate a garden in a flat area by building it up with the use of berms. Taking advantage of existing water features such as creeks, streams, or ponds can also create interest in any landscape design.

To help ensure that you are using the proper plants and a logical well developed design you can discuss these items with the self help representative and/or base landscape architect (BLA) or the local nursery that is providing the plants. This will help to ensure the success of your project.

7.2.2 WATER CONSERVATION

The need to conserve water is becoming more critical everyday. Many regions have inadequate water supplies for the population that they support. Approximately fifty percent (50%) of urban water use can be attributed to residential irrigation. The irrigation water usage can be cut by as much as seventy percent (70%) by applying conservation tactics and Xeriscape planning. Therefore, it is in the best interest of all parties to do what we can to conserve our water supply.

7.2.3 WHAT IS XERISCAPE?

Xeriscape is landscaping that conserves water without sacrificing beauty and variety. It takes advantage of low water using plants native to the region to improve the area around our homes. Xeriscape will aesthetically enhance the landscape while using minimal water and time for maintenance. By following the Xeriscape principles MFH residents can create a maintainable and economical landscape at their home.

7.3 PLANNING A SELF HELP PROJECT

The procedures for submitting work requests and receiving approvals for all MFH landscaping work is as follows:

- All work must be listed on an AF Form 332, Work Request, accompanied by a drawing outlining the basic concept of the work *(see Figure 7-1)*.
- The AF Form 332 must be coordinated through the Family Housing Office (CEH) and the Self Help Store (CEMSH).
- All landscape work to be performed under an AF Form 332 must be approved by the Base Landscape Architect, or equivalent CE staff.
- All work should be logical, buildable, safe and easily maintained. The prime focus of the project should be to minimize or eliminate a significant portion of the turf area around the home.
- All work should be completed in a timely manner.
- MFH Watering Policy limits those times when turf irrigation is allowable.
- Refer to the Installation Approved Material Lists for acceptable materials that can be used in your landscape project.
- Plants and materials that are not on the Installation Approved Material Lists can be purchased by the resident and installed in the MFH as long as all coordination and approvals are met.
- No digging deeper than 4" will be allowed without a completed AF Form 103 (BCE Work Clearance Request or "Digging Permit").
- All plants provided through the Self Help Store must be cared for and are the responsibility of the project requester. Plants that die may have to be replaced at the requester's expense prior to separation from MFH.
- Landscape project work orders will be accepted by CEH from 1 May to 1 September.

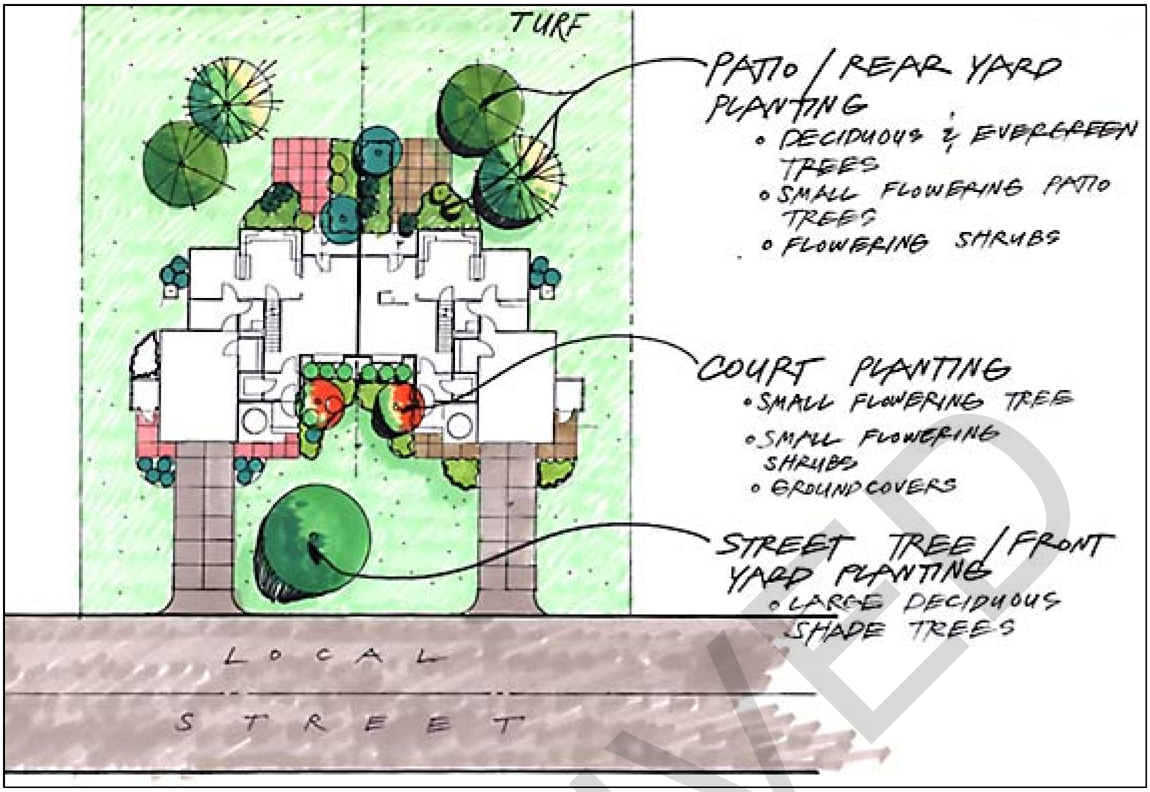

Figure 7-1: Planting Concept

7.3.1 SELF HELP LANDSCAPE CHECKLIST

The table below is a self help checklist that will give an estimated time for each task that will be required for a landscape project. The goal is to complete all landscape projects in ten (10) weeks.

Week	Step	Task
0-1	1	Fill out AF Form 332 at MFH Mgmt. Office, Bldg. (XXXX) and bring completed 332 to Self Help, Bldg. (XXXX).
2	2	Within one to two weeks you will be contacted by the Base Landscape Architect (BLA) to review your landscape project design for your home.
3	3	Pick up turf edging at Self Help Store. At this time, Self Help will initiate AF Form 103 ("Digging Permit"). Notify Self Help @ x ---- when edging is complete.
5-1/2	4	Pick up digging permit at Self Help Store.
6	5	Berm soil will be delivered. Begin grading near curbs, sidewalks, and driveways. Begin constructing berms. Notify Self Help when complete.

7	-	Call Self Help to have waste soil picked up from your yard.
8	6	Plants will be delivered. Call BLA @ x---- for assistance in locating plants. Install plants and notify Self Help when complete.
9	-	Self Help will order inert materials.
10	7	Self Help will deliver your inert materials. Spread and place inert materials and notify Self Help when your landscape project is complete.

7.3.2 LANDSCAPE DESIGN STANDARDS

Landscaping helps soften the hard edges of structures in the neighborhood and enhances the visual environment. It is DoD policy to utilize environmentally compatible and economically efficient landscaping practices that conserve water and prevent pollution. This includes the use of native plant species that fit naturally into the environment, and that can minimize maintenance demands.

- *General Planting*: Include both non-deciduous and deciduous plants of differing heights, shapes, colors, and textures in the design. Tree planting alone can provide a major improvement in the housing environment. It is also very important to remember that the choice of landscaping materials should minimize maintenance requirements.

- *Screening*: Provide privacy screening in the form of shrubs, berms, or fences to separate private outdoor spaces from public use areas. Privacy screening can also increase the effective size of the dwelling unit by providing more useable outdoor space. Screening private outdoor space from public streets and nonresidential areas also hides clutter such as toys, grills, lawn chairs, etc. that would otherwise be visible from public areas.

- *Trees*: Plant various types of trees to emphasize the individual character of each space. Use dense stands of trees to separate housing from nonresidential areas and streets. Plant clusters of trees to break up long repetitive building facades and barren landscapes.

- *Foundation planting*: Provide foundation planting around the base of buildings. Foundation planting visually ties the houses to the ground and to each other, and adds interest to a barren area. Arrange foundation planting in groups and clusters (never scattered at equal distance) to be fully effective.

- *Shrubs*: Plant shrubs in beds and separate from turf areas by turf headers such as steel edging or concrete mow strips.

- *Groundcover*: Use groundcover to lower overall maintenance requirements. Groundcovers other than grass can reduce mowing and other maintenance costs. Examples of groundcovers include ivy, wood chips, or hardy plants.

- *Conclusion*: Consult the installation's Base Comprehensive Plan and section 1 of the USAF Landscape Design Guide for a comprehensive source of information on landscape design that conforms to Air Force goals.

7.3.3 XERISCAPE PRINCIPLES

The following xeriscape principles need to be incorporated for a successful xeriscape project:

- *Start with a plan*: When you begin to formulate your project, keep maintenance and water requirements foremost in your mind. Usually, 500-1,000 square feet of turf remaining in a free-form pattern is about right. Think of grouping plants in zones based on their water requirements. An ideal theme to follow is to create a mini-oasis near the entry then gradually reduce the care and water required as you move away from the house. When making your preliminary design decisions remember that many other families will be utilizing your home in the future.

- *Limit turf areas*: Many of our homes have more turf than is needed or desired. By preserving easily maintained, well located turf areas, we can reduce the labor and time required to a manageable level. A drought tolerant variety of turf grasses should be selected. Then the use of a small, free form piece of turf adds to the aesthetics of the xeriscape by providing contrast and a slight cooling effect in the midst of long, hot summers.

- *Employ efficient irrigation methods*: Many of us feel that when the top of the soil is dry we need to water it. The fact is that many plants are watered too frequently and at an insufficient depth. Newly installed plants do need frequent watering, but our goal should be to wean our plants off frequent, shallow watering. Slow and deep should be the rule. Try to "target" your turf watering and never attempt to spray irrigate in heavy winds.

- *Harvest rainwater where possible*: In arid regions, if we can "collect" rainwater and trap it by gentle mounds or subtle depressions in our xeriscapes, we can supplement or even eliminate our watering efforts during certain times of the year.

- *Improve the soil*: A simple soil analysis will determine if soil improvement is required for better water absorption and improved water holding capacity. The use of mulches in flower and shrub beds is needed to increase water penetration during irrigation and to prevent water loss from the soil through evaporation.

- *Use appropriate plant selection*: The use of low water plants can greatly reduce the amount of required watering. Refer to the installation approved plant material list and try to keep the landscape in tune with the surrounding natural environment. This will help create a successful xeriscape.

- *Employ appropriate maintenance practices*: A xeriscape needs to be maintained. Proper maintenance preserves the beauty of the landscape and saves water. Pruning, weeding, proper fertilization, pest control and irrigation system adjustments will conserve water and help ensure the success of the xeriscape. Xeriscape will also cut the amount of time it takes to maintain your landscape dramatically.

7.3.4 MAINTENANCE STANDARDS

The success of your landscaping does not end with the planting. The plants will need help with moisture retention and upkeep. The following guidelines will help you to "think like a plant." Generally, the more xeric your planting, the less maintenance will be required.

- *Watering*: Over-watering can be more harmful than drought. To decide whether your plant needs water, look and feel. If it looks wilted at the end of a hot, dry day, reach down to feel whether the soil is moist. Your finger is the best moisture meter. If it comes up dry, then deep watering at the roots is needed. Use a hand-held garden hose to water inside the earth saucer.

- *Pruning*: Consider the plant's overall shape before pruning. Large, coarse-leafed shrubs that have a natural rounded shape can be destroyed by shearing off the top growth. Instead, they can be made smaller by taking out the tallest growth at the base of the plant. Shrubs with a long flowering season thrive with occasional pruning of dead flower heads *(see Figure 7-2)*.

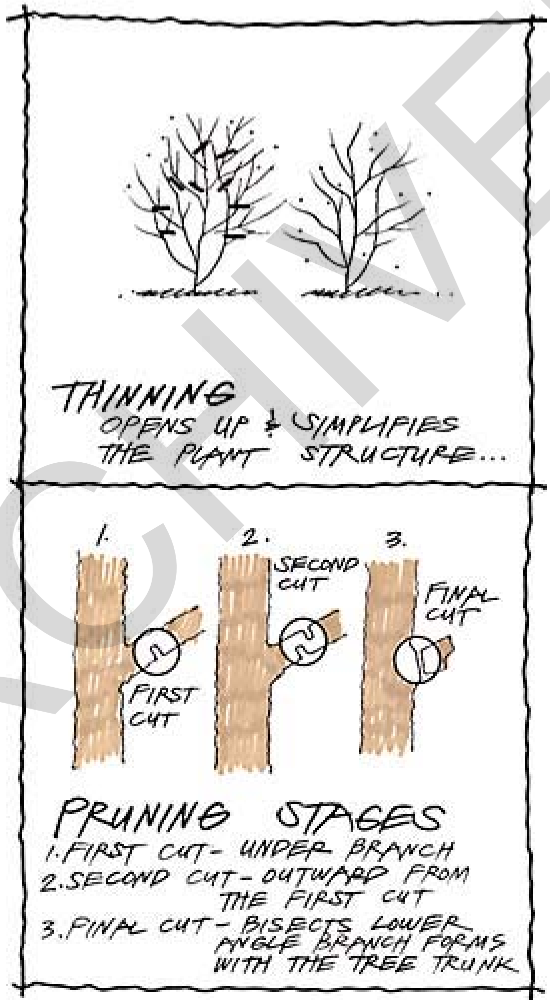

Figure 7-2: Thinning and Pruning Stages

- *Tools*: Pruning tools should always be kept sharp and clean. Good tools are hand pruners, long-handled loppers, and "pinch pruning" with your thumb and forefinger.

- *Top-dressing*: An annual spring-time top-dressing of compost is all that your plants require for nutrients. Mulch of shredded cedar or cypress will help retain moisture, but pine bark mulch may "lock up" the plant's nitrogen source.

- *Edging materials*: Historically, edging materials were not commonly used in home landscaping. If you choose to use edging, be certain that it will not hold water against the foundation.
- *Conclusion*: Consult section 3 of the USAF Landscape Design Guide for a comprehensive source of information on landscape maintenance.

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7.4 INSTALLATION APPROVED PLANT MATERIAL

Below is a listing of all the approved plants that can be ordered by the Self Help project coordinator after consulting with the Base Landscape Architect or equivalent CE staff.

Trees - *List to be inserted by each specific Installation.*

Common Name	**Scientific Name**

Shrubs - *List to be inserted by each specific Installation.*

Common Name	**Scientific Name**

Annuals/Perennials - *List to be inserted by each specific Installation.*

Common Name	**Scientific Name**

Groundcovers/Vines - *List to be inserted by each specific Installation.*

Common Name	**Scientific Name**

Local Nursery List - *List to be inserted by each specific Installation.*

Nursery	**Address**	**Phone Number**	**Contact**

Reference: tri-service landscape plant database (need database location).

7.4.1 INSTALLATION APPROVED INERT MATERIAL

Below is a listing of all the approved inert materials that can be ordered by the Self Help project coordinator after consulting with the Base Landscape Architect or equivalent CE staff.

Inert Materials - *List to be inserted by each specific Installation.*

7.4.2 INSTALLATION APPROVED IRRIGATION MATERIAL

Below is a listing of all the approved irrigation materials that can be ordered by the Self Help project coordinator after consulting with the Base Landscape Architect or equivalent CE staff.

Irrigation Materials - *List to be inserted by each specific Installation.*

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7.5 POTENTIAL HOUSING COMMUNITY PROJECTS

List to be inserted by each specific Installation.

7.5.1 MAKING DONATIONS TO AN AIR FORCE BASE

Charitable groups and individuals occasionally want to know how they can make charitable contributions to an installation. Offers of unconditional gifts, such as trees, should be made in writing to The Colonel, U.S.A.F. Base. The offer should completely describe the item being offered and its fair market value.

The Colonel, U.S.A.F. Base, may accept unconditional gifts worth $______or less.

Gifts to the United States are generally not deductible for federal income tax purposes. It is advisable that donations of tangible property be made, since cash donations must be deposited into the U.S. Treasury and are not available for local use.

Air Force regulations also state that no official or employee of the U.S. Air Force may solicit a gift on behalf of the Air Force. Also, special privileges, access or rights may not be granted because of a gift or donation.

All trees should be 6'-10' in height and have a caliper of not less than 4". The recommended tree species for donation are:

(List to be inserted by each specific Installation)

Common Name	Scientific Name

Sample Donor Letter.

Colonel Date
U.S. Air Force Base
Name of specific base Air Force Base, State Zip Code

It is my desire to make an unconditional donation of the following items to *Name of Air Force Base*:

List of items	Est. Fair Market Value
Tree, name and quantity of trees	$Amount
Tree, name and quantity of trees	$Amount

```
                                        Total:         $Amount


I understand the conditions under which you may accept these items.
The estimates include delivery and planting costs. Please appoint
a point of contact with whom I can meet, at your earliest convenience.
My daytime phone number is ____________.


Signature
```

7.5.2 PROMOTIONAL PROJECTS

Promotional projects can be added by specific installations.

Workshops and References

Training Videos - *List to be inserted by each specific Installation.*

Title	Distributor	Reference

Training Workshops - *List to be inserted by each specific Installation.*

Workshop	Date/Time	Location

Local Demonstration Gardens - *List to be inserted by each specific Installation.*

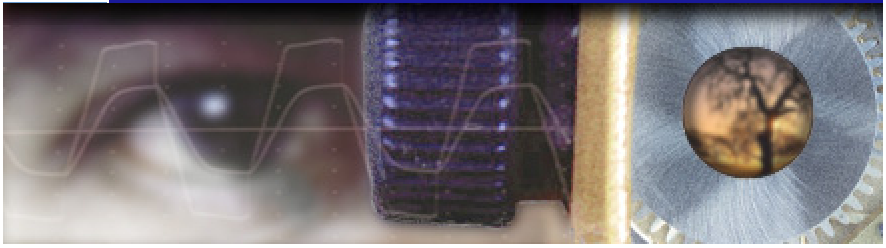
Garden	Location	Hours Open

Other Reference Material - *List to be inserted by each specific Installation.*

Book/Magazine Title	Author	Publisher	Date

USAF LANDSCAPE DESIGN GUIDE

8 VISUAL ANALYSIS



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8.1 INTRODUCTION

Visual character is an important aspect of the working and living environment of an Air Force installation. An installation's visual environment consists of land, water, vegetation, facilities, and other physical features. In addition to providing an expression of mission and function, the visual environment of an installation also provides residents and visitors with an overall impression. The character, quality, and relationships of physical features contribute to the comprehension and perception of the visual environment.

8.1.1 ACHIEVING A POSITIVE IMAGE

Achieving, enhancing, and maintaining a high level of visual quality strengthens the U.S. Air Force institution by developing installation's of excellence. The visual and physical environment in which people work and live has a significant effect on their attitudes and quality of life. The visual quality of installation's affects how missions are accomplished by influencing the performance of personnel. As homes and workplaces for military and civilian personnel, installation's should seek to achieve a visual image that reinforces professionalism and enhances daily life.

A positive image can be achieved and maintained by applying appropriate standards for visual design. These standards influence visual continuity, compatibility, and quality in the natural and man-made environment. Architectural compatibility, landscape development, and the treatment of natural areas are all characteristics of an installation that contribute to its overall image. The design, enhancement, and maintenance of these characteristics can reinforce and promote a unified and positive image for the installation.

Visual design awareness is important to achieving installation excellence. To achieve, maintain and enhance a consistently high visual image and quality, all persons with responsibilities for making decisions that affect the environment should understand the visual consequences of their decisions and practice. They should share a common understanding of visual design terminology and methodology, including design principles, vocabulary, and guidelines, as well as knowledge of the various steps associated with improving the visual environment.

8.1.2 PURPOSE

The purpose of this chapter is to promote an awareness and understanding of an installation's image and identity. It focuses on analysis of the visual environment as an important first step in developing an awareness of how the design of physical features contribute to image and visual quality. It provides guidance on analyzing and describing the installation's visual environment (i.e., its organization and its existing desirable and undesirable characteristics). It also describes a framework for accomplishing improvement and enhancement of the visual environment (i.e., translating the results of the visual analysis through planning and design recommendations). This includes outlining the types of improvements that can be made and how such improvements can be implemented by applying design guidance available in both the Landscape Design and Architectural Compatibility Guides.

8.1.3 GOALS AND OBJECTIVES

The goal of visual analysis is to improve the visual environment by:

- creating a unified and logical approach to analyze an installation's visual environment;
- recognizing and reinforcing an installation's identity and image; and
- maintaining and enhancing visual quality.

The objectives that support achievement of this goal are to:

- define a consistent procedure and vocabulary to describe and analyze the visual environment;
- provide guidance on how to identify an appropriate image and to reinforce this image through visual design, including enhancement of visual structure, hierarchy, and quality; and
- describe procedures to achieve a desired image and quality by translating visual quality proposals into actions that can be implemented through an existing planning framework.

8.1.4 AVAILABLE GUIDANCE

Guidance for visual design decision-making is available in both the Landscape Design and Architectural Compatibility Guides. These resources include support for developing an understanding of visual design principles as well as guidelines for the design, improvement, and enhancement of the physical elements that make up an installation's visual environment, including such features as facilities, roadways, parking areas, and open spaces.

8.2 FACTORS AFFECTING THE VISUAL ENVIRONMENT

Many man-made and natural features contribute to the overall image of an Air Force installation. While physical features such as land, water, vegetation, and facilities shape installation's, their characteristics and our perception of those features are influenced by many different factors.

8.2.1 MAN-MADE AND NATURAL FACTORS

The following factors and their characteristics affect an installation's visual environment.

- *Natural Influences*: Natural factors that may affect the character of an installation include landform, the presence and characteristics of vegetation and water, and climate. For example, landform may influence development form depending on whether it is flat or undulating, vegetation may provide spatial definition and/or softening effects, the presence of water can provide interest and diversity, and climate can influence building form.

- *Open Space*: The environmental setting of the installation, combined with the character of its open space, provides the background for the siting of architectural elements. In addition to providing a setting for facilities, open spaces provide visual relief from development and provide opportunities for visually and physically linking developed areas.

- *Land Use and Facility Siting*: The arrangement of land uses and the siting of facilities greatly influence visual design and compatibility. Compatible land uses reinforce visual compatibility. Incompatible land uses may contribute to visual incompatibilities. The siting of facilities in relation to each other can affect overall visual form.

- *Circulation Characteristics*: Vehicular, pedestrian, and bicycle circulation ways provide movement corridors. The arrangement of corridors can influence development form. For example, street patterns can be rectilinear, curvilinear, or radial. Development sited to reinforce the circulation network takes on the characteristics of the network in its building form.

- *Urban Design and Development Form*: Density, or the quantity of development, combined with the expression of building form, height, massing, and scale, influences the aesthetic relationships between facilities. Development form may include a few buildings with large footprints on small sites, or many buildings with smaller footprints spread over a larger area. Buildings may all be generally one story, or they may be more than one story. Buildings may be close to each other, or sited far apart with large expanses of open space in between. Higher density on a smaller land area may result in a greater feeling of enclosure. Lower density accommodated on a larger land area may result in a greater feeling of openness. Development form may also affect the sense of scale. Some buildings may exhibit a monumental scale, others a more human scale.

- *Site Planning*: The organization of uses on sites and site planning principles such as building orientation, relationship of internal circulation features, and location of loading and service areas all have an influence on visual character.

- *Architectural Style, Building Materials, and Colors*: The consistent application and use of building style, materials, and colors, in combination with the principles of building form, mass, and scale, can reinforce a desired visual theme and architectural style, promoting visual continuity and compatibility. While expression of these principles may be dictated by program and functional requirements, they may also be influenced by indigenous factors such as climate, cultural, or historic influences.

- *Landscape Development*: Landscape development can define spaces, buffer uses, soften large expanses of paving, reinforce vehicular and/or pedestrian corridors, and enhance the settings of buildings. Visual quality can be reinforced by consistently designed and compatible landscape treatments within open spaces, along streets, along pedestrian paths and bikeways, and in and around facilities and their entrances.

- *Site Furnishings*: The consistent design and successful integration of site furnishings, such as benches, seating walls, drinking fountains, telephone booths, bus shelters, bicycle racks or shelters, kiosks, fencing, trash receptacles, monuments, flagpoles, lighting, and signs, provide an opportunity to create visual design continuity and compatibility. A coordinated design approach can avoid clutter, reinforce function and hierarchy, and assure consistency in the appearance, use, and placement of site furnishing elements.

- *Hardscape and Paving Materials*: The use and selection of paving materials provide an opportunity to create consistency and continuity on the ground plane. The use and selection of paving materials can also denote areas of special function. The quality and condition of paving materials can contribute positively or negatively to the viewer experience.

- *Historical amd Cultural Features*: Historical significance may lead to historic district designations that contribute to a unique visual character, but may also present design challenges for the integration of future development. Buildings or features that have historical or cultural significance can form the basis of a visual theme or image for the installation.

- *Dominant Features and Views*: A significant or distinguished building, monument or other landmark, important open space, or significant view can represent a visually dominant feature. They can be a visual focus, reinforce visual characteristics, or serve an orientation function. Dominant features that are visually positive provide opportunities for the formulation of an installation theme or image. Dominant features that are visually negative should be the focus of visual improvement recommendations.

8.2.2 VISUAL PERCEPTION

While physical features affect the shape and form of installation's, their distinctive characteristics also influence the image of each installation. Awareness, comprehension, and interpretation of these characteristics contribute to human perception of the visual environment and the formation of a visual impression of an installation.

A visual environment is always experienced in relation to its surroundings, the events leading up to it, and the memory of past experiences. Perception of the visual environment is influenced by the variables of *visibility* (i.e., what can be seen given the distance and view angle between viewer and object), the *viewer environment* (i.e., immediate surroundings and a viewer's degree of mobility as a pedestrian, bicyclist, or vehicle occupant), and *viewer interpretation* (i.e., a viewer's psychological analysis of the content and meaning of what is being seen).

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8.3 VISUAL IMPROVEMENT PLAN DEVELOPMENT

The overall physical image of an installation can be maintained and improved by enhancing existing assets and resolving identified liabilities. The enhancement of assets and the resolution of liabilities can be accomplished by forming recommendations for visual improvements. Visual improvement recommendations can be formulated by applying recommended guidelines and considering the desired installation image and visual theme. These recommendations can be implemented through the existing installation planning and design framework and procedures, using the visual improvement plan as a medium.

8.3.1 VISUAL ANALYSIS OVERVIEW

A visual analysis should yield the type and depth of information necessary to enable a planner or designer to identify areas requiring visual improvement. In addition to identifying areas requiring improvement, the analysis should also recognize positive attributes that can be enhanced and built upon to reinforce an overall image. The type of analysis conducted should be consistent with the problems that are evident. The depth and level of analysis should be proportional to the degree of visual liabilities. For example, an initial analysis may be sufficient for an installation without major visual problems and should give an indication of whether a more detailed survey is required or whether other areas of analysis should be considered.

Visual analysis should focus on the determination of visual quality and character. An initial visual analysis or visual survey should reveal the basic framework and variables that contribute to its visual quality and character. It should include the observation and documentation of such variables as whether there are naturalistic or man-made influences, whether there is an appearance of organization or disorganization, or whether formal or informal characteristics abound.

Visual Quality

Visual quality can be described by identifying inherent characteristics and attributes. This includes the identification and summary of elements that contribute positively to the visual experience, as well as those elements that visually detract from a viewer's experience. Positive visual elements can include significant and well-designed architectural features, consistently applied finishes and colors, appropriate landscape treatments, significant views and vistas, and effective maintenance practices. Negative visual elements can include unscreened parking areas, uncoordinated finishes and styles, inappropriate use and lack of landscape development, negatives views, or other features or factors that degrade visual quality. Positive visual elements should be preserved and enhanced since they provide reinforcement of a higher quality visual image. Negative visual elements provide a focus for visual improvement recommendations.

Visual Character

The visual character of an environment is the product of distinguishing traits and features. Visual character is influenced by a variety of natural and man-made variables that give an installation its form, feeling, and character, and that may be indigenous to a particular installation. Natural influences might include the characteristics of topography, vegetation, open space, and water. Man-made influences might include density and form of development, circulation patterns, architectural style (including form, mass, scale, materials, and color of buildings), type and quality of paving materials, extent and nature of landscape development, and overall facility condition.

8.3.2 VISUAL SURVEY

A visual survey provides a framework to gather data for the assessment of an installation's existing visual environment. The purpose of the visual survey is to collect and document information needed to evaluate visual quality including both positive and negative characteristics. The survey can be accomplished either by an individual or by a group of individuals representing different professional disciplines.

While photographs provide a good record of existing conditions, information from the survey should also be recorded on existing base maps in the form of annotations and diagrams. A combination of photographs, maps, diagrams, sketches, and supportive narratives can be used to convey the visual environment of the installation.

Before preparation of any formal documentation, an initial visual reconnaissance should be conducted of the entire installation. The purpose of this initial reconnaissance is to provide an overview of visual conditions. Depending upon the findings of the initial reconnaissance, supplemental surveys may be conducted to gather more detailed information on certain locations or specific subjects, such as architectural character, landscape development, or signs.

Survey team members should approach the assignment as if visually experiencing the installation for the first time, beginning at the entry and proceeding along corridors to various destinations throughout the installation. It may be beneficial to conduct the initial reconnaissance at night as well as during the day. Photographic sequences taken along the installation's corridors can be very valuable in recording conditions and situations that illustrate both positive and negative features and in identifying areas that may require more study. Visual impressions of various areas should be noted on an existing base map with a system of words, diagrams, and symbols, documenting positive and negative visual elements as well as qualitative impressions.

8.3.3 DOCUMENTATION OF FINDINGS

The results of the initial reconnaissance and any supplemental surveys should be documented in both narrative and graphic form. This documentation should address the overall visual organization of the installation, summarize its visual assets and liabilities, and outline any specific problems. The visual survey documentation should use the installation's visual components (entrances, corridors, visual districts, activity nodes, landmarks, and edges) as an organizational structure for survey findings. The results of this documentation should be a prioritized list of problem areas to be resolved and visual assets and opportunities to be capitalized on in the development of a visual improvement plan. The documentation should also outline the goals and objectives for visual improvement based upon the desired installation image and a prioritization of visual improvement needs.

Narrative, tabular, and graphical information describing the existing visual environment should be compiled and displayed within the installation's existing report and mapping framework and in accordance with applicable Air Force standards. Narrative information should be included in the relevant sections of the Installation Landscape Development and Architectural Compatibility Plan. Graphical information regarding existing visual conditions should be compiled as a level or layer on Existing Landscape Development Maps and/or maps associated with the Architectural Compatibility Plan.

Visual Analysis Summary

Using the installation's base layout map, a graphical summary analysis should be prepared as an overlay that locates entries, delineates the hierarchy of corridors, and identifies any pedestrian and/or bicycle networks. Depending upon the scale of the map and the density of the information, the same map can be used to delineate the boundaries and edges that define the installation's visual districts. Any activity nodes and identified landmarks should be noted on this map, along with annotations that communicate the quality and condition of these components. Photographs and/or sketches that illustrate the nature of the findings should be used to support the summary analysis. One possible technique is to scan a photo, and then digitally annotate the photo with notes and or/diagrams to describe problem areas or other aspects of the analysis. Supporting narratives should be developed to document the characteristics, quality and condition of the analyzed components. *(see Figure 8-1)*

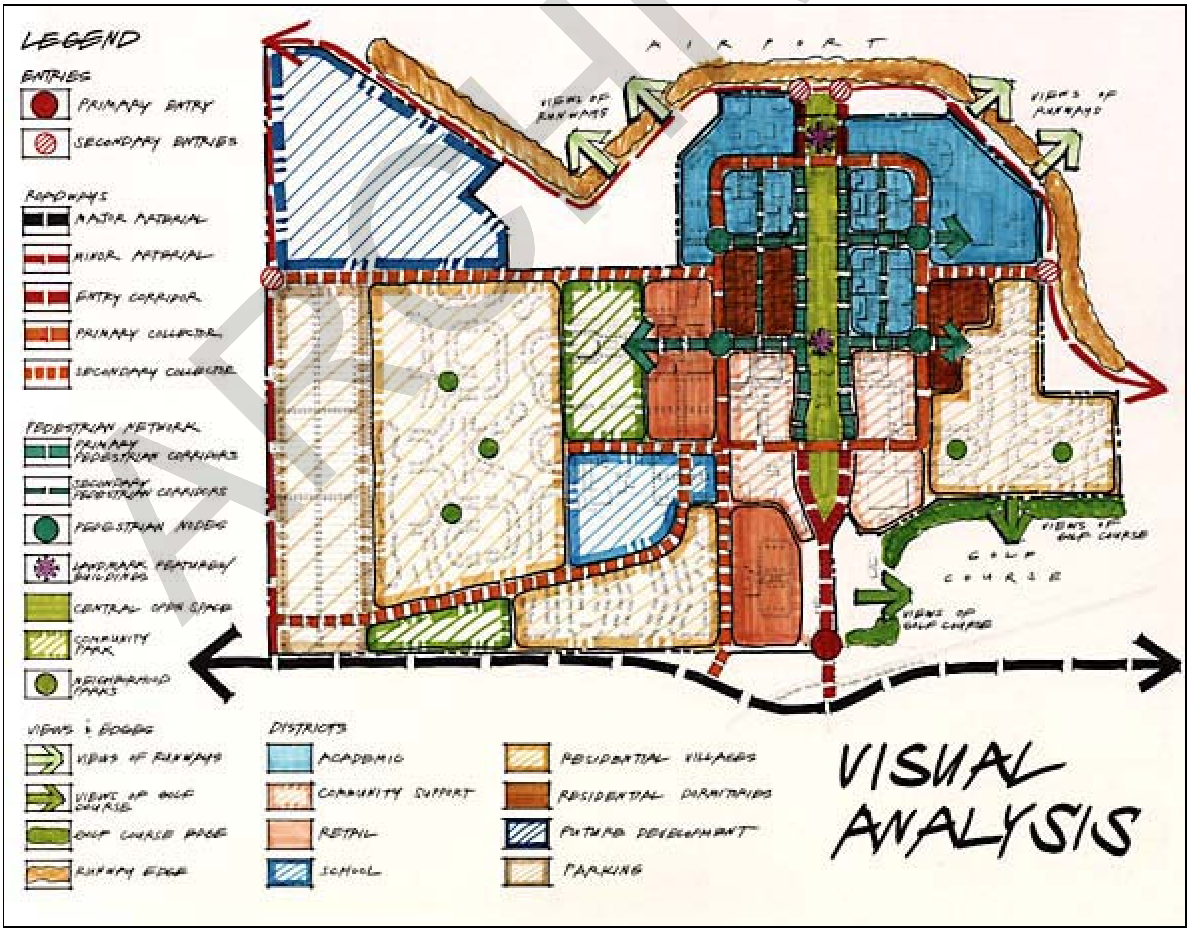

Figure 8-1: Sample Visual Analysis Summary Diagram

Priority Problem Areas and Opportunities

The results of the visual analysis should include a summary of visual problems and opportunities. This summary provides a basis for the goals of the visual improvement plan and guides the formulation of installation goals and objectives for visual improvement. It should identify visual assets that should be preserved and/or enhanced, and visual liabilities and special problem areas that require attention and/or resolution.

Categorizing Problems and Opportunities

The summary of problem areas and opportunities should be categorized by the nature and focus of the issues, using the organizational structure of the Landscape Design and Architectural Compatibility Guides. For example, problems associated with the definition of a corridor should be categorized under "streetscape," problems associated with illumination should be categorized under "exterior lighting," problems associated with landscape materials should be categorized under "planting design," and issues associated with buildings should be categorized under "architectural compatibility." Categorizing problem areas, opportunities, and issues in this manner provides a link to existing available guidance as well as to the process of developing improvement recommendations.

Prioritizing Problems and Opportunities

Problem areas and opportunities should be prioritized according to the severity of the problem, its degree of visual impact on the installation, and the relative visual importance and location of the problem or opportunity. Prioritization of problems and opportunities should be guided by the installation's goals and objectives for its image and visual improvement and the installation's visual development theme.

8.3.4 FORMULATION OF VISUAL IMPROVEMENT RECOMMENDATIONS

Visual improvement recommendations and concepts can be developed by applying existing available guidance to identified problem areas and opportunities. The recommendations and concepts should consider the installation's overall goals and objectives for achieving and/or maintaining a desired image and the installation's visual development theme.

Visual Improvement Goals and Objectives

The formulation of visual improvement goals and objectives is influenced by existing and future missions, existing visual assets and liabilities, and planned future development. Formulation of visual improvement goals and objectives should involve command level personnel as well as those individuals responsible for managing existing and future development. A beginning point for the formulation of visual goals and objectives may be a mission statement and any other visual improvement plans that may exist, including the Architectural Compatibility Plan or Landscape Development Plan.

Determining Image and Theme

A visual development theme should be established in collaboration with command level personnel, individuals responsible for managing and maintaining development resources, and interested installation residents. This can be accomplished though surveys and/or a series of meetings and workshops. The desired result is a visual development theme that reflects all interests of the installation community.

A visual development theme should represent the essence and character of the installation. As an example, an installation located in a European setting may be considered a complete, multi-faceted community that blends traditional neighborhood elements with the progressive outlook of the military workplace. The installation's character might be fundamentally American yet influenced and enriched by the surrounding European context. The resulting character could respect the best of American and European traditions while embracing a new spirit of enhanced morale, upgraded appearance, and a reinforced mission. The visual development theme might reinforce an enhanced quality of life by defining and advancing an upgraded visual image.

An installation's visual development theme can be a physical expression of its desired image. It can be represented by architectural style, or it may evolve from the installation's focus or mission (i.e., education, training, or testing). For example, Cape Canaveral Air Force Station adopted a visual development theme that related to its primary space mission. A high-tech space image was promoted and recommended for incorporation in all future facilities development. A visual development theme can also be represented by a significant space or other factor that may be the result of historic or cultural influences. For example, Patrick Air Force Base promoted a Mediterranean architectural theme that was rooted in regional and climatic influences. While a visual development theme can be expressed in many ways, it is important that it be representative of the installation.

The Air Force Academy offers a good example of the translation of a desired aesthetic for the Air Force into physical reality. Designers of the Academy believed that design concepts for development should reflect a modern way of life. Discipline, order, simplicity, and precision reminiscent of the the timelessness, efficiency, and versatility of modern aircraft influenced the architectural style of the Academy. The resulting respect for the character and quality of the visual environment at the Academy vividly illustrates the importance of establishing and following a theme in future development activity.

Visual Improvement Recommendations

With visual improvement goals and objectives established, and a desired visual development theme in place, visual design guidelines responsive to those goals, objectives, and theme should be applied to the installation's areas of need. A beginning point for the application of guidelines are the various chapters associated with the Landscape Design and Architectural Compatibility Guides. Though no two installation's are identical, the guidance found in these resources should be relevant for most installation's. While a consistent framework of visual design standards can be established for Air Force installation's worldwide, the application of these standards will vary with geographic location and local conditions and circumstances.

Visual improvement recommendations should be developed to address problem areas that require resolution as well as opportunities that can benefit from reinforcement and enhancement. Recommendations at this stage should be conceptual but detailed enough to communicate the intent. Each recommendation should include a brief narrative description, a location at which to apply the concept, and brief sketch or plan layout to convey the intent of the recommendation.

Priority Projects Development

Projects should be developed for the highest priority improvements. This should include a more detailed project description, a further detailing of the concept, and a plan or sketch of the intended improvement. Enough information should be provided to facilitate preparation of a preliminary cost estimate. Graphical information locating proposed improvements should be compiled as a level or layer on Landscape Development and Architectural Compatibility Plans, of the Capital Improvement Component in the Comprehensive Plan. Non-graphical information that can be compiled in a tabular form should be attached, if possible, to the corresponding map element.

Visual simulation techniques can be an effective way to communicate proposed improvements. Accomplished manually or digitally, visual simulations are useful in accurately and objectively depicting the visual impact of proposed actions. Manual techniques can simply involve altering photographs to illustrate such improvements as a renovated building facade or addition of landscape plantings, lighting, and signs to an installation entry. Digital techniques can accomplish similar simulation using three-dimensional modeling and animation techniques. *(see Figure 8-2)*.

Figure 8-2: Sample Visual Simulation of Proposed Improvement

Implementation of the Visual Improvement Plan

Visual improvement and enhancement are integral to the comprehensive planning process. While the Comprehensive Plan provides a framework to guide future development, the visual improvement plan is the medium for identifying visual improvement recommendations and conceptualizing priority improvement projects. As such, the visual improvement plan should reinforce the various components of the Comprehensive Plan. Recommended visual improvements should be coordinated carefully with all components to avoid possible conflicts.

There are a range of existing avenues to implement priority improvement projects. For example, projects associated with landscape improvements can be developed through the Landscape Development Plan. Projects associated with the Landscape Development Plan are then implemented through the Capital Improvements Component of the Comprehensive Plan. Projects associated with the enhancement of vehicular corridors can be developed though the Streetscape element of the Landscape Development Plan. Illumination improvement projects can be implemented through the Exterior Lighting Plan associated with the Infrastructure Component of the Comprehensive Plan and the Future Electrical Distribution Plan. Projects that enhance pedestrian or bikeway corridors can be developed through the walkway and bikeway network plans associated with the Landscape Development Plan.

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8.4 ANALYZING VISUAL COMPONENTS

Visual quality can be ascertained through an understanding of an installation's image in the eyes of its residents and visitors. The extent to which this image is clear and legible determines the ease with which the parts of an installation can be recognized and organized into a coherent pattern. Just as a page of printed words can be understood as a story, a "legible" installation is one whose parts or visual components are easily identified and grouped to form an overall pattern. Recognizing the components of an installation's visual environment, and the characteristics that contribute to a high quality environment, provides a basis to evaluate that visual environment.

The visual form, structure, and pattern of an installation are made up of distinct components, each with its own characteristics. Together, visual components make up the overall visual image of an installation. As such, visual components are a logical basis for organizing the installation into manageable parts to conduct a visual analysis. Separate analysis of each component provides an opportunity to isolate the installation's various parts, describe its visual characteristics and quality, and identify visual assets and liabilities. The successive analysis of each visual component builds a comprehensive view of the entire installation. In addition to benefiting the organization of a visual analysis, visual components provide a logical structure and consistent terminology to organize guidelines and concepts for visual improvement.

Much has been written about the analysis of urban form, how environment affects daily life, and how people perceive the environment in which they live and work in. An Air Force installation is not unlike a small city, given its types of uses, characteristics, and resultant form. In *The Image of the City*, Kevin Lynch considers the visual quality of the American city by studying the mental image held by its citizens. Recognizing the components that help form images of visual environments, Lynch developed a notational system of terms to describe a city's form. Considering the similarities between a city and an installation, Lynch's system of analysis can be reinterpreted, adapted and applied to installation's as a means to describe their physical form, characteristics, and image. Visual components of an Air Force installation based upon this system include entrances, corridors, edges, visual districts, activity nodes, and landmarks.

8.4.1 ENTRANCES

In addition to serving as gateways and checkpoints for access control and security, entrances are important places for directional and informational signage to guide motorists to their destinations. The visual design of entrances should be attractive as well as functional, conveying a ceremonial sense of entry that reflects the installation's desired image and identity. Physical elements of the entry, including roadway geometry, traffic islands, signs, gatehouse, paving materials, and landscape planting materials, should function together to physically define the entry and establish a positive first impression. (See the Streetscape Chapter for more specific guidance on entrances.) *(see Figure 8-3)*.

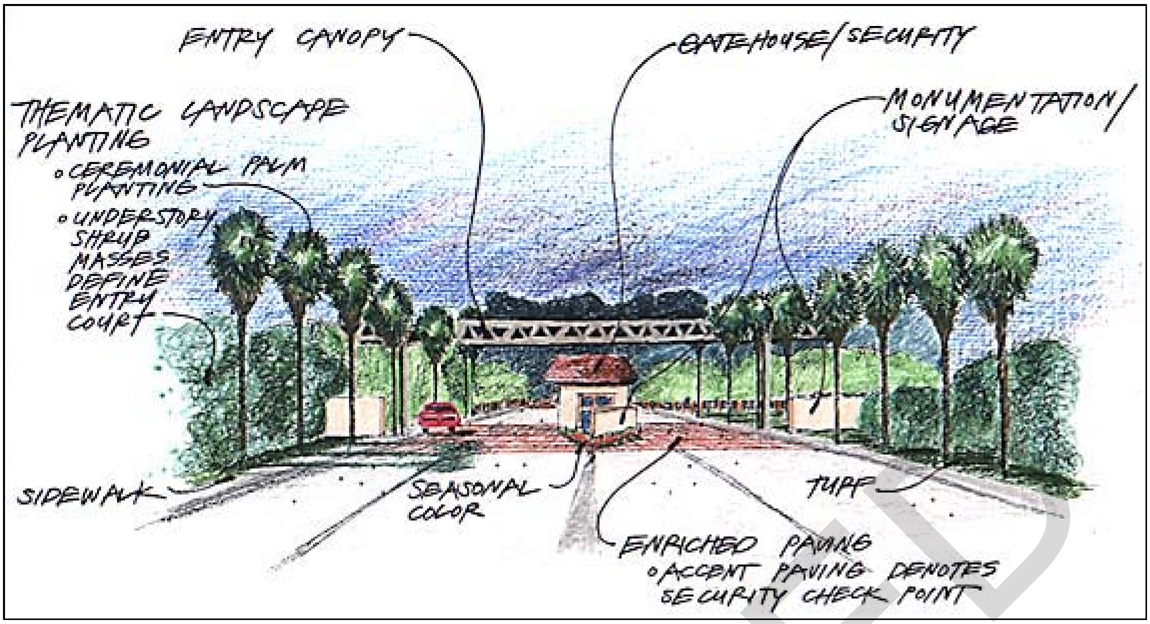

Figure 8-3: Example of Positive Installation Entry Features

An analysis of entrances should note their location with respect to the surrounding roadway network and their connection to circulation corridors, and should observe, record, and evaluate the following concerns:

- What is the overall appearance of the entry? Is there an appropriate sense of entry conveyed by physical features?
- Is there effective identification signing?
- Is there coordinated directional signing?
- Is there a sense of visual organization, or is there visual clutter and competition between elements?
- Are there unattractive overhead utility lines?
- What is the character of the entrance landscape development? Is it barren, or are landscape materials used to reinforce the entrance to create a positive image?
- Is security fencing unattractive along the installation boundary?
- Does the roadway geometry allow for efficient traffic channelization, turning movements, and temporary stopping without obstructing traffic?
- Is the parking associated with the entrance function and security control provided on- or off-street?

8.4.2 CORRIDORS

Vehicular, pedestrian, and bikeway corridors function as the circulation network providing a means of access for vehicles, pedestrians, and bicyclists. They also provide vantage points from which to visually experience the installation. Design treatments along corridors are referred to as streetscape.

Vehicular Corridors

A hierarchical network that efficiently guides traffic through an installation is typically established by traffic types and volumes. This hierarchical network is defined by the categories of primary, secondary, and tertiary corridors, which are usually expressed in the installation's Transportation and Streetscape Plans. The hierarchy of vehicular corridors can be reinforced visually with landscape development to promote comprehension and a sense of orientation as well as ease of circulation for the motorist. Visual reinforcement of corridors also can contribute to an attractive streetscape. (See the Streetscape Chapter for more specific guidance on vehicular corridors.)

An analysis of vehicular corridors should include the identification and mapping of the roadway hierarchy and the observation, recording, and evaluation of the following concerns:

- Is the vehicular roadway hierarchy visually evident through the application of landscape development?
- Are landscape planting treatments, site furnishings, and lighting consistent for each category of vehicular corridor?
- Is there a differentiation in the width of the landscape right-of-way between the categories of vehicular corridors?
- Is there a differentiation in the use of street tree species between the categories of vehicular corridors?
- Is there a differentiation in the spacing and alignment of street trees between the categories of vehicular corridors?
- Is there a differentiation of building setbacks between the categories of vehicular corridors that would allow for the application of a corresponding hierarchical landscape treatment?

Pedestrian and Bikeway Corridors

Pedestrian-oriented corridors should provide safe, accessible and continuous pathways for pedestrians and bicyclists. By contributing to the convenience, comfort and enjoyment of daily activities, appropriately scaled landscape development can greatly enhance the user experience. Similar to vehicular corridors, a hierarchical network of pedestrian and bikeway corridors can be established, including primary, secondary, and tertiary walkways, and can be reinforced visually with landscape development. (See the Walkways and Bikeways Chapter for more specific guidance on pedestrian and bikeway corridors.)

An analysis of pedestrian and bikeway corridors should include the identification and mapping of the corridors and observation, recording, and evaluation of the following concerns:

- Are pedestrian and bikeway corridors hierarchy visually evident through the application of landscape development?

- Are landscape treatments consistent for each category of pedestrian and bikeway corridors?

- Is there a differentiation in the intensity and density of landscape materials on the different categories of pedestrian and bikeway corridors?

- Is there a differentiation in the width of the pavement on the different categories of pedestrian and bikeway corridors that would allow for the application of a corresponding hierarchical landscape treatment?

8.4.3 EDGES

Edges are linear elements that can represent where an area begins or ends. Edges can be, for example, a boundary, a break in continuity, a shoreline, an edge of development, or a wall. They can function as barriers or can be penetrable. Edges function as organizational elements by demarcating generalized areas.

Edges can vary in their expression, being formed by architectural or natural elements and being continuous or discontinuous. Some are hard and definite, such as a boundary or edge formed by a wall, solid fence, water, or a complex of buildings. Other boundaries or edges may be soft or uncertain, such as the transition from an industrial area and the flightline. The composition and characteristics of an edge will dictate its visual effect on adjacent areas. Understanding edges and their characteristics is also useful when identifying visual districts and their boundaries.

An edge can also provide spatial definition of a feature within a district, such as a pedestrian plaza or courtyard defined by a group of buildings, or a golf course defined by masses of vegetation. As the boundary of an entire installation, perimeter edges are the transitions between military and public right-of-ways. They represent a continuous edge of exposure to adjacent properties and uses, and as such, create linear opportunities to present a favorable image. *(see Figure 8-4)*.

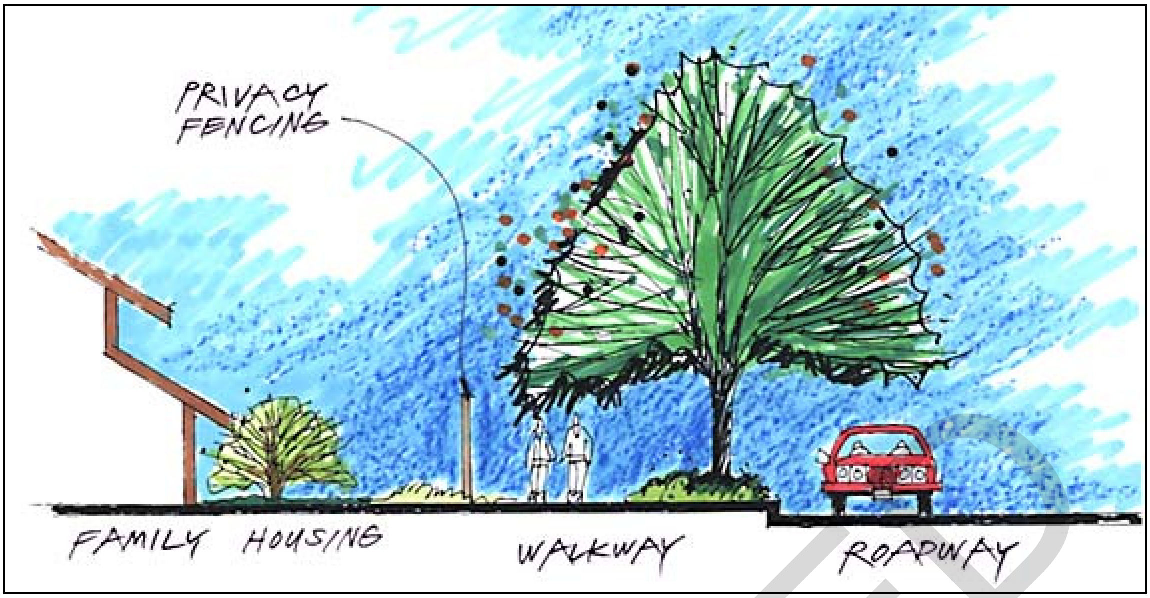

Figure 8-4: Example of Edge Condition

An analysis of edges should include their identification and notation on maps as well as observation, recording, and evaluation of the following concerns:

- Does an edge exist, and is it well defined?
- Is the edge a break in continuity of character, style, or quality?
- Does the edge function as a barrier, or is it penetrable?
- Is the edge formed by architectural elements, or by natural elements?
- Is the edge continuous, or discontinuous?
- Does the edge provide spatial definition?
- Does the edge represent a transition between uses and/or ownership?

8.4.4 VISUAL DISTRICTS

Visual districts are areas of the installation that are recognizable as having characteristics that are homogeneous throughout. Homogeneity may be reflected in spatial characteristics, as in the openness of a parade ground; in building types, as in the residential character of family housing; or in style, as in the industrial character of a maintenance zone. Homogeneity may be expressed as a continuity of architectural detail or building color, landscape planting, paving materials, lighting techniques, or other treatments. The number of visual districts will vary given an installation's size and mission.

Defining Visual Districts

Visual districts have definite boundaries or edges. They can correspond to functional areas that may have common visual characteristics (such as administrative, housing, community, recreation, operational, or industrial areas), or to areas that are not defined by function but that simply have homogeneous characteristics. Visual districts can also correlate to open areas such as a golf course, areas areas of natural vegetation, or other forms of open space. Natural areas can sometimes function as an orientation feature such as a grassy quadrangle around which administrative buildings are arranged.

Continuity and commonality of physical characteristics, such as identity and cohesiveness, contribute to defining the extent of a district. While visual districts can correspond to functional or land use areas, function or use alone are not the only determinants of a visual district's boundary. The observer should focus first on the visual characteristics of the various areas of the installation to delineate the extent of visual districts, looking for commonalties and consistency. Difficulty in identifying continuity in characteristics may be evidence of the lack of an installation's visual clarity and an indication of the need for visual definition and enhancement. Visual improvement recommendations can then be focused to resolve the lack of clarity in those areas.

When identifying visual districts, there is no set formula as to how many characteristics should be present or to what extent one characteristic is more prevalent than another. It is, however, important to record the factors and rationale used to delineate the extent of a visual district. Identified visual districts should be given names that are unique to each district and that represent a recognizable characteristic of the district such as "central core area," "parade field," or "historic housing area."

Analyzing Visual Districts

While an overview analysis of a district should reveal the basic framework and variables that contribute to its visual quality and character, it should be noted that visual districts may represent the majority of the physical area of an installation, and as such, may contain many visual components. It should also be noted that the components that make up a district may be influenced by many distinct yet overlapping factors.

An analysis of districts should include the delineation of their boundaries and their identification by name, and should observe, record, and evaluate the following concerns:

- Is there evidence of areas defined by edges or physical barriers?
- Is there a consistent topographic characteristic present? (topography can define a district)
- Is there a common architectural style?
- Are the facilities of a similar scale, mass, form, material, and/or color?
- Is there a consistent use (or non-use) or similarity in landscape materials?
- Is there a consistent use of paving materials and quality?
- Is there a consistent quality in the type and finish of site furnishings and elements?
- Are there consistent lighting elements and features?

8.4.5 ACTIVITY NODES

Activity nodes are places on an installation characterized by concentrations of activity, either by vehicles or by pedestrians. On an installation, activity nodes may be distinguished by vehicular features, such as a traffic circle or street corner, or by pedestrian plazas, open space, or other gathering places. As a junction or break in a vehicular or pedestrian corridor, a node may have particular importance to an observer. Decisions must be made at junctions, so such places may heighten observers' attention and visual awareness more so than other areas along the corridor. As such, activity nodes are sometimes the focus or dominant feature of a district and are logical places for visual reinforcement and enhancement.

Vehicular Nodes

Vehicular intersections or other areas where corridors converge are examples of activity nodes on an installation. An analysis of a vehicular node should include the identification and mapping of the node and observation, recording, and evaluation of the following concerns:

- What is the hierarchy of the corridor intersected by the node?
- What is the level of importance of the node on the installation?
- What is the degree of prominence of the location of the node?
- Has an opportunity been taken to visually reinforce the node?
- Is the node reinforced with landscape development? If so, what is the nature, quality and condition of the landscape development?
- Are signs and/or lighting used appropriately and effectively at the node?

Pedestrian Plazas and Open Spaces

Pedestrian plazas and open spaces are examples of activity nodes on an installation. They can be created from spaces that are enclosed or partially enclosed by buildings and may be enhanced with special paving, plant materials, site furnishings, or water features.

An analysis of a plaza or open space as a pedestrian node should include the identification and mapping of the node and observation, recording, and evaluation of the following concerns:

- What is the spatial organization of the open space or plaza?
- Do the space and the buildings that may contain or define the plaza or open space relate in a functional and visually compatible manner?
- Considering the spatial and scale relationship between the height of the buildings defining the plaza or open space and the size of the space itself, does the resultant space create a sense of enclosure or sense of place?
- Is the space oriented inward or outward?
- Is the space articulated, for example, with special paving, landscape treatments, changes in level

or other vertical features?

- What is the type, quality, and condition of the paving?
- Are landscape plantings used effectively and appropriately?
- Is there a presence of water to add aesthetic interest?
- Are areas illuminated properly for nighttime use, and is the design of the light fixtures coordinated with other installation standards?
- Are site furnishings such as benches, seating, trash receptacles, and bike racks provided, and are their designs and finishes consistent and compatible?

8.4.6 LANDMARKS

Landmarks are points of reference that function as orientation elements. Landmarks can be monuments and other ceremonial features, or they can simply be a sign, landscape feature, topographic feature, or an architecturally unique building.

Landmarks may vary widely in size and scale and can be take on a variety of forms. The key characteristic of a landmark is its singularity or some attribute that is unique or memorable. Landmarks are most easily identifiable and significant when they stand out or are in contrast with their background. For example, a feature may be visible from many locations (e.g., a tall tower) due to its impressive scale and prominent location. A landmark may also be established because it contrasts dramatically with nearby elements (e.g., a uniquely designed facade of a facility located in a mass of similarly designed facades). Historical or architectural significance also tends to reinforce a landmark. Landmarks on an installation often represent positive visual elements that can benefit from visual reinforcement and enhancement. *(see Figure 8-5)*.

An analysis of landmarks should note their location and should observe, record, and evaluate the following concerns:

- Why is the feature a landmark?
- Is the landmark a monument, ceremonial feature, sign, landscape feature, topographic feature, or an architecturally unique building?
- How does the landmark contribute to orientation?
- What is the approximate size and scale of the landmark?
- What are the materials and color of the landmark?
- From which locations can the landmark be seen (e.g., from all areas of the installation, or only within certain districts)?
- What are the memorable characteristics of the landmark?

- What is the nature of the background of the landmark (e.g., is it natural surroundings, or man-made development)?
- Is the landmark in dramatic contrast with nearby elements?
- Is there any historical or architectural significance to the landmark?

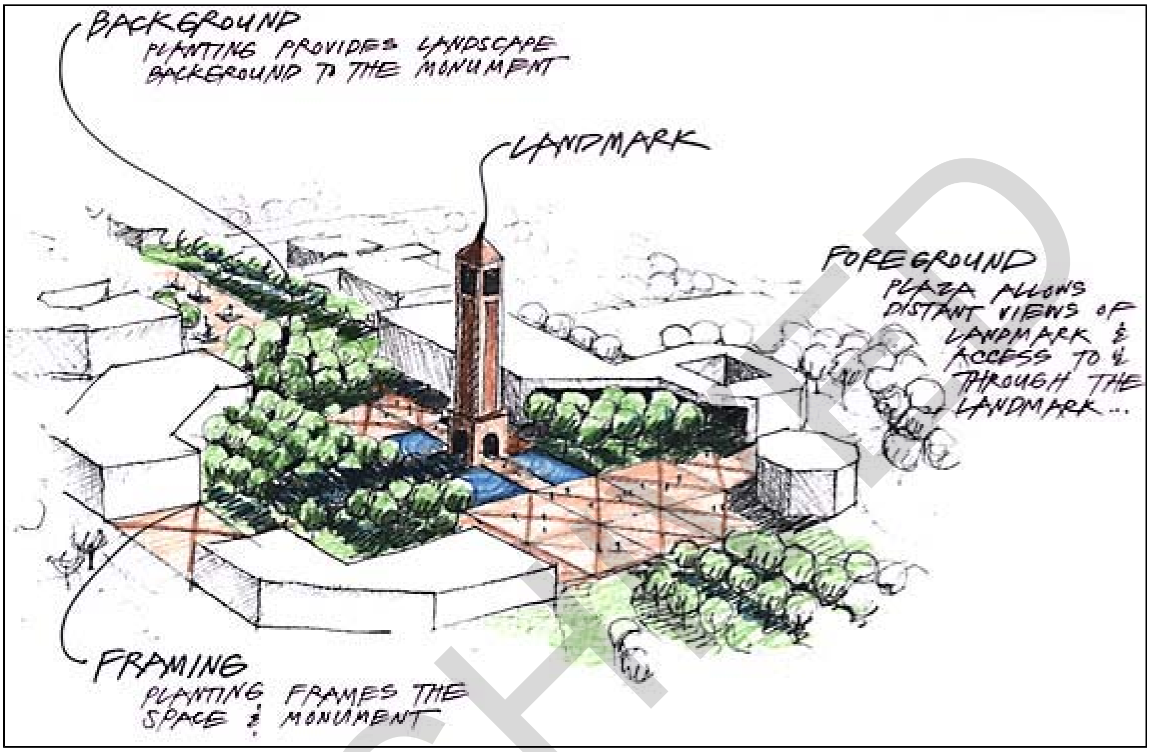

Figure 8-5: Example of Landmark as an Orientation Feature

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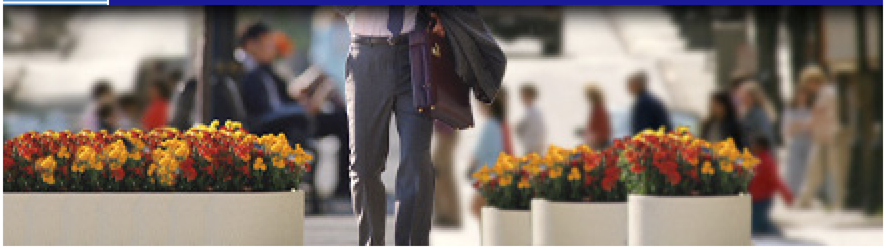
9 STREETSCAPE



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9.1 INTRODUCTION

The roadway system on an Air Force installation not only provides the primary means of circulation but is also a major vantage point from which the installation is viewed and comprehended. The streetscape environment consists of the roadways and the visual corridors through which they pass. Elements within these visual corridors can include landscape planting, signs, light fixtures, site furnishings, walkways and bikeways, and utilities, as well as the roadways themselves. A streetscape that is well planned in terms of the appearance and placement of elements can help reinforce the vehicular circulation system hierarchy, reduce potential safety conflicts, and enhance the visual image of the installation.

9.1.1 PURPOSE

The purpose of this chapter is to provide guidance related to the appropriate development of streetscape corridors on an Air Force installation. This includes guidance for preparation of a streetscape plan as well as guidelines regarding the type, size, and placement of the various elements that the streetscape comprises. The guidelines are intended to help establish streetscapes that relate to the function of each roadway, minimize safety conflicts, and are coordinated and attractive in appearance.

9.1.2 GOALS & OBJECTIVES

The goal for a streetscape is to enhance the functionality and image of installation transportation corridors by:

- assisting with orientation and contributing to a general sense of organization for the installation;
- providing for the safety of drivers and pedestrians; and
- contributing positively to the visual image of the installation.

The objectives for a streetscape that support achievement of this goal are to:

- reinforce the street circulation hierarchy;
- provide clarity, uniformity, and continuity in transportation corridors;
- minimize visual and physical obstructions and other potential safety conflicts; and
- minimize clutter and coordinate the appearance of streetscape elements.

9.2 STREETSCAPE PLANNING PROCESS

The streetscape is composed of many distinct elements that relate to the installation landscape, roadway, and infrastructure design. These include paving, landscape planting, site furnishings, lighting, signs, and utilities. In order to successfully integrate these diverse elements, the streetscape planning process should be logical and comprehensive and should include a corridor identification analysis, an existing conditions survey, an adequacy analysis, and the development of a streetscape corridor plan.

- A *corridor identification analysis* defines the hierarchy of transportation corridors and establishes the relative type and level of streetscape treatment that each corridor should receive. Each corridor should be identified as primary, secondary, or tertiary based on the volume and type of traffic it receives. Corridors should also be identified relative to their function and that of adjacent areas.

- An *existing conditions survey* should include written and mapped information related to existing streetscape corridors. This information should include the dimensions of streets, medians, and adjacent walkways and bikeways and the location, type, and condition of all existing streetscape elements, including landscape planting, paving, site furnishings, lighting, signs, and utilities. The general visual character of the streetscape should be noted, and potential safety hazards should be identified. This survey provides the physical data upon which an adequacy analysis will be based.

- An *adequacy analysis* should evaluate the extent to which existing streetscape elements reinforce the vehicular circulation hierarchy and should identify existing visual assets that should be preserved and enhanced and visual liabilities that should be improved or eliminated. Nonconformance with design guidelines should be identified, and safety conflicts should be ranked in terms of potential severity. This analysis forms the foundation upon which the streetscape plan will be developed.

- A *streetscape corridor plan* should be prepared to indicate all proposed improvements for existing streetscapes and future streetscape development. The streetscape plan should be correlated with other installation development plans to assure compatibility in the selection and placement of elements such as landscape planting, lighting, and utilities. Relationships between the various elements should be closely coordinated to maintain consistency, avoid clutter, and prevent visual or physical obstructions. The plan should reflect the hierarchical and functional nature of each streetscape corridor and provide continuity of treatment between like corridors. It should indicate the location of new streetscape elements and identify existing streetscape elements that should be preserved, enhanced, repaired, or removed.

Narrative, tabular, and graphical information describing corridor identification, existing conditions, the adequacy analysis, and the streetscape corridor plan should be compiled and displayed within the installation's existing report and mapping framework and in accordance with applicable Air Force standards. Narrative information should be included in the Installation Landscape Development Plan in the Capital Improvements Program Component of the Comprehensive Plan. Graphical information regarding existing conditions should be compiled as a level or layer on Existing Landscape Development Maps. Graphical information locating proposed improvements should be compiled as a level or layer on Future Landscape Development Plans. Non-graphical information that can be compiled in a tabular form should be attached, if possible, to the corresponding graphical map element.

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9.3 STREETSCAPE GUIDELINES

Many elements must be considered in planning a streetscape on an Air Force installation. While these elements are distinct and may be individually addressed in other plans (e.g., landscape, lighting, or bikeway plans), they must be appropriately integrated to develop an effective streetscape. The planning for and integration of these elements should respond to the hierarchy of installation transportation corridors, the safety of pedestrians and motorists, and the visual image of the streetscape.

9.3.1 STREETSCAPE HIERARCHY

The visual character of the streetscape should convey the function of streets and reinforce the circulation hierarchy, thereby assisting in orientation and contributing to a sense of organization for the installation. Streetscape visual character is influenced by the width of the corridors, the scale of various streetscape elements, and the level and uniformity of treatment.

The function of a corridor, along with its hierarchical classification, is important in determining the appropriate streetscape treatment. Depending on function, not all corridors of the same hierarchy should receive similar treatment. This especially pertains to the inclusion of elements such as site furnishings, pedestrian lighting, and accent paving. As an example, a secondary corridor in the community commercial zone of an installation may receive a relatively high amount of pedestrian use and be active in both day and nighttime hours. It should receive, therefore, a different treatment in terms of pedestrian-oriented elements than a secondary corridor located in the industrial zone, which may be characterized by relatively low pedestrian use and active primarily in daytime only. Likewise, a primary corridor should receive a different treatment as it traverses an area of open space than it should receive within the administrative core of the installation.

Primary Streets

Primary streets provide access to major activity areas and to secondary streets. They carry the highest volume of traffic and are therefore the most visually prominent and largest streetscape corridors on an installation *(see Figure 9-1)*. Primary streetscape corridors should be designed to:

- provide two to three moving lanes in each direction;
- provide a minimum twelve-foot-wide landscaped median, where space allows;
- provide channelization for left and right turns;
- provide vehicular access only to major facilities or facility groupings to minimize traffic conflicts;
- prohibit on-street parking;
- provide, where walkways are required and appropriate, a minimum eight-foot-wide sidewalk, reflecting the scale and nature of the corridor;
- provide a minimum eight-foot-wide landscaped zone adjacent to the street where it is necessary to buffer walkways and reduce the impacts of traffic on adjoining uses;
- avoid, where possible, the shared use of the road surface for bicycle travel or, where bikeways are

required, provide a minimum 6'-6" wide Class II Bike Lane for one-way travel;
- include elements such as trees, light fixtures, signs, and site furnishings to spatially define the streetscape zone, reinforce the purpose and importance of the corridor, and complement the character and function of surrounding uses; and
- insure that elements such as trees, light fixtures, and signs are appropriate in their scale and placement relative to the size of the corridor and the moderate-to-high speed of travel along the corridor.

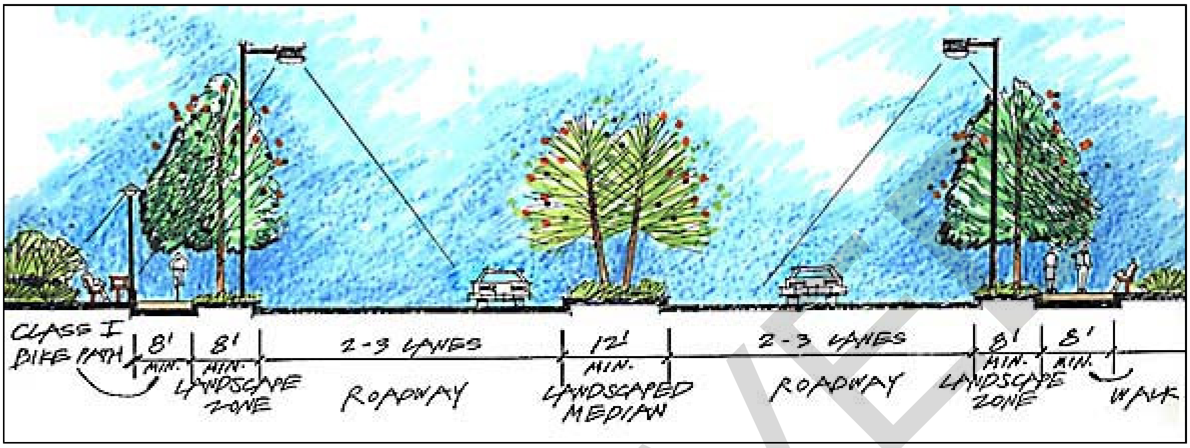

Figure 9-1: Typical Primary Street Section

Secondary Streets

Secondary streets provide access to facilities and connection between primary and tertiary streets. They carry a moderate volume of traffic and are relatively visually prominent streetscape corridors *(see Figure 9-2)*. Secondary streetscape corridors should be designed to:

- provide one to two moving lanes in each direction;
- provide direct vehicular access to adjacent facilities but minimize the number of turning conflicts;
- prohibit on-street parking where possible;
- provide, where walkways are required and appropriate, a minimum six-foot-wide sidewalk, reflecting the scale and nature of the corridor;
- provide a minimum eight-foot-wide landscaped zone adjacent to the street where it is necessary to buffer walkways and reduce the impacts of traffic on adjoining uses;
- provide a minimum 6'-6" wide Class II Bike Lane for one-way travel where bikeways are required;
- include elements such as trees, light fixtures, signs, and site furnishings to spatially define the streetscape zone, reinforce the purpose of the corridor, and complement the character and function of surrounding uses; and
- insure that elements such as trees, light fixtures, and signs are appropriate in scale and placement relative to the size of the corridor and the moderate-to-slow speed of travel along the corridor.

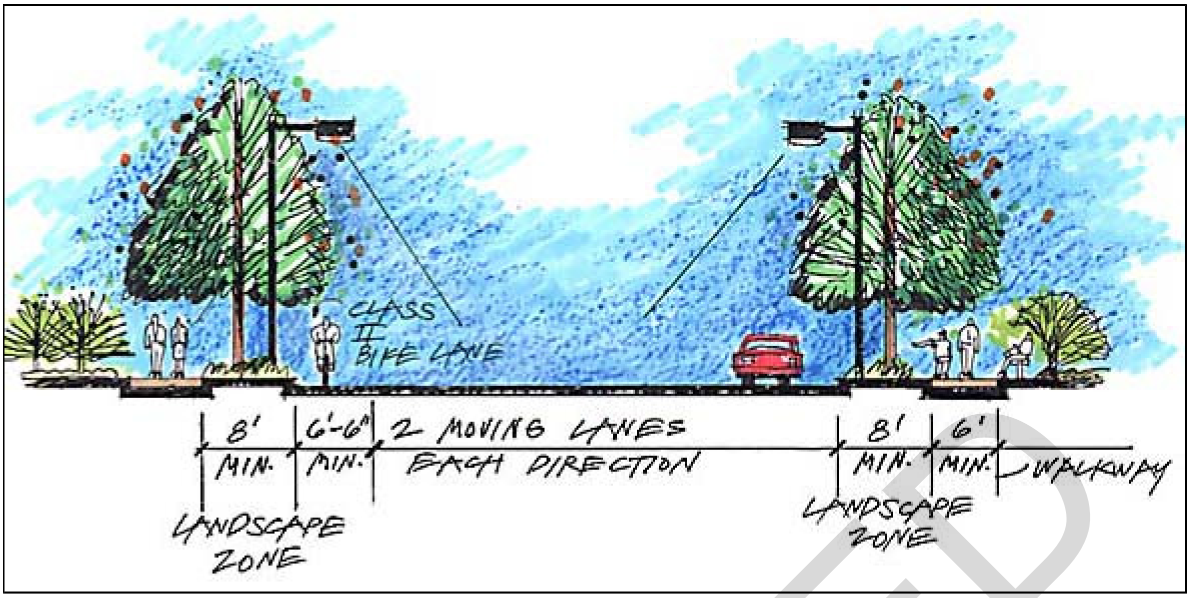

Figure 9-2: Typical Secondary Street Section

Tertiary Streets

Tertiary streets accommodate local traffic and provide direct connection to adjacent uses. They carry a relatively low volume of traffic and are therefore less visually prominent streetscape corridors *(see Figure 9-3)*. Tertiary streetscape corridors should be designed to:

- provide one moving lane in each direction;
- provide direct vehicular access to adjacent facilities;
- allow, where necessary, on-street parking by including a parallel parking lane;
- provide, where walkways are required and appropriate, a minimum four-foot-wide sidewalk, reflecting the scale and nature of the corridor;
- provide a landscaped zone adjacent to the street where possible to buffer walkways and reduce the impacts of traffic on adjoining uses (walkways may be adjacent to the street in residential areas);
- provide, where bikeways are required, a minimum 4'-0" (preferred 6'-6") wide Class III Bike Route for one-way travel;
- include elements such as trees, light fixtures, and site furnishings to spatially define the streetscape zone, reinforce the purpose of the corridor, and complement the character and function of surrounding uses; and
- insure that elements such as trees, light fixtures, and signs are appropriate in scale and placement relative to the smaller size of the corridor and the slower speed of travel along the corridor.

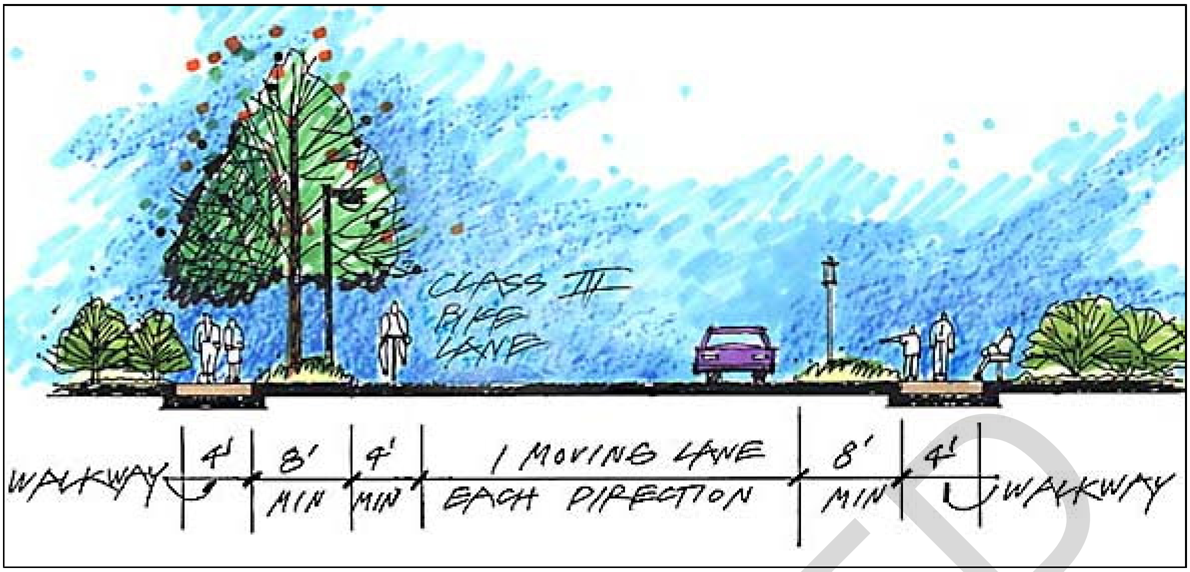

Figure 9-3: Typical Tertiary Street Section

Entrances

Entrances provide the first encounter with the installation and its streetscape for personnel and visitors. Entrances can also project an image of the installation to the outside world. Many issues related to the development of streetscape corridors, such as scale, identity, functionality, and attractiveness, also apply to entrances. Main entrances, as the primary access and initial orientation point for most traffic entering the installation, deserve the highest level of treatment and may need to accommodate pedestrians and bicyclists as well as vehicles. Secondary entrances may handle a comparative low volume and specific type of traffic, and they should be treated accordingly. Based on use patterns, there may be no need to accommodate pedestrians or bicyclists at secondary entrances. Entrances should be designed to:

- provide a queuing area for waiting vehicles, multiple through lanes or a passing lane for vehicles that are not required to stop, and channelization for left and right turns;
- provide a planted center median that is large enough to accommodate a gatehouse and entry landmarks such as flagpoles or monuments;
- provide a parking area that is physically separated from traffic lanes but that maintains a safe pedestrian link to a gatehouse checkpoint;
- include streetscape elements such as trees and light fixtures to accent and spatially define the entrance;
- provide a prominent but simple entry sign and clear, grouped directional signs;
- provide entry walkways and bikeways that are physically separated from vehicle traffic lanes but maintain access to a gatehouse checkpoint;
- place new utilities and relocate existing utilities underground where they cross the entrance;
- use planting material to screen chain link perimeter fences near the entrance; and
- consider the use of walls to further define the entrance, reduce noise, and screen unwanted views.

9.3.2 SAFETY

Because the streetscape corridor is essentially a transportation route for vehicles, bicycles, and pedestrians, safety should be a major consideration in its design. This primarily involves eliminating physical obstructions, maintaining visibility, and providing traffic control devices and barriers. Generally, these actions will also improve the appearance of the streetscape by reducing clutter and coordinating various streetscape elements.

- All signs, light poles, hydrants, fences, and other physical obstructions should be set back a minimum of two feet from the face of the curb. Where there is no curb, this setback should be increased.

- Barriers to sight lines should be avoided. These include both barriers that might prevent drivers from seeing other vehicles or pedestrians and barriers that might block the view pedestrians have of oncoming vehicles. Because eye level will vary between pedestrians, bicyclists, and drivers in different types of vehicles, obstructions at various heights should be considered. For drivers in an automobile, the critical area of view is generally below 4'-6", so while pedestrians and bicyclists may be able to see over a barrier such as a low-growing shrub, a driver's view may be blocked. Conversely, a driver in an automobile may be able to see beneath a low-branching tree, but the view of a pedestrian, bicyclist, or driver in a truck may be obstructed.

- Clear sight lines are especially critical at street intersections, driveways, and pedestrian crossings. At each corner of an intersection, a triangular area whose sides extend back a minimum of 50 feet from the face of the curb should be kept clear of visual obstructions *(see Figure 9-4)*. A similar clear area should be maintained, if possible, at driveways and mid-block pedestrian crossings. Some objects, such as traffic signals, post-mounted signs, or high-branching trees, may still be located within this area and not significantly affect visibility. However, the placement of individual objects must be coordinated with each other so that they collectively do not create a visual obstruction.

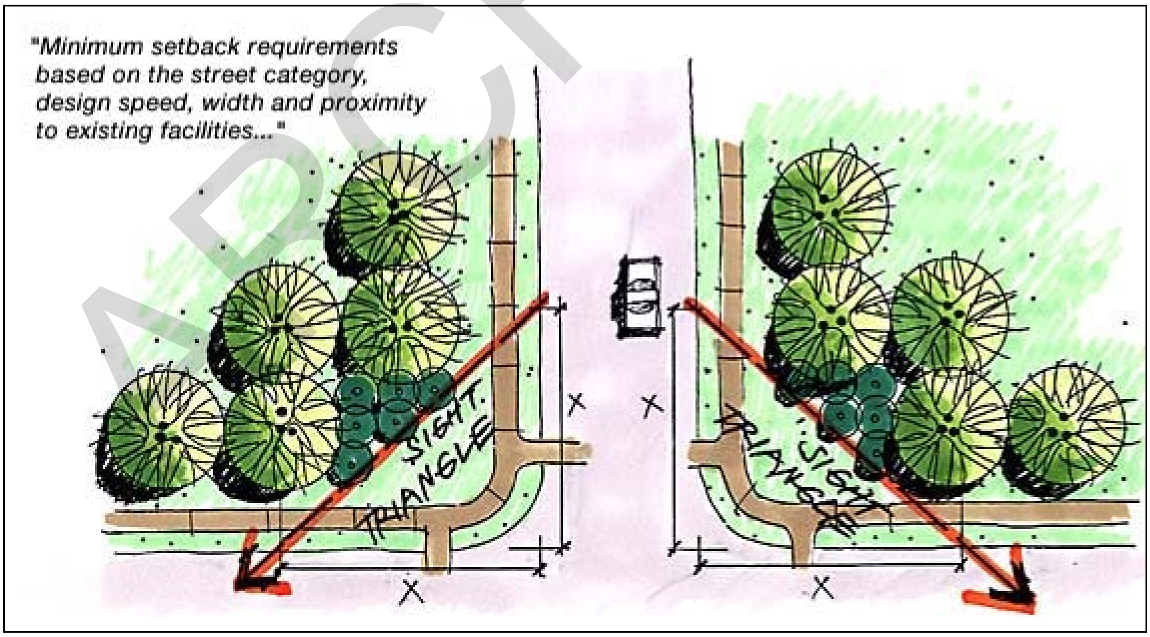

Figure 9-4: Visual Clear Zone at Intersection

- Street lighting levels should allow drivers at nighttime to clearly distinguish the alignment of the road and quickly ascertain signs, traffic control devices, obstacles, pedestrians, and other vehicles. Intersections, pedestrian and bicycle crossings, and other potentially hazardous locations should be illuminated at a higher level than other sections of the street. Glare created by light fixtures should be minimized by the use of appropriate luminaires that direct the light in a manner that will not interfere with the driver's view.

- All street intersections where pedestrian traffic occurs should include crosswalks. Crosswalks should be conveniently located and clearly designated to encourage pedestrians to use safe street crossings. Crosswalks should be marked with clearly visible painted stripes or by a change in the street paving. Mid-block crosswalks between intersections are dangerous and should be avoided. If mid-block crossings cannot be avoided, they should be signalized. At mid-block crossings and major intersections, textured Achatter stripes located in the street are desirable to provide pedestrians with an audible warning of approaching vehicles and to alert drivers of a pedestrian crossing. Curb-cut ramps for wheelchair access should be provided at each crossing, and a textured finish or raised devices should be applied to the ramp to warn of oncoming vehicle traffic.

- All bikeways that share the road surface on primary and secondary streets should be clearly indicated with a continuous stripe on the pavement or separated by a continuous or intermittent curb or other low barrier.

- All intersections should include some form of traffic control device. Intersections where two primary streets cross should be signalized. Intersections of primary and secondary streets or two secondary streets should be signalized where traffic patterns or other conditions, such as poor visibility, warrant. They should otherwise be controlled by signs. Intersections of tertiary streets or a tertiary and secondary street can generally be controlled by signs, but a case-by-case analysis should be conducted to determine if a signal is warranted.

- Regulatory and directional signs should be unobstructed, easily discernible, and properly located so that they can be ascertained by drivers in a timely manner and without undo distraction.

- Medians should be used not only to reinforce the streetscape hierarchy but also to separate opposing traffic, channelize turns to minimize conflicts, and provide a mid-crossing island for pedestrians.

- All walks should be separated from a road by, at a minimum, a raised curb. Planted buffer strips provide an additional barrier for safety and comfort. The placement of bollards or other vertical barriers directly adjacent to the street should be avoided because they represent physical obstructions.

- Site furnishings should be located adjacent to rather than on walkways, such that they do not present a hazard or impede pedestrian traffic.

- Lighting levels should allow pedestrians to clearly distinguish the edge of the walkway, changes in direction, intersecting walkways, and any potential obstacles or hazards. Light fixtures should be located so they do not impede pedestrian traffic. To provide a sense of security, light fixtures should be located to eliminate shadows and to illuminate areas adjacent to the walkway.

- The protection of military forces may be a factor to be considered in developing the streetscape in some locations on an installation. The type, size, and placement of streetscape elements should be established in accordance with the installation force protection plan. Various elements may be appropriately employed as visual screens and/or physical barriers for force protection and still reinforce the function and image of the streetscape. Streetscape elements should be located such that they do not interfere with lines of sight or provide opportunities for concealment in clear zones designated in the force protection plan.

9.3.3 IMAGE

The appearance of the streetscape should contribute positively to the visual image of the installation. To achieve this, individual streetscape elements should be attractive, simple in form and material, and compatible in appearance with the architectural theme of the installation. However, equally significant to the visual image is the successful integration of the individual elements within the total streetscape setting. This involves a coordinated design approach for the streetscape that avoids clutter, reinforces function and hierarchy, and assures consistency in the appearance, use, and placement of elements. This approach entails the close coordination of various design and construction contracts within the streetscape corridors. This will require coordination among different organizations on the installation but will help avoid unnecessary conflicts or duplications of effort and assure successful streetscape development.

Landscape Planting

The use of planting material is one of the simplest and most effective means to achieve a desirable impact on the streetscape setting. Plant material provides many environmental benefits including shade, climate modification, air purification, erosion control, and glare reduction. Plant material can be an effective visual screen and provide a psychological buffer between traffic and adjacent uses. Plants provide color and visual variety and can effectively reinforce or establish scale for pedestrian settings and vehicular settings.

- Trees and other plantings should be of an appropriate scale in relation to the corridor width to help define and reinforce the streetscape hierarchy.

- Trees should be used in repetitive patterns to help establish streetscape continuity and differentiate between various types of streets. Formal rows provide a uniform and orderly appearance, which can strengthen the streetscape image; however, the loss of individual specimens due to disease or accident is often apparent and difficult to remedy. Therefore, formal rows should be used selectively, in areas such as parade grounds and some segments of primary streets. Where possible, such rows should include a second or even third row of planting behind them to help soften the visual impact of the potential loss of an individual specimen.

- Informal planting patterns provide a less orderly image, but groupings that are repeated in their general composition and arrangement can still reinforce and strengthen the streetscape hierarchy. The loss of individual specimens in plant groupings is less disruptive to the overall appearance of the streetscape and is easier to remedy.

- The streetscape planting design should reflect the architectural character and natural environment of the installation. Indigenous material that is well adapted to local climatic conditions and will require only supplemental irrigation should be used where possible.

- Trees should be selected and placed according to the height and spread they will achieve at maturity. This includes such considerations as the damage that may be inflicted to pavements from mature trunks and root systems and the spacing and setbacks required to accommodate mature canopies, which could interfere with signs, lighting, and vehicular traffic.

- Plant material should be used to screen unsightly views such as those of storage yards, substations, or overhead utility lines. Plant material in medians should be used to screen headlight glare from opposing traffic.

- The streetscape planting design should be closely coordinated with existing utilities and plans for future utilities to avoid maintenance and repair problems such as interference with overhead electrical lines and damage to underground water or sewer lines. Coordinating location in relation to utilities can also lessen the potential for damage to the plant material associated with utility construction and maintenance projects.

- Ground cover and shrubs planted in the streetscape corridor should be low maintenance, especially in medians, where access is limited and maintenance operations can be hazardous or difficult. For the security and safety of pedestrians, shrubs should not obstruct views into or out of walkways, especially at street crossings.

- If possible, existing mature plant material should be preserved and integrated into the streetscape. For existing trees not currently located in paved areas, preservation involves protecting as much of the root zone out to the drip line as possible. The ideal strategy to achieve this is to leave the root zone entirely unpaved; however, this may be difficult in an urban streetscape area. If the root zone must be paved over, the existing grades around the tree should be disturbed as little as possible and drain openings should be provided in the pavement to allow air to circulate in the root zone. If the root zone is damaged, the crown of the tree should be pruned to reduce the demand for nutrients and water.

Lighting

Adequate lighting facilitates the use of the streetscape environment at nighttime, increases safety and security, and helps convey a sense of organization. Through their appearance, street light fixtures can reinforce the streetscape hierarchy and lend a sense of organization even in the daytime.

- Lighting should be used to reinforce the hierarchy of the streetscape by helping to visually differentiate between various types of streets. This differentiation should be achieved not only by the level of illumination but by the appearance of the light fixtures themselves. Appearance is influenced by such factors as the type, height, and mass of the fixture and the number of luminaires per fixture.

- The spacing between fixtures and whether fixtures should be placed on one or both sides of a street is a function of the required level of illumination. When fixtures are required on both sides of a street, they should be placed in an opposite rather than staggered arrangement to increase the sense of organization and symmetry in the streetscape.

- To help establish continuity, light fixtures should reflect similar design, materials, and finishes throughout the streetscape and relate in appearance to other site furnishings. Fixtures should be used consistently in each type of application and should be appropriate in scale and character with the particular streetscape setting.

- To eliminate clutter and potential conflicts with trees and other elements, lines supplying power to light fixtures should be placed underground rather than overhead.

- The placement of light fixtures should be coordinated with street tree locations to prevent tree canopies from interfering with the proper distribution or level of lighting.

- Street light fixtures should be located so they do not present an obstacle to pedestrians or a hazard to vehicles that may leave the roadway if a driver loses control. If a pole must be located where it may be an obstacle to a vehicle, a breakaway type pole mounting should be used.

- Directional and regulatory signs should be well lighted with the ambient light from street light fixtures or, where necessary, with direct lighting.

- Walkways in the streetscape corridor should be well lighted with the ambient light from street light fixtures or, where necessary, with additional pedestrian-level lighting fixtures (12 to 15 feet high). Pedestrian-level fixtures will not only provide necessary illumination but also lend a more human scale to the streetscape. The placement of these fixtures must be coordinated with the placement of street lighting fixtures to minimize obstructions and clutter. Street and pedestrian lighting can be successfully mounted on the same pole.

- Bus shelters, telephone booths, kiosks, and other site furnishings should be adequately lighted for nighttime use for both security and function. Where possible, the light source should be incorporated into the structure of the furnishings.

- Landmarks such as monuments or flagpoles that are located within the streetscape corridor should be lighted with floodlights or spotlights. The lamp should be directed away from the viewer, and, if possible, the light fixture should be hidden.

Signs and Signals

The basic purpose of signs on an Air Force installation is to convey regulatory, directional, or identification information. To effectively accomplish this, signs located within the streetscape corridor must be properly designed and sited. In addition to communicating information, signs can also affect the visual image of the streetscape, both in their individual design and in their relationship with other signs and streetscape elements.

- All signs should use a standard and legible letter style and a simple and consistent layout format. Sign messages should be short and simple. Signs that have a similar purpose should be consistent in style, materials, and detail. Signs should also be coordinated in their design, materials, and finishes with other site furnishings.

- Signs should be installed only where necessary to communicate information. Signs that carry a duplicate or conflicting message should be avoided. The number of individual signs should be reduced by combining messages, but no more than five messages should be placed on a single sign. Where appropriate, signs should convey a hierarchy of information by the arrangement and letter size of messages.

- Signs should be placed perpendicular to the direction of travel, and a clear line-of-sight should be available for the entire reading distance (i.e., the distance at which a message must be read in order to inform the viewer prior to a decision point). This distance is related to the rate of speed of the viewer, and as that rate increases, letter size (and therefore, sign size) must also increase.

- Signs with a similar purpose should be placed in the same position relative to streets and walkways. Signs should be placed no closer than two feet to the face of the curb and should not impede pedestrian traffic. Signs should not be placed where they will obstruct a driver's view of pedestrians or other vehicles or a pedestrian's view of traffic.

- Directional signs intended for pedestrians and those intended for vehicles should be kept separate because of different viewing requirements related to size and location. Pedestrian-oriented signs should be scaled appropriately and located to be readily viewed from walkways but so as not to present potentially conflicting or confusing information to motorists.

- Traffic control and regulatory signs should conform to the standards set forth in the U.S. Department of Transportation Manual of Uniform Traffic Control Devices for Streets and Highways.

- Installation entrance signs should be sized appropriately to their function and the rate of speed of approaching vehicles. Entrance signs should be designed to reflect their unique role in the sign hierarchy, but should remain consistent in character with other signs in the streetscape.

- Signs should be installed in sleeves to facilitate repair and replacement, and they should be surrounded by a concrete base to facilitate landscape maintenance.

- Traffic signals should be used at intersections where necessary for traffic control or safety.

- Traffic signals should be consistent in their design and complement light fixtures and site furnishings. To reduce clutter, regulatory and street signs should be integrated with traffic signals.

Site Furnishings

Site furnishings, including such elements as benches, trash receptacles, bus shelters, drinking fountains, kiosks, and phone booths, can improve the function of the streetscape and help unify and enhance its appearance. They also reinforce the streetscape hierarchy by helping define the role of various corridors, and they provide a human scale to a vehicular-oriented environment.

- Streetscape site furnishings should be simple and straightforward in their design and reflect the architectural character of the installation. The same types of furnishings should be consistent in their design and use. Different types of furnishings should be unified in their design by the use of common materials, finishes, and details. Site furnishings should also be coordinated in appearance with other streetscape elements such as light fixtures and signs *(see Figure 9-5)*.

Figure 9-5: Street Furnishings

- Site furnishings should be located based upon a demonstrated or anticipated need for their use. Compared to other corridors located in a similar use area, primary corridors should receive the highest level of treatment in terms of the number and variety of furnishings. This is consistent with their role as the most prominent segments of the streetscape. However, depending on surrounding uses, not all primary corridors warrant an equal level of treatment. For example, a primary corridor in an open area of the installation should contain fewer furnishings than a primary corridor in the community core. Similarly, a secondary corridor located in an administrative area might contain more furnishings than a primary corridor in an industrial zone.

- Site furnishings should be placed adjacent to walkways, out of the flow of traffic. Furnishings should be clustered to avoid clutter, consolidate the space required, and group complementary functions.

- Seating areas should be located along the walkway edge farthest from the street and should be enhanced with planting. Unsightly views should be screened and desirable views should be emphasized. Bus benches and shelters should be set back a minimum of four feet from the face of the curb.

- All furnishings, including seating areas, tables, drinking fountains, and phone booths, should be selected and sited to accommodate physically challenged individuals.

- Furnishings should be made of durable and low maintenance materials such as metal and concrete. A hard paving surface should surround each furnishing for ease of access and maintenance.

- Flagpoles, fountains, and monuments should be used selectively so as not to dilute their individual impact and sited in prominent locations to maximize their visibility.

Paving

Along with plant material, paving composes the ground plane of the streetscape. Differences in paving can help reinforce the hierarchy of the streetscape, accent special areas, or define areas of potential conflict.

- All streets should be paved with asphalt or concrete. All streets in developed areas of an installation should have similar and continuous curbs and gutters to define the street edge and carry runoff. In rural areas, swales or ditches can be employed.

- In general, paving should be consistent throughout the streetscape to establish continuity. Varied paving treatments, such as colored or textured concrete, should be reserved to accent special areas such as primary intersections or the walkways in front of major facilities.

- Paving treatments should be used to differentiate between vehicular and pedestrian traffic areas, including special coloring and texturing to highlight potential areas of conflict such as crosswalks and driveways *(see Figure 9-6)*.

Figure 9-6: Crosswalk/Street Paving

- Paving should be installed as required in medians to provide a mid-crossing island for pedestrians.

- All repairs and patches to pavements, curbs, and gutters should be carefully matched to the existing paving material.

Utilities

Utilities perform the necessary functions of supplying water, power, and telephone service and removing storm water and wastewater. However, they are generally not visually compatible with the streetscape environment, and they are often in physical conflict with various streetscape elements, resulting in operations and maintenance problems. With proper coordination and placement, many of these conflicts can be eliminated or reduced.

- The placement of all streetscape elements should be closely coordinated to avoid existing underground and overhead utility lines and future utility corridors located within the streetscape. These elements include plant materials, paving, site furnishings, signs, and light fixtures that may complicate access for utility maintenance and installation projects and/or result in damage to the utilities or the streetscape elements themselves.

- Installations should develop and adopt a consolidated utility program that designates planning corridors for utility lines. By consolidating lines within corridors reserved for that purpose, potential conflicts between utilities and other uses can be minimized. These corridors should indicate the location of both existing lines that are appropriately located and all future lines. Existing lines that are located outside these corridors should be relocated, if possible, in association with new construction or renovation projects. The designation of corridors in advance will facilitate the planning and design of the streetscape to minimize potential direct and indirect impacts to both utilities and streetscape elements.

- To reduce negative visual impacts, utility lines should be located underground, especially at intersections, where they are most apparent. Existing overhead utilities should be buried in association with new construction or renovation projects.

- When utilities located in the streetscape cannot be placed underground, their visual impact should be reduced by using non-reflective materials on lines and poles, screening views with plants or other elements, and providing a backdrop to lines to eliminate their silhouette against the sky.

- Aboveground structures such as substations, control boxes, and pipe risers should be located in visually unobtrusive areas or should be screened with plant materials, fences, or walls.

- Fire hydrants should be placed in clearly visible locations, and sufficient access should be maintained on all sides.

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9.4 REFERENCES

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10.1 INTRODUCTION

As in most urban areas, the use of the automobile as the primary means of transportation has become prevalent on Air Force installations to travel between the home, workplace, and community and commercial areas. Alternative circulation systems, including walkways for pedestrians and bikeways for bicyclists, can help reduce problems related to automobile travel, including traffic congestion, the consumption of resources, air pollution, parking area requirements, and potential safety conflicts. Adequate pedestrian and bicycle networks can provide convenient, efficient, and esthetically pleasing pathways and create opportunities for healthful activity.

10.1.1 PURPOSE

The purpose of this chapter is to provide guidance related to the development of walkway and bikeway networks on Air Force installations. This includes guidance for preparation of walkway and bikeway network plans as well as guidelines for size, layout, materials, and other aspects of the design of walkways and bikeways. The guidelines are intended to help establish a clear, continuous, uniform, and safe circulation network that will encourage people to walk and ride bicycles.

10.1.2 GOALS & OBJECTIVES

The goal for walkway and bikeway networks is to encourage walking and bicycling to:

- reduce vehicular traffic congestion and automobile parking needs;
- reduce air pollution;
- conserve resources; and
- increase physical fitness.

The objectives for walkway and bikeway networks that support achievement of this goal are to:

- provide accessible and continuous pathways;
- provide accessibility to all users, including physically impaired or challenged persons;
- reduce safety conflicts between pedestrians, bicyclists, and automobiles;
- provide amenities for the pedestrian and bicyclist; and
- provide design consistency throughout the pedestrian and bicycle networks.

10.2 WALKWAY AND BIKEWAY PLANNING PROCESS

Although walkways and bikeways are distinct elements that often require physical separation, the planning process for walkway and bikeway networks is essentially the same. In order to create successful walkway and bikeway networks, this process should be logical and comprehensive and should include an *existing conditions survey*, an *origin-destination study*, an *adequacy analysis*, and the development of a *network plan*.

- An *existing conditions survey* should include written and mapped information on existing walkways and bikeways. This information should include the location, width, material type, and physical condition of existing walkways and bikeways. The existing conditions survey should encompass both formally designated pathways as well as informal paths that have been worn into the landscape by continual use, indicative of actual pedestrian and bicyclist patterns. This survey provides the physical data upon which an adequacy analysis will be based.

- An *origin-destination study* should identify major generators of pedestrian and bicycle traffic, such as residential areas, major work places, commercial centers, and recreation areas. The average and peak volume of traffic on pathways and the distance between primary destinations should also be identified. This study provides information about current and potential pedestrian and bicyclist demand in terms of the volume and location of activity.

- An *adequacy analysis* should evaluate the capability of the existing walkway and bikeway network to accommodate current and potential demand. It should identify deficiencies in terms of the extent, location, and condition of pathways. Nonconformance with design standards and actual or potential safety conflicts with automobiles and between pedestrians and bicyclists should be noted. This analysis forms the foundation upon which the network plan will be developed.

- A *walkway* or *bikeway network plan* should be prepared to indicate all proposed improvements to the existing network. The plan should provide for a continuous network that is hierarchical in nature, based upon the traffic volume and the purpose of each segment. The design indicated for each segment should reflect its role within the network. The plan should indicate the location of all new segments in the network and all existing segments to be repaired, upgraded, replaced, or removed.

Narrative, tabular, and graphical information describing existing conditions, origin-destination identification, the adequacy analysis, and the walkway and bikeway network plans should be compiled and displayed within the installation's existing report and mapping framework and in accordance with applicable Air Force standards. Narrative information should be included in the Installation Landscape Development Plan in the Capital Improvements Program Component of the Comprehensive Plan. Graphical information regarding existing conditions should be compiled as a level or layer on Existing Landscape Development Maps. Graphical information locating proposed improvements should be compiled as a level or layer on Future Landscape Development Plans. Non-graphical information that can be compiled in a tabular form should be attached, if possible, to the corresponding graphical map element.

10.3 WALKWAY GUIDELINES

Many factors must be considered in planning a walkway system on an Air Force installation. While these factors are distinct, they must be integrated to develop a successful pedestrian network. The following guidelines address these factors, including the hierarchy and location of walkways; walkway materials and finishes; street crossings, steps, and ramps; and furnishings.

10.3.1 WALKWAY NETWORK HIERARCHY

Based upon projected levels and types of use, a hierarchical pedestrian circulation system should be planned that organizes walkways into a logical network according to each segments function and reinforces the function through the width, treatment, amenities, and location of each segment.

Primary Walkways

Primary walkways are those segments that link major generators of pedestrian activity and carry the highest volume of pedestrian traffic *(see Figure 10-1)*. Primary walkways should:

- be at least eight feet wide to comfortably accommodate two-way traffic;
- have hard surface paving to accommodate a high level of use of all types;
- be well lighted for nighttime activity; and
- be furnished at a relatively higher level with amenities such as benches and trash receptacles.

Figure 10-1: Primary Walkway Adjacent to Primary Roadway

Secondary Walkways

Secondary walkways are those segments that link secondary generators of pedestrian activity and carry moderate volumes of pedestrian traffic *(see Figure 10-2)*. The majority of walkways on an installation should fall into this category. Secondary walkways should:

- be at least six feet wide to comfortably accommodate two people walking abreast and allow passing room;
- have hard surface paving to accommodate a moderate level of use of all types;
- be well lighted along those segments that receive nighttime activity; and
- be furnished at a moderate level with amenities.

Figure 10-2: Secondary Walkway Adjacent to Secondary Roadway

Tertiary Walkways

Tertiary walkways are those segments that provide physical and visual continuity within the pedestrian network but carry a low volume of traffic *(see Figure 10-3)*. They are also used as recreational paths such as jogging trails or fitness courses. Tertiary walkways should:

- be at least four feet wide to comfortably accommodate one-way traffic;
- have hard or soft surface paving, depending on the volume and type of use;
- have lower-level or no lighting; and
- be furnished at a relatively lower level with amenities.

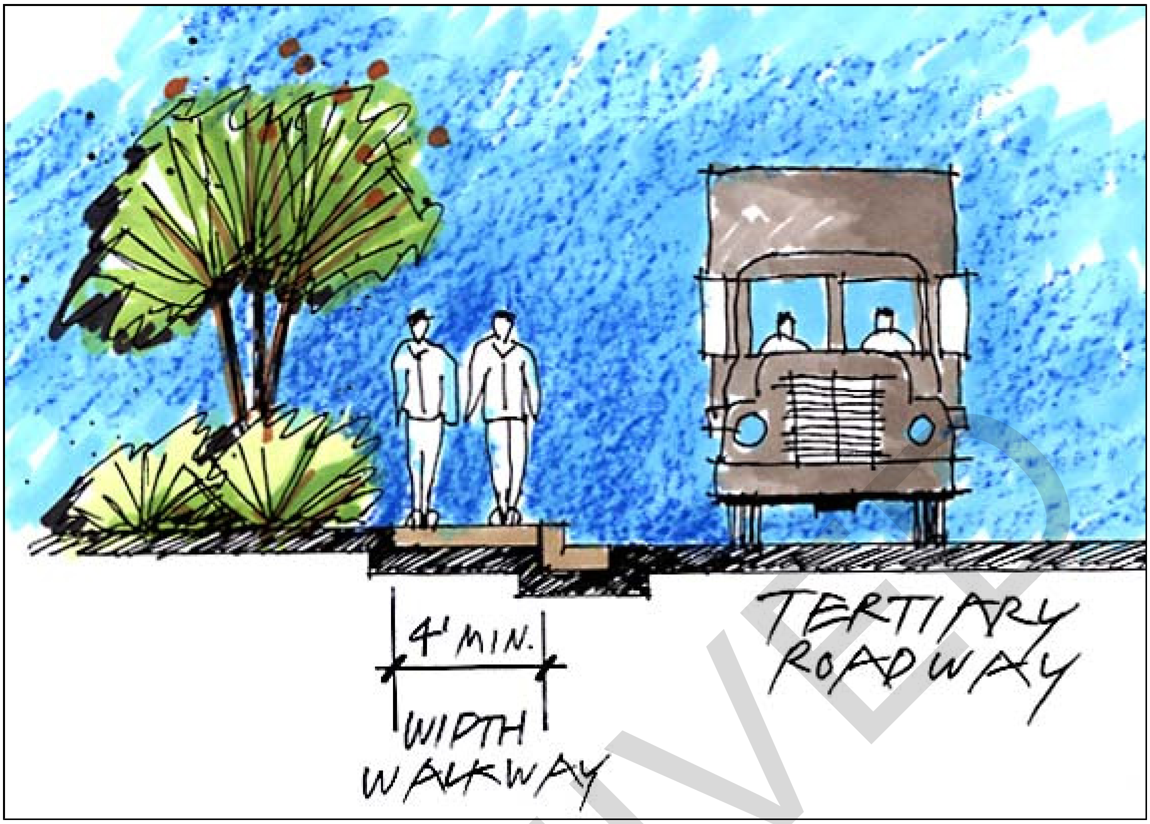

Figure 10-3: Tertiary Walkway Adjacent to Tertiary Roadway

Troop Movement Walkways

Troop movement walkways are required at installations that must accommodate troops marching in formation. These walkways should be appropriately located to provide paths between dormitories, classrooms, dining facilities, parade grounds, and any other location where troops must march. Troop movement walkways should:

- be at least ten feet wide to accommodate troops marching four abreast;
- have a hard surface; and
- require no street furnishings unless they also serve as general purpose walkways.

10.3.2 WALKWAY LOCATION

In general, walkways should be located in response to the levels and patterns of user demand and provide direct routes between destinations. However, walkways may not always provide direct linkage between destinations, but may instead provide physical and visual continuity where the pedestrian network may otherwise be discontinuous.

Walkways Adjacent to Streets

Walkways adjacent to streets may be acceptable and even desirable, based on development and circulation patterns. Depending on the volume of vehicular and pedestrian traffic, some degree of separation between the walkway and the street may be necessary.

- Walkways parallel to primary and secondary roadways should be separated from the road by a minimum eight-foot-wide planted buffer strip.

- Walkways parallel to tertiary roadways should also, if possible, be separated from the road by a planted buffer strip but may be located adjacent to the curb in residential or other low traffic areas.

- Planted buffer strips less than six feet wide should be avoided because they are too narrow for street tree planting and pose maintenance problems.

- All walks should be separated from a road by, at a minimum, a raised curb.

- If possible, new walkways should be laid out to accommodate existing mature street trees. Preservation of trees involves protecting as much of the root zone out to the drip line as possible. The ideal strategy to achieve this is to leave the root zone entirely unpaved; however, this may be difficult in an urban area. If the root zone must be paved over, the existing grades around the tree should be disturbed as little as possible and drain openings should be provided in the pavement to allow air to circulate in the root zone. If the root zone is damaged, the crown of the tree should be pruned to reduce the demand for nutrients and water.

- At driveways, a triangular area whose sides extend back a minimum of 50 feet from the face of the curb should, if possible, be kept clear of visual obstructions. Some objects, such as traffic signals, post-mounted signs, or high-branching trees, may still be located within this area and not significantly affect visibility. However, the placement of individual objects must be coordinated with each other so that they collectively do not create a visual obstruction.

Walkways Interior to Sites

Walkways located in the interior of sites minimize many of the potential health and safety problems associated with walkways located adjacent to streets and can provide for efficient and accessible pedestrian circulation.

- When sited in the interior of a development parcel with buildings on both sides, a single walkway should be utilized to provide access.

- Walkways located in open space areas can provide less direct access and should meander in response to the terrain and other site features.

- To provide for pedestrian security, walkways that are located away from active areas like streets should avoid places for concealment and should be adequately lighted if they may be used at night.

Walkways Adjacent to Buildings

All facilities should be clearly connected to the pedestrian network to encourage walking.

- Walkways should be widened at building entrances to visually reinforce the entry and accommodate pedestrian traffic in and out of the building.

- Narrow, hard-to-maintain planting strips between walkways and buildings should be avoided. Along the edge of walkways opposite buildings, planting areas can be used to help soften the appearance of buildings.

- Arcades should be incorporated into building designs in major activity areas as an element of the pedestrian network. Arcaded walks can provide direct connections between buildings and provide protection from the sun or inclement weather to allow year-round use of the pedestrian system.

- Walkways should be provided along the building side of all parking lots and within large lots to provide clear and safe access to buildings.

Utilities

The placement of walkways should be closely coordinated to avoid, as much as possible, existing utility lines and future utility corridors. Walkways may complicate access for utility maintenance and installation projects, which could also result in damage to the walkways themselves. Installations should develop and adopt a consolidated utility program that designates planning corridors for utility lines. These corridors should indicate the location of both existing lines that are appropriately located and all future lines. Existing lines that are located outside these corridors should be relocated, if possible, in association with new construction or renovation projects. The designation of corridors in advance will facilitate the planning and construction of walkways to minimize potential direct and indirect impacts to both utilities and walkways.

10.3.3 PAVING MATERIALS

The function and location of a walkway will dictate the most appropriate type of paving material. In general, harder materials, such as concrete or asphalt, are more expensive to install than soft materials, such as decomposed granite. However, they are also more stable, easier and less expensive to maintain, and suitable for a larger group of users, including the physically challenged. A consistent treatment for similar types of walkways in terms of their material and finish is important in visually defining the function of each walkway segment and the continuity of the walkway network.

Hard Paving Surfaces

Hard materials should be used for walkways in areas that receive a high level of pedestrian use of all types, including walking, wheelchairs, and strollers.

- Hard materials that can provide a firm, regular, and even surface, such as concrete, should be used in high-traffic areas. The surface should have a non-skid finish to prevent slipping, and expansion joints should be kept narrow and filled to the level of the surrounding walkway.

- Hard materials such as cobble, flagstone, or exposed aggregate concrete with large-sized stones should be avoided because their irregular and rough surface is difficult to negotiate for wheelchairs, strollers, and even some pedestrians. These materials may be appropriate in limited applications such as in historic zones. Exposed aggregate concrete with small-sized stones provides an even surface and is an appropriate hard paving for accent or where texture is desired to provide warning or traction.

- Concrete is the most widely used material for walkways. It is easily installed and versatile in appearance. It is also relatively inexpensive, especially when its durability and ease of maintenance are considered.

- Bricks or other paving material set in mortar can also be used in high-traffic areas. However, the additional expense in material and labor may limit use of these surfaces to accent areas, such as the entries to buildings.

- Interlocking concrete pavers set on sand can provide a relatively smooth and regular surface and can add visual interest to walkways. The additional expense in material and labor may also limit use of pavers to accent areas such as major walkways or the entries to buildings. To control weed growth in pavers, a geotextile weed barrier, some of which are impregnated with herbicide nodules, can be placed beneath the sand layer. In addition, herbicides may be mixed with the sand to reduce weed growth above the barrier.

- Asphalt is an inexpensive and flexible hard surface that can be used in high-traffic areas, but it can soften under the hot sun and may not be appropriate for all areas or applications.

- Wood used as a paving material should be avoided because of its irregular surface, wide joints, and greater long-term maintenance requirements.

Soft Paving Surfaces

Soft paving materials should be reserved only for walkways that receive a low level of pedestrian use. Properly installed, some soft materials can provide a relatively firm, regular, and even surface.

- Soft paving materials are consistent in appearance with informal and open space settings. Materials that can be leveled and firmly compacted should be used for recreational paths such as jogging trails and exercise courses. Soft paving includes decomposed granite, oyster shell, soil cement, and other regionally indigenous materials.

- Materials that cannot be firmly compacted, such as gravel or bark, are more difficult to walk on and require more maintenance, and their use should be minimized.

- Soft paving materials should be properly stabilized with a hard edge such as a wood header, concrete curb, or metal edging to minimize erosion and reduce maintenance.

10.3.4 CROSSWALKS

Crosswalks should be conveniently located and clearly designated to encourage pedestrians to use safe street crossings. All street intersections where there is pedestrian traffic should include crosswalks.

- Crosswalks should be marked with clearly visible painted stripes or by a change in the street paving consistent with the walkway paving material.

- Crosswalks should be the width of the walkway but a minimum of six feet wide.

- Mid-block crosswalks between intersections are dangerous and should be avoided except in those cases where intersection crossings are few or very inconvenient. If possible, mid-block crossings should be signalized.

- Curb-cut ramps for wheelchair access should be provided at each crossing. A textured finish or raised devices should be applied to the ramp to warn of impending vehicle traffic.

- Adequate street lighting should be installed at each crosswalk to provide for clear nighttime visibility for both pedestrians and drivers.

- Adequate sight lines should be maintained to give both pedestrians and drivers an unobstructed view at crosswalks. At each corner of an intersection, a triangular area whose sides extend back a minimum of 50 feet from the face of the curb should be kept clear of visual obstructions *(see Figure 10-4)*. A similar clear area should be maintained, if possible, at mid-block pedestrian crossings. Some objects, such as traffic signals, post-mounted signs, or high-branching trees, may still be located within this area and not significantly affect visibility. However, the placement of individual objects must be coordinated with each other so that they collectively do not create a visual obstruction.

- Where a walkway and bikeway intersect, pavement markings should be provided to warn both pedestrians and bicyclists.

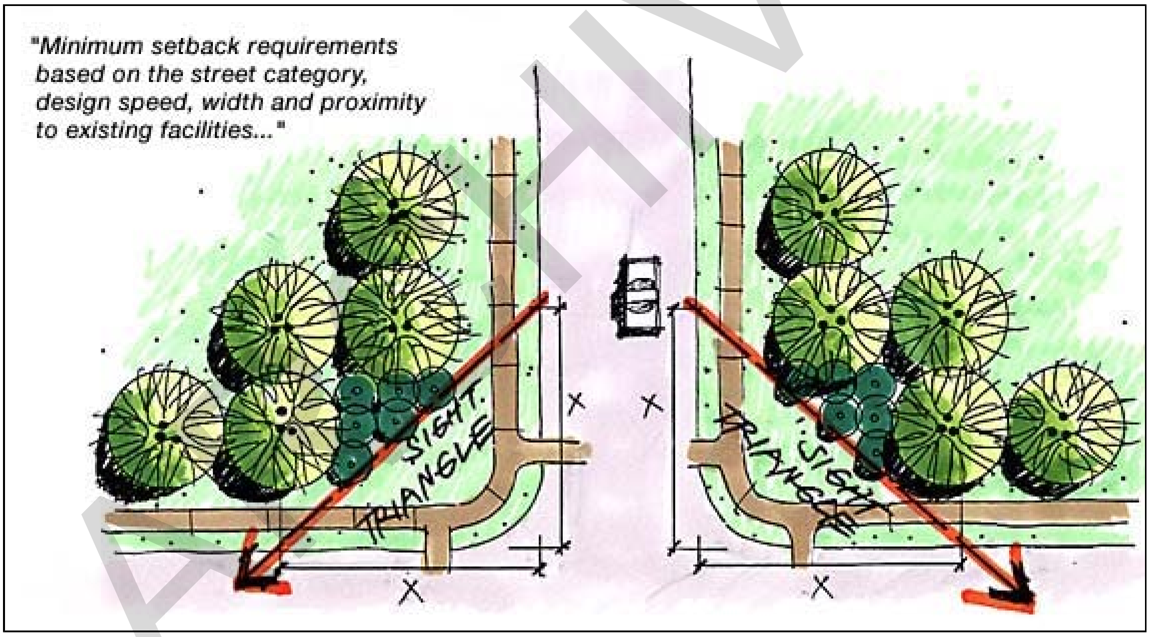

Figure 10-4: Visual Clear Zone at Intersection

10.3.5 STEPS AND RAMPS

The use of steps and ramps should be minimized along walkways because they are more difficult to negotiate or, for some users, impassable. Gradients of 3 percent or less are preferred along walkways, and any walkway that exceeds a 4.2 percent gradient should be designated as a ramp.

Steps

Where significant grade changes along a walkway cannot be avoided, steps may be required for the convenience of the pedestrian and to maintain continuity in the walkway network.

- Steps should be equal in width to the walkway but no less than four feet wide.
- Steps with less than three risers should be avoided because they are difficult to see and can present a hazard.
- All steps in a single stairway should maintain the same tread width and riser height. Riser height should be between five and seven inches, and tread width should be between 12 and 16 inches. A general formula for riser-to-tread proportion is twice the riser height plus the tread width equals 26 inches. A 5-3/4" riser with a 14-1/2" tread is preferred.
- Whether precast or cast-in-place, steps should have solid risers with rounded or chamfered nosing.
- All steps should be adequately lighted to ensure safe nighttime use.
- All steps with three or more risers should have handrails on both sides that extend beyond the treads at both the top and bottom of the stairway.
- A stairway greater than four feet in height or consisting of more than nine risers should be broken by a landing.

Ramps

To provide wheelchair access, ramps should be used to accommodate significant changes in grade. Ramps will generally be necessary adjacent to or near any stairway to provide a similar level of convenience and walkway continuity for physically challenged persons. To achieve the same vertical climb, ramps require significantly more horizontal distance than stairs, so careful planning that minimizes grade changes along a walkway and that integrates ramps into the site development plan is recommended.

- Ramps should not exceed an 8 percent gradient; a 6 percent gradient is desirable.
- A five-foot-long landing should be provided for at least every 2'-6" of vertical climb. A six-foot-long level platform should be provided at the top and bottom of a ramp.
- Ramps should be no less than four feet wide.
- All ramps should be adequately lighted to ensure safe nighttime use.
- All ramps should have handrails on both sides that extend beyond the top and bottom of the ramp.

10.3.6 FURNISHINGS

Site furnishings, including benches, trash receptacles, drinking fountains, telephone booths, bus shelters, and kiosks or information signs, should be part of a coordinated system that provides pedestrian amenities within the walkway network. Site furnishings should be selected and sited to support the function of a walkway.

- Where possible, furnishings should be grouped together rather than scattered to consolidate the space required and to provide complementary functions. A greater number and type of furnishings should be located in higher-use pedestrian traffic areas than in lower-use areas.

- Furnishings should be located adjacent to rather than on walkways, in a manner that does not impede pedestrian traffic.

- Provisions to accommodate the physically challenged should be incorporated into the design and siting of furnishings. This includes a provision for space adjacent to walkways for wheelchair and/or stroller parking.

- Site furnishings should be simple and straightforward in their design and reflect the architectural character of the installation. The same types of furnishings should be consistent in their design and use. Different types of furnishings should be unified in their design by the use of common materials, finishes, and details.

10.4 BIKEWAY GUIDELINES

Bikeways pose unique planning and design challenges because the bicycle is not compatible with either automobiles or pedestrians, the automobile being a hazard to the bicyclist and the bicycle presenting dangers to the pedestrian. The following guidelines address the various factors for bikeway planning, including levels of separation from roadways and walkways, widths and clearances, paving materials, gradients and curvature, stopping distances and street crossings, and bicycle parking.

10.4.1 BIKEWAY CLASSIFICATION

Bikeways should be planned and designed according to classifications that define the level of separation they maintain from roadways and walkways. The ideal solution for the development of bikeways is to physically separate them from both roadways and walkways. With proper planning, this can sometimes be accomplished, but cost considerations and a lack of adequate space can often make such separation impractical.

Class I Bike Path

A Class I Bike Path is intended for the exclusive use of bicycles. While it may parallel a roadway, it is physically separated by distance or a vertical barrier *(see Figure 10-5)*.

- A Class I Bike Path provides the safest and most efficient means of bicycle travel and is the preferred option for bikeway development.
- Crossings of a Class I Bike Path by pedestrians or automobiles should be minimized.
- If a Class I Bike Path does not closely parallel a roadway, it should be designed to provide appropriate bikeway gradient and curvature.
- Class I Bike Paths require the greatest amount of space and advanced planning to reserve land and assure appropriate routing.

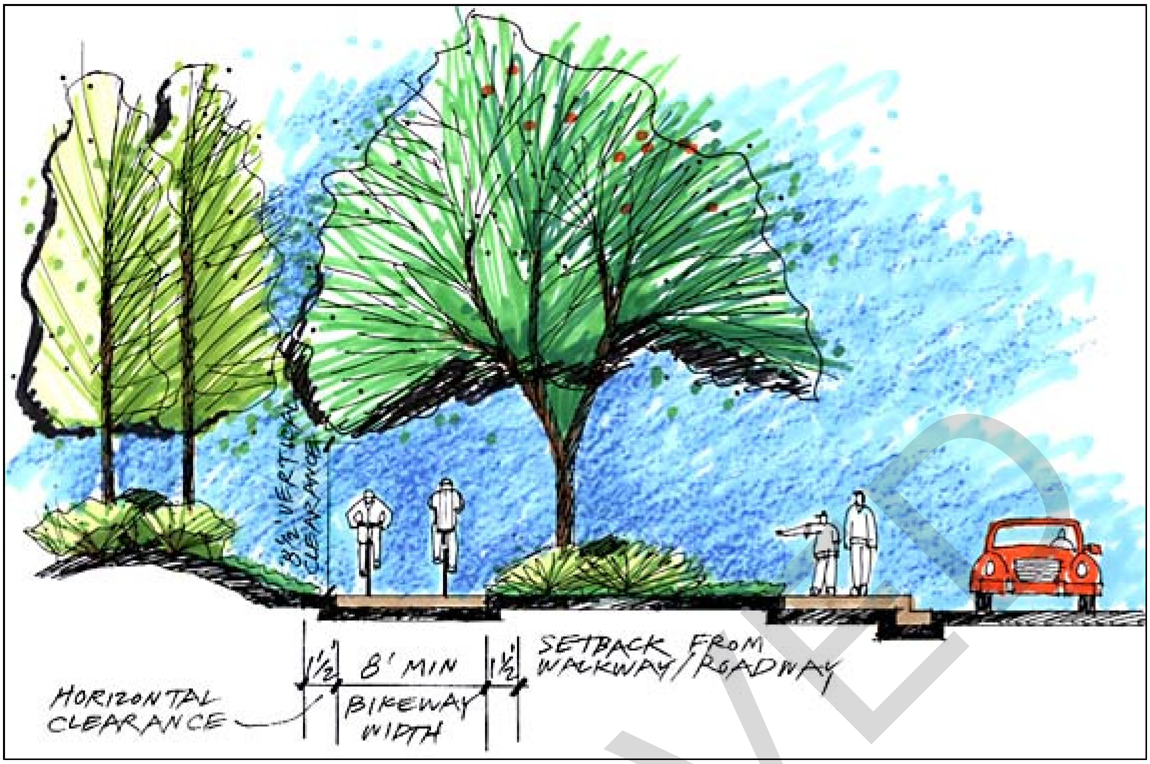

Figure 10-5: Two-way Class I Bike Path

Class II Bike Lane

A Class II Bike Lane shares the right-of-way with a roadway or walkway. It is indicated by a bikeway pictograph on the pavement and a continuous stripe on the pavement or separated by a continuous or intermittent curb or other low barrier *(see Figure 10-6)*.

- Because some separation is provided for bicycle travel, a Class II Bike Lane provides some level of safety for the bicyclist and pedestrian.
- While crossings by pedestrians or automobiles are discouraged, they are not as controllable as they are on a Class I Bike Path because the Class II Bike Lane is adjacent to the walkway or roadway.
- Because Class II Bike Lanes are tied to the adjacent roadway or walkway, route selection is important to maintain appropriate bikeway gradients and curvature.
- Class II Bike Lanes generally require less space than Class I Bike Paths because they follow the alignment of and share the right-of-way with a roadway or walkway.

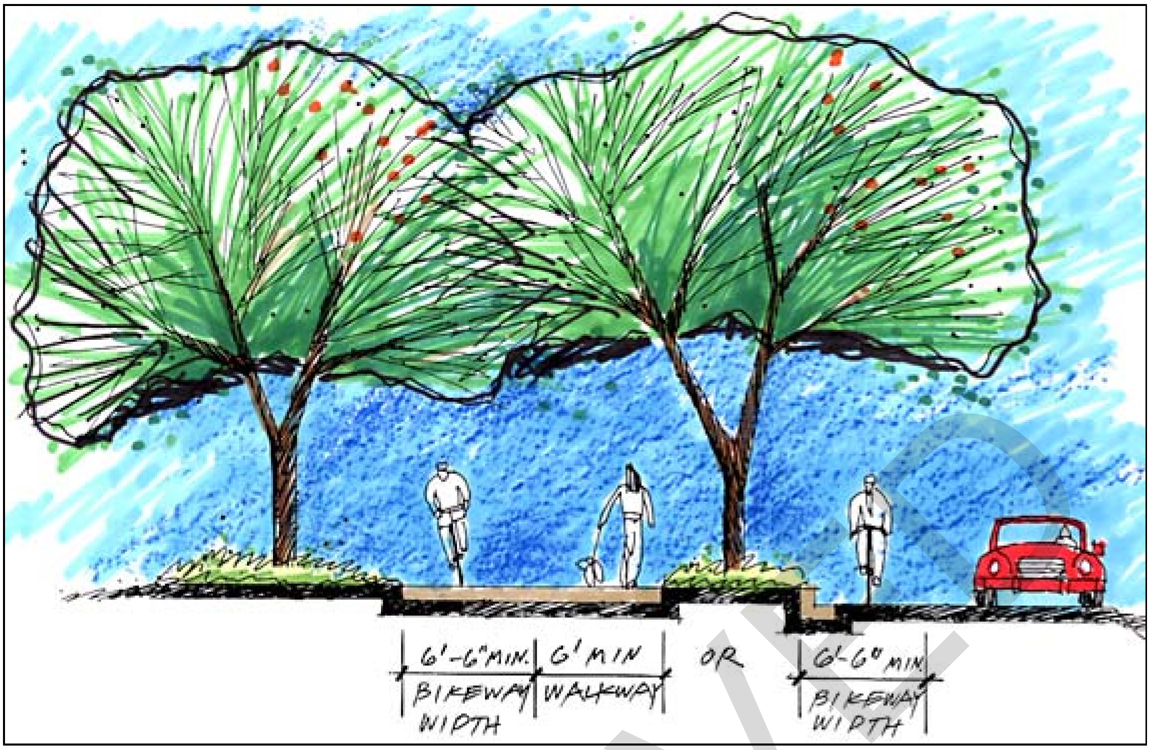

Figure 10-6: One-way Class II Bike Lane

Class III Bike Route

A Class III Bike Route also shares the right-of-way with a roadway or walkway. It is not indicated by a continuous stripe on the pavement or separated by any type of barrier, but it is identified as a bikeway with signs *(see Figure 10-7)*.

- Because no separation is provided, there is a higher potential for safety conflicts between automobiles and bicycles and between bicycles and pedestrians.
- Class III Bike Routes provide continuity within the bikeway network and designate preferred shared routes to minimize potential conflicts. To maintain safety for bicyclists and pedestrians, Class III Bike Routes should be developed, if possible, only where automobile and pedestrian traffic is moderate to light.
- Because Class III Bike Routes share the roadway or walkway, route selection is important to maintain appropriate bikeway gradients and curvature.
- Class III Bike Routes require the least space because they share the pavement with a roadway or walkway.

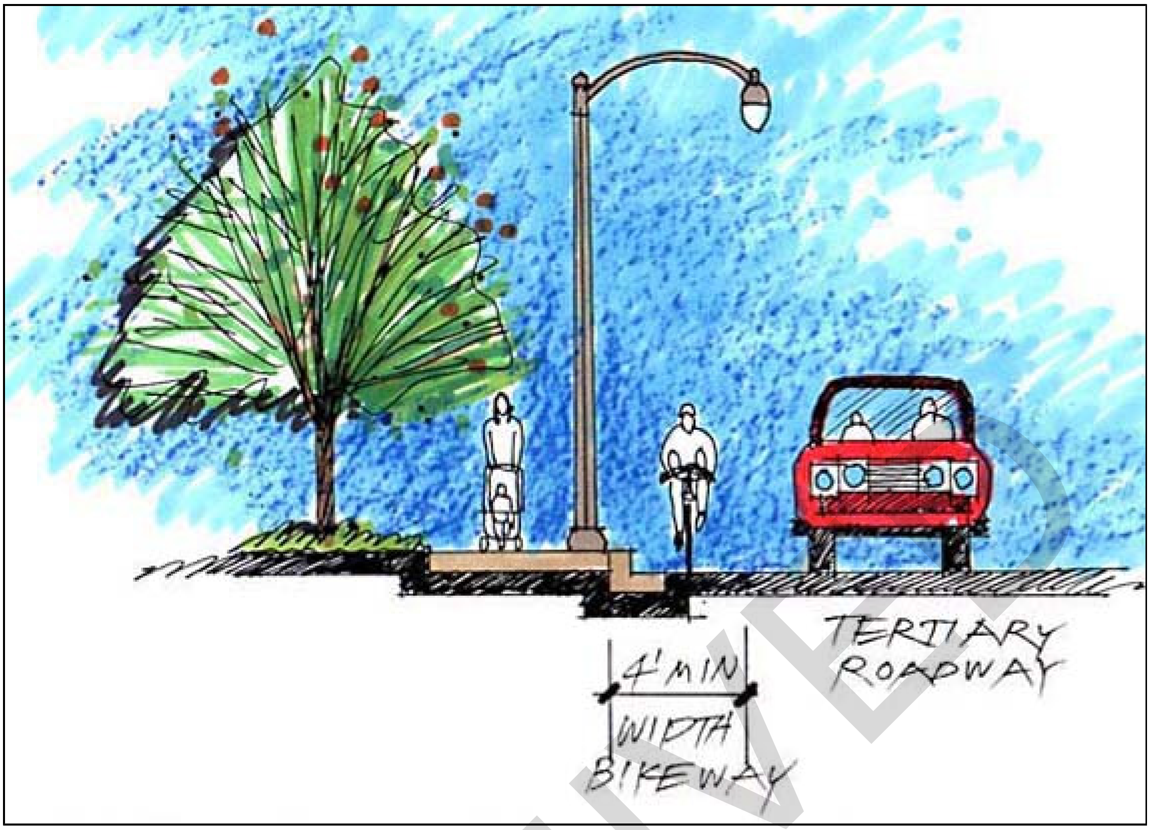

Figure 10-7: One-way Class III Bike Route

10.4.2 PAVEMENT WIDTHS AND CLEARANCES

The approximate width of a bicycle is two feet, but additional pavement width and horizontal and vertical clearances must be provided to accommodate a moving bicycle.

Pavement Widths

The basic minimum width for one lane of travel is four feet. This should be adjusted based upon the bikeway classification and traffic conditions.

- A minimum of eight feet of pavement should be provided for a two-way Class I Bike Path. This width will also allow access by maintenance vehicles on Class I Bike Paths that are isolated from roadways.
- A minimum of 6'-6" of pavement should be provided for a one-way Class I Bike Path or Class II Bike Lane. This width will allow one-way travel with room for passing.
- Two-way bikeways are not recommended adjacent to roadways because of the complications that would result at intersections. Instead, opposing one-way lanes should be located on opposite sides of the street.
- A minimum of four feet of pavement should be provided for a one-way Class III Bike Route.

Since a Class III Bike Route is not separated from the adjacent roadway or walkway, a passing bicycle can use the walkway or roadway pavement. If bicycle, pedestrian, and/or automobile traffic makes passing in this manner difficult or unsafe, a pavement width of 6'-6" should be provided for a one-way Class III Bike Route.

Bikeway Clearances

Because a bicycle and rider are considerably wider than that part of the bicycle that makes contact with the road and a bicyclist is taller than an individual on foot, horizontal and vertical clearances should be provided along the bikeway *(see Figure 10-6)*.

- A minimum horizontal clearance of 1'-6" (2'-0" desirable) should be provided from the edge of the bikeway pavement to any stationary object, change in grade, or soft shoulder.

- A minimum of 8'-6" of vertical clearance should be provided from the bikeway surface to any stationary overhead object.

Utilities

The placement of bikeways should be closely coordinated to avoid, as much as possible, existing utility lines and future utility corridors. Bikeways may complicate access for utility maintenance and installation projects, which could also result in damage to the bikeways themselves. The designation of consolidated utility corridors on the installation will facilitate the planning and construction of bikeways to minimize potential direct and indirect impacts to both utilities and bikeways.

10.4.3 PAVING MATERIALS

Hard paving materials are the most appropriate for bike travel and can be traveled on even in wet weather. While the cost of installing hard materials is higher than that for soft materials, they are more durable and easier and less expensive to maintain.

- The most appropriate materials for bikeways are concrete and asphalt. The pavement for Class I Bike Paths that are isolated from roadways should be capable of supporting a maintenance vehicle. The pavement normally used for a roadway or a hard walkway surface is generally acceptable for an adjacent Class II Bike Lane or Class III Bike Route.

- The surface of the bikeway pavement should have a smooth but not slick finish, which can be dangerous to bicyclists during wet conditions. Hard materials such as exposed aggregate concrete or masonry units should be avoided because their irregular and rough surface is difficult and uncomfortable to negotiate.

- The bikeway shoulder should be compacted and leveled to the elevation of the pavement surface to lessen the hazard in running off the edge of the bikeway and to help reduce breakage of the pavement along the edge.

- Expansion and control joints in the bikeway pavement should run perpendicular to the direction of travel and be as narrow as possible.

- If possible, drainage inlets should not be located along the bikeway. If inlets along the bikeway cannot be avoided, as in an existing street right-of-way, grates should be turned so that the openings run perpendicular to the direction of travel or modified to provide support for passing bicycles.

10.4.4 GRADIENTS AND CURVATURE

Because bicycles are vehicles, albeit human-propelled, bikeway design factors such as gradient and curvature are more critical considerations for user comfort and safety than they are in walkway design. For Class II Bike Lanes and Class III Bike Routes, the gradient and/or curvature of an existing walkway or roadway may exceed those that are desirable for a bikeway, and this should influence route selection.

Bikeway Gradients

Gradients between 3 percent and 5 percent will place some strain on a bicyclist, but the desirable gradient for a particular bikeway is related to the length of the grade.

- A 15 percent grade is the maximum for short runs, and 10 percent is the recommended maximum for distances of no greater than 50 feet. A maximum grade of 4.5 percent is recommended for distances of no greater than 100 feet. For longer distances, grades not exceeding 3 percent are desirable.

- On straightaway portions of a bikeway, cross slopes that exceed 2 percent will be uncomfortable for the average bicyclist.

Bikeway Curvature

The radius of curvature for turns on a bikeway is measured to the inside edge of the pavement. The turning radius that is required is directly related to the speed of travel. The greater the design speed of the bikeway, the larger the required turning radius *(see Figure 10-8)*.

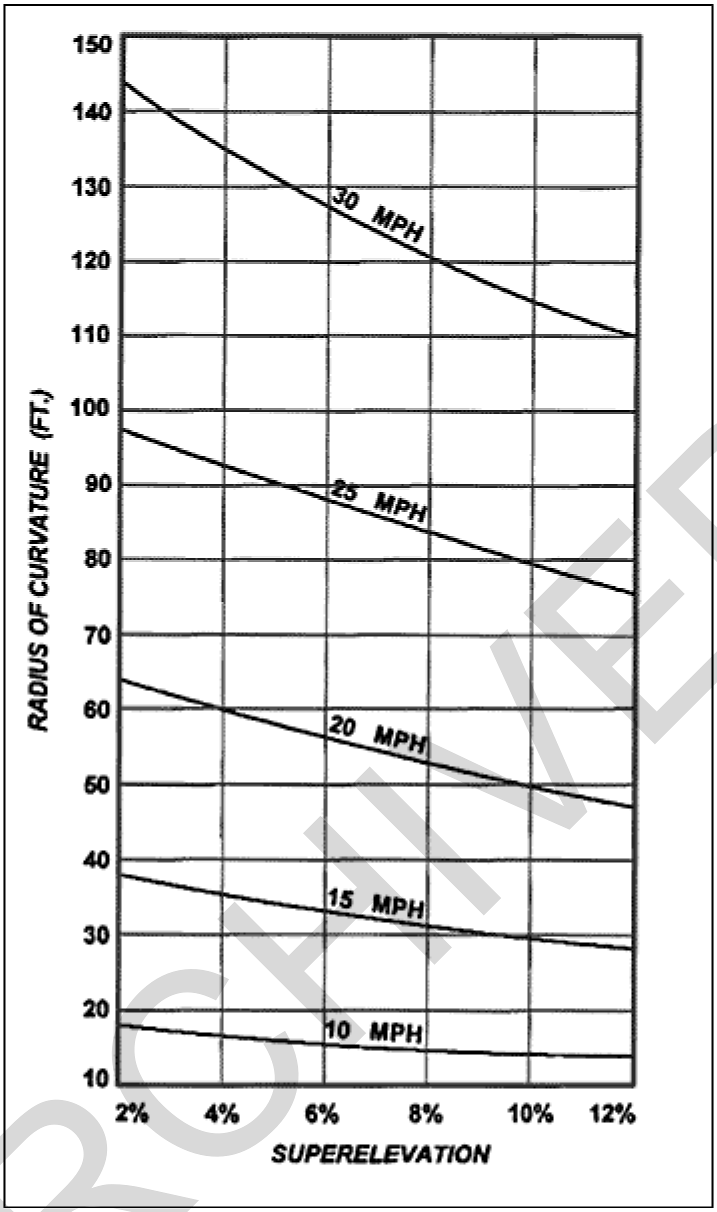

Figure 10-8: Radius of Curvature and Superelevation Based on Design Speed

- At 10 m.p.h., an 18-foot turning radius is preferred and a 15-foot turning radius is a comfortable minimum.

- For various bikeway classifications or conditions, the design speed may considerably exceed 10 m.p.h., and turning radii must be adjusted accordingly.

- As the turning radius decreases, the bank (or superelevation) of the bikeway should increase to safely accommodate the design speed. If the bikeway shares the right-of-way with a walkway, banks should be limited to a 6 percent slope for the comfort of pedestrians.

- On tight turns, it may be necessary to widen the pavement along the inside edge to accommodate the turning movement of bicyclists.

10.4.5 STOPPING DISTANCES AND STREET CROSSINGS

Potential conflicts caused by such elements as intersections or obstructions should be minimized through the layout and design of the bikeway and adjacent areas.

Stopping Distances

Stopping distance is the distance required for a bicycle rider to see an object or situation, react, and brake to a stop. It is determined by a combination of factors, including the initial velocity of the bicycle, the reaction time of the rider, and the gradient and material of the bikeway *(see Figure 10-9)*.

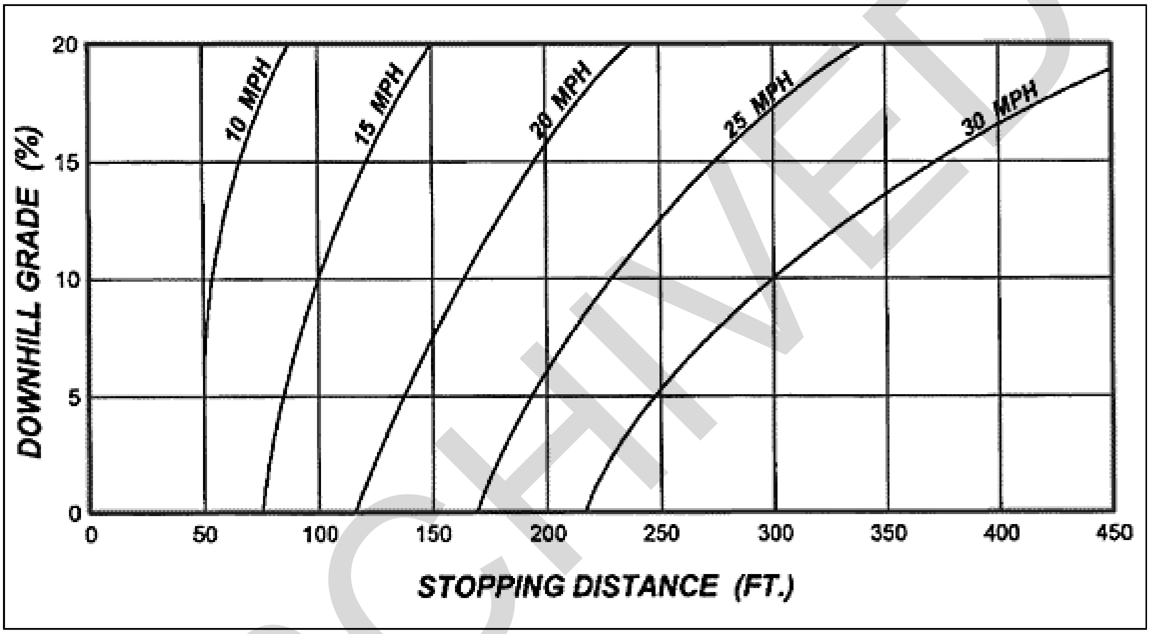

Figure 10-9: Sight Distance Based on Speed and Gradient

- Adequate stopping distances should be maintained along bikeways at all locations of possible conflict. This includes maintaining clear site lines for bicyclists at intersections with roadways and walkways and avoiding vertical curves that could block a rider's view too close to intersections, turns, or potential obstructions.
- The area around horizontal curves should also be kept clear to the extent necessary to maintain required sight lines to potential hazards.
- Where sight lines are less than desirable, signs warning bicyclists of an approaching conflict should be installed.

Street Crossings

Most bicycle-automobile accidents occur at intersections. Unless all bicycle street crossings are grade separated, conflicts will continue to exist but can be minimized.

- Crossings should be marked with clearly visible painted stripes or by a change in the street paving consistent with the bikeway paving material.

- If the bikeway is not located on the roadway, curb-cut ramps should be provided at each crossing. A textured finish should be applied to the ramp to act as a warning of impending vehicle traffic.

- Where possible, bicycle crossings should be located slightly away from road intersections so that they do not interfere with the turning movement of vehicles. Such a location will allow a turning automobile to stop for crossing bicycles but still clear the intersection. Such a crossing would apply only to a bikeway not located on the roadway.

- If the bikeway shares the right-of-way with a roadway, automobiles may be allowed to enter the bikeway at an intersection approach to begin a turning movement. In such cases, the bikeway markings should not continue through the intersection and should be a broken stripe at the approach to the intersection to indicate to both the bicyclist and the driver that an automobile may enter the bikeway. If an intersecting roadway is minor, then the bikeway markings may cross it and continue through the intersection.

10.4.6 BICYCLE PARKING

The provision of an adequate number of properly located and secure bicycle parking facilities is a significant element in the development of a viable bikeway network. When compared to automobile parking, these facilities are inexpensive and can generally be placed relatively close to destination points.

- Parking facilities equal to the demand should be located near all bikeway network destination points, preferably within 50 feet of main entrances. An adequate number of bicycle parking spaces is especially important near enlisted personnel living quarters.

- Covered bicycle parking areas should be provided in climates where protection from the elements is necessary. If possible, covered parking should always be provided at enlisted personnel living quarters.

- Parking facilities should be located such that bicycles do not impede pedestrian traffic but are in an area that can be visually supervised.

- Bicycle racks should be spaced two feet on center to facilitate use. Racks should be such that a wheel and the frame can both be anchored to prevent theft.

- Racks should be carefully integrated into the overall site design to prevent clutter. Many racks, such as precast units set flush with the pavement, are unobtrusive, especially when not in use.

- To help support the use of the bicycle network, showers and lockers should be considered in facilities that are primary destination points.

10.5 RESOURCES

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USAF LANDSCAPE DESIGN GUIDE

11 PLANTING DESIGN

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11.1 INTRODUCTION

The traditional and most visible task of the landscape architect is planting design. In the minds of the general public, the layout and selection of plant material is the primary role of the landscape architect. Right or wrong, this perception underscores the importance of proper planting design.

The inherent nature of planting design dictates a view toward the future. Plants are dynamic elements, constantly changing, growing, and maturing. Planting design errors can damage facilities and may create maintenance requirements for twenty to fifty years or more.

This document provides basic guidance and direction to improve the planting design process to produce attractive, affordable, and sustainable installation landscapes.

11.1.1 DEFINITION

Planting design is the orderly and logical process of selecting and arranging various types of vegetation on a project site. Good planting design provides an aesthetically pleasing, functional, and maintainable landscape. The proper selection and location of landscape plant materials enliven, complement, and unify existing and proposed site features.

11.1.2 GOAL

The goal of the Planting Design Guide is to facilitate the creation of efficient, attractive, and functional installation landscapes. This will be accomplished by fostering an increased awareness and understanding of the numerous issues facing the designer.

11.1.3 OBJECTIVE

The objective of the Planting Design Guide is to provide a framework for the successful delineation and implementation of logical planting plans. This will be accomplished by providing insight into an appropriate design process and incorporating basic, time proven design principles.

11.1.4 GUIDE ORGANIZATION

Design

Provides insight into the basic issues that must be addressed and integrated into the early phases of the planting design process to develop functional and attractive installation landscapes

Outlines and defines the basic steps to facilitate the creation of quality landscape development solutions

Plants

Identifies and defines the standard planting design elements and how they may be used to satisfy the aesthetic and functional requirements of the designer

Conclusion

Lists planting design situations to emulate or avoid

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11.2 DESIGN

11.2.1 INTRODUCTION

Plants perform many diverse roles. Plants provide human scale, define space, conserve energy, direct circulation, mask unsightly elements, cleanse the air, and provide habitat and food for wildlife. Their inherent natural aesthetic value significantly contributes to the visual quality and image of the installation.

Aesthetic and functional landscapes that fulfill the needs and requirements of the facility and its users should be the primary goal of the designer. A well-defined method or process will greatly increase the possibility of creating sustainable planting designs that satisfy this goal. This chapter will address the following factors of planting design:

- **11.2.2 DESIGN CONSIDERATIONS**
- **11.2.3 DESIGN PROCESS**

11.2.2 Design Considerations

Planting design considers many issues. This section provides a detailed insight into some of the more significant ones including:

- **Sustainability**
- **Landscape character**
- **Maintenance**
- **Energy conservation**
- **Wildlife habitat**
- **Soils**
- **Erosion control**
- **Grading and drainage**

Sustainability

Sustainability is the tendency to endure, support, or to bear up under prolonged stress. In planting design, the idea of sustainability is economically beneficial because it considers project cost from cradle to grave. A sustainable planting design may initially even cost more to install, but it can ultimately result in a more viable and attractive landscape. Some of the other benefits:

- Requires less maintenance
- Maximizes installation operational efficiency
- Contributes to the overall visual quality of the installation
- Increases the quality of life on the installation

- Increases erosion control

Landscape character

Each installation is a unique environmental entity. It has its own historical and architectural character, seasonal climatic variations, native vegetation, soil types, and topography. These regional elements create design opportunities and constraints that influence and contribute to the regional landscape character.

By synthesizing these opportunities and constraints into a workable planting design philosophy, the designer can define the style of landscape development. A cohesive landscape style can give the installation a recognizable visual identity through the organization and unification of landscape design solutions.

Compatibility

The installation should promote a simple, low maintenance planting style. To ensure consistency in planting design solutions, all designers, design agents, and tenants must comply with the installation Landscape Development Plan requirements.

The Base Civil Engineer office has the oversight responsibility through project programming and design review to ensure each planting design is compatible with the installation landscape character. Other actions that can guarantee consistent planting design:

- Coordinate Landscape Development Plan standards with the project Requirements and Management Plan (RAMP)
- Regularly perform timely and thorough review of design documents to ensure plant material is cceptable and overall planting design style is compatible with the installation landscape character

Maintenance

While planting designs should focus on function and beauty, maintenance requirements should be a primary consideration during the design process. Landscape maintenance becomes the key issue considering dwindling budgets and personnel.

Since poor planting design generally increases maintenance requirements, the designer must be extremely careful when selecting and locating plant material. Some of the more common mistakes:

- Inadequate site analysis
- Overplanting
- Oversized plant material at maturity
- Improper exposure and sunlight
- No separation between planting beds and turf areas
- Insufficient or improper soil preparation and treatment for unwanted weeds and vegetation

Further information can be found in the Landscape Maintenance Guidelines supplement.

Energy Conservation

Conservation of resources should be a primary consideration for any project. A well-planned landscape design can contribute significantly to the overall energy efficiency of installation facilities. In many cases, the energy conservation attributes of a planting plan can be the sole justification for the landscape development.

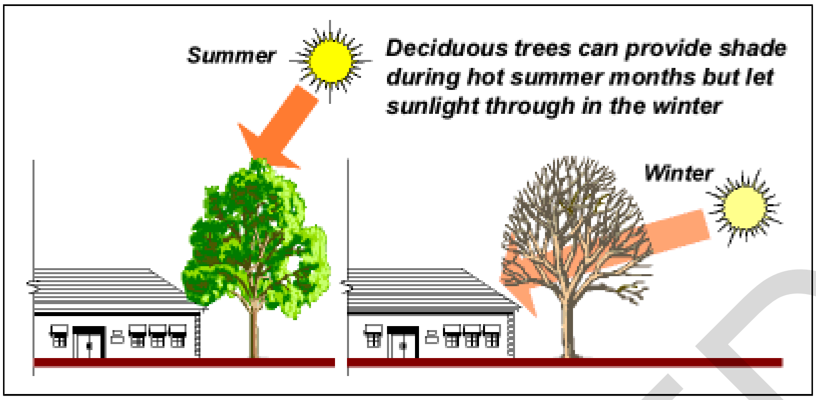

Figure 11-1: Solar Reduction and Gain

Many simple planting design techniques can improve the energy efficiency of a facility including:

- Reducing radiant solar heat gain by shading south and west facing walls and windows
- Directing or blocking wind by planting dense evergreen plant material
- Increasing relative humidity through properly locating and sizing of turf and groundcover areas

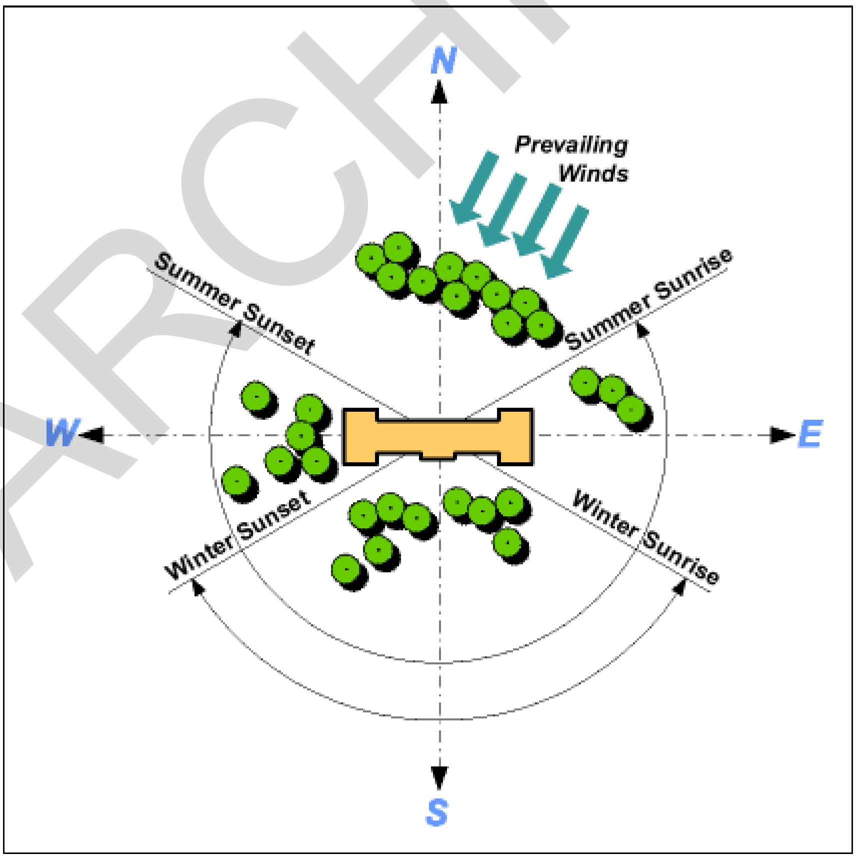

Figure 11-2: Wind and Solar Radiation Protection

Wildlife habitat

Plants that produce food such as acorns, nuts, seeds, buds, fruit, nectar, berries, and pollen sustain wildlife populations on the installation. Take care to avoid creating potentially detrimental situations such as excessive fruit near parking areas or entries and attracting nuisance insects.

Native plant materials support significantly more species of wildlife than do introduced or exotic species. Consult your local county extension agent or the National Wildlife Federation for a list of plants that best suits the installation climate and wildlife population.

Existing and natural wildlife habitat is an extremely valuable installation resource. Each project site plan and planting design should focus on minimizing the potentially harmful impacts to this resource. Methods to accomplish this goal include:

- Increased sensitivity to the ecology of the site
- Subtle integration of structures with the natural and cultural environments
- Include landscape elements to reinforce existing natural site environment

Soils

Native soils may be remarkably similar or widely varied as to organic matter content, permeability, percolation rate, erosion potential, pH, and their ability to support specific plant material. The installation usually will have a large amount of data on the native soils and their characteristics from soil boring data, specific laboratory analysis, or recently compiled soils maps.

The designer should consider the plant growing capabilities of the soils for each project. Many plants can thrive in a wide variety of conditions whereas others have specific requirements. Usually there will be a desirable plant of the right mature size and form that is compatible with the existing soil limitations while satisfying the intent of the design.

Erosion control

The designer should strive to limit potentially damaging erosion problems throughout the life of a project. Take special care to mitigating soil erosion during the construction phase of a project. Good design and construction practices prevent downstream water quality and drainage structure degradation and loss of valuable top soil.

Grading and drainage

Another critical element closely associated with soils and erosion is grading and drainage. The designer must consider the effects of heavy rainfall, drainage patterns, downspouts or roof drains, and potential ponding areas in the final planting design solution. Also, many projects are required to include retention or detention facilities to impound or delay storm water runoff, potentially creating special planting design situations.

Plants and inert material can be chosen and located to make drainage and grading elements more attractive and functional. In drier climates, grading and drainage should direct rainfall runoff to landscape areas to minimize irrigation requirements. What may be considered a constraint to the designer can be transformed into an opportunity when considered early in the planting design process.

11.2.3 DESIGN PROCESS

The planting design process closely parallels all successful problem solving methods and consists of three basic steps:

- **Analysis**
- **Concept**
- **Implementation**

At this point of the project design process, the site plan has been finished including major site elements such as parking areas, screen walls, and sidewalks and the following tasks have been completed:

- Determine existing vegetation to be saved
- Determine major grading requirements
- Locate both proposed and existing utilities

Analysis

Almost every planting design project will include the requirement for public, private, and service areas. These functional areas are determined by examining the project site from the user's point of view. The designer can outline the approximate boundaries of these areas on the site plan. Identifying the functional areas will greatly assist in plant material location and selection later in the planting design process.

Public

These are areas of the project the general public, employees, facility customers, or installation visitors will see or use in normal daily activities. The public zone may require special planting treatment to highlight the facility entry, establish a positive first impression, or generally portray a polished visual image.

Private

Areas used by the people who live or work in the facility are classified as private. This area may require screening, fencing, pedestrian access limitations, and special site amenities for seating, shade, or cover.

Depending on the type of the facility and its function, private zone areas can vary from a small patio or courtyard to be used as an employee break area to an enclosed backyard in Military Family Housing. Again, user and facility requirements dictate the size and location of the private zones and required amenities.

Service

Nearly every facility has mechanical rooms, utility areas, or entrances that require special access for maintenance or delivery of supplies. These service areas create separate planting design opportunities. These areas are generally screened from public view and kept free of obstructions because of the associated activity that occurs there.

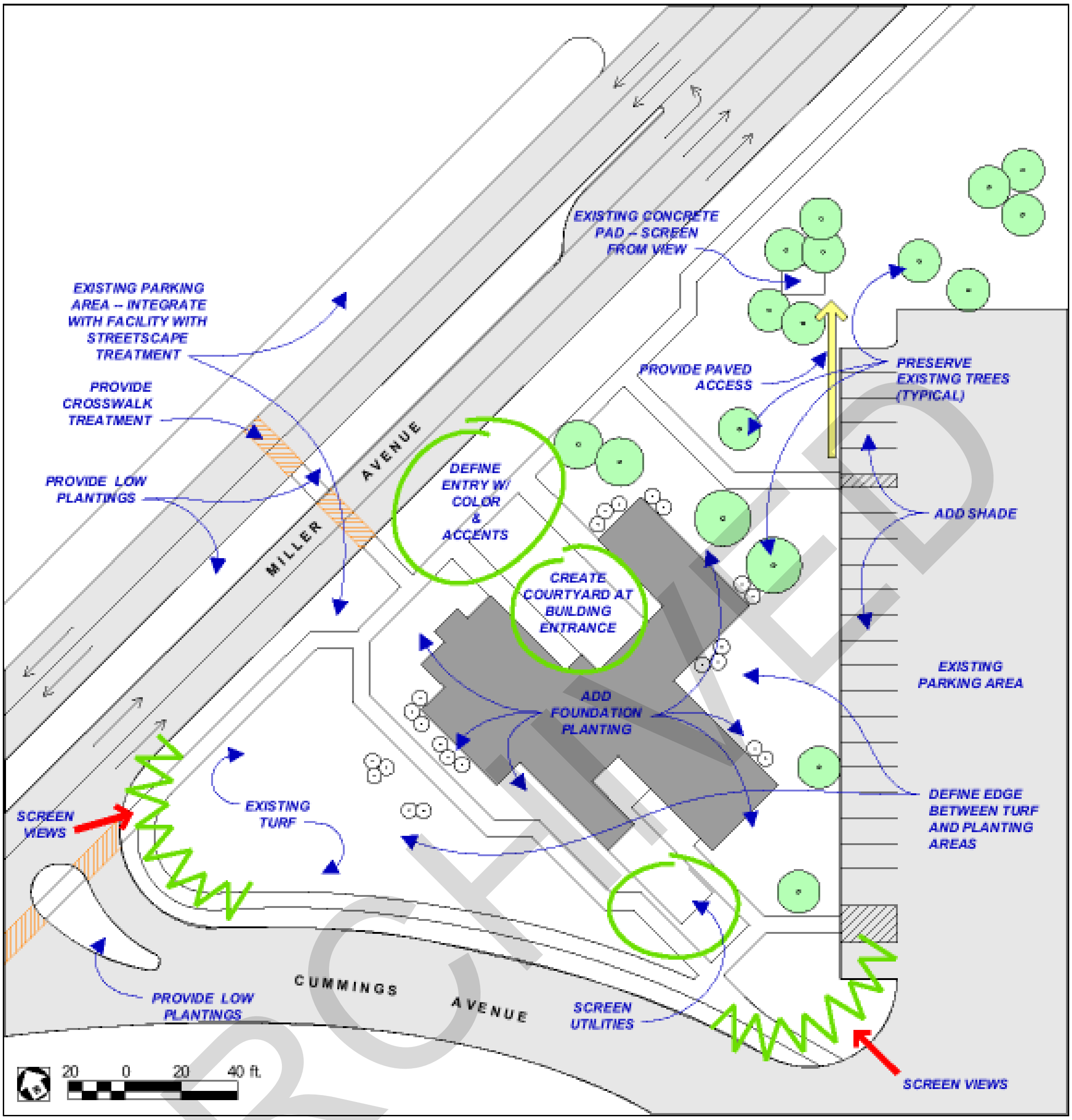

Figure 11-3: Planting Design Analysis

Concept

At this stage of the planting design process, the designer can begin to make spatial and functional decisions. Rather than making specific plant choices, the designer should think in terms of general plant size and character. Following are a few examples of the approach to concept design:

- Providing shade for a break area may be satisfied by a group of medium deciduous trees
- Solving a screening need can be accomplished by a mass planting of medium to large shrubs depending on the size of the element to be screened
- The recreational needs of a dormitory complex can be accommodated by providing an open and well-defined turf area
- Small flowering trees and a unique accent shrub can serve to enhance and highlight an entry
- Large, upright evergreens planted in mass can buffer entries and walkways form cold winter winds

- Small to medium, hardy shrubs can be massed to direct pedestrian traffic and control movement

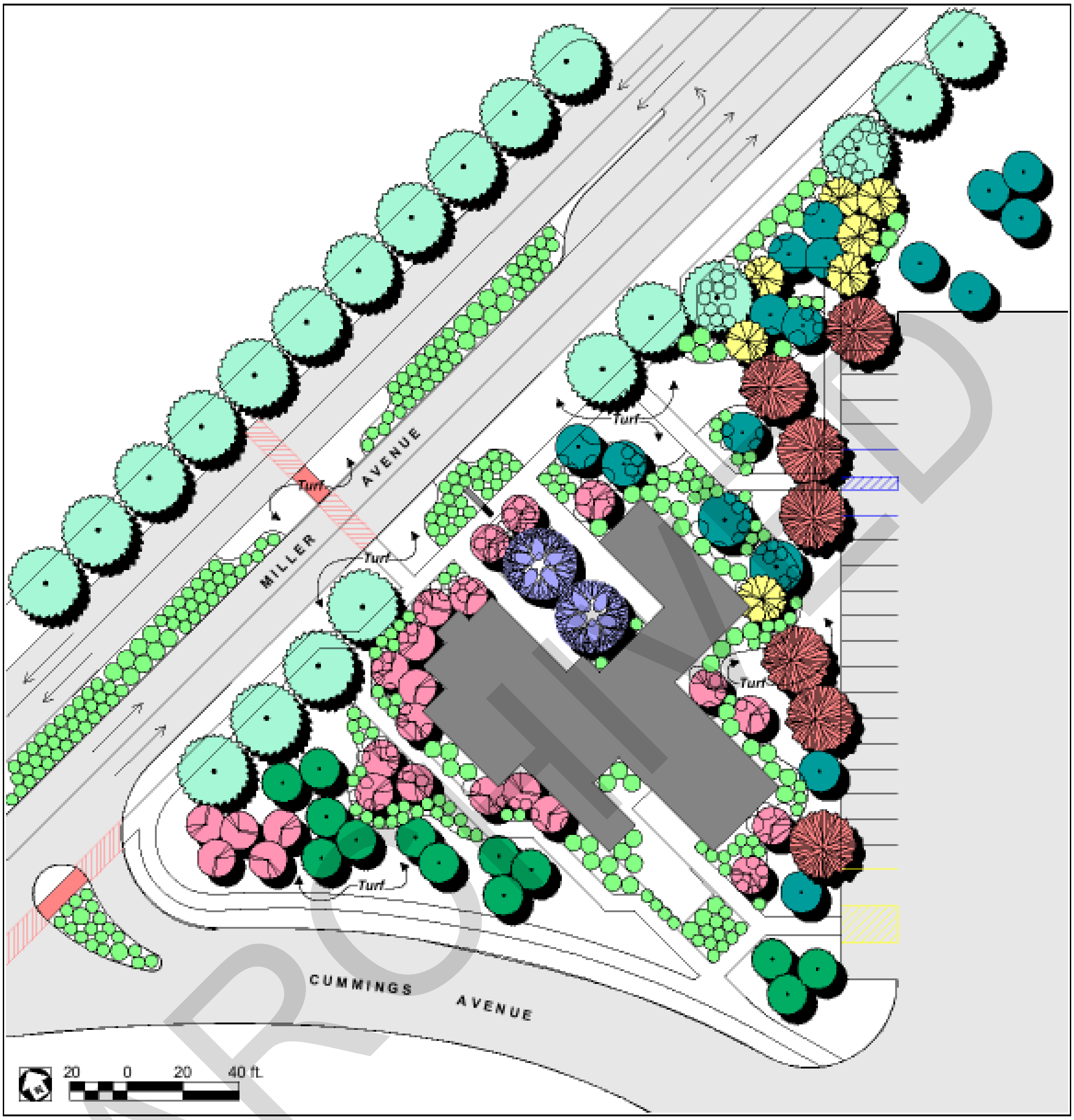

Figure 11-4: Concept Planting Plan

This process is performed for the entire site and graphically translated into the planting concept plan. This plan serves as the starting point for the final design process. It can be used to discuss design concepts and plant choices with commanders, nursery personnel, customers, facility users, or other landscape professionals.

Implementation

It is finally time for the designer to begin selecting, locating, and sizing the plant material that will appear on the project planting plan construction documents. The designer must communicate the elements of the final design for construction on the planting plan. Specific requirements for the planting plan implementation document are listed in Chapter Four of the Landscape Design Guide. The designer must consider the following concepts during the implementation phase of the planting design process:

Location

Accurately locate and represent the plant material on the drawing. Representation of plant material should be to scale and depicted at the mature width or spread. Proper spacing of plants is important to create the desired effect as well as reduce future maintenance requirements.

Identification

Identify all proposed plant material used in the planting plan. This can be done any different numbers ways. The symbols used to identify the plants will correlate with the plant schedule.

Quantification

Plant groupings on the drawing are usually shown by the identifying symbol and the number of plants in that particular group. The total number of each plant by type and size is provided in the plant schedule.

Clarification

List any other necessary information to communicate special construction requirements, materials, or methods such as specific plants that must be field located or approved by the designer and size or form matching of an important plant grouping.

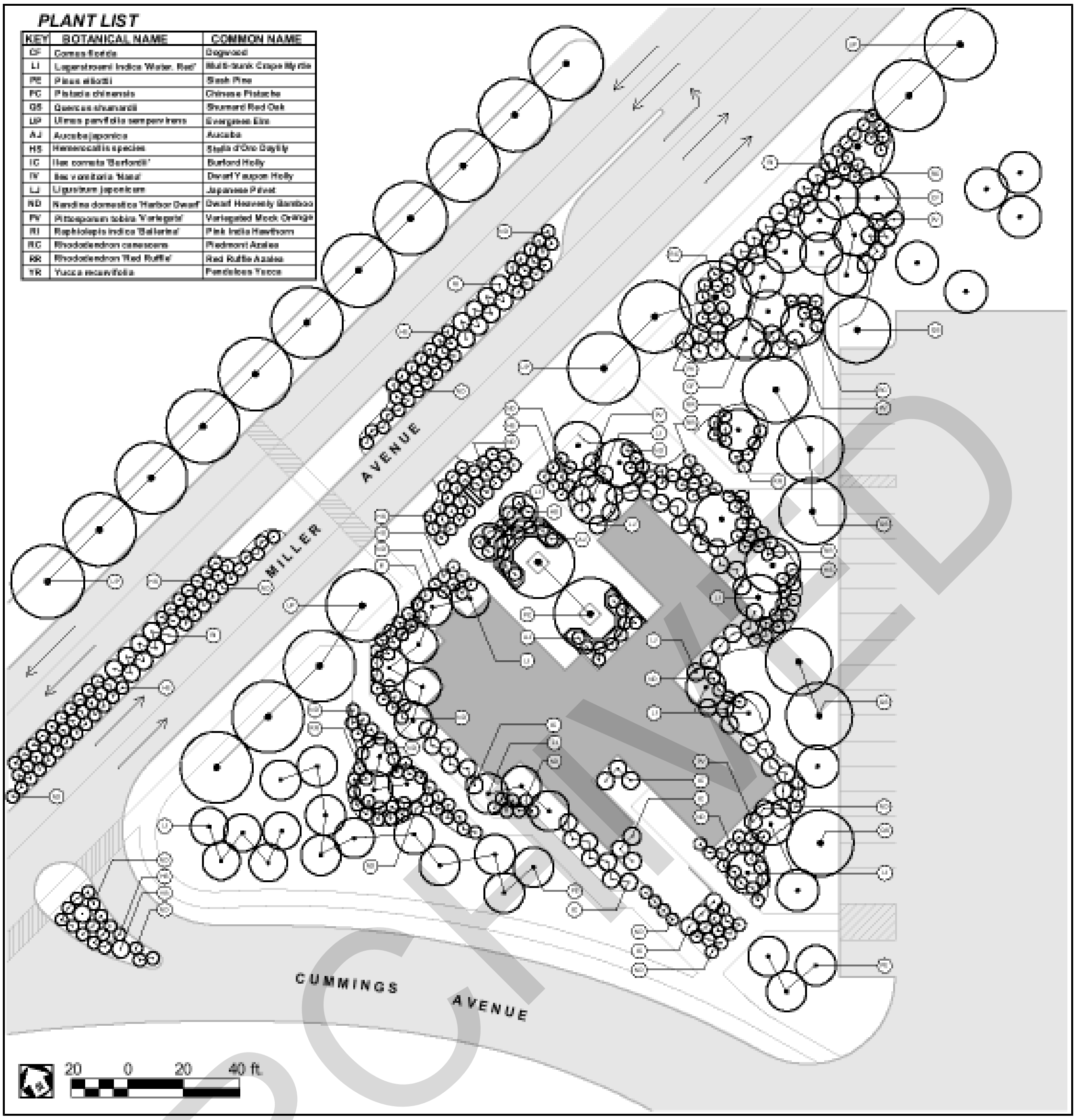

Figure 11-5a: Planting Plan

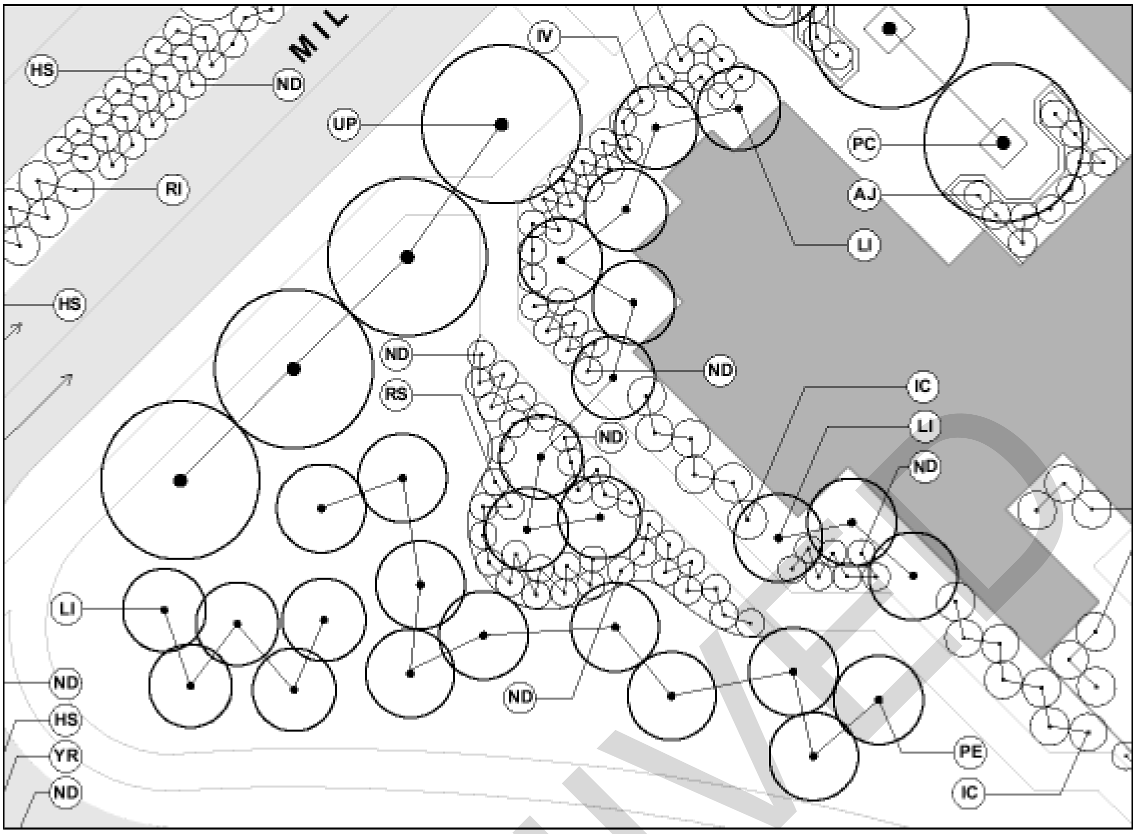

Figure 11-5b: Planting Plan Enlargement

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11.3 PLANTS

11.3.1 INTRODUCTION

Exemplary and sustainable planting design selects and locates each plant to contribute to the intended overall effect. Proper use of regionally native or indigenous trees, shrubs, groundcovers, vines, annuals, perennials and grasses creates a synergistic effect and character to enhance the natural and built environment.

A good landscape design is attractive, costs little to maintain, and improves the quality of life as well as the environment. The expertise and experience of a designer well versed in the regional plant material is important in producing designs with the following attributes:

- Less reliance on fertilizers, herbicides, and pesticides
- Avoids major plant replacement
- Preserves and enhances the natural wildlife habitat
- Minimizes water use

This chapter addresses the elements and applications of planting design:

11.3.2 PLANT TYPES

- **Trees**
- **Shrubs**
- **Groundcovers**
- **Vines**
- **Annuals**
- **Perennials**
- **Grasses**

Trees

Being the largest plants in the landscape, trees are the most valuable design element. Trees come in a variety of shapes, sizes, colors, and textures. As such, they not only provide diversity to the visual landscape as the most visually dominant plant type. Besides aesthetically enhancing an installation, trees provide:

- Shade
- Enclosure

- Screening
- Barrier
- Facility energy efficiency and conservation
- Glare reduction
- Seasonal diversity in foliage, fruit, and flower
- Enframement
- Air purification
- Erosion control
- Wildlife habitat and food sources
- Spatial scale
- Directional guide for vehicles and pedestrians
- Noise reduction
- Wind control

The Installation Plant List should contain a wide variety of trees to satisfy any of the design requirements or functions listed above.

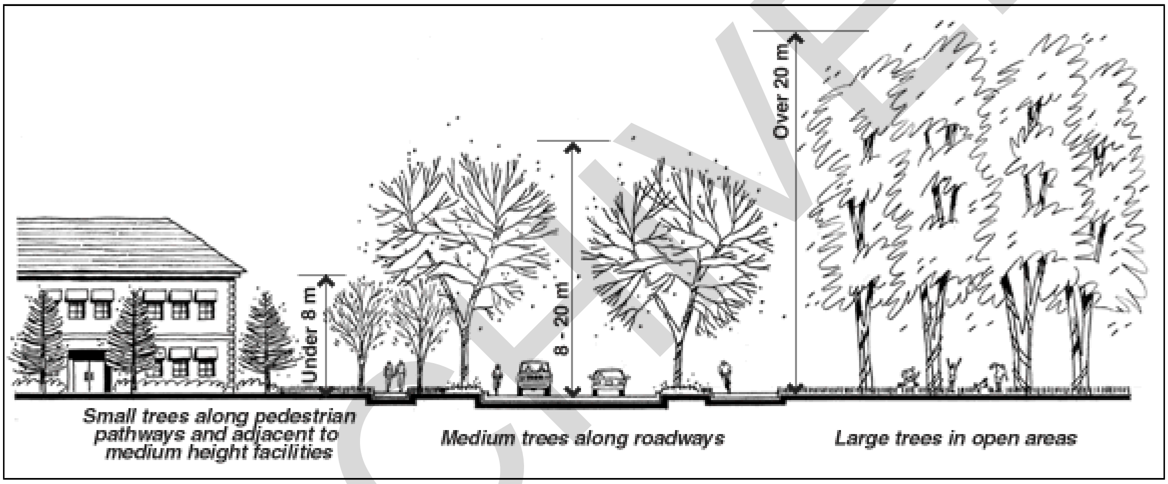

Figure 11-6: Plant Trees Appropriately in Relation to Their Size

Small

This category of trees generally reach 8 meters or less in height at maturity. It includes most of the ornamental flowering trees and many of the multi-trunked specimens. Small trees can be appropriately used:

- In patios and courtyards
- As accents at or near facility entries
- As foundation plantings near medium height facilities
- Under or near overhead utility lines
- Near pedestrian walkways or other high use site amenities such as gazebos and benches
- As part of a larger planting scheme to reduce the apparent scale of tall or massive facilities

Medium

This category generally attains a height of between 8 and 20 meters at maturity. Most of the tree species cultivated for use in landscape design fit this size category. In addition to being appropriately scaled for use around most facilities, medium sized trees are suitable for the following:

- As the primary element in streetscape plantings
- Open spaces between facilities
- In parks, recreational areas, and Military Family Housing to provide shade
- As definition and background for golf course fairways and greens
- To provide cooling shade in summer and allow solar gain in winter
- To modify wind exposure in temperate climates

Large

The final category of trees attain mature heights in excess of 20 meters. Care should be taken when planting large trees near utility lines and smaller facilities. Excellent for wide open spaces, large trees can be effectively used to:

- Reduce the scale of large, multi-story facilities such as hangars and dormitories
- Block or redirect winds
- Golf course roughs and perimeters

Shrubs

Shrubs are plant material that perform a wide variety of aesthetic and functional roles in the landscape. Ranging in height from just under 1 meter to 6 meters, shrubs may be deciduous, semi-evergreen, or evergreen. They can provide year-round accents through colorful or variegated foliage, contrasting stems, attractive flowers, and fruit.

Shrubs selected for their natural shape and size will enhance any planting design composition. Shrub foliage texture and color are extremely important design considerations since they are largely viewed at or below eye level. Like trees, they can be categorized by their mature size.

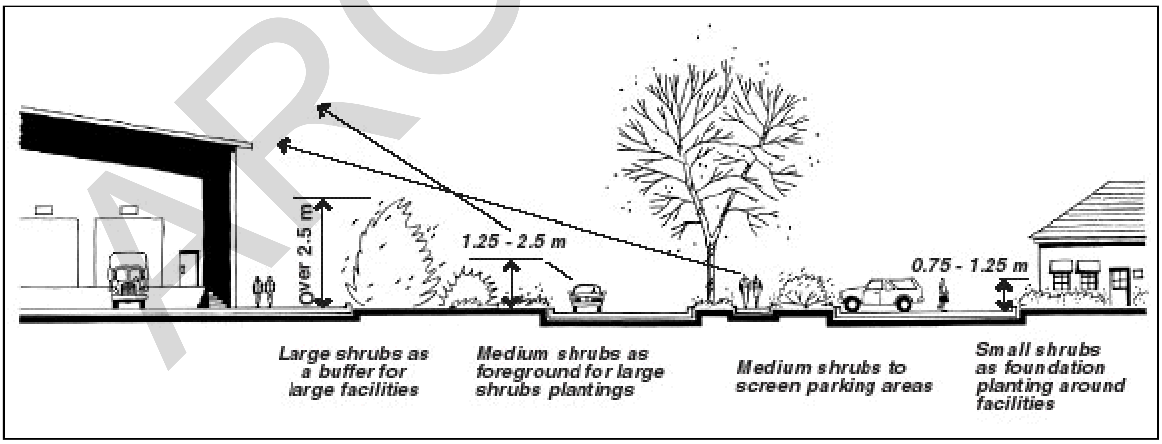

Figure 11-7: Plant Shrubs Appropriately in Relation to Their Size

Small

Small shrubs range from .8 to 1.25 meters in height. Small shrubs are probably the fastest growing plant category. Nurseries are constantly producing newly hybridized varieties with superior foliage, flower, and growth characteristics.

Small shrubs can be extremely valuable additions to the landscape. Generally they require little to no maintenance. The following are appropriate situations for the use of small shrubs:

- As a flowering accent mass in the foreground of taller contrasting shrubs
- As a foundation planting around facilities with low windows
- As the primary or secondary shrub in small or enclosed housing unit backyards
- As a low barrier planting or hedge
- As an accent or mass planting in raised planters

Medium

Medium shrubs range from 1.25 to 2.5 meters in height. Another rapidly growing plant category, medium-sized shrubs are the backbone of many planting design solutions. Many new hybrid selections are available for use.

- As an informal screening of parking areas and small mechanical or utility features
- As spatial definition, buffer, or barrier betweenpublic and private facility use areas
- As background foundation planting
- As a physical barrier between facilities or uses

Large

Large shrubs include those above 2.5 meters in height at maturity. Many small trees are actually large shrubs pruned to create the appearance of a tree. Improper use of large shrubs over the last 30 years has created many of the maintenance requirements encountered by the installation. Failure to factor in the mature height and spread of these shrubs has created the need for continual pruning. The designer must be careful to plan for the full, unrestricted growth of these shrubs over time. Some acceptable uses for large shrubs:

- As a buffer or screen along perimeter fences
- As a background for ballfields
- As spatial definition between large, unrelated facility types or land uses
- As foundation planting for large, windowless facilities

Groundcovers

Low growing evergreen plants that can be used where turfgrass is difficult to establish or maintain are classified as groundcovers. Usually less than .75 meters in height, groundcovers provide color, texture, and pattern contrasts with pavement or other plants. True groundcovers are trailing and root from new stems as they spread.

Most groundcovers do not tolerate foot traffic. In general, the use of groundcovers should be minimized. This is especially true at installations where highly mobile and fast growing turfgrasses such as common Bermuda are used. Although chemicals are available to control these invasive grasses in broadleaf groundcovers, treatment is an on-going, never ending process. Groundcovers are valuable planting design elements that control erosion and absorb runoff. They can be used:

- In areas where mowing is difficult or expensive
- To direct or control pedestrian circulation
- Raised or contained planter beds

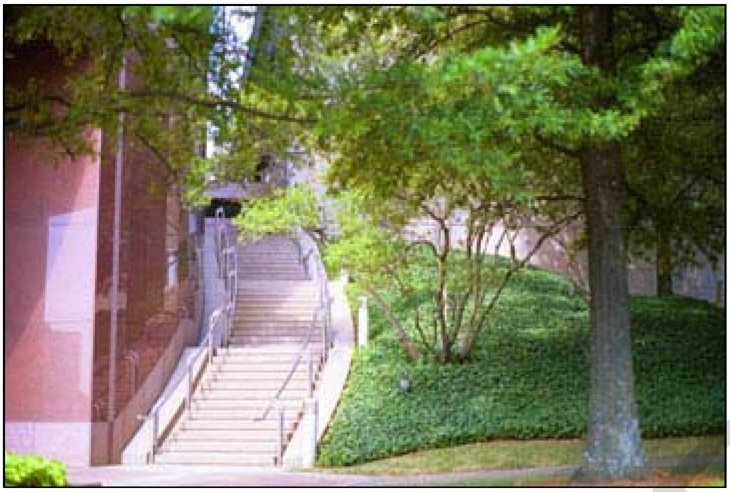

Figure 11-8a: Groundcover Used in Area Difficult to Mow

Figure 11-8b: Groundcover Used in Raised Planter

Figure 11-8c: Groundcover Used io Direct Pedestrians

Vines

Vines are evergreen or deciduous, usually rapidly growing, self-supporting curvilinear plants. They can serve many aesthetic and functional uses in the landscape:

- Conceal and soften unattractive walls, fences, and structures
- Provide seasonal color through flower and foliage

Many vines support themselves by tendrils that cling to supporting structures like an arbor or trellis. Others employ suction cups which allow them to attach to almost any surface. Many of these vines can cause damage to the structure or its surface.

Vines are effective in the following planting design situations:

- As additional seasonal shade on overhead trellis
- As a dense foliage screen on chain link fence
- As a flowering accent on a post or pillar at a primary facility entry

Figure 11-8d, e: Vines Used to Enhance Structure

Annuals

Plants that complete their life cycle in a year or less are classified as annuals. Many annuals grow, bloom, set seed and die in single season. Although annuals are among the smallest of the plant types, they can have great visual impact in the landscape. Their concentrated use at carefully chosen, highly visible locations can provide a colorful accent highlighting facility signs and entries.

Since the maintenance requirements of annuals are significant, they must be judiciously employed by the designer. Proper exposure, soil preparation, mulching, and specific fertilization and irrigation needs should limit their use to the public areas of primary and secondary development zone facilities.

Figure 11-8f: Annuals Used to Accent Vehicular Entry

Figure 11-8g: Annuals Used to Accentuate Pedestrian Entry

Perennials

Often used as the term to describe plants in which the top growth dies each winter and regrows in the spring, perennials are non-woody plants that live for more than two years. Generally, perennials are used similarly to annuals. Their longer lives usually dictate they attain greater size and value to the designer. Perennials are a diverse assortment of plants that are grown for their flowers, though some have excellent foliage. They can be left in place for several years with little maintenance beyond annual pruning and fertilization.

Figure 11-8h: Perennials and annuals use to accent pedestrian path

Grasses

Grasses make up the largest plant category in the world. Grasses have jointed stems, sheaths, and narrow leaves and range from the very finest turfgrasses like bentgrass and hybrid Bermuda grass to the ornamental white plumes of the 3 meter tall Pampas grass.

Figure 11-8i: Ornamental Grass Used to Soften Fence

Figure 11-8j: Ornamental Grass Used as Accent in Foundation Planting

Ornamental

Generally upright and shrub-like ornamental grasses are largely utilized in the planting design as dramatic accents. Many varieties of these grasses are available for use in the landscape. Most ornamental grasses require seasonal pruning to maintain an acceptable appearance. Check these requirements prior to any large scale plantings of ornamental grasses.

Turfgrass

Plants that form a continuous groundcover that can thrive under regular mowing and foot traffic are classified as turfgrasses. Extreme care must be taken when specifying turfgrass varieties. They are the most expensive plant type in the landscape to establish and maintain. Some of the significant issues to consider when selecting turfgrass varieties for the installation include:

- Irrigation requirements
- Exposure
- Wear tolerance
- Mowing heights
- Fertilizer requirements

Consult local county extension agents or reputable nursery employees for specific information on the proper variety of turfgrass for the installation.

Turfgrasses that aggressively spread by rhizomes or stolons tend to grow beyond desired bounds. Mowing strips of almost any type prove to be tremendously valuable. Maintenance requirements are reduced and the planting design inherits a clean, well defined edge between turfgrasses and other plants.

Turfgrasses are classified as either warm or cool season.

Cool Season

- Generally thrive in light shade
- Optimum growth temperatures: 60-75 degrees F
- Includes the following varieties: bentgrasses, fescues, bluegrasses, and ryegrasses

Warm Season

- Tolerate high temperatures: 95-110 degrees F
- First frost causes browning or dormancy
- Generally grow best in full sun
- Includes the following varieties: Bermuda, carpetgrass, St. Augustine, buffalo grass, centipede, and zoysia

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11.3.3 SELECTING AND LOCATING PLANTS

Plants are found in almost every ecological niche. From the tiny wildflowers of the arctic tundra to the foreboding Joshua trees of the Mojave desert, plants have adapted to almost every climatic condition. In each of these special niches, a group or community of plants thrive together due to their remarkable ability to adapt to nature's demands. In order to create low maintenance and attractive landscapes, the designer should respect nature's selective process and use plants that work together in these plant communities.

Plant communities

Plant communities are usually identified by the dominant plant species or the physically depicted character of the natural environment. For example, the palo verde/saguaro community of the upper Sonoran desert in Arizona and the sandy pine/palmetto/holly woodlands of panhandle Florida are native plant communities that have evolved according to regional climatic, soil, and rainfall conditions.

Selecting plants from the same natural community reinforces the regional landscape character while having inherent benefits such as:

- Naturally compatible soil and nutrient needs reduces significant requirements for planting pit preparation and amendments
- Similar visual image provides cohesiveness and unity to eventual planting design composition
- Comparable water needs reduce requirements for expensive irrigation systems

An experienced, conscientious designer will become intimate with the species composition, plant distribution patterns, natural order, and diversity of the commonly occurring plant communities native to the installation's region.

Layout

Although there are no absolute guidelines for locating plants in a design, there are a few principles which guide their efficient use.

Spacing

Triangular spacing of an odd numbered group of plants tends to be more natural and visually appealing. Whether the designer is creating a mass of low evergreen foundation shrubs or locating medium deciduous shade trees, triangular spacing creates a subtly random, yet organized visual effect.

Shrub masses should be spaced to establish a uniform foliage density without inhibiting the plant's natural mature form or increasing maintenance requirements.

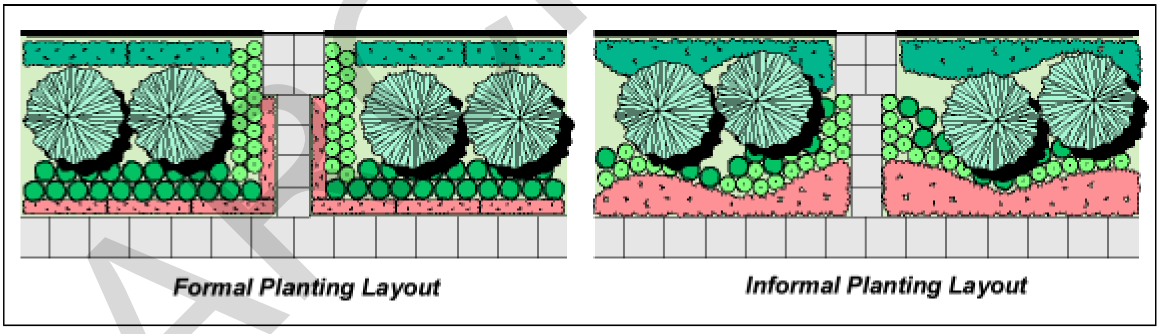

Figure 11-9: Formal and Informal Planting Layout

Mature plant sizes

Considering the mature sizes of plants at the design phase ensures proper spacing and foliage density over the long term. Since overcrowding and inefficiency are common mistakes in planting design solutions, this principle minimizes their occurrence.

In shrub massing, use at least 80% of the known mature width or diameter. The same ratio can be used when tree canopies are designed to intersect when the intent is long term, continuous cover.

As a general rule, use 80-100% spacing of the plants mature diameter to create attractive and maintainable long term planting design solutions while minimizing installation and establishment costs.

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11.4 CONCLUSION

This guide promotes planting design principles and practices which minimize impacts on the environment while maximizing long term value and efficiency. Sustainable planting design solutions can be realized by employing an appropriate process that considers all significant issues, project user needs and requirements, and implemented by a qualified professional.

11.4.1 PLANTING DESIGN DO'S & DON'TS

Follow these principles for efficient and attractive long term planting design solutions:

- Consult local extension agents and nurseries on the suitability and availability of plant material on the Installation Plant List
- Require that all designers, design agents, and tenants comply with installation landscape development policy
- Use only qualified, experienced landscape architects on contracted planting design projects
- Informally locate plants using triangular spacing to reflect natural distribution patterns
- Always visit the site and perform a detailed analysis prior to beginning design
- Factor all site, user, and environmental considerations into the final design solution
- Preserve desirable trees and shrubs
- Specify the minimum installation sizes required to satisfy initial aesthetic desires and needs
- Don't plant weak branched trees
- Don't locate trees where their shade will detract from the appearance, performance, and economic value of desirable shrubs
- Don't locate plants in areas too small for full and natural mature growth
- Don't locate trees closer than 2 meters from walkways, streets, curbs, parking lots, and other hardscapes
- Don't plant too many varieties in an attempt to create diversity
- Don't plant shrubs in turf areas without spatial planter bed definition or mow strips
- Don't use a formalized planting design style on a majority of installation streetscapes or facilities
- Don't assume all information obtained at nurseries to be fact

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11.4.2 REFERENCES

Suggested further reading:

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12.1 INTRODUCTION

Irrigation is among the most ancient civilized devices of mankind. Throughout history, man has sought new and more efficient ways to supplement nature's fresh water supply. Many early engineering and architectural successes were associated with redistributing water resources. Even today, irrigation systems can be an essential part of installation landscape development. Limited water and energy resources require wise system planning and places greater importance on the need for irrigation efficiency.

12.1.1 DEFINITION

Irrigation is the supplemental application of water to support intensive and regular plant growth. Successful irrigation systems consider the unique characteristics of the soil, climate, topography, and the quantity, quality, and availability of water as well as the specific plant material requirements.

12.1.2 GOAL

The primary goal of the Irrigation Guide is to provide installation designers and planners information necessary to understand the irrigation design process and implement cost effective and efficient installation irrigation systems.

12.1.3 OBJECTIVE

The objective of this guide is to provide a process framework to guide the planning and design of installation irrigation systems.

12.1.4 IRRIGATION GUIDE ELEMENTS

The following explains the Irrigation Design Guide elements covered in this guide:

Systems and Components

Describes the various types of irrigation systems typically utilized to satisfy the unique requirements of supplemental water demands for installation plant material. It also identifies and describes the numerous components comprising an irrigation system

Design Process

Describes the process necessary to design and implement irrigation systems including delivery analysis, component selection, and zonal delineation

Conclusion

Details the significant maintenance actions and issues necessary to ensure cost-effective, long-term irrigation system design

Summarizes actions required by installation project managers, planners, and designers to implement an installation landscape irrigation design program.

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12.2 SYSTEMS AND COMPONENTS

12.2.1 INTRODUCTION

Irrigation systems require basic components to ensure efficient water delivery and operation. Specialized components can improve performance and maintainability. There are different methods of delivering water to plant material once it has been routed to an area.

12.2.2 COMPONENTS

- **General**
- **Specialized Components**
- **Delivery Devices**

General

There are basic, components or elements required for most irrigation systems. They include:

- Point of connection
- Controllers
- Backflow prevention devices
- Emergency shutoff valve
- Control valves
- Wiring
- Pipe
- Fittings

Point of connection

The point of connection is where the water source is linked to the irrigation system. It usually occurs at the main water line or just past the water meter or shut-off valve for the facility or project.

Controllers

Controllers serve as the "brain" of an irrigation system. They control the opening and closing of the system valves at a pre-set programmed time. Controllers come in two primary categories, hydraulic and electric. Hydraulic controllers apply or release water pressure through "hydraulic tubing" to the hydraulic remote valves. Electric controllers send an electrical signal to open and close the electrical remote valves. Types of controllers include:

- **Hydraulic**

- **Electrical**

Hydraulic

Normally open

- Valves remain open until higher pressurized water is sent by the controller through a small polyethylene tube to the top of the valve diaphragm, closing the valve
- Primarily used on golf courses and large projects
- Used mainly with "dirty water" through the mainline, not potable
- Filtered potable water is used through the small polyethylene tubing to minimize clogging
- When the water pressure in the small tube is turned off by the controller, the valve opens and begins irrigation

Normally closed

- Valves are closed by main line water pressure above the diaphragm created by porting through the diaphragm
- The only water pressure source available is via the mainline
- The controller activates water flow above the diaphragm through a small tube back to the controller where it is placed into a sump
- Pressure below the valve diaphragm is greater than above, therefore, the valve opens and irrigation begins

Electrical

Electromechanical

- Was the first non-hydraulic all electric "clock-timer" controller developed; seldom used today
- Totally mechanical in operation using a motor, wheels, dials, pins, and gears
- Not very accurate in water duration timing

Solid state

- Digital readout and button keyboard control
- There are no moving parts and very accurate
- If power is interrupted, a battery back-up will retain the program
- Somewhat difficult to program and operate

Hybrid

- Has solid state circuitry for function and mechanical dials for programming
- Very easy to program and operate and very accurate
- If power is interrupted, a battery back-up will retain the program

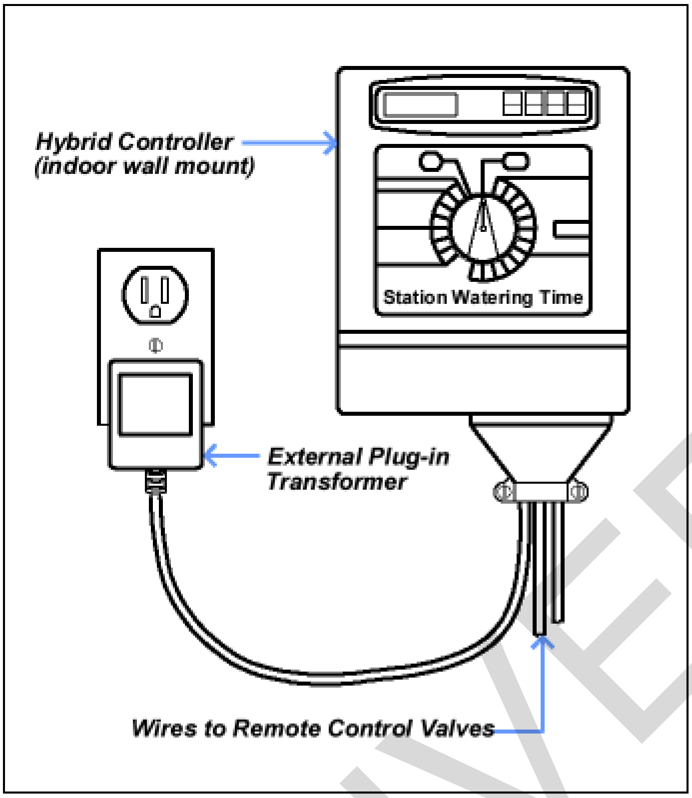

Figure 12-1: Hybrid Controller

Central Satellite

- A central/satellite control system is where one centrally located controller acts as a master to operate other auxiliary controllers
- Many satellite controllers can either stand alone in their programming and operating capabilities, or can be operated by electrical signals from the central controller
- A central/satellite controller is ideal for golf courses, large park areas, or entire bases
- Can be remotely radio controlled and operated

Ambient light powered devices

- Will result in considerable energy savings as no external power is required
- Used for remote areas without AC power readily available
- Useful in areas susceptible to lightning, power fluctuations, or outages
- Very accurate and can be remotely radio controlled and operated
- Functions day and night in any weather andvirtually any outdoor location
- No direct sunlight required

Backflow prevention devices

Backflow prevention devices prevent irrigation system water or other mixture or substance from flowing back into the potable water supply. Water flow in the opposite direction of "normal" may be the result of back-pressure or back-siphonage.

Backflow may occur when there is an imbalance in the hydraulic forces in a potable water system whereby non-potable chemical injection tank or irrigation water can be forced or drawn into the potable water system. Always adhere to local code restrictions when selecting backflow prevention devices.

Back-pressure backflow occurs when a greater pressure is generated in a non-potable water system by any pressure producing equipment, such as a pump, or elevation differences.

Backflow due to back-siphonage is caused by atmospheric pressure exerted upon a body of water forcing it into a connected potable water piping system in which there is a full or partial vacuum. A full or partial vacuum results from any extreme use or demand on the main supply water line. Examples include a main line rupture or increased demand on the main by fire personnel in an emergency. In either case, a non-potable substance can be forced to "backflow" through a cross connection into a potable water system. Types of backflow prevention devices include:

- **Atmospheric Vacuum Breaker (AVB)**
- **Pressure Vacuum Breaker (PVB)**
- **Double Check Valve Assembly (DCVA)**
- **Reduced Pressure Backflow Preventer (RP)**

Atmospheric Vacuum Breaker (AVB)

When the water supply is shut off or if line pressure drops to atmospheric or lower, the AVB opens an atmospheric vent allowing air to enter the piping system eliminating the possibility of siphoning.

- Designed to prevent back-siphonage only
- Not effective against backflow due to back-pressure, and should not be installed where it will be under continuous operating pressure
- Must be installed between the circuit valve and the delivery devices
- Should be installed a minimum of 15 centimeters above the highest outlet it serves

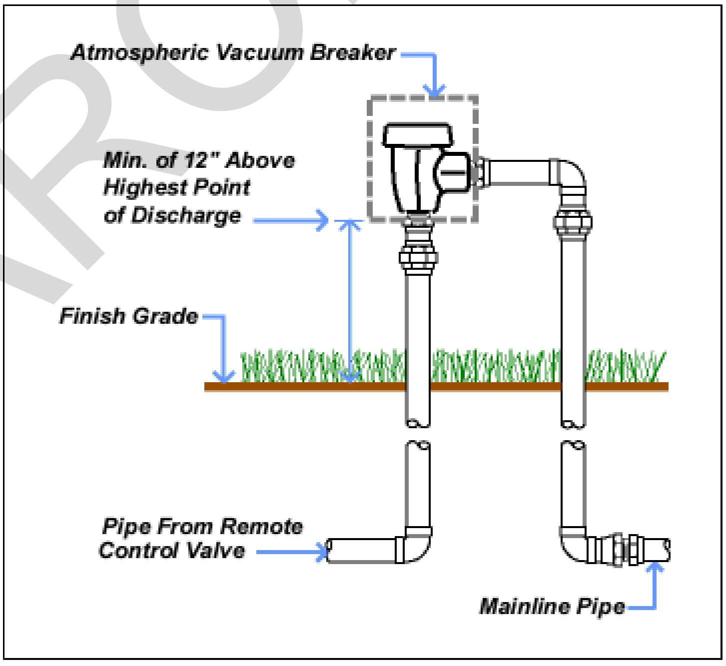

Figure 12-2: Atmospheric Vacuum Breaker Backflow Preventer

Pressure Vacuum Breaker (PVB)

PVBs can be installed on the pressure side of a shutoff valve and are designed to prevent back-siphonage only.

- Not effective against back pressure backflow
- Should be installed a minimum of 30 centimeters above the highest outlet served
- Installed after the water meter and before any valves

Double Check Valve Assembly (DCVA)

DCVAs are installed as a unit between two tightly closing shutoff valves and are fitted with unit test cocks.

- Effective against backflow caused by back-pressure and back-siphonage
- Plumbing codes in many areas require a DCVA
- Installed just after the water meter in its own box for inspection and service

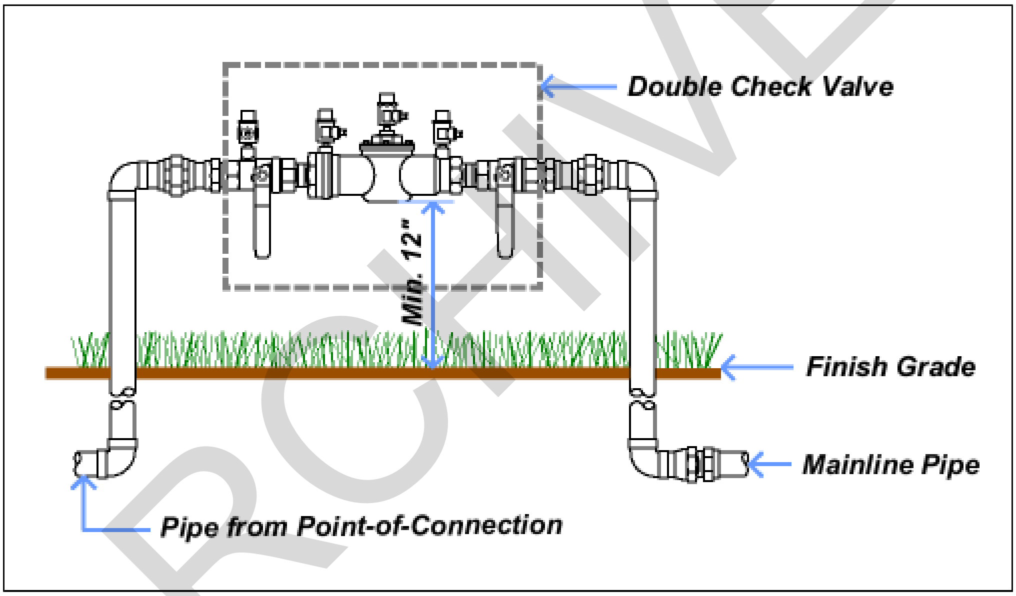

Figure 12-3: Double Check Valve Assembly Backflow Preventor

Reduced Pressure Backflow Preventer (RP)

RPs consist of two check valves and an automatically operating pressure differential relief valve. It is installed as a unit between two tightly closing shutoff valves and is fitted with unit test cocks.

- During normal operation, the pressure in the irrigation zone between the RP's two check valves is maintained at a lower pressure than the supply line pressure
- It is the most sophisticated and expensive backflow device
- RP's are effective against backflow caused by back-pressure and back-siphonage
- The device should be installed a minimum of 30 centimeters above grade

Emergency shutoff valve

An emergency shutoff valve is an in-line, on/off gate valve mounted prior to the system's first circuit valve in its own plastic protection box. It is an easily accessible, quick system shutoff valve.

Control Valves

Control valves are devices connected to a pipe regulating water flow automatically upon command from the controller. Most valves can be operated electrically or manually. Valves are constructed either of brass, bronze, or plastic. Brass and bronze valves are available although more expensive than PVC. The vast majority of control valves used in residential and commercial irrigation systems are of plastic construction.

The most commonly used electrical control valve is the diaphragm type. To operate, a water pressure differential must be maintained between the top-side and under-side of the internal diaphragm. An advantage of electric diaphragm valves is that there is practically no wear on the parts and reducing maintenance and replacement costs.

Most electric control valves include a water flow adjustment device or feature. This reduces flow and pressure to small zones in order to balance them hydraulically with larger zones. This feature can also be used to partially shut-off the valve for maintenance or adjustment. There are two types of electric control valves:

Angle

- Water moves at a 90 degree angle through the pipe and valve from the main pressure line into the lateral line

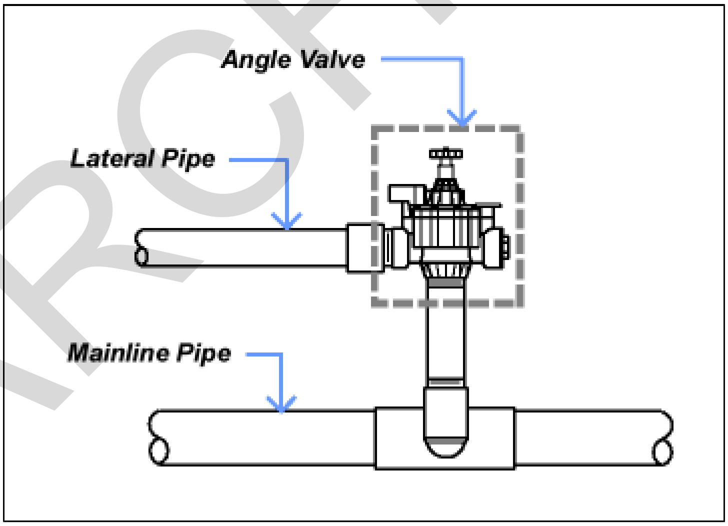

Figure 12-4: Angle Valve

Globe

- Generally used when all irrigation pipe is placed at the same nominal depth in the trenches

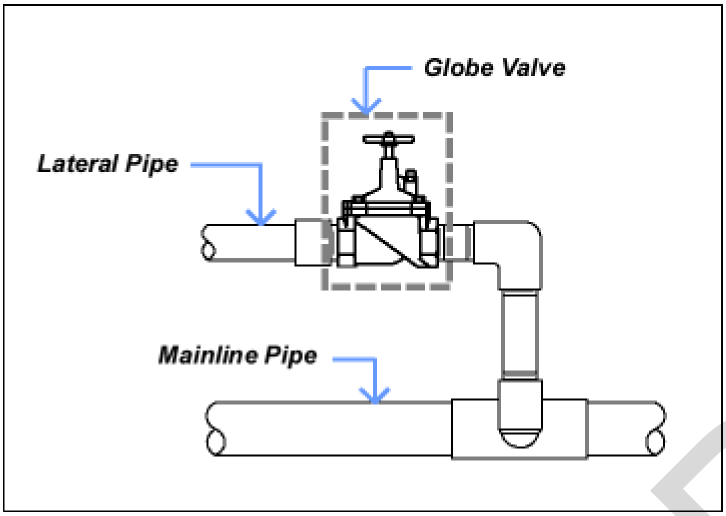

Figure 12-5: Globe Valve

Wiring

Electrically-operated valves require less than 30 volts to operate; usually 24 volts. This electrical work is classified as Class II, therefore a licensed electrician is not required. Direct underground burial of type UF wire (without conduit) is safe with less than 30 volts. Wire sizes depend on the controller model and input voltage, static pressure, length of wire, and the current and voltage requirements of the control valve solenoid. Always comply with local electric codes before designating wire specifications.

Pipe

Rigid polyvinyl chloride (PVC) or flexible polyethylene (PE) pipe is used almost exclusively to move water from the source to the delivery device. It comes in various sizes, thickness, and length. PVC pipe is produced in two categories, schedule rated pipe and pressure rated pipe.

Schedule 40 Rated PVC Pipe

Schedule 40 rated pipe in smaller sizes (19 to 76 millimeters) is sometimes used. It is suitable for use in conditions where greater resistance to damage is necessary. Typical applications might be as sleeving for smaller pipes under walls, slabs, roadways, or as mainlines in areas where rock is prevalent in the soil.

A common mistake often made by planners and designers is to assume schedule 40 PVC pipe is universally thicker-walled throughout its size range. This is not the case. Sizes above 76 millimeters are nearly equal in wall thickness to pressure-rated class 200 PVC pipe. Above 104 millimeters, however, schedule 40 PVC pipe is increasingly thinner-walled by comparison. Schedule 80 and schedule 120 rated PVC pipe are rarely used except as shrub risers due to high cost.

Pressure-Rated PVC Pipe

Pressure-rated pipe is produced according to uniform water pressure for each class of pipe, regardless of pipe size and is used as pressure mainlines and lateral lines in irrigation systems. Pressure-rated pipe is manufactured in four main classes or pressure categories of pipe:

- Class 125--guaranteed to 125 psi or 8.6 bars
- Class 160--guaranteed to 160 psi or 11.3 bars
- Class 200--guaranteed to 200 psi or 13.8 bars
- Class 315--guaranteed to 315 psi or 21.7 bars

In each class category, the ratio of wall thickness to the outside diameter of the pipe is the same. The difference is on the inside opening diameter. Most designers and installers use Class 200 PVC pipe almost exclusively.

Polyethylene pipe (PE) is black, flexible pipe used with drip systems and for lateral lines in standard, rigid PVC systems:

- Comes in rolls rather than 6 meters long rigid pipe lengths like PVC
- The pipe is flexible allowing ease in making turns within a system without using elbow fittings
- PE pipe has ultraviolet stabilizers mixed into the plastic construction material making it far less susceptible to sunlight's deteriorating effects than PVC pipe
- While inherently weaker than PVC pipe, one of the biggest advantages of PE is that it resists cracking and bursting when water freezes in the pipe

Fittings

Fittings are usually rigid or swing-jointed PVC or polyethylene in different sizes and shapes used to "piece together" an irrigation system.

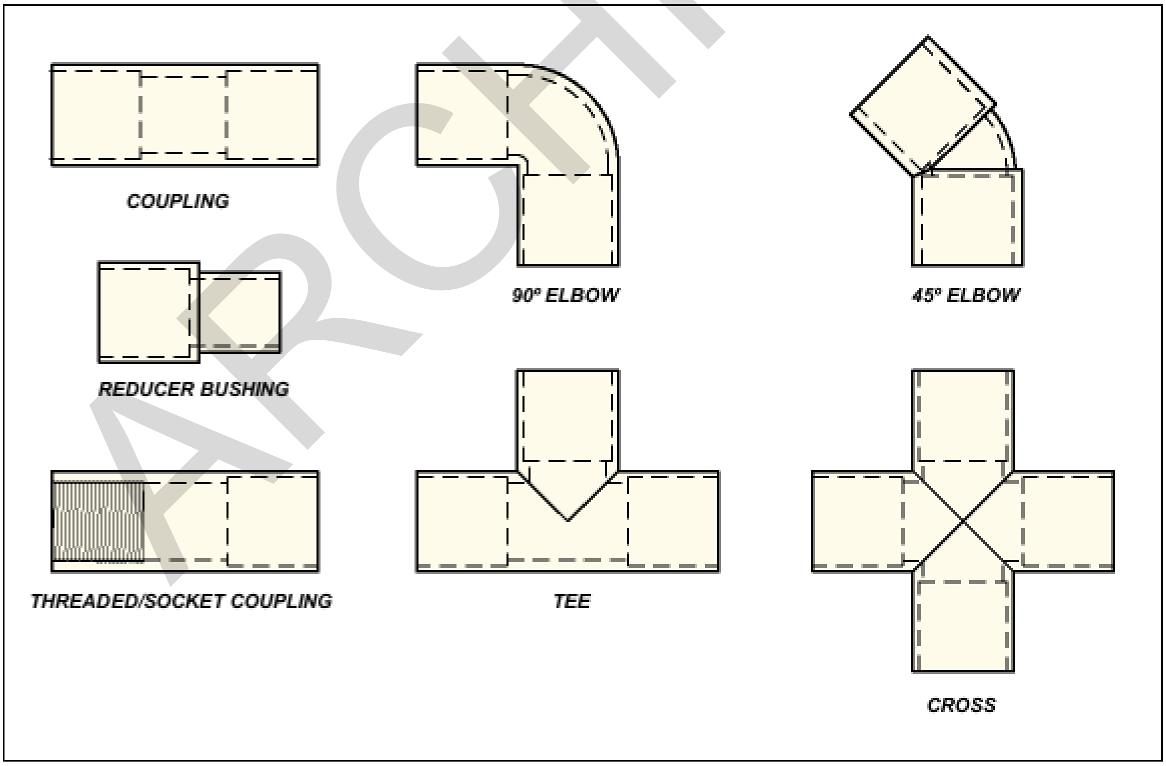

Figure 12-6: Irrigation Fittings

Specialized Components

There are a number of specialized components available for most irrigation systems:

Gate valve

A gate valve is used to prevent water flow in any lateral or main line when maintenance or repair is necessary. It can be used as an emergency shut off valve as well. A gate valve is installed inline on any lateral or main line and is protected and accessed within a protective plastic box. Gate valves cannot be used as control valves.

Drain valve

A drain valve is used where freezes in an area are no greater than one foot in depth. They are placed at low points within the main and lateral lines to drain water from the system to winterize it. There are two types of drain valves:

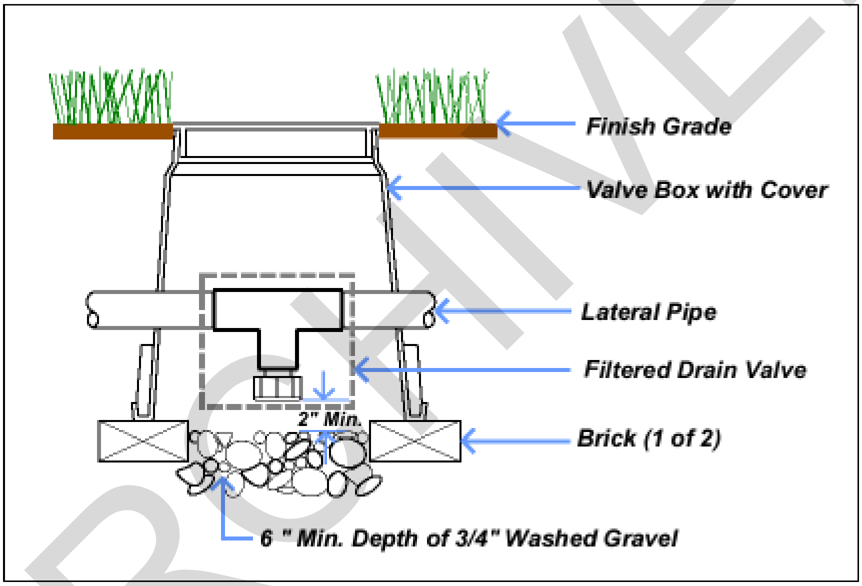

Figure 12-7: Drain Valve

Automatic

An automatic drain valve is a small appendage attached to low points on lateral lines. When the line is pressurized, the valve closes. When pressure is shut off or watering cycle is complete, the valve opens and drains the line.

- Always install an automatic drain valve at an angle of 30 to 45 degrees below horizontal to minimize debris depositing on the inlet screen
- Never install at the end of pipe lines as dirt can easily wash into the inlet screen

Manual

A manual drain valve is placed at the low point of each mainline, circuit, or lateral. When draining is desired, a manual globe or ball valve is opened to drain the system

- Manual drains should be installed with a sump pit of gravel below the drain valve

Pressure regulator

A pressure regulator is installed below the sprinkler to keep constant system pressure applied regardless of whether the pipelines run up or downhill. On drip systems it is used to reduce water pressure to the psi relative to the needs of the system emitters.

Pressure booster pump

Booster pumps are used when the existing pressure in a water supply is insufficient to offset all pressure losses in the system piping and provide adequate pressure at the delivery devices. These devices are generally centrifugal pumps. As their name implies, booster pumps boost an existing water pressure flow to a higher pressure.

Rain sensor

Rain sensors collect and measure rainfall. These devices prevent valves from operating when a set amount of rainfall has occurred. The sensor unit will reset for system operation after excess water evaporates from the collection component.

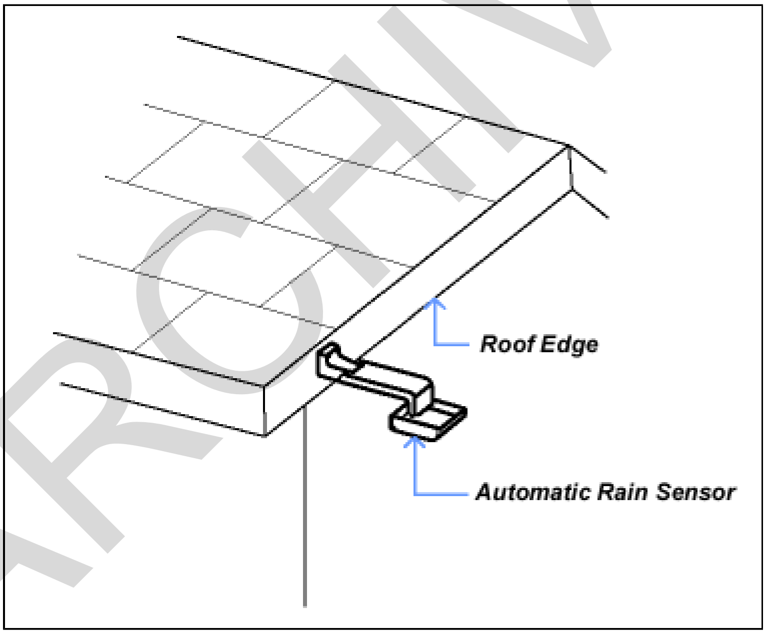

Figure 12-8: Rain Sensor

Low temperature sensor

A low temperature "override" switch is normally used in climatic regions where systems are operated year-round and low temperatures during the winter months may be below freezing. This sensor will eliminate any operation programmed to avoid the hazards of ice accumulation on walks, drives, and roadways.

Moisture sensor

A moisture sensor measures optimum soil moisture levels. It measures soil moisture tension and indicates whether soil needs additional or less water.

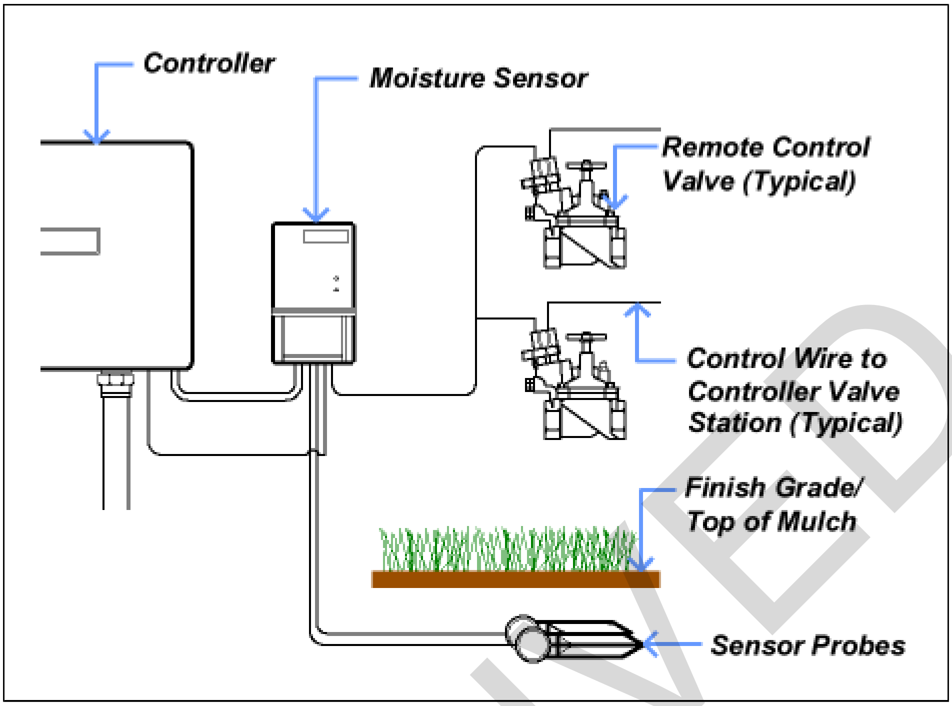

Figure 12-9: Moisture Sensor

Delivery Devices

Different plant material and planting situations dictate the type of irrigation system to design and install. The type of plant, plant size, and location are important considerations confronting irrigation designers.

The designer has a number of methods and devices available to deliver water to the planting areas:

Fixed sprayers

Fixed sprayers are usually placed on top of rigid plastic risers within a shrub adapter body. They spray water in any desired pattern, range, shape, or flow.

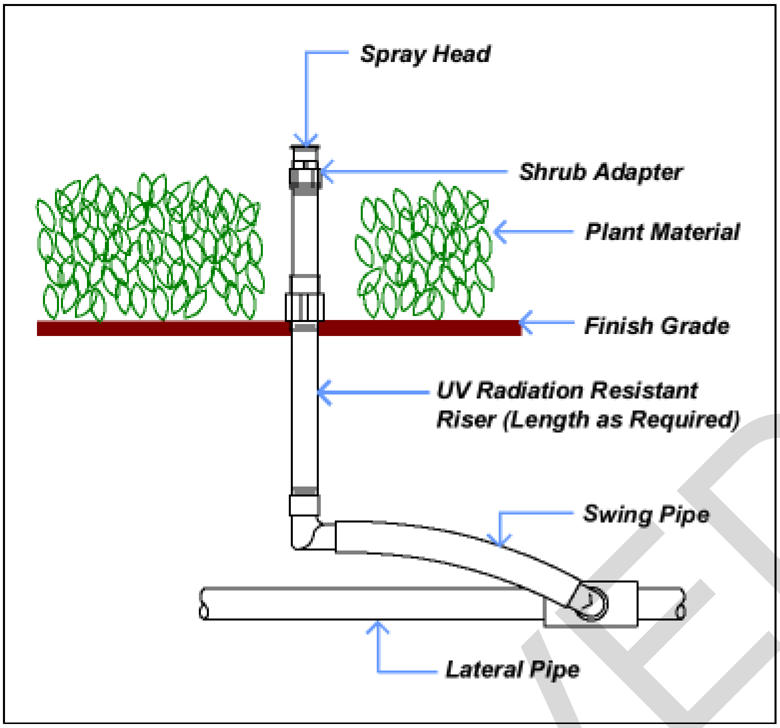

Figure 12-10: Fixed Spray Irrigation Head

Pop-up sprayers

Pop-up sprayers have no moving parts except for the actual popping up and down of the spray nozzle assembly within a rigid body housing. Pop-up sprayers are usually installed on the top of rigid risers, flexible swing, or triple swing joints. These sprayers come in many shapes, sizes, ranges, and liters per minute (lpm)ratings.

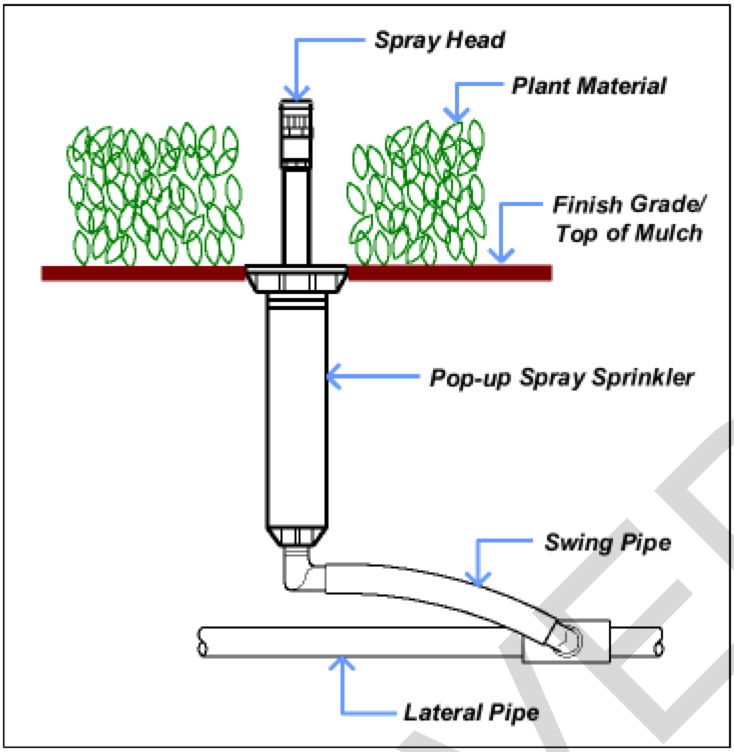

Figure 12-11: Impact Rotary Pop-up Irrigation Head

Rotary sprayers

Rotary sprayers move in a circular manner propelling water further than spray heads. They concentrate water into streams propelled by pressure over adjustable distances as the head moves or rotates. The pattern of coverage is adjustable, too. Rotary sprayers are usually installed on the top of rigid risers, flexible swing, or triple swing joints. Rotary sprayers come in many shapes, sizes, and lpm ratings.

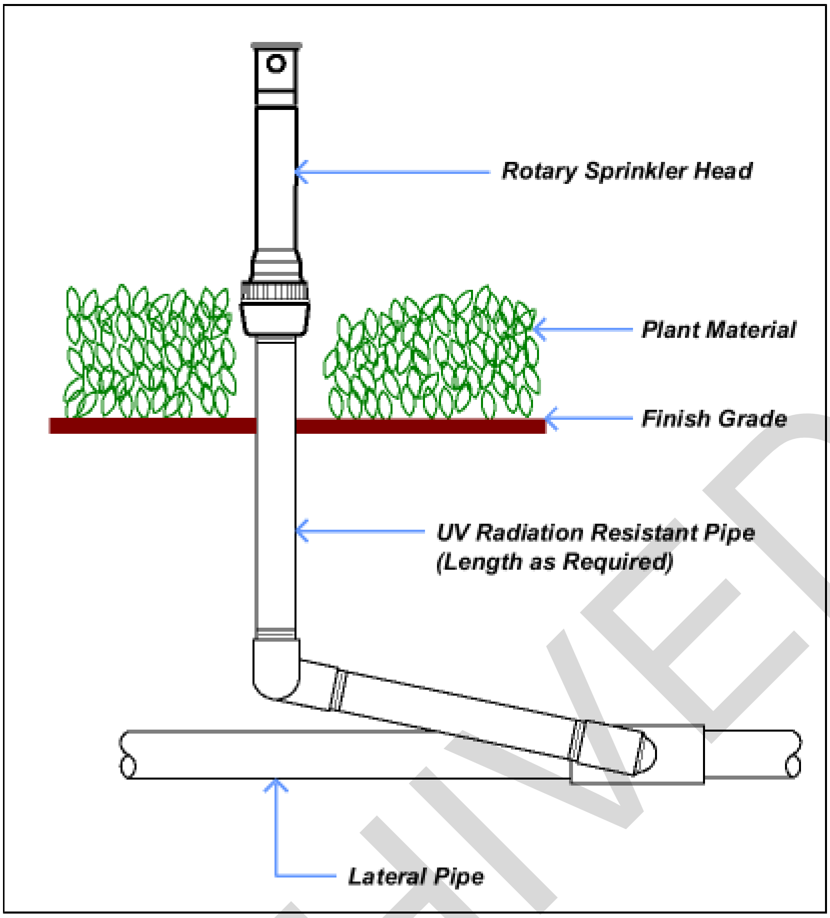

Figure 12-12: Rotary Irrigation Head

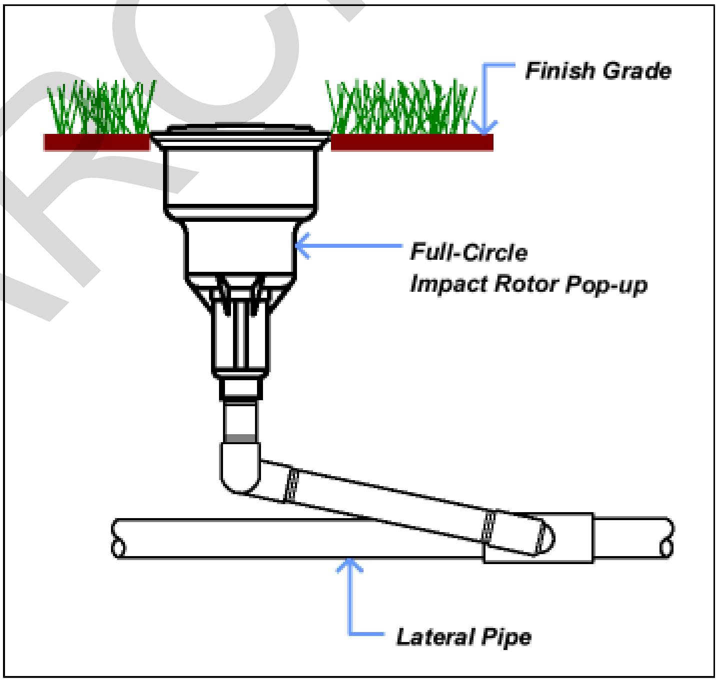

Figure 12-13: Impact Rotary Pop-up Irrigation Head

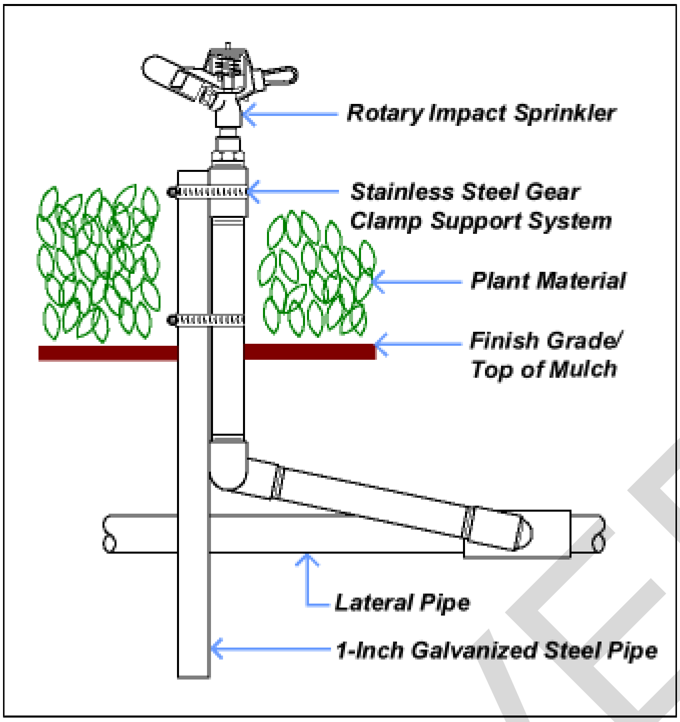

Figure 12-14: Impact Drive Irrigation Head

Bubblers

Bubblers distribute water with a gurgling effect from a head on a rigid plastic riser. Bubblers are adjustable from very low flows to relatively high. They are used primarily for deep root watering of a defined planter area or street trees.

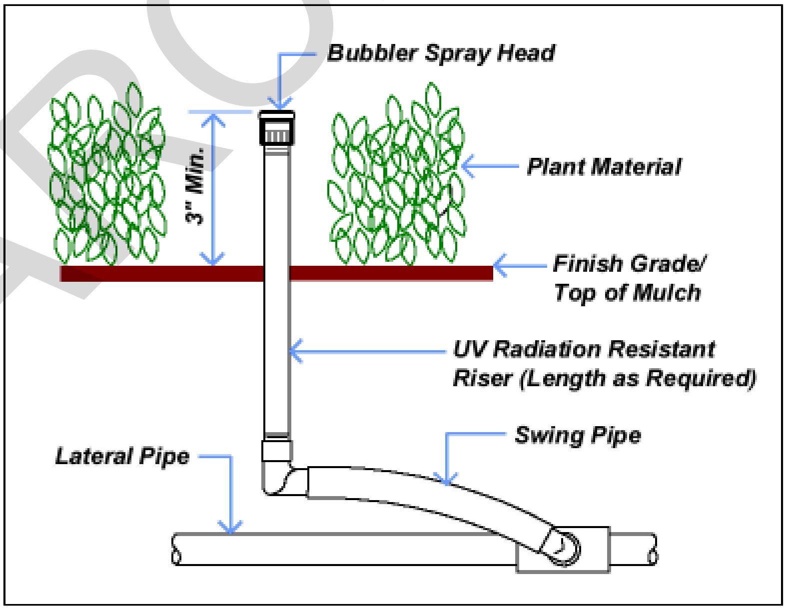

Figure 12-15: Bubbler Irrigation Head

Drip systems

Drip systems deliver water at very low flow rates. Application is normally rated in liters per hour (lph). There are many components required for drip systems:

Electric zone valves

Electric zone valves are designed to open and close at very low water flow rates. Solenoids should be high quality given the length of operating time required for drip systems.

Filters

All drip systems need a filter to remove very small particles from tubing water. The most commonly used drip filter is the wye-type. Filter size depends on the total flow rate of the water outlets. Filters should be in a plastic in-ground box and installed for easy access.

Pressure Regulator

A pressure regulator reduces existing pressure for the lower pressure requirements necessary for drip system operation. Pressure regulators should be installed on the discharge side of the system's filter.

Tubing and Pipe

There are many different types and sizes of piping material available to the drip system designer. Installation of the piping material is either underground with only the emitter tubing above the surface, or entirely above ground. Piping may be described as tubing or drip tubing. Most drip tubing and pipe is flexible. Small distribution tubing, commonly referred to as spaghetti, is used to connect emitters to the main water line. Common tubing and pipe sizes available are 5, 10, 13, and 25 millimeters.

Fittings

One of the primary differences between rigid PVC and drip irrigation systems is in the method of fitting the components together. Unlike PVC systems which use pipe glue to cement to pieces together, drip systems are pieced together with compression and insert (barb) fittings.

Drip Emitters

Drip emitters act as the "sprinkler head" for drip irrigation systems. Water is sent under pressure through a small plastic or polyethylene pipe or spaghetti tube to the emitter. Water is delivered by the emitter in a precise amount of liters per hour (lph). Most deliver either 2, 8, or 16 liters per hour.

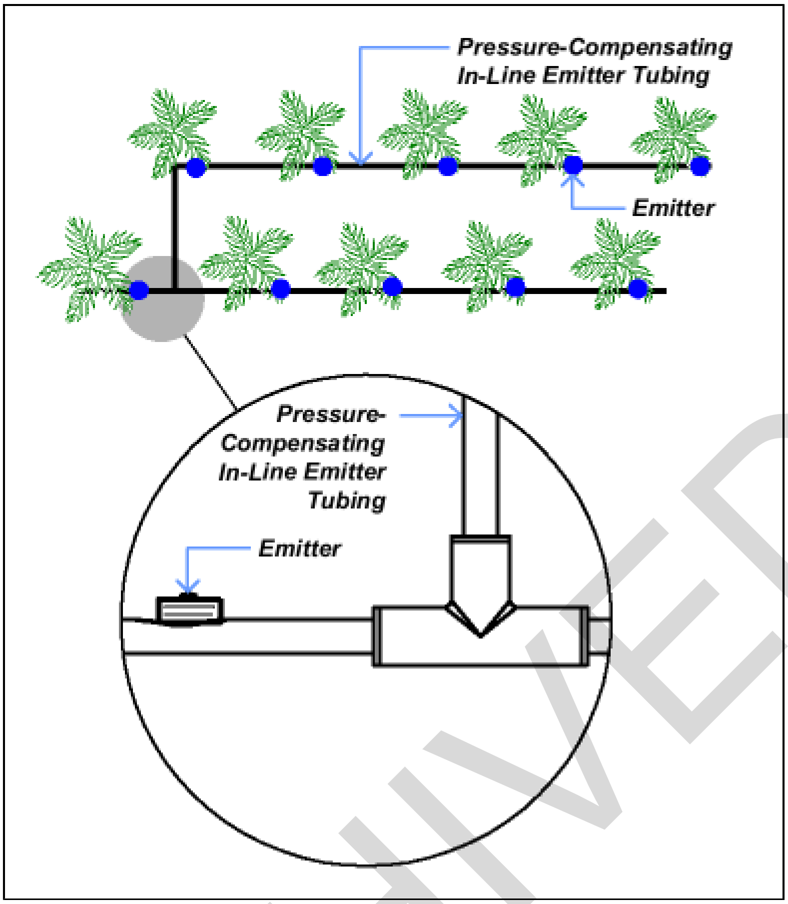

Figure 12-16: Drip Irrigation Emitters

Irrigation Water Delivery Selection Guide					
Plant Types or Planting Situation	Water Delivery System Options				
	Fixed Sprayer	Pop-up Sprayer	Rotary	Bubblers	Drip
Trees In planters	X			X	X
Trees in turf		X	X		
Trees in street planters				X	X
Shrubs in planters	X	X		X	X
Shrubs in narrow beds				X	X
Groundcovers	X	X		X	X
Vines	X	X			X
Annuals	X	X		X	
Perennials	X	X		X	X
Ornamental grasses	X	X			X
Turf >15' radius			X		

spray					
Turf <15' radius spray		X			
Container plants					X

Figure 12-17: Irrigation Water Delivery Selection Guide

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12.3 DESIGN PROCESS

12.3.1 INTRODUCTION

Irrigation design should be an orderly process. There is a definite starting and ending point. Each step in the process builds on the other resulting in an efficient and cost-effective system.

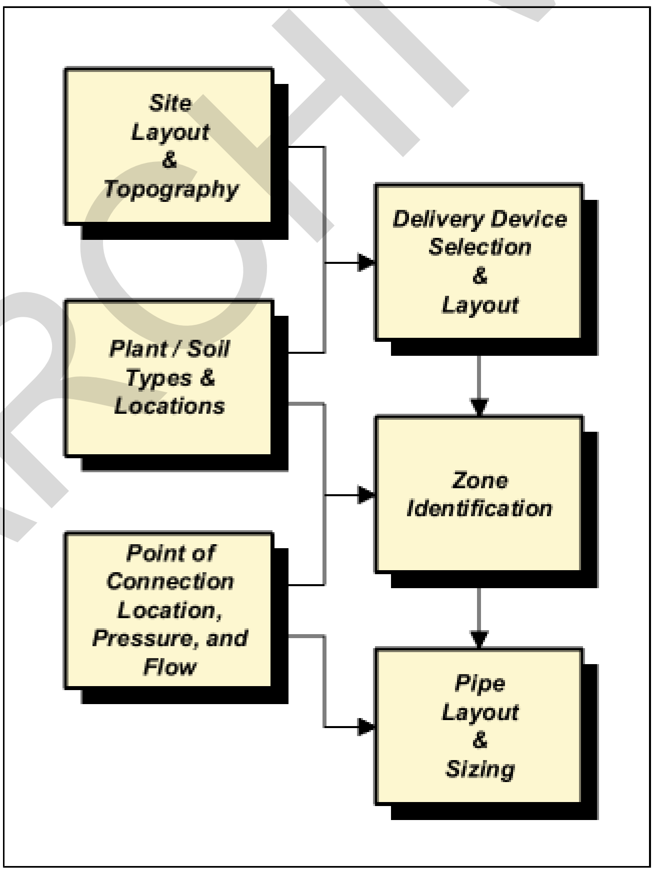

Figure 12-17: Irrigation Design Process

12.3.2 ANALYSIS

Before designing an irrigation system, the designer must analyze the project site. The designer must know building location(s), paved areas, the size of planters, turf area, kinds of plants, site elevations, soil type, water and electrical sources, and other considerations prior to beginning actual system design.

After completing the analysis, the designer will have a "feel" for the project and can begin formulating an approach to design the irrigation system.

Water supply/pressure

The first consideration facing the designer is the water supply source for the project -- the "point of connection." The designer must know where the water is located and the source pipe size. In addition, the designer must know how far the water source is to the project site, the (lpm) flow, and available pressure. The available flow will determine the maximum (lpm) size of the irrigation circuits. The available pressure will determine the sizes of pipe and types of delivery devices used. The designer must have accurate hydraulic data to ensure proper computations and component selection.

In most situations, a system will begin by tapping into the installation water main using a stop valve or using a smaller service line already tapped. The designer must note the size, length, and material of the service line. The main may be cast iron or PVC pipe supplying 2.8 to 5.2 pressure bars. A bar is a unit of measure equal to 0.987 standard atmosphere. The tapped service line is usually soft, bendable copper tubing 19 to 76 millimeters in length connected to a brass water meter. The tapped service line can be greater than 76 millimeters on larger installation projects such as dorm complexes or golf courses. The construction of most irrigation systems begins downstream from the water meter or shut-off valve.

An irrigation designer must know the flow limitations and static water pressure from the water source. Flow will depend on the size of main, water meter (if provided), shut-off valve, and the size and length of the service line. Elevation changes between the main and the water meter must also be considered.

In some cases, a water pump will be necessary to supply water for the irrigation system. Pump horsepower, hydraulic, and electrical data is information required to aid system design. The designer must place the pump in the best location for optimum service.

The installation Civil Engineering flight should provide information on the size of the water meter and service line. It is also the responsibility of the designer to verify the static pressure at the nearest hose bib/outlet to the project location.

12.3.3 DELIVERY DEVICE LAYOUT

The irrigation designer now determines the type of delivery devices to use on a project. Determine the shrub beds and turf areas. Some areas may require bubblers or drip devices. The designer has the type of delivery devices in mind at this time and begins developing a rudimentary delivery device layout. After the delivery device layout is completed, total water flow requirement can be calculated by adding flows of all devices.

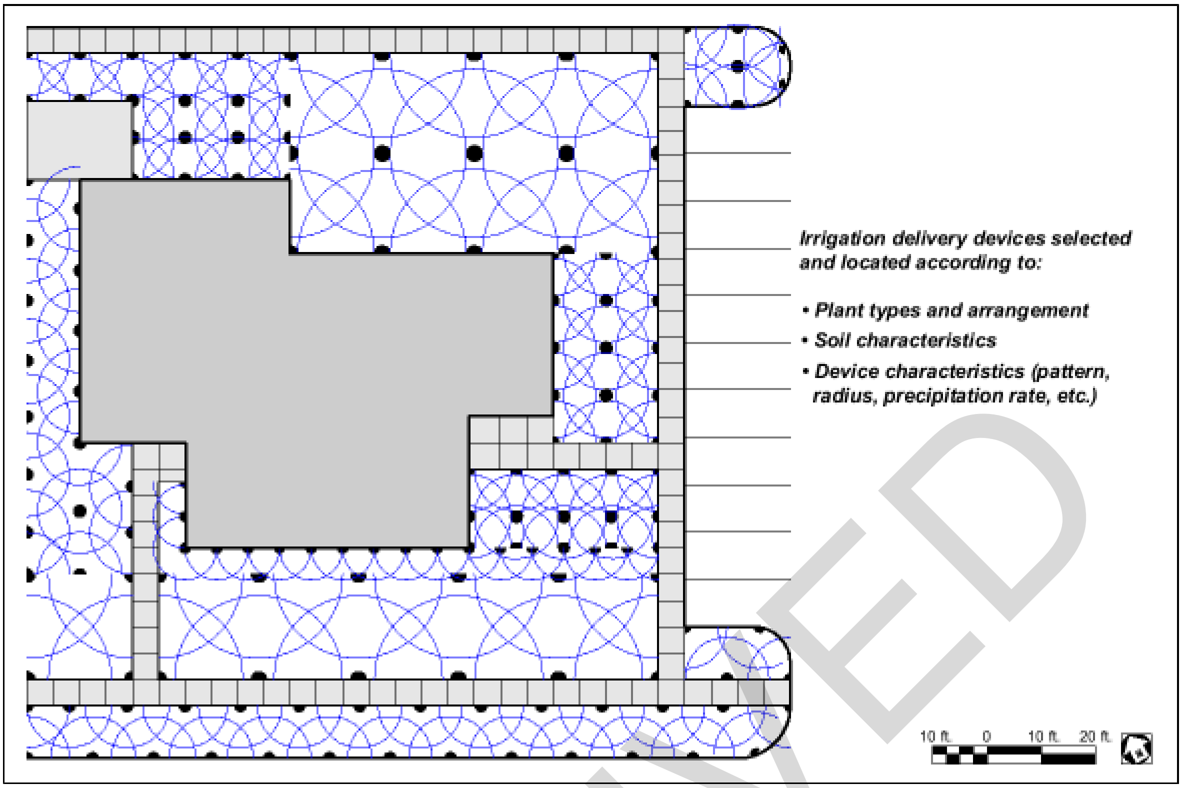

Figure 12-18: Water Delivery Device Layout Plan

12.3.4 ZONE IDENTIFICATION

A zone is defined as the components and delivery devices connected to one control valve. A series of zones constitutes an irrigation system. The designer needs to determine the total flow for the project before roughly laying out the approximate number of zones. These zones and their sizes can be approximated based on the site analysis, including meter and/or pump limitations. Next, divide the approximate zone size into the total water flow. The resultant figure is the total target zone quantity.

On larger projects, the designer must determine the approximate total watering time for each zone. The precipitation (watering) rate can be calculated using the following:

- number of rotary head zones x approx. 45 min = watering time
- number of spray head zones x approx. 15 min = watering time

The total time needed to accomplish correct watering duration must not exceed the allowable watering time. Check with local codes and guidance to determine approved watering times. If this schedule is acceptable, a trial pressure loss calculation from the point of connection to the furthest zone must be completed. If the calculation indicates there is adequate pressure bars available, proceed with zone identification maintaining approximate zone sizes.

If, however, the calculation indicates inadequate pressure bars, zone size must be reduced. Repeat the process until the appropriate zone size is determined. Continue the identification process by applying site information to determine similarity in plant material, soil, and elevation characteristics to optimize zone identification.

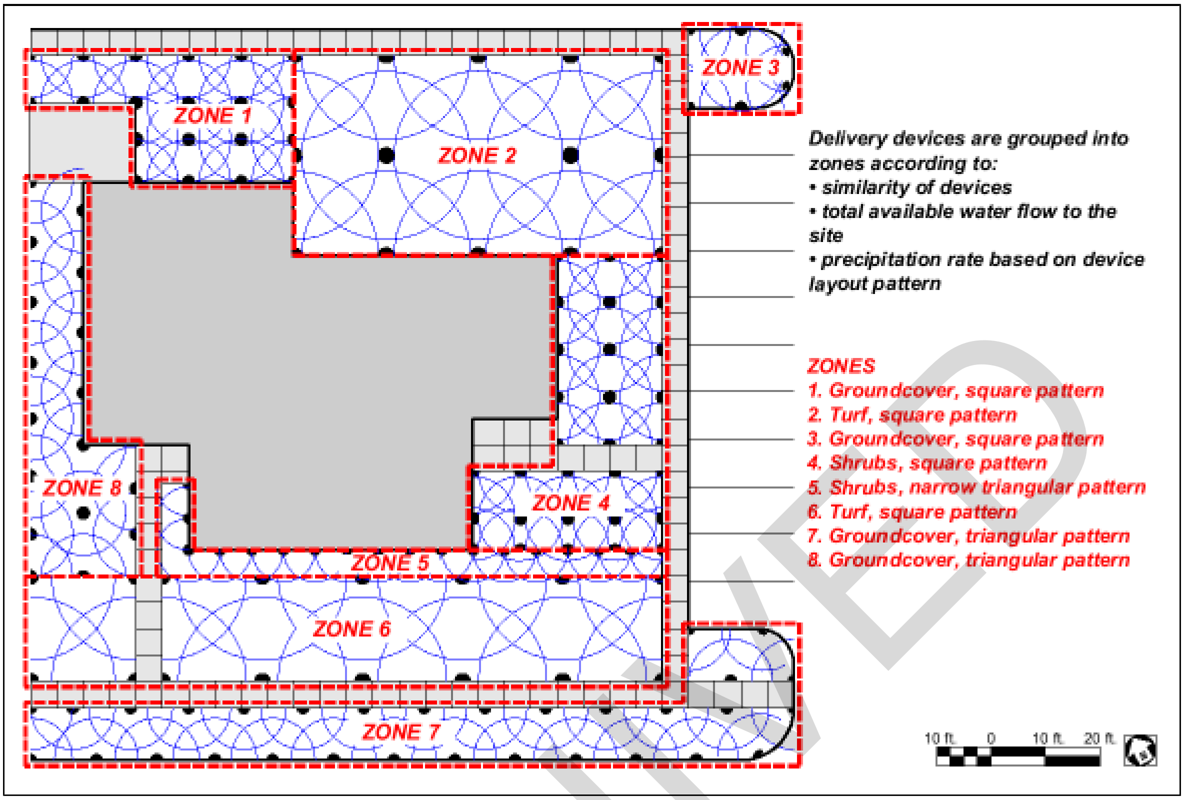

Figure 12-19: Zone Identification Plan

Pipe placement and location

The next step confronting the designer is establishing the best possible mainline (from water source) pipe routing. It is important to establish the shortest pipe routing. Do not bore under a driveway or sidewalk if routing around the obstacle is possible at reasonable cost.

Connect the delivery devices maintaining logical routing within the zones. Space them to ensure proper spray coverage and pattern overspray, thus eliminating dry spots. Locate valves logically to facilitate installation. Attempt to center valves within the center of zones whenever possible to minimize pipe use.

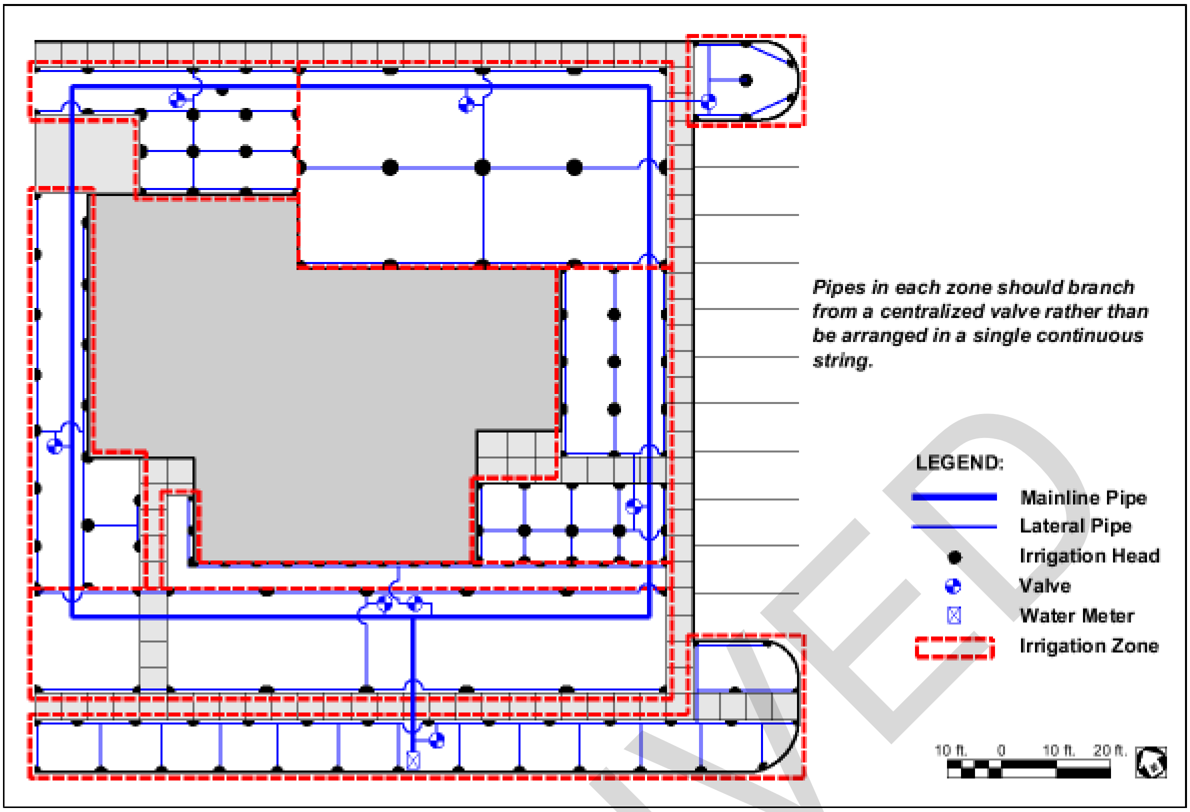

Figure 12-20: Piping Plan

12.3.5 PIPE SIZING

This function and step in the design process is simplified by the use of friction loss tables and velocity tables provided by irrigation manufacturers or found in various design manuals. This step is also the most frequently misapplied or mistakenly utilized exercise in irrigation design.

Additional information on pipe sizing planning factors is available in the appendix on page A-9.

12.3.6 VALVES

A valve is a device connected to a pipe regulating the flow of water. In an irrigation system, the function of a valve is to let water flow into a circuit automatically upon command from a controller.

Selecting valves for an irrigation system is based on several considerations. Determine the lpm demand for each circuit and how much pressure loss is acceptable. The designer must determine whether the irrigation system will be electric or manual. As a general rule of thumb, most installation irrigation projects require 25 to 76 millimeter electrical valves. It is better to have more pressure and volume available than not enough. All valves can be manually adjusted to control desired flow for each irrigation circuit.

Placing valves singularly throughout the system closer to the center of the controlled circuit splits the circuit into equal parts. This split results in duplicating pipe sizes and fittings on each circuit half and results in minimizing water pressure differential throughout the entire pipeline run.

Single circuit valves are put in plastic boxes to facilitate maintenance. Locate the valves and boxes such that a maintenance person will not get wet when turning the circuit on manually.

12.3.7 WATER DELIVERY

There are a number of things to consider when deciding on the best method of water delivery to a desired area:

- **Sprinkler performance**
- **Sprinkler location**
- **Sprinkler choices**
- **Precipitation rate**
- **Matched precipitation heads**

Sprinkler performance

When water is available and turned on, it travels through pipe up to the sprinkler head, and is forced out by water pressure in a pattern determined by the head selected. Patterns can be rectilinear or circular. Rectilinear patterns are excellent for medians in street boulevards and narrow areas between curbs and sidewalks. Circular patterned heads are much more common and come in various radii. Circular heads may be used for watering curvilinear shapes as well as rectilinear and square configurations.

Rectilinear patterns are defined by the area covered. Circular patterns are defined by radius of water throw, the arc of the water pattern, and the trajectory of the water as it is thrown from the sprinkler head. There is a sprinkler head and nozzle available for most any location or situation.

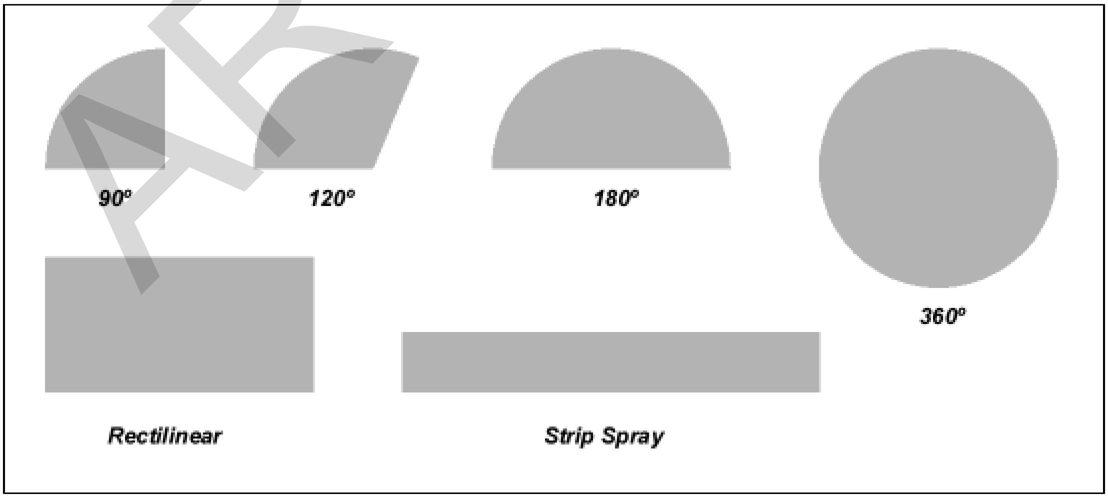

Figure 12-21: Sprinkler Head Spray Patterns

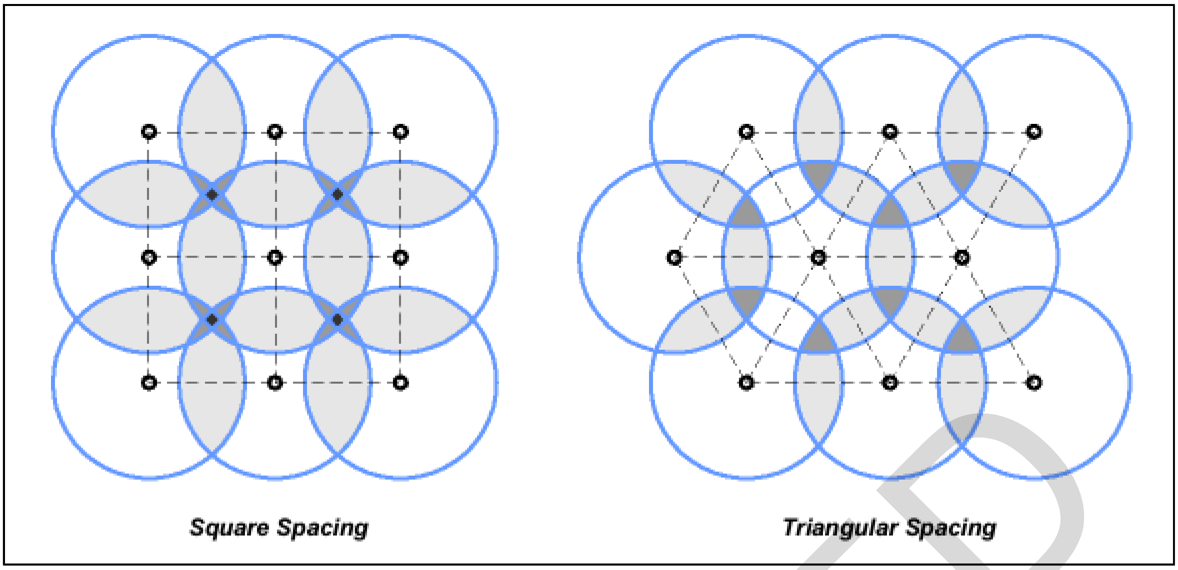

Figure 12-22: Sprinkler Head Layout Patterns

Radius of water throw

Sprinkler heads can be adjusted to throw progressively larger radii of water in order to cover a wide range of irrigated areas.

Arc of the water pattern

Circular patterns come in various arcs other than the full circle pattern. These arcs, or parts of circles, are available in many configurations. Some sprinkler heads have adjustable arcs ranging from 20 to 345 degrees of arc.

Trajectory of water

As water comes out of the sprinkler head, it travels in a curved path through the air to the ground. This curved path is the trajectory of spray. Trajectories of spray include:

- 0 degree trajectory -- this flat spray can be used for throwing water under low shrubs
- 10 degree trajectory -- this low angle spray can be used in a high wind situation and for shrub and groundcover beds
- 22-26 degree of trajectory -- this is the standard trajectory thrown by most sprinklers
- 30-35 degree trajectory -- this is a special trajectory used for throwing water over plant material such as groundcovers and gardens

WIND SPEED (mph)	■ SPACING	▲ SPACING
0	0.65 Diameter	0.75 Diameter
5	0.60 Diameter	0.70 Diameter
10	0.50 Diameter	0.55 Diameter

Figure 12-23: Sprinkler Head Spacing

Sprinkler location

Knowing specific sprinkler head patterns and radius of throw aids in proper location within an irrigation project. The main consideration for locating a sprinkler head is placement to achieve even distribution of water, much like rainfall.

Even distribution of water requires an understanding of how a common sprinkler head distributes water. Each head has its own distribution pattern. Areas closer to the head receive more water than areas at the furthest reach of the spray. A rule of thumb -- a single turf sprinkler can sustain live grass only two-thirds of the area covered by the spray pattern. Therefore, in order to get even water distribution, sprinklers must overlap spray patterns.

Sprinkler choices

Sprinkler head choice depends on the factors listed in Chapter Two as well as the following performance statistics of several industry common rotary and spray heads.

Performance Statistics			
Head	Lpm	Radius	Precipitation Rate
standard gallonage spray	12.9-18.2	3.7-5.2 meters	40.6-57.6 mm/hr
low gallonage spray	6.4-9.8	3.1-4.3 meters	32.5-41.7 mm/hr
small rotary	10.6-18.4	4.9-9.2 meters	8.1-21.1 mm/hr
medium throw rotary	15.6-42.7	9.8-15.1 meters	10.4-14.2 mm/hr
larger throw rotary	15.9-63.2	11.6-21.3 m	6.4-7.8 mm/hr

Rotary heads

Rotary heads move in a circular manner and throw water longer distances than spray heads. They concentrate water into thin streams propelled by pressure over long distances as the head moves. There are two different types available:

Impact Driven Heads

- Uses the stream of water that throws the sprinkler pattern to bump a spring loaded arm which slowly turns the sprinkler head

Gear Driven Heads

- Water turns a series of gears in the sprinkler body causing the sprinkler head to rotate in a slow and quiet manner

Spray heads

Spray heads are stationary, moving only when popped up or down by water pressure.

- Use 5 centimeter pop-ups only on short turfgrass varieties such as bermuda
- Use 10 to 15 centimeter pop-ups for longer turfgrasses such as St. Augustine and Kentucky blue grass
- Use 15 centimeter pop-ups for tall turf grasses and groundcovers
- 30 centimeter pop-ups used for groundcovers annuals, and shrub beds
- Plastic rigid risers from 30 to 90 centimeters tall can be used to water shrubs and ornamental grasses. The risers are capped with a shrub adapter/nozzle which sprays water in the selected pattern

Precipitation rate

Any discussion of irrigation design must include a look at precipitation rate. Precipitation rate is simply the millimeters of water per hour placed over a certain area. As an example, if the sprinklers in a front yard deliver 25 millimeters of water over the entire front yard in an hour, the precipitation rate of the sprinkler heads is 25 millimeters per hour.

Matched precipitation heads

Another important consideration for the irrigation designer is matched precipitation heads on any system. Families of sprinklers have nozzles with matched precipitation heads. This means using half circle heads with full circle heads will result in the half circle heads producing half the amount of water, or lpm than the full circle heads produce. The matched precipitation feature allows the mixing of quarter, half, three-quarter, and full circle patterns together from the same family of heads and still achieve an even distribution of water on all areas irrigated.

Designers should not mix different families of sprinkler heads together. For example, do not mix spray heads with rotary heads because the precipitation rates of the two families will not be alike. Based on manufacturer's data and recommended head spacing, spray heads have precipitation rates ranging from about 25 to 50 millimeters per hour while rotary heads have precipitation rates ranging from 6.4 to 21.1 millimeters per hour. Mixing different families of heads and precipitation rates will result in uneven watering patterns.

12.3.8 CONTROLLER PROGRAMMING

A controller tells the valves when to activate and how long to remain on so the correct amount of watering can be accomplished. The controller executes the programmed watering schedule. When the controller sends out a signal to a valve, it slowly opens and allows water from the pressurized mainline to flow into the circuit and out through the sprinkler heads. When the programmed time duration is complete, the controller ceases output of the signal and the valve closes.

Controllers are available with a large array of features and versatility. Controllers are classified by the number of stations (circuits) they can control. For example, if a project has eight valves and circuits then an eight station controller is required. Generally, one station controls one valve, although certain controllers could open two or more circuit valves if wired to do so.

Minimum features desired for a controller include: 2-3 start times per station per day, 14 day watering cycles providing increased watering flexibility, manual control switch to override the automatic cycle for maintenance or testing, system on/off switch, station run times usually 1-90 minutes available, program retention with battery back-up in case of power outage, and a seasonal adjustment switch allowing for percentage increases or decreases of programmed water amounts.

12.3.9 ESTABLISHMENT

After an irrigation system has been installed on a newly planted project, there is an establishment period required. New plantings are in a stressful situation and require additional care, observation, and water to promote growth and vigor. In addition, the irrigation system will need monitoring and evaluation to ensure proper operation and area coverage.

The first several days after a project is completed are key to an irrigation system. Not only are the plants trying to adjust to the new environment, the irrigation system itself must be monitored and adjusted to ensure it is functioning as designed and installed. Ensure beds are getting proper amounts of water through the drip emitters, bubblers, or spray heads. Adjust heads to ensure proper coverage and avoid watering undesired areas such as project perimeters and driveways. Ensure turf areas receive enough water and that overspray is sufficient to provide adequate coverage.

Personnel responsible for maintaining the project after installation must be aware of the watering needs of the plants on site as well as the operation of the total irrigation system from controller to individual heads.

Adjustments to the irrigation system must be made in a timely and correct manner. Do not hesitate to replace heads not providing adequate coverage or needing a higher lpm rating. Establishment greatly increases the chances of the landscape providing years of function and beauty.

Preceding page | Next page | Back to Topic Outline

12.4 CONCLUSION

12.4.1 MAINTENANCE

Immediately following installation of an irrigation system, maintenance of that system begins. Numerous operations and tasks are required to ensure proper and optimum system operation. The design, installation, and operation of an irrigation system is a costly undertaking. It is therefore wise to immediately establish a comprehensive and aggressive maintenance program to ensure lasting results on the investment.

The following are some actions recommended for an irrigation system maintenance program:

- Establish a schedule to clean all filters and strainers on the entire system
- Ensure controllers are operating correctly by checking them at least weekly
- Regularly check the connections and fuses and test the rechargeable program back-up battery, too
- Manually start the zones and walk the area covered by the individual zones. Ensure delivery devices are properly adjusted ensuring adequate coverage
- Check spray and rotary head spray patterns are not spraying undesired areas such as driveways or open areas
- Test backflow prevention devices operate correctly at least twice a year
- Educate grounds maintenance personnel to ensure they minimize lawnmower and string trimmer damage to risers and delivery devices
- During inspection tours of the project site, look carefully for dry or overly wet spots and adjust components as necessary
- Open plastic box covers and inspect the general condition of the enclosed component
- Establish a schedule to clean all delivery device orifices annually
- In cold winter areas, establish dates to purge and drain the irrigation system and ensure the components are protected
- Adjust the controller program as seasonal changes necessitate
- On drip systems, ensure the narrow "spaghetti" tubes with the emitters on the end are protected and those installed in the ground remain covered

12.4.2 ACTION ITEMS

Listed below are some actions associated with executing a thorough landscape irrigation design process at the installation:

- Use this Landscape Irrigation Design Guide on all appropriate installation projects
- Strive for standardization of irrigation system component parts for ease of maintenance and operation
- Ensure a comprehensive establishment program is developed and executed to ensure proper system operation

12.4.3 REFERENCES

Suggested further reading:

A B C's of Lawn Sprinkler Systems, The, A. C. Sarsfield, 14th Edition, 1973, Irrigation Technical Services

Buckner Irrigation Systems Design Manual, Editors, Buckner Irrigation Systems, First Edition 1988, Buckner Irrigation Company

Irrigation, Claude H. Pair, Fifth Edition 1983, The Irrigation Association

Landscape Design, Volume 8, Number 4, April 1995, Nancy Sappington, Editor, 1995, Adams Publishing Company

Landscape Irrigation Design Manual, Edited by Keith Shepersky, 1992, Rain Bird Sales, Inc., Turf Division

Practical Guide to Home Landscaping, Editors, Reader's Digest, 1972, Reader's Digest Association, Inc.

Simplified Irrigation Design, Pete Melby, 1988, Van Nostrand Reinhold

Trickle Irrigation Design, David Karmeli and Jack Keller, First Edition, Rain Bird Sprinkler Manufacturing Corporation

Turf Irrigation Manual, Richard B. Choate, Fifth Edition, 1994, TELSCO Industries

12.5 APPENDIX

12.5.1 SOIL COMPARISON MATRIX

The matrix below can be used to compare and determine water intake, retention, and drainage erosion by soil type.

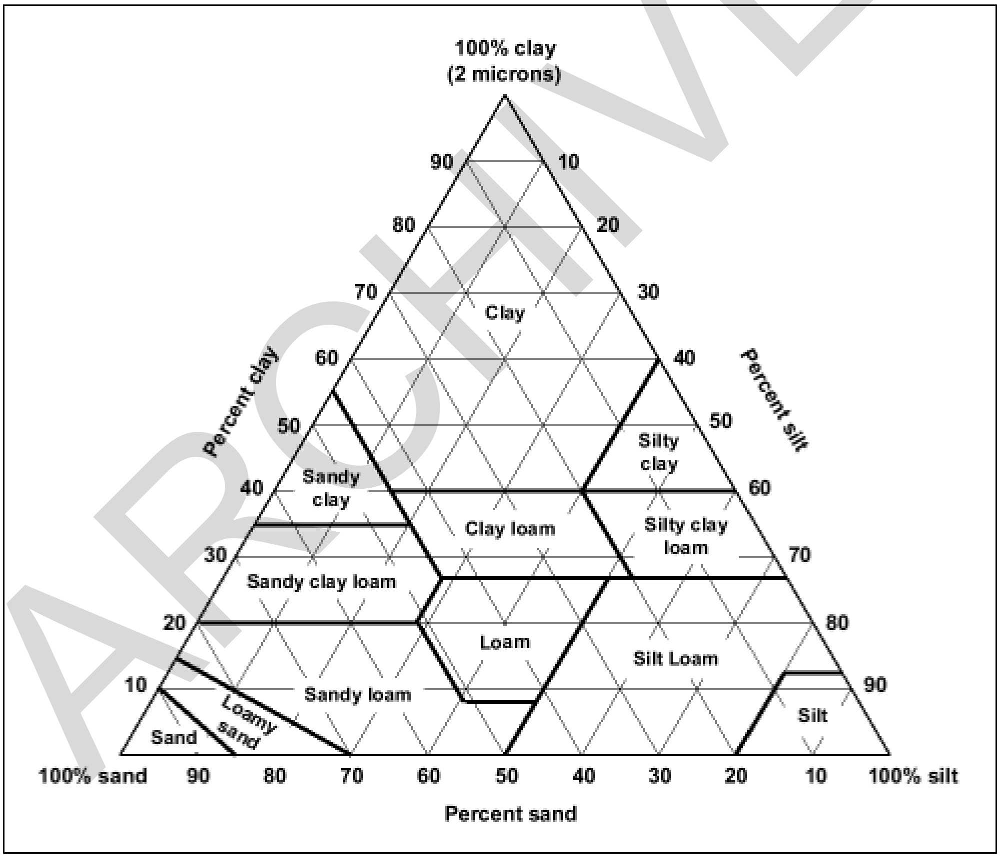

Figure 12-24: Soil Texture

General Soil Comparisons						
Soil Type	Soil Texture	Soil Components	Intake Rate	Water Retention	Drainage	Erosion
sandy	course					

soil	texture	sand	very high	very low	good	low
sandy soil	course texture	loamy sand	high	low	good	low
loamy soil	moderately coarse	sandy loam	moderately high	moderately low	good	low
loamy soil	moderately coarse	fine loam	moderately high	moderately low	good	low
loamy soil	medium texture	very fine loam	medium	moderately high	moderate	low
loamy soil	medium texture	loam	medium	moderately high	moderate	low
loamy soil	medium texture	silty loam	medium	moderately high	moderate	low
loamy soil	medium texture	silt	medium	moderately high	moderate	low
loamy soil	moderately fine	clay loam	moderately low	high	average	average
loamy soil	moderately fine	sandy clay loam	moderately low	high	average	average
loamy soil	moderately fine	silty clay loam	moderately low	high	average	average
clay soil	fine texture	sandy clay	low	high	poor	severe
clay soil	fine texture	silty clay	low	high	poor	severe
clay soil	fine texture	clay	low	high	poor	severe

12.5.2 IRRIGATION INDUSTRY DEFINITIONS GLOSSARY

Semantics is always a potential problem when discussing irrigation definitions in different areas of the United States and the world. The following list of terms and definitions are generally accepted as the standards within the irrigation industry.

Absorption rate - the rate at which soil will absorb water. It is not a static rate as it incorporates the infiltration rate and the infiltration capacity of the soil.

Acre foot - the volume of water that will cover one acre to a depth of one foot, 325,850 U.S. Gallons or 1,233,342 liters (approximately).

Acre inch - volume of water that will cover one acre one inch deep, 27,154 U.S. Gallons or 102,778 liters (approximately).

Adhesion - in irrigation, the property of attraction soil particles have for water.

Angle valve - a valve from which water flows out at a 90 degree plane from the plane at which it enters.

Anti-siphon device - a device to protect domestic water from possibly contaminated water in sprinkler system lines. Also called a vacuum breaker.

Application rate - the rate at which water is applied to an irrigated area by the delivery devices.

Arc - the degrees of coverage of a sprinkler from one side of the throw to the other. For example, a 90 degree arc would be a quarter circle sprinkler.

As-built plan - a finished plan of an installed irrigation system designating valve, sprinkler and controller locations, routing of pipe and control lines, and all other pertinent information.

Atmospheric vacuum breaker - an anti-siphon device which uses a floating seat to direct water flow. Water draining back from the irrigation lines is directed to the atmosphere to protect domestic water supply.

Automatic control valve - a valve in a sprinkler system which is activated by an automatic controller by way of control lines.

Automatic system - an irrigation system which will water in accordance to a pre-set program decided upon and programmed into the automatic controllers.

Available water - the amount of water held in the plant root zone between field capacity and the wilting point.

AWWA - abbreviation for American Water Works Association.

Backflow - water which drains back, or is sucked back from irrigation lines. Contamination of this water by insecticides, herbicides, fungicides, fertilizers, and bacteria is possible.

Backflow prevention device - a device which prevents backflowing water from irrigation lines, possibly contaminated, from mixing with domestic water supplies.

Battery (of sprinklers) - a group of sprinklers controlled by one valve.

Block (of heads) - a section of sprinklers controlled by one valve.

Block system - an irrigation system in which several groups of sprinklers are controlled by one valve for each group.

Body (of head) - the exterior case or shell of the sprinkler.

Booster pump - a pump which has a pressurized suction and is designed to raise the existing pressure of the water in the irrigation main.

Brackish water - water polluted or contaminated by organic matter, salts or acids, or a combination thereof.

Bushing - the method of adapting a fitting to either a larger or smaller size.

Caliche - a soil deposit of fine salts or clays impregnated with crystalline salts such as sodium nitrate or sodium chloride. May be a zone of calcium or mixed carbonate in soils found in semiarid regions.

Cavitation - the formation and collapse of vapor bubbles forming in a pumping situation when the pressure in the suction line or pump is reduced to the vapor pressure of the water; may cause pumping inefficiency and damage to the pump.

Check valve - a valve which permits water to flow in one direction only.

Chlorides - a compound of chlorine with another element, especially a salt or ester of hydrochloric acid.

Class (of pipe) - a method by which pipe is grouped according to the working pressure at which it can be used. Class 160 pipe can be used where pressures don't exceed 160 PSI or 11.3 pressure bars.

Clay - soil particles visible only with magnification of 100 power or more; plate-like in shape (less than .002 millimeter in diameter).

Coefficient of uniformity - a numerical expression serving as an index of the uniformity of water application to a given area within a specific geometric arrangement of sprinklers.

Cohesion - the attraction water molecules have for each other.

Consumptive irrigation water requirement - the amount of water that must be applied by irrigation to supplement stored moisture, or that furnished by precipitation, in order to supply the total moisture required.

Consumptive use - combined total of moisture withdrawn from the soil by the plant (transpiration) plus that evaporated from the soil plus the amount of water intercepted by the plant foliage. The term evapotranspiration is often used. May be expressed as acre inches or acre feet.

Control wires - the wires which transmit the signals to open and close from the automatic controller to the automatic valves.

Controller - the timing mechanism and its mounting box. The controller signals the automatic valves to open and close on a pre-set program.

Coupler key - a hollow shaft to which a sprinkler or hose can be attached and is inserted into a quick coupling valve, causing the valve to open and provide water.

Coverage - general term referring to the manner in which water is applied to the ground, with respect to the spacing between sprinklers.

Cycle - refers to one complete run of a controller through all programmed controller stations.

Design - to recommend the use of sprinkler system components which make up the total system. A design can be an informal field plot location or a formal hydraulically engineered drawing.

Designer - the individual responsible for specifying which sprinkler system components to use and how they should be utilized. The individual responsible for analyzing the performance and operation of the irrigation system.

Diaphragm - the portion of an automatic valve which regulates the passage of water through the valve.

Direct burial wire - plastic coated single-strand copper wire for use as a control line for electric valves.

Distribution - the manner in which a sprinkler applies water to the irrigated area.

Distribution curve (of a sprinkler head) - a curve showing the rate of water application by a sprinkler at various points along the radius.

Distribution pattern - the pattern of water application by a sprinkler over the area the sprinkler covers. Usually applied to sprinklers in pattern.

Double check valve - a backflow prevention device employed on irrigation systems.

Drain valve - a valve used to drain water from a line. It can be a manual drain valve in mains or laterals or an automatic drain valve in nonpressurized lines.

Dual programming - the feature on some automatic controllers which allows two diverse watering schedules.

By-pass valve - a pressure relief valve in a pumping station which opens when pumping pressures rise, dumping excess water back into the reservoir, eliminating repetitive on-off cycles of the pumps.

Electric valves - automatic valves usually controlled by a 24-30 volt current carried in direct burial ground wire between the controller and valves.

Elevation gain - pressure gained as water is used downhill from its source. It is figured at the rate of .433 pounds per square inch for each foot or .3040 kilograms per square centimeter for each meter of elevation gain.

Elevation loss - pressure lost as water is used uphill from its source. It is also figured at the rate of .433 pounds per square inch for each foot or .3040 kilograms per square centimeter for each meter of elevation gain.

Emitter (trickle) - a delivery device used in trickle (drip) irrigation to reduce the water pressure within the lateral line to nil before discharging the water to the soil.

Evaporation - the loss of water from a surface, soil, or otherwise, into the atmosphere in the form of vapor.

Evapotranspiration - refers to the total water utilized by the plant through transpiration, evaporation, and water intercepted by the plant's foliage.

Field capacity - amount of moisture held by a soil after drainage following a water application. This figure may be stated as a percentage based on a dry weight basic or in inches per foot or centimeters per meter of moisture of depth.

Flooding - excess of water on turf resulting from lone watering cycles and/or run-off from higher elevations.

Flow - the movement of water through pipe, fittings, valves, or other vessels.

Flow control valve - a valve which is pre-set and remains constant.

Flow restrictions - physical restrictions in the lines of water flow.

Foot-head - a measurement of pressure. Equivalent to .433 pounds per square inch and equal to one foot of elevation. May also be stated as .0304 kilograms per square centimeter equal to one meter of elevation.

Friction loss - the loss of pressure caused by water flowing in a pipe system. Pressure loss due to turbulence produced by water flow against the inside wall of the pipe. Friction loss is a function of the pipe inside diameter, wall surface roughness, and the velocity of the water flow.

G.P.M. - abbreviation for gallons per minute.

Globe valve - a valve through which water flows in the inlet, up through the sealing and flow control opening and out the outlet.

Gravity flow - flow of water in a pipe on a descending path.

Ground water - water found below the surface and usually not including the water flowing in underground streams.

Gauge (wire) - standards used for wire sizing. The larger the gauge number, the smaller the actual wire.

Head feet - a measure of pressure in feet of water. Equivalent to .433 psi per foot of water or .003 pressure bars of water.

Head to head spacing - spacing of sprinklers so the radius of the sprinklers match the spacing of them.

Hydraulic conductivity - refers to the readiness of soil to permit fluid flow through it; both soil and fluid characteristics determine the extent of this property.

Hydraulically controlled - an automatic valve controlled by the controller supplying and releasing water under pressure to the diaphragm or piston of the valve through use of control tubing.

Impact drive - a method of providing rotational movement to a sprinkler through the use of weighted or spring loaded arm being pushed away from the sprinkler by the water stream and returning to collide with the sprinkler to force a movement.

Infiltration - the flow of water downward through the soil.

Infiltration rate - generally used in relation to sprinkler irrigation, the rate at which the soil will take in water. Expressed or measured in inches or centimeters per hour.

Insert fittings - a fitting which fits into an irrigation pipe. It is usually used on polyethylene pipe and tubing.

Intake rate - the rate at which the soil will take in water. Often used instead of the term infiltration rate.

Expressed in inches or centimeters per hour.

Irrigation efficiency - the percentage of irrigation water that is actually stored in the soil and available for consumptive use by the plant when compared to the total amount provided to the plant.

Irrigation system - a complete set of system components including the water source, the water distribution network, and the general irrigation equipment.

Irrigation frequency - the amount of time that can be allowed between irrigation, during periods of peak water use. In agriculture, the frequency is usually expressed in days. in turf and planter applications, the frequency may be expressed in days or even hours.

Irrigation requirement - the quantity of water required to be added to the turf, shrubs, etc. to satisfy the evaporation, transpiration, and other uses of water in the soil and general environment. The irrigation requirement is usually expressed in inches or centimeters and equals the net water required divided by the irrigation efficiency.

IPS - abbreviation for pipe size: Iron Pipe Size.

Lateral - a pipe line other than the main water pressure line used to move water to the various delivery devices.

Leaching - the removal of harmful soluble salts from the plant root zone by an extra heavy application of water. The undesirable salts are carried by gravitational water to a point below or out of the root zone.

Loam - soil which has a relatively uneven mixture of different grades of sand, silt, and clay.

Loop - a piping network which allows more than one path for water to flow from the supply to the point (s) of demand.

Main - a large pipe sized to carry the water for the irrigation system. Usually sprinklers are not connected directly to the main. Main pipe lines are usually under pressure at all times unless drained during the winter.

Manual drain valve - a manual valve located at a low point in the irrigation system which allows the laterals, valves, and the mainlines to be drained during winterization of the system.

Manual system - an irrigation system in which control valves are opened manually.

Master valve - a valve installed at the supply point of the main controlling water flow into the system.

MIP - abbreviation for threads: Male Iron Pipe.

Mist irrigation - a sprinkler concept involving the application of water in the form of extremely small drops, or mist, to a plant on the basis of moisture content measurements taken off plant leaves at various times.

Moisture control - an automatic feature on the control equipment which will control the programmed cycles based on the moisture content of the soil in the area of the moisture sensor.

Net irrigation requirement - the depth of irrigation water, exclusive of rain, stored soil moisture, or ground water required for plant consumptive use.

Normally closed valve - an automatic valve through which no water will flow unless externally activated by hydraulic or electrical forces. A normally closed valve will fail to the closed position if external activation power is lost.

Normally open valve - an automatic valve through which water will flow unless external forces are applied to close the valve. Normally open valves will fail to the open position if external activation power is lost.

Operating cycle - refers to one complete run of a controller through all programmed controller stations.

Operating pressure - the pressure at which a system of sprinklers operate. Static pressure less pressure losses. Usually indicated at the base or nozzle of a sprinkler.

Orifices - openings in pipe, tubing, and nozzles.

Overlap - the coincidence of coverage by more than one sprinkler into a common area. The amount of overlap is expressed as a percentage of the radius or spacing of the sprinklers.

Peak consumptive use - the average daily rate at which moisture is used during the growing season at periods when evapotranspiration is at the highest level. Peak consumptive use may be expressed in inches or centimeters of water per day.

Peak moisture demand - the amount of moisture required by a plant during its period of maximum growth which usually occurs during the time when temperatures are at a maximum; transpiration and evaporation are generally at their highest levels at this time.

Percolation - the movement of water through the soil.

Permanent wilting point - refers to the moisture content of the soil at which plants can no longer obtain enough water to meet transpiration requirements.

Permeability - the quality of soil that permits water and air to be moved through it.

Precipitation rate - the rate at which sprinklers apply water to the turf. Usually figured for a pattern at a given spacing. It is expressed in inches per hour.

PSI - abbreviation for pounds per square inch, the standard pressure measurement of water.

PVC pipe - unplasticized polyvinyl chloride pipe. A semi-rigid plastic pipe in general use in irrigation systems.

Polyethylene pipe - a black flexible pipe commonly used in drip and sprinkler irrigation systems. PE pipe for irrigation usage is manufactured with controlled inside and outside diameters.

Potable water - water meant for human consumption. Domestic or drinkable water. it can be used for irrigation systems as long as protection through a backflow prevention device is provided to prevent contamination to the domestic supply.

Pressure - the force per unit area measured in pounds per square inch or centimeter, psi or kilograms per square centimeter, or head feet or meter.

Pressure loss - the loss of pressure under flow conditions caused by friction or elevation.

Pressure regulator - a device which regulates the available pressure to a pre-set maximum under static or flow conditions.

Pressure rating - a rating of pipe for a given pressure.

Pressure relief valve - a valve which opens when the pressure exceeds a pre-set point.

Pressure vacuum breaker - a backflow prevention device incorporating the use of a spring loaded seat for positive sealing to protect domestic water from possibly contaminated irrigation water.

Program - the watering plan or schedule.

Programming - the act of devising and applying groups of sprinklers to the controllers; a plan or procedure for irrigating the plant material.

Pump circuit - the feature on some automatic controllers allowing a connection to be made with the pump starter of the pump so the starter will be energized when the watering cycle begins.

Quick coupling system - a sprinkler system which uses quick coupling valves, keys, and impact heads. The valves are permanently installed with the keys and sprinklers manually moved from valve to valve.

Rain shut-down switch - a device stopping the watering program when a pre-set amount of rain falls.

Rate of application - the rate at which water is applied to the ground by the sprinklers within a pattern, sometimes referred to as precipitation rate.

Reduced pressure backflow preventer - a reduced pressure principle backflow preventer is a device consisting of two positive seating check valves, and an automatically operating pressure differential relief valve internally located between the two check valves, installed as a unit between two tightly closing shut-off valves, and fitted with properly located test cocks. During normal operation, the pressure in the zone between the two check valves is maintained at a lower pressure than the supply pressure. If the zone pressure starts to approach the supply pressure, the differential pressure relief valve will automatically maintain a differential of not less than .14 pressure bars between the supply pressure and the zone between the two check valves by discharging to the atmosphere. This device is effective against backflow caused by backpressure and back-siphonage and is used to protect the water system from substances which are hazardous to health.

Remote control unit - the device used to activate automatic remote control valves. It can be automatically or manually controlled.

Repeat cycle - the programming of an automatic controller to repeat an irrigation cycle automatically for those controller stations so set.

Riser - usually refers to a length of pipe affixed to a lateral line, or submain for the purpose of supporting a valve or sprinkler head.

Run-off - water which is not absorbed by the soil and turf to which it is applied. Run-off occurs when water is applied at too great a rate or when there is severe slope.

Quick coupling valve - the valve used in a quick coupling system which is activated by a coupling key.

SDR - abbreviation for Standard Dimension Ratio.

Saddle - a type of fitting which goes over a pipe. A hole is drilled through the pipe to furnish water to the outlet of the saddle.

Sand - soil particles that can be seen with the naked eye and felt as an individual grain; they vary in size from fine to coarse.

Sandy loam - a soil made up predominately of sand particles by having enough silt and clay particles to make it cohesive.

Silt - soil particles that appear and feel flour-like; a grain of silt requires approximately 4-power magnification before it can be seen; it may be either rough or angular in shape, just as sand.

Sleeve - pipe through which hydraulic tubing or electrical wiring is run for added protection or for ease in replacing tubing or wire when running under pavement or sidewalks.

Slip fitting - a fitting that is solvent welded on PVC or ABS pipe.

Solvent - a material causing a partial dissolving of PVC or ABS pipe and fittings so a chemical fusion can be accomplished between the pipe and the fitting.

Solvent welding - the act of chemically fusing pipe and fittings together using solvent.

Spacing - the distance between individual delivery devices.

Static pressure - the pressure of water when it is not moving (stationary).

Station - a position on the controller which indicates control of automatic valves.

Surge - an energy wave in pipe lines caused by sudden opening or closing of valves.

Swing check valve - a valve allowing water flow in only one direction. Closure against a backflow is provided by the weight of the pendulum action seat.

Swing joint - a threaded connection between pipe and sprinkler allowing movement to be taken up in the threads rather than as a sheer force on the pipes. Also used to raise or lower sprinklers to final grade.

Tensiometer - a device for measuring the moisture content of the soil that works on the principle that a partial vacuum is created in a closed tube when water moves out through a porous ceramic tip to the surrounding soil; the tension causing the movement of water is measured on a vacuum gauge.

Tension - energy used in moving moisture from a soil or exerted by soil particles to hold moisture; the higher the moisture content of a soil, the lower the tension and vice versa.

Threaded fitting - a fitting having threads to receive the standard pipe thread.

Transpiration - the process by which a plant removes water from the soil throughout itself to its leaves and transpires moisture to the atmosphere.

Uniformity of application - a general term designating how uniform the application of the delivery device is over the area it is covering while in pattern.

Vacuum breaker - a type of backflow prevention device which prevents the reverse flow of water from a potentially contaminated source to the potable water supply by allowing air to enter the supply line to break the vacuum or siphon condition.

Valve-in-head - indicates the automatic control valve is part of the sprinkler.

Valve-under-head - a sprinkler system in which there is a separate automatic valve under each sprinkler. The valve is a separate and independent component of the system.

Velocity (of water) - the speed at which water travels.

Wall-to wall coverage - indicates complete coverage of the area to be irrigated from one border to the other.

Water hammer - a shock wave created by a fast closing valve throughout the entire irrigation zone piping.

Water pressure - pressure which water exerts as measured in pounds per square inch, kilograms per square centimeter, head feet, or head meter.

Wire gauge - size standards for wire, the higher the number the smaller the wire.

12.5.3 ZONE LOSS CALCULATION CHART

The following chart should be used by the designer to figure typical water pressure losses due to installed irrigation system components. Total design bars must be less than the available system static bars or the system will not function to its full capability. Utilize tables from irrigation industry manufacturers or found in various design manuals for further explanation and assistance. Some allowance for pressure variation must also be calculated in. Many designers allow a minimum of 10% pressure variation.

Item	Pressure Loss	Cumulative Total
Service line loss (installation main to meter)		
Meter loss		
Backflow prevention device		
Gate valve, master valve, or cut-off		
Main line loss		

Remote control valve loss		
Zone loss		
Elevation (+ or -)		
Pressure required under each head or delivery device		
TOTAL		

12.5.4 PIPE SIZING PLANNING FACTORS

Guidance for all zones

- Maximum recommended water velocity is 15 cm/second
- Maximum allowable bar loss for each different pipe size is .35 bars
- Use the lesser flow when considering maximum allowable velocity and maximum bar loss for each pipe size determines the size of the pipe to apply

Zones less than or equal to 40 meters

When total zone pipe distances between the closest head from the valve to the furthest head is less than or equal to 40 meters, the industry "rule of thumb" is applicable and acceptable:

- 13 millimeter pipe use 5 liters per minute (lpm) or .3 cubic meters per hour
- 19 millimeter pipe use 10 lpm or .6 cubic meters per hour
- 26 millimeter pipe use 16 lpm or 1 cubic meters per hour
- 32 millimeter pipe use 26 lpm or 1.6 cubic meters per hour
- 38 millimeter pipe use 35 lpm or 2.3 cubic meters per hour
- 52 millimeter pipe use 55 lpm or 3.3 cubic meters per hour

Zones greater than 40 meters

When zone pipe distances are greater than 40 meters between the closest and furthest head from the valve, "rule of thumb" sizing makes no allowance for excessive accumulation of pressure loss. Therefore, use the following guidance:

- Excessive pressure differential between the closest and furthest points is unacceptable and causes uneven distribution of water
- In these instances, recommend referral to a professional design manual or an individual in the irrigation industry

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13.1 INTRODUCTION

With the passing of the National Environmental Protection Act in 1971, there has been increased awareness regarding conservation of our natural resources. Pure, fresh water is nature's most precious resource. Increasing demand and diminishing resources make it necessary to reduce waste and increase the efficiency with which we use the available supplies. Out of this necessity has come remarkable innovations in many fields of study for application to this effort.

In landscape architecture, the application of conservation-oriented ideals has led the profession in diverse directions. The most basic of these are using native, naturally-occurring plant materials in landscape design and highly-efficient water delivery systems in irrigation design. In addition, the landscape architectural field has embraced the creation of sustainable landscapes and the preservation of native and endangered species fostering a sense of pride and a deeper understanding of responsible landscape development.

An associated phenomenon of this conservation movement was the coining of the term "xeriscape" by the City of Denver, Colorado Water Department. Xeriscape is derived from the Greek work, xeros, or dry. The xeriscape philosophy embodies rudimentary landscape architectural principles regardless of the region or climate. This philosophy challenges the designer to create landscapes that convey a sense of regional context in plant selection and placement with the intent purpose of minimizing supplemental irrigation.

This document provides basic guidance and direction to improve the understanding and implementation of the xeriscape philosophy in landscape design.

13.1.1 DEFINITION

Xeriscape is the conservation of water and energy through creative and adaptive landscape design. Xeriscape landscapes provide attractive solutions that save money, water, and maintenance.

13.1.2 GOAL

The goal of the Xeriscape Design Guide is to facilitate the design and construction of water-efficient, attractive, and easily-maintainable landscapes at Air Force installations.

13.1.3 OBJECTIVE

The objective of the Xeriscape Design Guide is to provide a framework for the successful implementation of water-efficient landscapes. This will be accomplished by providing insight into the design process that incorporates the seven xeriscape design principles.

13.1.4 GUIDE ORGANIZATION

Design Principles

- Provide insight into the overall conceptual approach and specific design principles of the xeriscape design process

Conclusion

- Provide tips on xeriscape design application

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13.2 DESIGN PRINCIPLES

13.2.1 INTRODUCTION

The human body needs only about two gallons of water each day to maintain itself. Yet, even in a water-conscious community like Tucson, Arizona, residents use an average of nearly 30 gallons of water per person per day maintaining their landscapes. In some communities, outdoor water use for landscape purposes consumes 40% or more of available area fresh water supplies. Although outdoor water use cannot be eliminated, it can be greatly reduced through appropriate xeriscape design techniques and proper maintenance practices.

This chapter will address the following issues of xeriscape design:

- **13.2.2 WATER BUDGETING**
- **13.2.3 XERISCAPE DESIGN PRINCIPLES**
- **13.2.4 ADDITIONAL TECHNIQUESS**

13.2.2 WATER BUDGETING

The concept of budgeting water use in the landscape is integral to xeriscape design. Concentrating plants with similar water-use requirements, or creating hydrozones, simplifies and economizes irrigation system design and maintenance requirements.

Hydrozoning a landscape development project based on site use patterns, plant material densities, supplemental water requirements, and microclimates is fully embodied in the concept of water budgeting. There are three xeriscape hydrozones:

- **Inner zone**
- **Intermediate zone**
- **Outer zone**

Inner zone

The inner zone of a xeriscape planting is the area which will have high visibility and be significantly important to the facility in terms of appearance, image, and usage. Even though this zone has a higher water demand the other zones, it can still require less irrigation than a traditional landscape. Supplemental irrigation will most likely be required. The inner zone may be a modest entry feature at the Family Support Center, a backyard planting in Military Family Housing, or a special memorial area of a large, multi-use park.

Regardless, this zone should be kept relatively small and functional in size. Water-loving plants can be used in this zone if they are placed where irrigation or other runoff can be collected or redirected. In low rainfall regions, this zone functions as a mini-oasis. The landscape design is generally characterized by increased plant densities and relative lushness.

Intermediate zone

The intermediate zone functions as the transitional area between the inner and outer zones. Plants in this zone may require more water than available from natural precipitation. They probably will require some supplemental irrigation in drier climates. Plant densities are reduced as compared to the inner zone. Overall, maintenance and water use should be minimal. By taking advantage of runoff from paved areas or roof drains, supplemental irrigation can be further reduced.

Outer zone

The outer zone is generally characterized by plants having the least water requirements and lowest intensity of human use. Once established, plants in the outer zone generally require very little to no irrigation or maintenance with the exception of weed control and occasional pruning. Plant materials should be chosen especially for their hardiness and extremely low water requirements.

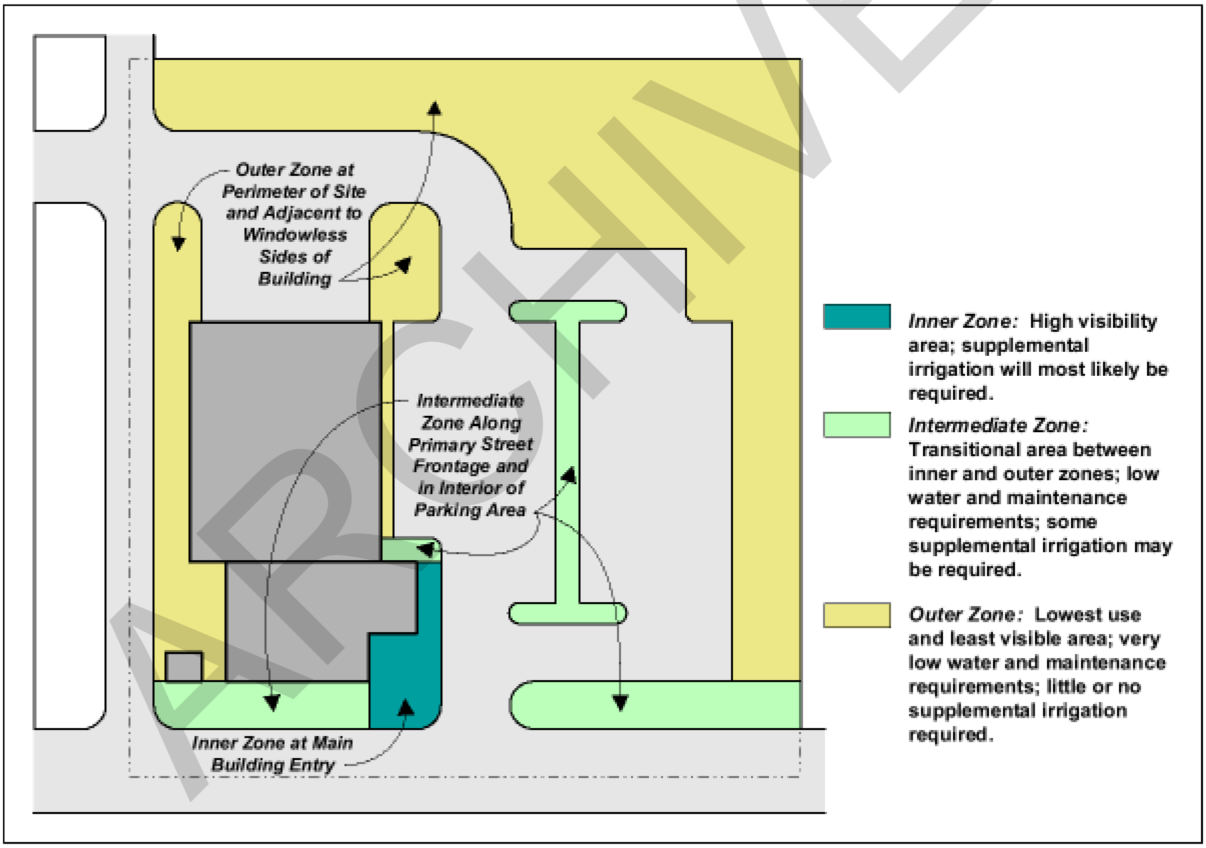

Figure 13-1: Hydrozoning Concept Plan

13.2.3 XERISCAPE PRINCIPLES

By applying the following principles of xeriscape design, installations can use valuable water resources efficiently and lower maintenance requirements while increasing the aesthetic appeal of the landscape:

- **Start With A Plan**
- **Minimize Turf Areas**
- **Improve The Soil**
- **Irrigate Efficiently**
- **Select Water-Efficient Plants**
- **Use Mulches**
- **Practice Proper Maintenance**

Start with a plan

Imagine beginning a vacation to a remote location with no maps, no hotel reservations, or even an idea how much money or what currency you will need during your trip. A similar type of journey can be taken in the landscape simply by not having a plan.

Developing a plan before starting any landscape project is the single most important step in the design process. Chapter 3, Landscape Design Guide and Chapter 2, Planting Design Guide provides further information on developing a plan.

Minimize Turf Areas

Turf requires the most water and maintenance of all plant types. For example, a 3000 square foot turf area, irrigated 3 to 5 times a week for 10 to 30 minutes each time uses between 9000 to 15000 gallons of water per month. The same area planted with a low-water groundcover requires only about 10% of that amount of irrigation. Therefore, the designer needs to consider size, location, and variety of turfgrass for each project. The following issues on turf areas should be reviewed in creating an efficient xeriscape:

- Select and maintain turf areas where they will be the most beneficial based on local irrigation limitations
- Select turf varieties that will thrive in the local environment and require minimal additional irrigation
- Design larger turf areas in shallow depressions to passively collect rainwater
- Consider using alternative plant materials that may be less water-demanding; or inert materials in place of turf

Improve the soil

Soils can vary greatly over an installation or even over a job site. A soils analysis will determine exactly what improvements may be required. In general, organic matter and amendments that decrease or increase soil acidity, or pH, are the most common additives used to improve soils.

Although native plants in a region may not require soil improvements to thrive, the addition of organic matter allows better absorption of water and improves water-holding capacities while providing beneficial nutrients for the plants.

Most plants seem to thrive in slightly acid or neutral soils, so the addition of lime and sulfur can respectively raise or lower the pH to create a more effective plant growing medium. Improving the soil in xeriscape plantings provides the following benefits:

- Plants will grow better and use water more effectively and efficiently
- Rainfall will more readily be absorbed by the soil surrounding the plants thereby reducing runoff, erosion, and the frequency of supplemental irrigation

Irrigate efficiently

The Irrigation Design Guide covers important topics related to efficiently delivering supplemental water to plant material. There are three important practices associated with irrigating a xeriscape planting: watering slowly, deeply, and infrequently.

Water slowly

Never apply water faster than the infiltration rate of the soil. Sandy soils absorb water quickly, clay soils slowly, and loam soils somewhere in between.

Slow and even irrigation allows for proper soil moisture to be maintained in the root zone, providing for the best growing conditions for plant material while eliminating or minimizing runoff and potential erosion.

Water deeply

Irrigate each plant variety long enough for water to reach the root zone. Determine depth of water penetration by pushing a metal rod into the wet soil. The rod will stop when it reaches dry soil. Irrigation water should reach at least to 2/3 the actual depth of plant roots for optimum irrigation cycle timing. Record the amount of time it took the system to reach this depth to assist in proper programming of irrigation controllers.

Water infrequently

During hot summer months, plants obviously will require more supplemental water. This does not mean plants should be irrigated every day. A deep soaking once a week is much more beneficial than several light sprinklings every day or so. Deep watering promotes deeper roots further reducing irrigation requirements by naturally providing more soil between the hot dry sun and tender roots. Never water more than every other day, and during high winds.

Select water-efficient plants

In most climatic regions there are a number of attractive trees, shrubs, groundcovers, vines, and grasses that require little or no supplemental water to thrive. Installations should populate their plant lists with these natives that have demonstrated their long term landscape value through their hardiness, availability, and minimal maintenance and water requirements.

Nursery owners are regularly testing new "discoveries" from the wild that can be used by the designer to create functional, beautiful, and water-efficient landscape solutions.

An important consideration for developing a plant list at an arid region installation is to ensure a sufficient number of plant varieties for all three hydrozones. Many native, arid region plants will not perform well in shade. The installation plant list should provide for sufficient diversity of shade-tolerant plant materials.

Please see Chapter 2 of the Landscape Planning Guide for further details on the installation plant list selection process.

Use mulches

Organic or inert mulches applied to proper depths will reduce water needs and weed growth while providing visual interest and surface erosion control. Organic mulches such as pine needles and shredded or chipped bark provide the added benefit of improving the soil through slow decomposition.

Mulch should be placed directly on the soil around all plant materials. Avoid plastic sheeting and certain plastic-based fibrous matting. These materials do not prevent weed growth and slowly decompose over time creating maintenance difficulties.

Practice proper maintenance

In general, an established, well-designed xeriscape planting naturally requires minimal maintenance. A xeriscape planting will save water and require less fertilizer and insecticides. Use of systemic contact herbicides on noxious weeds like Bermudagrass in non-turf areas along with regular applications of pre-emergent herbicides will greatly reduce labor requirements over the long term. Some maintenance practices that can save water are:

- Raise the height of turfgrass mowers
- Regularly inspect irrigation sprinklers for leaks or breaks
- Prune and thin out heavily-foliated trees and shrubs to reduce evapotranspiration through the leaves
- Replenish mulch around plants

13.2.4 ADDITIONAL TECHNIQUES

Some additional techniques to minimize landscape water use:

Rainwater harvesting

Since many arid region installations use potable drinking water for a large quantity of irrigation needs, additional methods of supplying water to plants should be employed. A simple, yet effective way to accomplish this is through passive rainwater harvesting. Rainwater harvesting is a technique for collecting, concentrating, and storing natural rainfall for use by plants.

There are many ways to collect or redirect rainfall runoff from roofs, paved areas (such as walkways, driveways, and streets), or through the manipulation of the groundplane. The following are a few ideas for harvesting rainwater in the landscape:

- Gentle berming can guide rainfall to higher water using plants
- Sensitive site grading can direct water to collect in turfgrass or groundcover areas

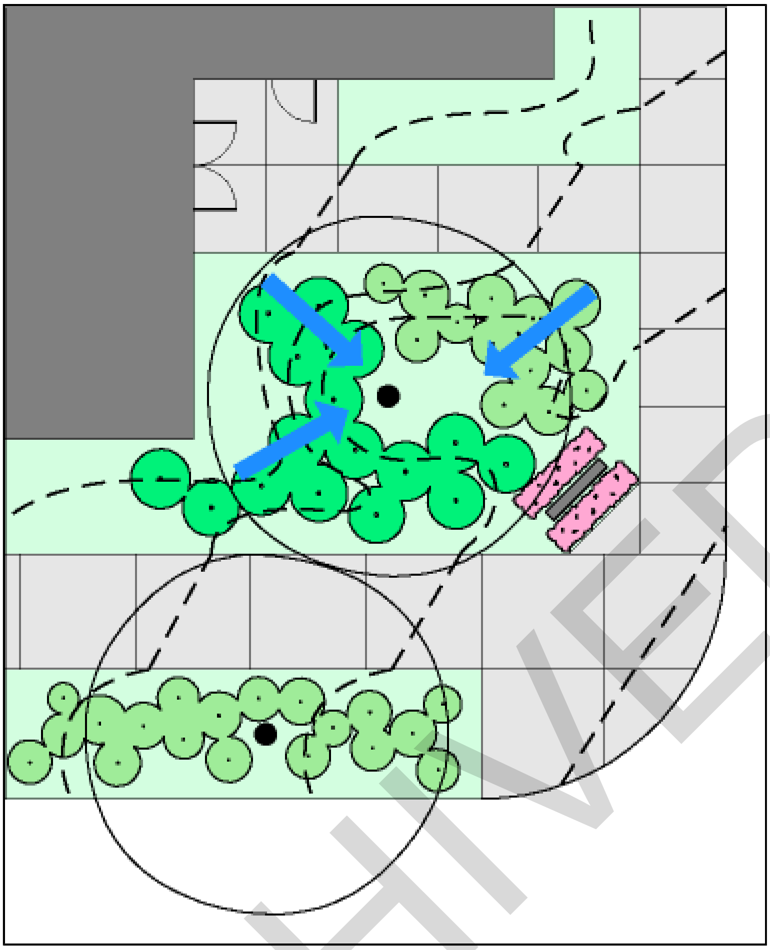

Figure 13-2: Water Harvesting with Grading

Planting

Horticulturists are constantly striving to improve plant materials, planting details, and soil mixes. There has been significant development in each of these areas. The following are a few pointers that may be applicable in implementing a xeriscape program:

- Consult with local nursery owners and county extension agents to ensure that the installation plant list contains a good selection of water-efficient plant material. It is also an opportune time to see what new varieties are available and adding them to
- Investigate new water-absorbing soil additives and conduct experiments in the field to determine success and cost effectiveness prior to modifying standard installation landscape construction specifications and details
- In arid regions, experiment with planting details that create a mini, water harvesting basin below grade that collects rainwater directly around the plant

13.3 CONCLUSION

This guide promotes xeriscape design principles and practices that minimize water use while maximizing long term aesthetics and maintainability. These xeriscape design principles are not new to the industry. They have been practiced for many years. By combining the seven xeriscape principles with the overall project design process, unique and attractive solutions can be realized while significantly reducing overall water use.

13.3.1 XERISCAPE DESIGN DO'S AND DON'TS

Do's

Follow these design and maintenance principles for functional and attractive xeriscape plantings:

- Contact local landscape architects, nursery personnel, and county extension agents to obtain specific xeriscape information
- Regularly update the installation plant list to include newly-available water-efficient material
- Replace missing or broken sprinkler heads or emitters immediately
- Adjust irrigation controller programs according to temperature and seasonal changes
- Regularly inspect emitter flow, flush distribution tubing and clean filters on drip systems
- Consider replacing turf areas with groundcovers or inert materials
- Mulch plants wherever possible
- Integrate well-timed applications of fertilizers, pesticides, and herbicides to the maintenance program of xeriscape plantings
- Conduct regular xeriscape seminars to assist the understanding and appreciation of water-conserving practices among Military Family Housing residents and facility managers and custodians

Don'ts

- Don't use sun-loving turfgrass varieties in dense shade
- Don't apply more water than the plant or planting area can readily absorb
- Don't mow turfgrasses lower than prescribed by local county extension agents or other experienced landscape professionals
- Don't install large areas of lava rock or gravel
- Don't use plastic sheeting under xeriscape plantings or inert materials attempting to prevent weed growth
- Don't rule out metering, leak detection, and water reuse when examining overall installation water reduction programs

13.3.2 REFERENCES

Suggested further reading:

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14.1 INTRODUCTION

Some of the most visually dominating elements of an installation are its parking areas. Every facility has parking requirements - residents, workers, customers, visitors, students, and delivery personnel all have parking needs. When parking areas are properly and concurrently planned, designed, and developed with facilities; installations can realize long term efficiency and convenience while minimizing costs.

- *Parking area design* is the logical process of determining the physical area requirements and providing for installation and facility vehicle parking needs. Good parking area design contributes to an aesthetically pleasing and maintainable installation. Proper siting and construction of safe and functional parking areas fulfill the needs of facility users.

- The *goal* of the Parking Area Design Guide is to facilitate the design and construction of efficient, attractive, and functional parking areas. This will be accomplished by fostering an increased awareness and understanding of the issues facing the designer.

- The *objective* of the Parking Area Design Guide is to provide a framework for the successful delineation and implementation of logical parking areas. This will be accomplished by providing insight into the design process that incorporates basic, time-proven design principles.

14.2 PARKING DESIGN CONSIDERATIONS

Provide insight into the basic issues that must be addressed and integrated into the early phases of the parking area design process

14.3 CONCLUSION

Lists parking area design situations to follow or avoid.

14.2 PARKING DESIGN CONSIDERATIONS

Aesthetically pleasing and functional parking areas that fulfill the needs and requirements of the users should be the primary goal of the designer. A well-defined design process will greatly increase the probability of creating parking areas that satisfy this goal. This chapter will address the following factors of parking area design:

14.2.1 NEEDS ANALYSIS

Air Force Handbook, 32-1084 provides criteria for parking associated with facility types. An excerpt of the handbook is provided in the Appendix for the designer's convenience. Commanders and managers who plan, program, review, certify, and approve Air Force projects should use the handbook as a guide.

Parking study

In determining needs for a specific facility, the designer must perform a comprehensive and detailed analysis. Often part of a larger transportation plan, a parking study can be a valuable analytical tool. A parking study can inventory existing parking areas, spaces, and their use to determine the adequacy and efficiency of current configurations. These studies can be used to determine deficiencies in the total number of spaces and how long the spaces are being occupied. The parking study may be used as the basis for recommending additional spaces as well as altering configuration or circulation patterns.

The parking study may include the following items:

- Inventory of total parking spaces within a specific area
- Analysis of specific problems such as poor location or deficiency of visitor or reserved parking areas and employee parking
- Determination of parking duration and turnover rates
- Identifying access difficulties and poor pavement or plant material condition
- Refuse collection or service access requirements

Parking requirement factors

Overall parking requirements can be influenced based on the following:

- Collocation of compatible facilities to use common parking areas
- Reducing vehicle use through encouraging use of alternative transportation methods
- Providing safe and attractively landscaped bike paths and walkways

14.2.2 PHYSICAL REQUIREMENTS

Siting

To most people, the ideal parking space is a few steps from their home or office door. The designer must look at a number of concerns to logically, efficiently, and economically site parking areas. Some of these include:

- Minimizing excessive grading operations and balancing cut and fill
- Integrating adequate parking spaces with surrounding facilities and existing circulation patterns
- Locating parking areas convenient to building entrances
- Using topography and trees to mitigate negative visual impacts
- Separating customer and employee parking areas
- Preserving sight lines to entries and significant landscape and architectural features
- Minimizing negative impacts to the natural environment such as unnecessarily removing mature vegetation or degrading soil stability
- Preserving and integrating existing mature trees in future parking

Orientation

To create safe and convenient parking areas, the orientation and configuration of the parking area must be considered early in the siting process.

- Align rows of parking spaces perpendicular to the facility minimizing the number of pedestrian aisle crossings
- Provide access points and crosswalks from parking areas to facility entries

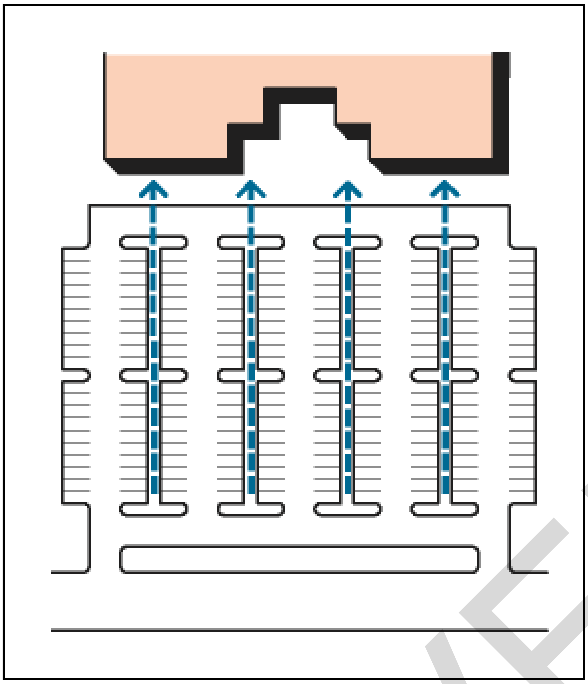

Figure 14-1a: Orient Parking Bays Perpendicular to Facility

Figure 14-1b: Orient Parking Bays Perpendicular to Facility

User walking distance

Long term users, such as employees, will generally accept longer walking distances from parking areas to their workplace. Short term users such as customers or visitors expect shorter walking distances. Parking spaces for a specific facility should not be more than 75 meters from the facility entrance.

Miscellaneous

General planning and design

Some common parking area planning and design guidelines are:

- Use 36 square meters per vehicle (includes entry, circulation, and parking spaces) as a typical planning and cost estimating factor
- Minimize parking area entrance and exit curb cuts

- Locate separate visitor and reserved parking at the front entry of the facility
- Eliminate dead-end parking areas
- Locate entrances and exits away from busy intersections
- Locate aisles and rows of parking parallel to the long dimension of the site with parking on each side of an aisle
- Use rectangular parking areas to minimize land area requirement

Setbacks

The designer should observe proper setbacks in designing parking areas:

Suggested Parking Area Setbacks

From	To	Minimum Distance (Meters)
Parking area curbing	Facility walls	6
Parking area entrances & exits	Roadway intersections	15-45
Parking area curbing	Perimeter screen walls	1.5
Parking area perimeter	Parallel roadway	6
Parking area curbing	Outside edge of adjoining walkways	2

Grading and drainage

Parking areas must be properly sloped and drained to take care of runoff. Apply the following minimums:

- Ideal slope for all parking area pavements is 2%
- Longitudinal pavement slope should be between 1%-5%
- Pavement cross slope should be between 1%-10%
- Storm water should be collected on the perimeter of parking areas with a minimum of 2% slope along concrete curb and gutter

Curve radii

The radius of a parking area entry or exit curb return should be at least 4 meters. When significant use by buses or tractor trailers is expected, the radius should be increased to 13 meters. Interior radii for perimeter curbing and islands can be reduced to 2 meters. Care should be taken to provide an inside turning radius of at least 4 meters on all internal vehicle circulation aisles.

Islands

Curbed or painted non-parking zones inside a parking area are referred to as islands. They can increase safety and aesthetics and control circulation. Ideally, islands are curbed. They should be at least 2.5 meters wide if trees are to be planted.

Islands can be created using reflective striping or paint on the pavement surface. Painted islands do not provide a physical barrier to vehicle circulation. Plants should not be installed without curbed islands for protection.

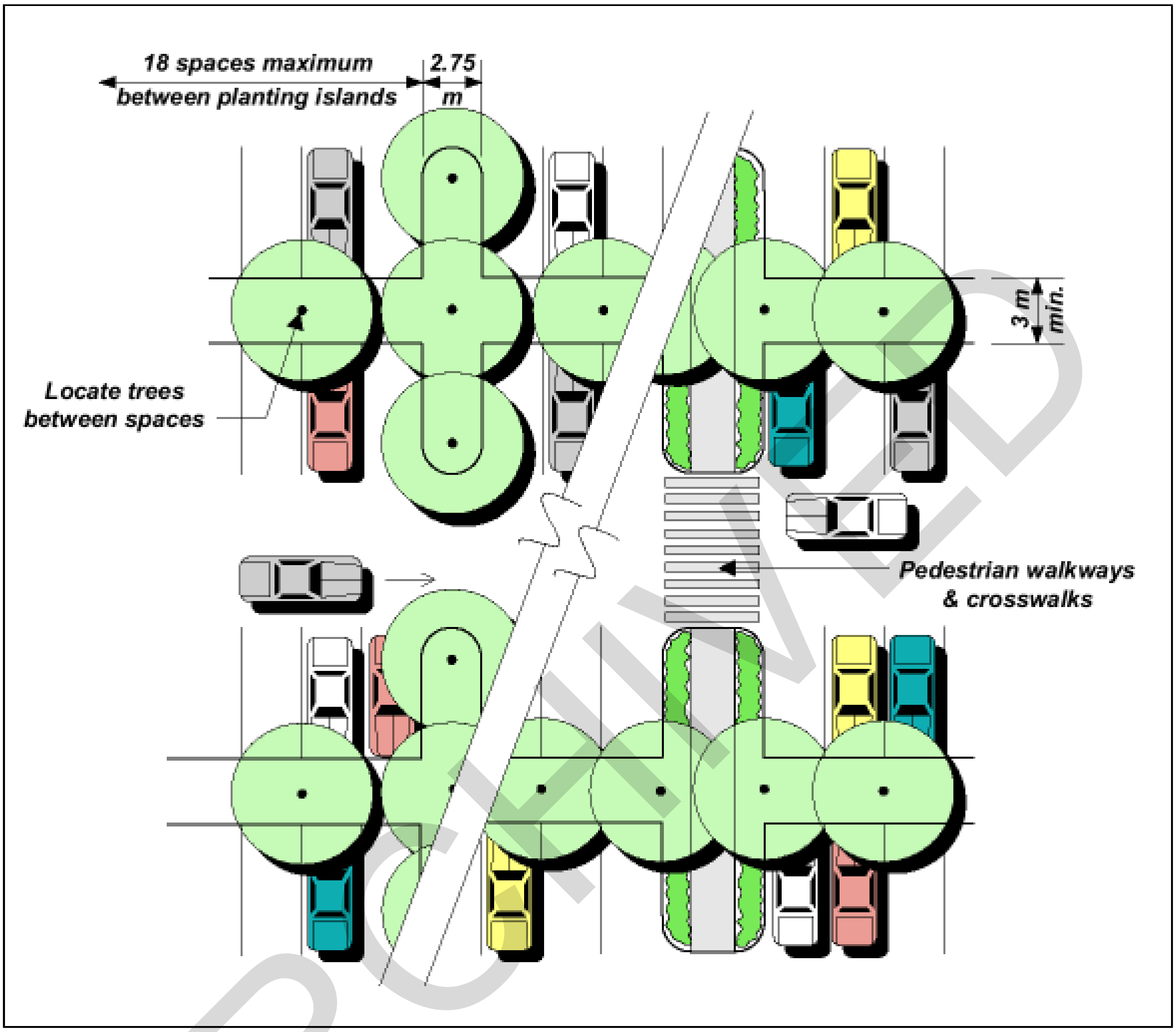

Figure 14-2a: Planting Islands and Pedestrian Paving

Figure 14-2b: Example of Pedestrian Paving in a Parking Island

Parking Area Types

Off-street

Off-street parking is the most common and accepted method of satisfying facility parking needs. In many cases, these areas are developed as one large mass parking area. The result is often an installation dotted with huge expanses of asphalt with little consideration of the negative visual impacts. When siting off-street parking areas, the designer should consider:

- Creating multiple smaller parking areas rather than one large mass
- Integrating planted islands to increase aesthetics
- Minimize extensive grading operations by designing to the topography
- Ensuring a distance of at least 15 meters is provided from proposed parking area entrances and exits to intersections
- Minimizing the number of entrances and exits

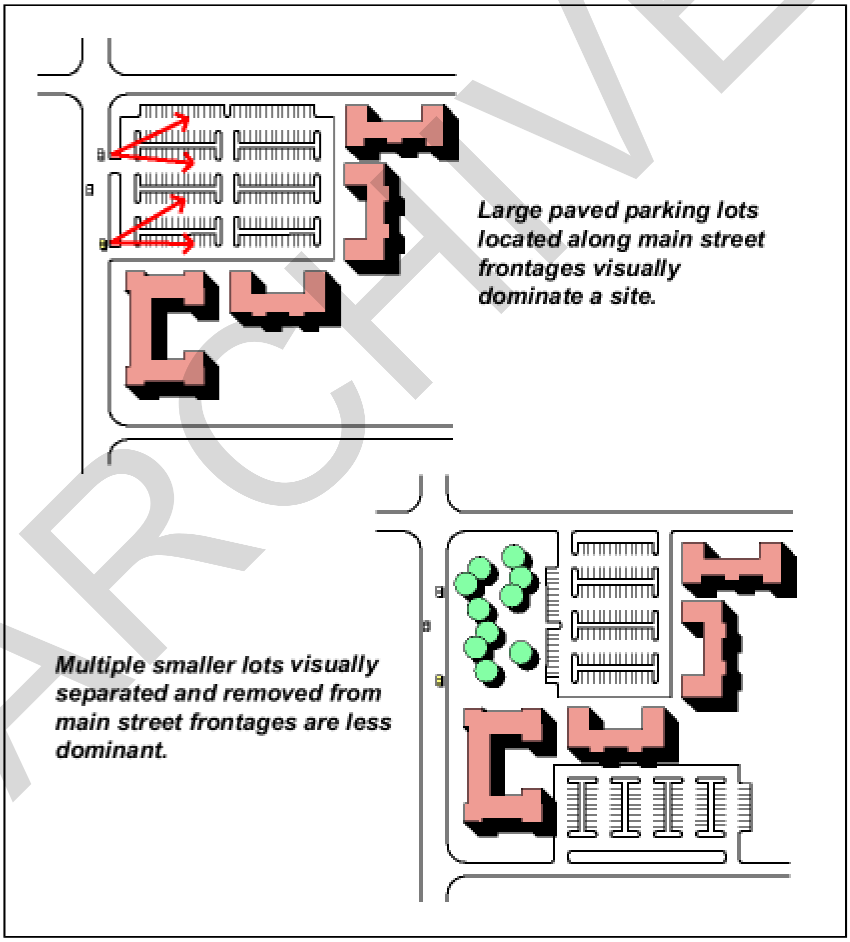

Figure 14-3: Multiple Smaller Parking Areas

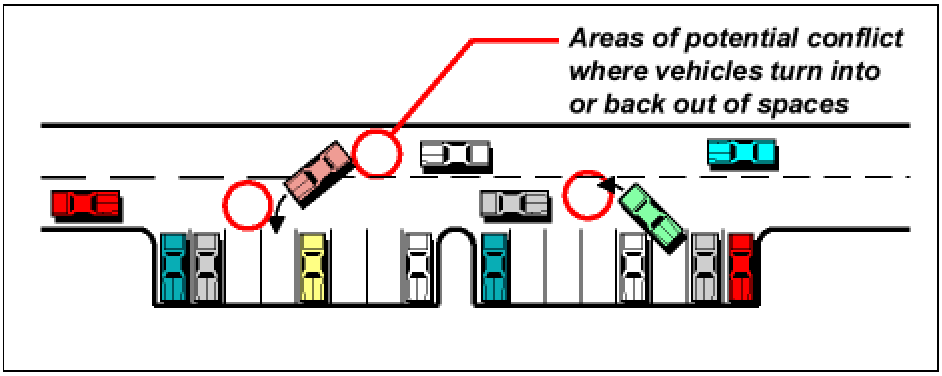

Figure 14-4: Avoid On-street Perpendicular Parking

On-street

According to Air Force Handbook, 32-1084, the Department of Defense does not support constructing streets that include on-street parking. Many installations however, are using existing streets to accommodate their parking needs this way. If on-street parking is used, the following factors must be considered:

- Permit only parallel parking
- Maintain a minimum distance of 15 meters from on-street parking spaces to intersections and off-street parking area entrances
- Break up long lines of vehicles with occasional planting island projections if appropriate
- Ensure streets maintain required traffic-carrying capacities and provide safe vehicular and pedestrian passage

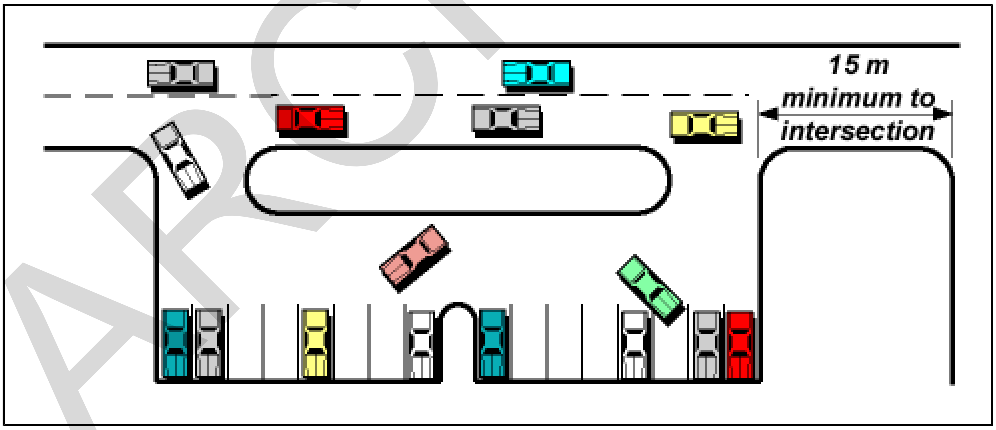

Figure 14-5: Off-street Perpendicular Parking

Geometry

Parking areas take on many configurations. Parking spaces may be parallel, perpendicular, or angled (30, 45, or 60 degree) to the driving lane, or aisle. A common factor among these various parking layouts is the size of the parking space. The minimum standard automobile parking space should be 6 meters long and 2.75 meters wide. Aisle widths vary based on the angle chosen and if they are one- or two-way. Two-way aisles should be a minimum of 7 meters wide.

The area required by each parking configuration will vary. As a general rule of thumb, the closer to perpendicular, the more vehicles can be parked per linear meter. Perpendicular, or 90 degree parking, accommodates 82 vehicles per 100 linear meters versus just less than 40 vehicles for 30 degree. A summary of the dimensions and attributes of the parking area configurations is provided in the Appendix. Some of the advantages and disadvantages of the various parking configurations are addressed in the following paragraphs.

Parallel

For the designer, the parallel parking configuration can be used where suitable off-street parking cannot be accommodated or is not practical. For the driver, parallel parking requires experience, confidence, and patience.

Parking spaces should be a minimum of 7.5 meters long and at least 2.75 meters wide. On-street parallel parking spaces should be 3.35 meters wide.

Advantages

- Works well in extremely narrow, linear spaces
- Requires minimum pavement area

Disadvantages

- Difficult maneuvering for most drivers
- Less than ideal visibility of adjacent traffic
- Inefficient use of on-street space

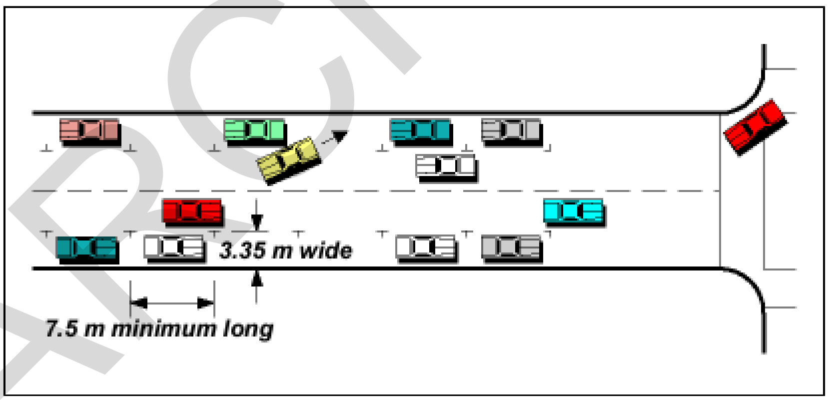

Figure 14-6: On-street Parallel Parking

Perpendicular

Especially effective in low turnover rate or long term parking areas, the perpendicular, or 90 degree parking configuration is the most efficient and economical since it accommodates the most vehicles per linear meter. Standard dimensions for this configuration are:

Description	Dimension
Parking space width	2.75 meters

Parking space length	6 meters
Driving aisle width (2-way)	7 meters
Two rows plus aisle width	19 meters
Vehicles per 100 linear meter double row	82

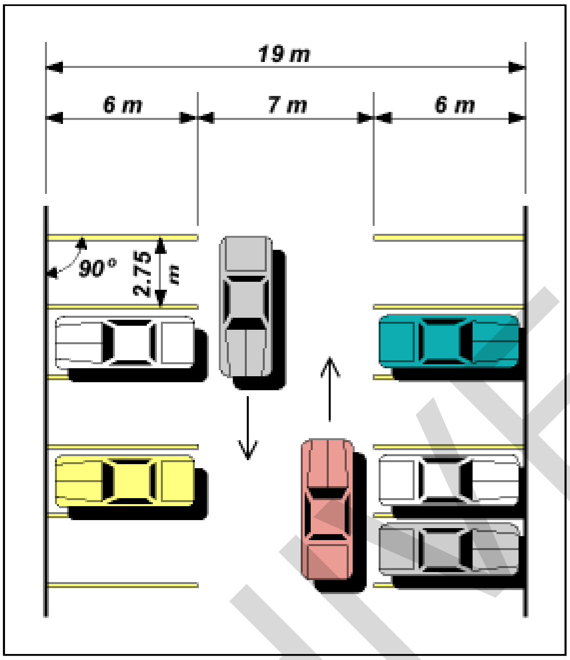

Figure 14-7: 90 Degree Parking Dimensions and Geometry

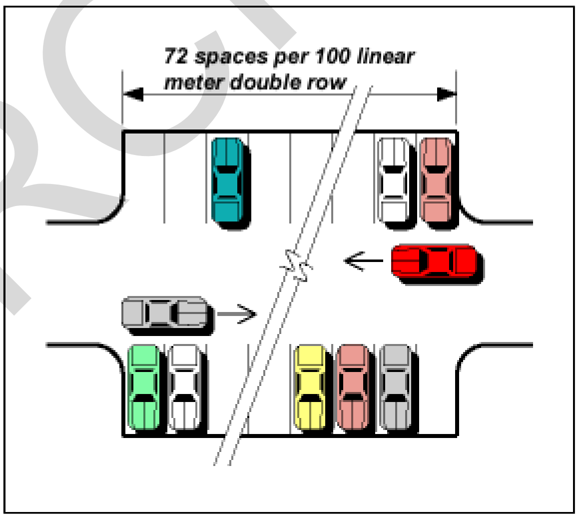

Figure 14-8: 90 Degree Parking Pattern

Advantages

- Works well with either one- or two-way aisles
- Handles the most vehicles per square meter of pavement
- Handles most vehicles per linear meter

Disadvantages

- Requires widest area
- Difficult maneuvering for some drivers
- Two-way traffic can create some visibility problems

Angled - 60 Degree

This parking area configuration is ideal for a fast turnover rate or predominantly short term use. This is often offset by difficulties of inefficient circulation patterns and one-way aisles. Standard dimensions for this configuration are:

Description	Dimension
Parking space width	2.75 meters
Parking space length	6 meters
Driving aisle width (1-way)	5.5 meters
Two rows plus aisle width	16.5 meters
Vehicles per 100 linear meter double row	65.6

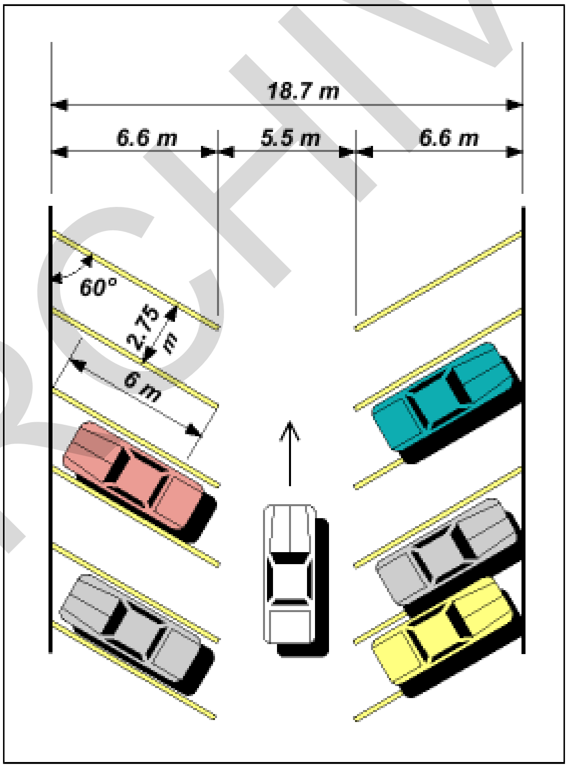

Figure 14-9: 60 Degree Parking Dimensions and Geometry

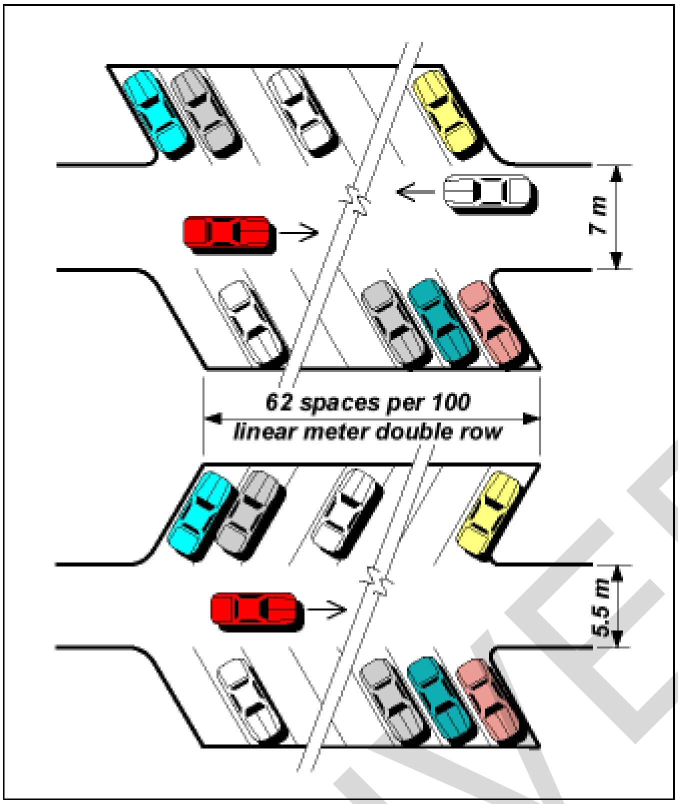

Figure 14-10: 60 Degree Parking One-way and Two-way Patterns

Advantages

- Easy maneuvering in and out of parking spaces
- Good visibility
- Lends itself to either one-or two-way aisles
- Most common short term parking configuration

Disadvantages

- Requires more pavement per vehicle than perpendicular configuration
- Handles less vehicles per linear meter

Angled - 45 Degree

The 45 degree angled parking configuration displays similar benefits and limitations as the 60 degree. Standard dimensions for this configuration are:

Description	Dimension
Parking space width	2.75 meters
Parking space length	6 meters
Driving aisle width (1-way)	4.5 meters
Two rows plus aisle width	14 meters
Vehicles per 100 linear meter double row	52.5

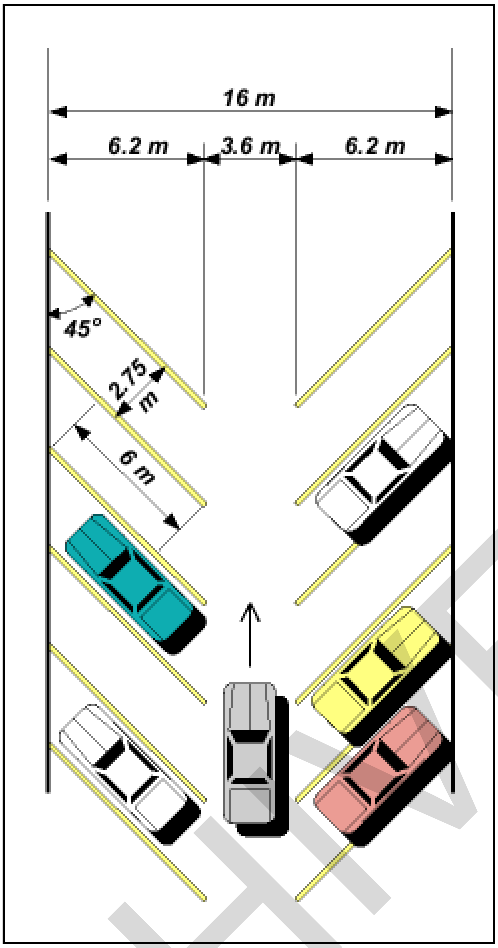

Figure 14-11: 45 Degree Parking Dimensions and Geometry

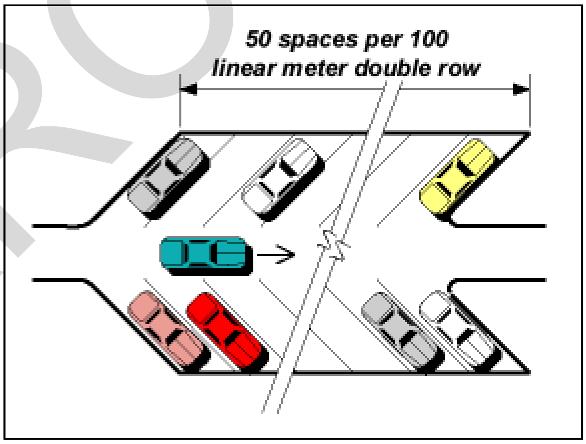

Figure 14-12: 45 Degree Parking Pattern

Advantages

- Reduced width requirements for layout
- Easy maneuvering in and out of parking spaces
- Good visibility to the rear

Disadvantages

- Doesn't work well with two-way aisles
- Requires more pavement per vehicle than perpendicular parking configuration

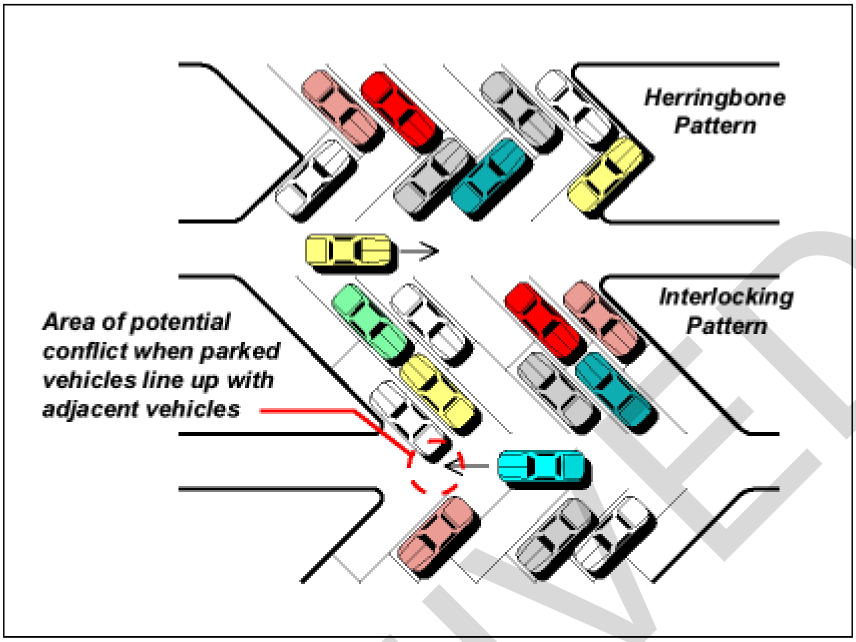

Figure 14-13: 45 Degree Parking Interlocking and Herringbone Patterns

Angled - 30 Degree

Standard dimensions for this configuration are:

Description	Dimension
Parking space width	2.75 meters
Parking space length	6 meters
Driving aisle width (1-way)	7 meters
Two rows plus aisle width	19 meters
Vehicles per 100 linear meter double row	39.4

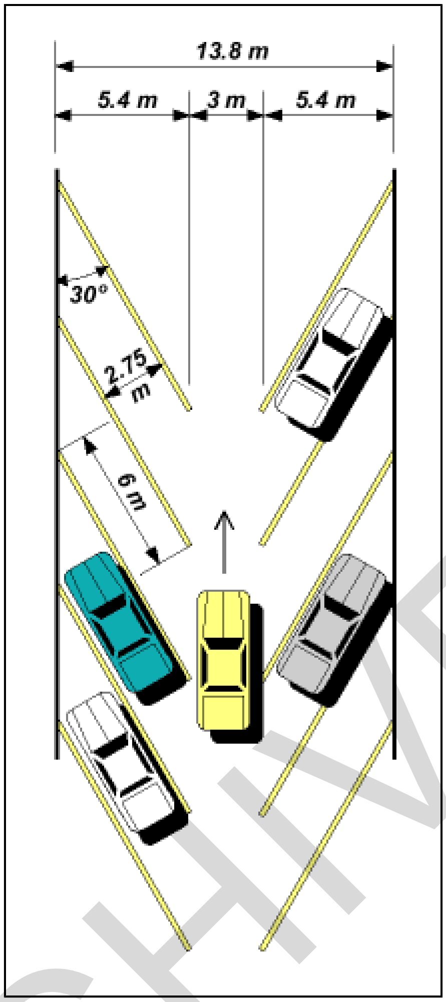

Figure 14-14: 30 Degree Parking Dimensions and Geometry

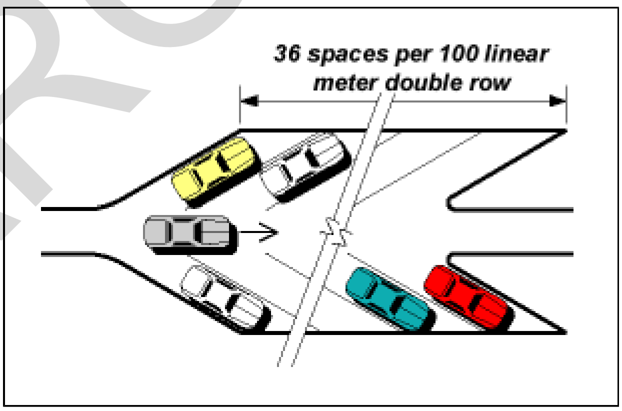

Figure 14-15: 30 Degree Parking Pattern

Advantages

- Easy parking
- Reduced width requirements for layout

Disadvantages

- Requires the most pavement per vehicle
- Doesn't work well with two-way aisles

Special Vehicles

In addition to automobiles, there are parking and circulation requirements for vehicles such as motorcycles, buses, refuse haulers, and tractor trailers. An overview of these requirements can be valuable to the designer.

Motorcycles

Many times parking areas are designed and built with little concern for motorcycles and their unique needs. Dormitories, dining facilities, major recreational facilities, and clubs are a few of the facilities that may require motorcycle parking. Rather than using leftover spaces for these needs, the designer should provide parking areas for motorcycles early in the project. Consult with the applicable facility managers to determine historical needs for motorcycle parking spaces.

Since motorcycles generally employ a kickstand for support when parked, a rigid surface such as concrete should be provided to ensure stability while minimizing potential pavement damage in summer months or at warm climate installations. Some standard parking dimensions for motorcycles are:

Description	Dimension
Parking space width	1.5 meters
Parking space length	2.5 meters

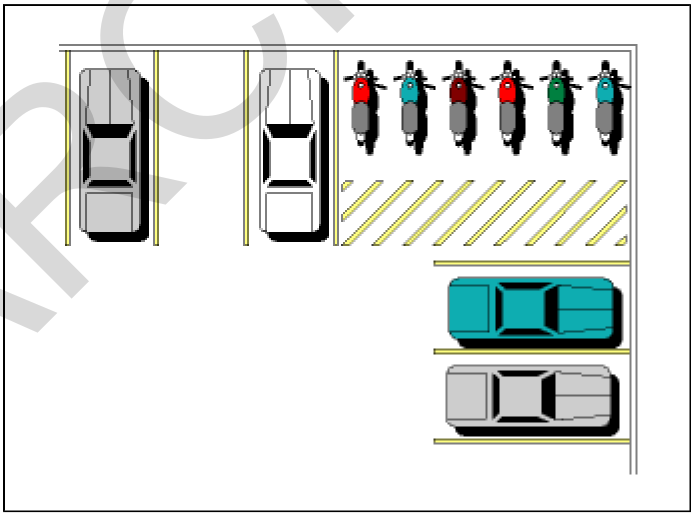

Figure 14-16: Motorcycle Parking Area

Buses

The designer must consider use of buses at dormitories, schools, training centers, clubs, dining halls, and major recreational facilities on the installation. Some of the key dimensions for the layout of parking and circulation of buses are:

Description	Dimension
Parking space width	3 meters
Parking space length	12-15 meters
Minimum turning radius	12 meters

Refuse haulers

Many installations use large, centrally-located dumpsters for disposal and collection of refuse and recyclable materials. Many are located in parking areas. Specially-designed vehicles are used to empty dumpsters. Most use a front-end method while others use the side of the vehicle. The designer must consider refuse collection requirements during the layout and siting of parking areas. Dumpsters should be located to accommodate user convenience, ease of access for emptying, and aesthetic appeal.

Besides addressing refuse collection requirements in terms of siting, access, and circulation, the designer should consider:

- Screening dumpsters with fences, walls, or shrubs
- Coordinating grade requirements within dumpster areas in addition to overall parking area grading
- Providing protection with concrete-filled pipes or bollards for fences and walls from damage caused by vehicle operations

Tractor trailers

Large tractor trailers may have a need to access some installation parking areas. These vehicles have specific requirements. The designer should consider the following minimum dimensions when designing for tractor trailers:

Description	Dimension
Parking space length	15 meters
Parking space width	2.75 meters
Outside turning radii	18 meters
Vertical clearance	4.25 meters
Backing and maneuvering area	15 meters
Loading dock width	3 meters
Loading dock height	1.2 meters
Loading dock area	2x area of truck bed

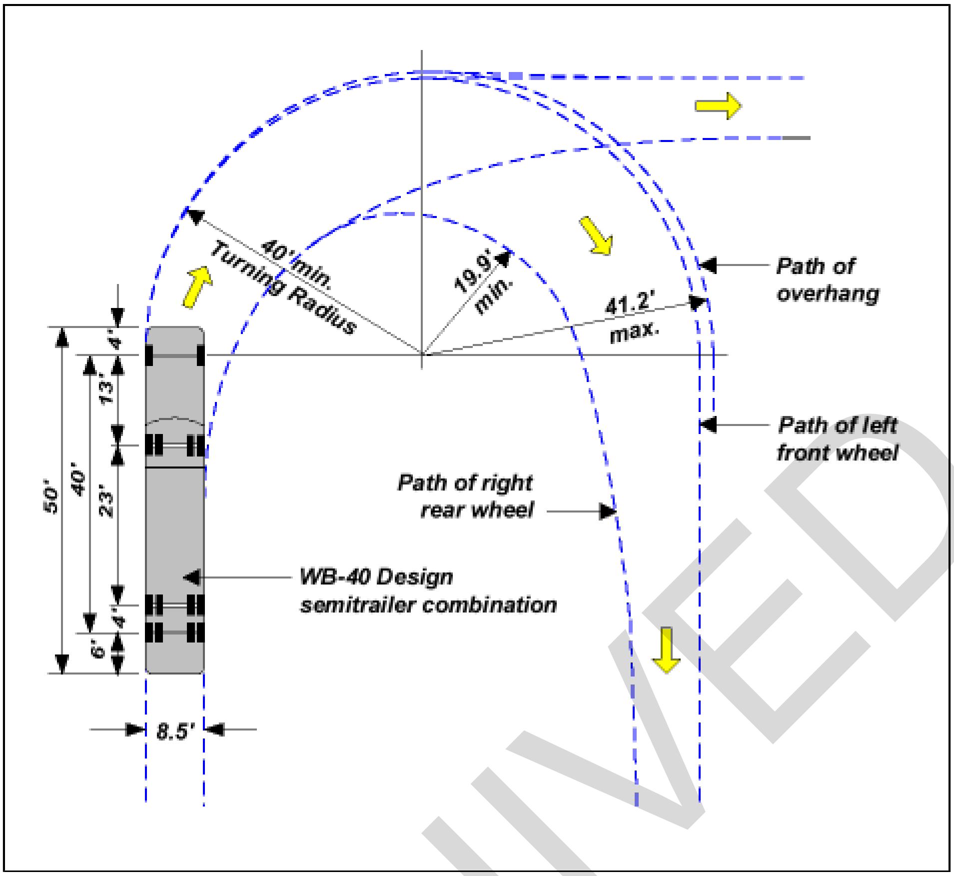

Figure 14-17: Tractor Trailer Turning Geometry

Access

Good parking area design provides convenient and safe access of vehicle occupants within parking areas to adjacent facilities. This includes those who are physically challenged. The designer should:

- Provide separated pedestrian walkways whenever possible and integrate with planted, curbed islands
- Provide walkway access from all parking spaces to facility entrances
- Minimize the number of vehicle circulation aisles pedestrians must cross to enter adjacent facilities
- Integrate parking area walkways with existing installation pedestrian network

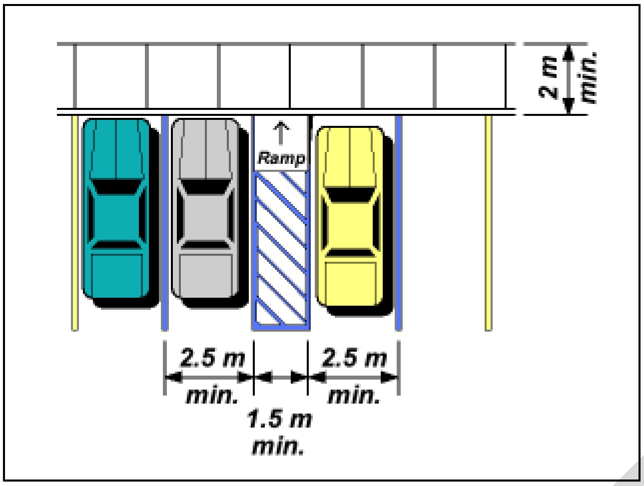

Figure 14-18: Accessible Parking Space

ADA requirements

The Federal Register (56 Fed. Reg., 35,464, 35,483, 1991) details the requirements of the Americans with Disabilities Act (ADA). An excerpt of those requirements for parking is provided below.

Required Accessible Spaces

If parking spaces are provided for employees and/or visitors, then accessible spaces will be provided in conformance with the table below:

Total spaces in parking area	Required minimum number of accessible spaces
1 to 25	1
26 to 50	2
51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 to 300	7
301 to 400	8
401 to 500	9
501 to 1000	2% of total
1001 and up	20 plus 1 for each 100 over 1000

Location

Accessible parking spaces serving a specific facility should be located on the shortest accessible route of travel from the adjoining parking area to an accessible entrance. In parking areas that serve several facilities, accessible parking should be located on the shortest accessible route of travel to an accessible pedestrian entrance of the parking area. If facilities have multiple accessible entrances, accessible parking spaces should be dispersed and located closest to the accessible entrances.

Space sizing, access aisles, and slope

Accessible parking spaces should be at least 2.5 meters wide. Parking access aisles should be part of an accessible route to the facility entrance. Two accessible parking spaces may share a common access aisle. Parked vehicle overhangs should not reduce the clear width of an accessible route. Parking spaces and access aisles should be level with surface slopes not exceeding 1:50 or 2% in all directions.

Signage

Accessible parking spaces should be designated as reserved by a sign showing the symbol of accessibility. Such signs should be located so they cannot be obscured by a vehicle parked in the space.

Maintenance

Regular maintenance can greatly prolong the life and utility of parking area pavements. They should be regularly policed for litter and plant material debris. Parking spaces should be restriped as required.

Removal of debris and snow are special considerations for the designer. Elements such as islands and curbs can interfere with expediency of these activities. Street sweepers have difficulty effectively reaching confined areas created by perimeter or island curbing. Snow removal becomes especially difficult in these areas as well.

The designer must also consider ample and well-located snow piling areas where frequent and significant snow accumulation is expected.

14.2.3 AESTHETICS AND SAFETY

The most attractive parking areas are well landscaped. Trees are the most valuable additions to parking areas, whether planted in curbed islands or on perimeters. They provide shade, visually reduce the mass of open pavement, and mitigate heat gain. Use plant materials to improve installation parking areas:

- Incorporate appropriately-scaled, well-graded and planted earth berms on parking area perimeters to screen the parking area from streets and other facilities
- Minimize the use of medium to tall shrubs on internal curbed parking islands
- Integrate regionally native groundcovers and small shrubs at island ends to add interest while maintaining visibility of pedestrians and vehicles
- Provide convenient and accessible walkways from all parking spaces to facility entrances

Horticultural Requirements

Parking areas are not conducive to healthy plant growth. Reflected sunlight, heat gain, and exhaust fumes each contribute to this problem. Plants can become weak and unsightly making them susceptible to further damage and reduced lifespans.

Non-porous pavement limits important oxygen and water exchange between plant roots and the atmosphere. Construction practices further hamper proper growing conditions through soil compaction.

For healthy plant growth, it is imperative to protect vital plant components - roots, trunks, and leaves.

Roots

Large roots near the trunk serve to anchor the plant. Fine, fibrous roots at the root tips along the drip line take up moisture and minerals from the soil. Roots spread radially from the trunk and are rarely more than a meter deep. Some species have a taproot that can search out moisture to depths of 15 meters or more. Any damage to the root zone of plants should be accompanied by pruning to balance the ratio of roots to leaves. Protect plant roots through the following practices:

- Avoid compacting the soil around existing trees
- Consider the use of porous pavements such as cast-in-place, monolithic turf and concrete combinations over specimen tree roots to allow water and air exchange if paving around the tree is required

Trunks

The trunk transports water and micronutrients from the roots to the leaves through the cambium which lies just below the bark. This thin layer is responsible for the plant's growth. It is the most vital part of any plant. Small horizontal cuts or abrasive damage to the cambium can severely stunt a plant's growth or kill the plant. It is extremely important to avoid damaging the trunks of all plants.

- Use curbs for planted islands
- Ensure parking spaces provide sufficient separation from trees and shrubs to avoid damage
- Protect existing tree or shrub trunks during construction activities

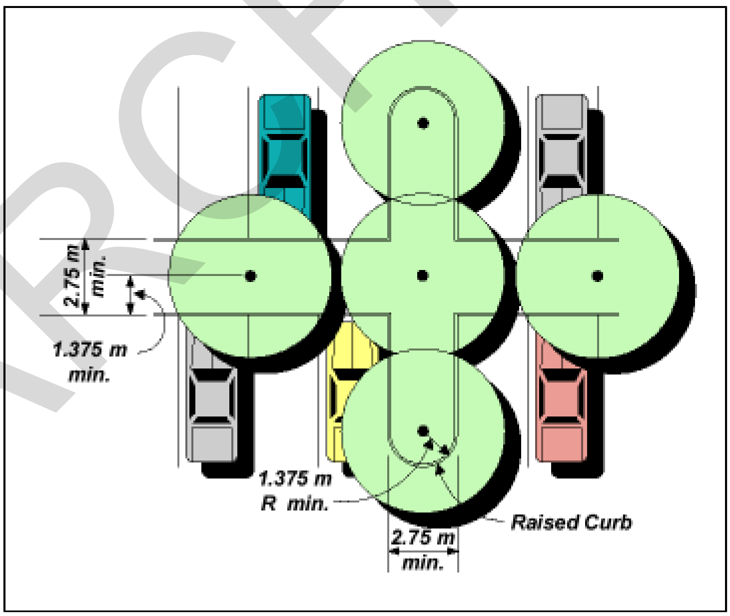

Figure 14-19a: Tree Protection

Figure 14-19b: Example of Tree Protection in Parking Island

Leaves

Leaves transpire oxygen and excess moisture to the atmosphere while absorbing carbon dioxide. Without healthy leaves, plants will eventually die. Vehicle exhaust fumes can damage foliage. Constant foot traffic on woody groundcovers damages plants and creates an unsightly appearance.

- Use regionally native drought and heat tolerant species whenever possible
- Ensure plants installed in or around parking areas receive proper irrigation that encourages deep root growth

Tree Selection Criteria

Trees do the most to improve the aesthetics of parking areas. There are reasons to avoid using some species and reasons to select others.

Avoid:

- Large-leafed deciduous trees like some maples that can clog drains and make walking hazardous
- Trees with messy fruits or berries, like the female gingko, olive, or mulberry
- Brittle-limbed species such as the Siberian elm, eucalyptus, or poplar
- Trees susceptible to insects and diseases such as American elm, birch, hawthorn, and mountain ash
- Short-lived trees such as Lombardy poplar, Arizona ash, and willow
- Trees that can damage pavements such as Norway maple, silver maple, and sycamore

Select trees:

- That cast medium to dense shade in summer
- Have normal lifespans over 60 years
- That thrive in pollution and direct and indirect heat of a typical urban environment
- That demonstrate salt and deicing compound tolerance such as red oak, white oak, and red cedar
- Which require little pruning and are structurally sound
- Which are resistant to insects and diseases

Lighting

Lighted parking areas are an important consideration for facilities that expect early morning, late afternoon, or night time use. All parking areas should be safely illuminated. Intersections with major pedestrian routes and at parking area entrances and exits are especially important when choosing light fixtures and locations. The designer should provide lighting for parking areas that meet the minimums of 1-2 foot-candles and 10-20 lux. Lighting should not disturb nearby residential areas.

Lighting standards or poles vary from 6-9 meters tall and should be located in islands or on parking area perimeters. Poles that are not protected by a curb or other structure should be constructed with a concrete base at least 1 meter high or be buffered by concrete filled pipes or bollards.

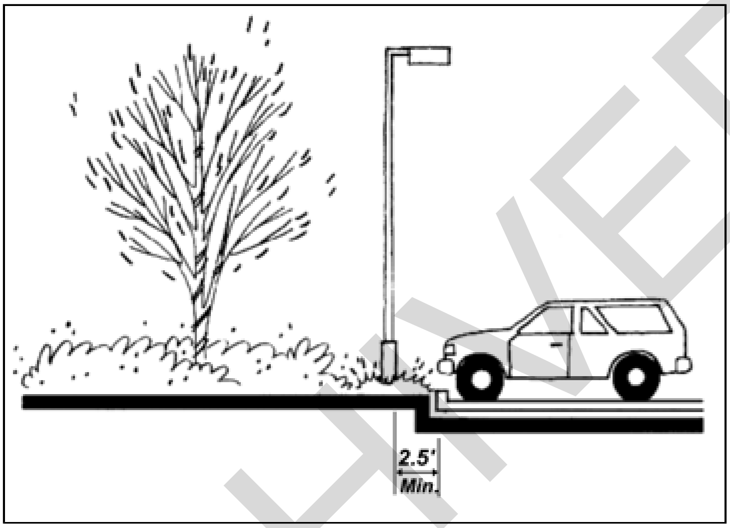

Figure 14-20a: Light Fixture Location

Figure 14-20b: Example of Light Fixture Location

14.3 CONCLUSION

This guide promotes parking area design principles and practices that minimize impacts on the environment while maximizing long term convenience and efficiency. Appropriate parking area design solutions can be realized by employing a process that considers all significant issues and facility user needs and requirements.

14.3.1 PARKING AREA DESIGN DO'S AND DON'TS

Do's

Follow these principles for functional and attractive parking area design solutions:

- Don't pave all the way up to facility walls
- Don't create dead-end parking areas
- Don't plant shrubs in islands that will impair line of sight and create unsafe situations for pedestrians or vehicles
- Don't use gravel, stone, or pebbles in islands where they can become a maintenance problem and a hazard
- Don't create large mass parking areas without planted islands and perimeter screening

Don'ts

- Consider constructing curbed and planted islands in large parking areas
- Integrate parking areas in conjunction with the planning and programming of new facilities
- Screen negative visual impacts of parking areas
- Minimize on-street parking
- Separate vehicle and pedestrian circulation patterns whenever possible
- Shield headlight glare with berms and evergreen plants
- Consider providing special small car parking spaces in large parking areas
- Use concrete under motorcycle parking
- Use curbed islands for heavy vehicle or pedestrian traffic areas
- Protect existing plant root zones and trunks during construction

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14.3.2 REFERENCES

Suggested further reading:

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14.3.3 APPENDIX

Parking Space Guidelines for Non-organizational Vehicles

Facility	**Number of Parking Spaces**
Administration, Headquarters and Office Buildings	60 percent of assigned personnel
Bakeries	38 percent of civilian employees, largest shift
Bank and Credit Union *	2 percent of authorized customers served

Cafeteria, Civilian	15 percent of seating capacity
Central Food Preparation Facilities	38 percent of military and civilian food service personnel, largest shift
Chapels	30 percent of seating capacity
Child Development Centers	8 percent of children, 80 percent of staff
Commissary Stores, Food Sales *	Contact HQ DeCA for parking requirements
Community Shopping Center, including Main Exchange, Misc. Shops, Restaurant, Commissary, Food Sales, Bank, Theater, Post Office	4 percent of authorized customers served
Dormitories	70 percent of design capacity
Enlisted Personnel Dining Facilities	38 percent of military and civilian food service operating personnel, largest shift, plus 8 percent of enlisted personnel (patron parking) to be served during a meal period
Exchanges, Main *	2.5 percent of authorized customers served
Family Housing	2.5 spaces per living unit
Field House, comb. with Football/Baseball Facility	1 percent of military strength
Fire Stations	200 percent of positions per shift
Guard Houses, Brigs, Military Police Stations	30 percent of guard and staff strength
Fitness Center (if only one at an installation)	1 percent of military strength served
Fitness Center; Area	10 spaces
Laundries and Dry Cleaning Plants	38 percent of civilian employees, largest shift
Libraries:	
Central	1 space for each 46 sm (500 sf) of gross floor area
Branch	8 spaces
Maintenance Shops	38 percent of assigned personnel, largest shift
Medical Facilities	Refer to MIL HDBK 1191
Officers' Quarters	100 percent of living suites
Schools, Dependent:	
Without Auditorium	2 spaces/classroom

With Auditorium	2 spaces/classroom, plus 15 percent of auditorium seats
Security Offices (at gates) for installations of:	
100 to 2,000 population	5 spaces
2,001 to 4,000 population	10 spaces
4,001 to 6,000 population	15 spaces
6,001 to 10,000 population	20 spaces
10,001 and over	To be based on a special study
Service Clubs	2 percent of enlisted personnel or officer strength served
Swimming Pools	20 percent of design capacity
Temporary Lodging Facilities	100 percent of bedrooms
Theaters *	25 percent of seating capacity
Warehouses	1 space for each 46 sm (500 sf) gross area of office area, plus one space per 4 persons assigned to storage activities

This table should be used for planning purposes. Use actual parking requirements for individual facilities.

* = When not in a Community Shopping Center

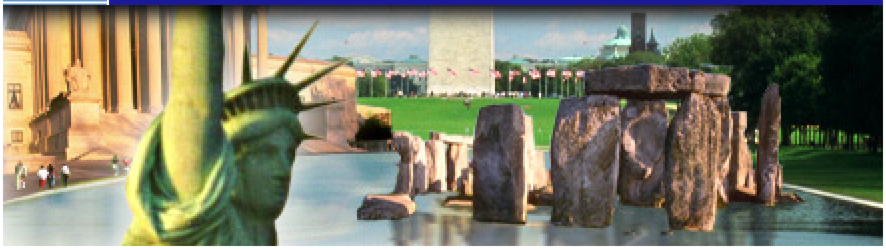
Parking Area Configuration Summary

	90 Degree	**60 Degree**	**45 Degree**	**30 Degree**
Aisle circulation	One-way and two-way	Can work with either but best with one-way	Best one-way	Best one-way
Maneuvering	Difficult for some	Easy	Easy	Easy
Backing visibility	Less than ideal	Good	Better	Best
Parking space width	2.75 meters	2.75 meters	2.75 meters	2.75 meters
Parking space length	6 meters	6 meters	6 meters	6 meters
Aisle width	7 meters (2-way)	5.5 meters (1-way)	4.5 meters (1-way)	3.1 meters (1-way)
Two rows plus			14	13.5

aisle	19 meters	16.5 meters	meters	meters
Vehicles per 100 linear meter double row	82	65.6	52.5	39.4

September 1998.

15 MONUMENTS



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15.1 INTRODUCTION

Monuments identify places, memorialize individuals, and commemorate events and missions that are significant to the history of an Air Force installation. Monuments can be as simple as a memorial plaque attached to a building, or they can be statues or sculptures, historic military equipment, or other freestanding commemorative displays. Because they possess a special status and can be prominent visual elements in the outdoor environment, monuments should be an integral part of an installation design and be appropriately planned for relative to their visual and functional setting. With proper planning and design, monuments can fulfill their intended function as aesthetic and cultural objects and contribute positively to the visual quality and identity of an Air Force installation.

15.1.1 PURPOSE

The purpose of this chapter is to provide guidance related to site selection and site planning for freestanding monuments on an Air Force installation. It is not intended to guide the actual selection or design of monuments, which can embody a wide variety of subject matter and forms that are best determined by each installation in response to its particular needs, desires, and resources. Instead, these guidelines concern the appropriate relationship between a monument and its setting. This involves application of criteria for the evaluation of such factors as the relevance of the setting to the monument, the physical character of the monument, the placement of the monument within a site, and the viewpoint of the observer. The criteria are intended to help guide the development of an effective display of monuments to increase the historical awareness, identity, and visual image of the installation.

15.1.2 GOALS & OBJECTIVES

The goal for monuments is to increase awareness of an installation's history and strengthen its image and identity:

- preserving historically or culturally significant objects or features;
- commemorating places, events, individuals, and missions that are significant to the history and identity of the installation, the region, or the Air Force; and
- contributing positively to the visual quality of the installation.

The objectives for monuments that support achievement of this goal are to:

- apply a coordinated and consistent approach to the siting of monuments;
- provide relevant and appropriate settings for monuments;
- provide visually prominent and accessible locations for monuments; and
- ensure that monuments are compatible in scale and character with their setting.

15.2 MONUMENT PLANNING PROCESS

The monument planning process can involve both site selection to determine a general location for a monument and site planning to establish the proper relationship between the monument and its immediate surroundings. Site selection applies to monuments that are not place specific (i.e., monuments that do not commemorate an existing location or permanent structure). Site planning applies to both place-specific and non-place-specific monuments. It involves the precise placement and/or design of a monument within a given site to maintain compatibility with the setting and assure that the monument is properly presented. In order to create an effective display of monuments, this planning process should be logical and comprehensive and should include a *site selection*, a *site analysis*, and the development of a *site plan*.

- A *site selection* should consider such factors as the nature of a monument in terms of its purpose and size and the appropriateness of a site in terms of its relevance to the monument, its general size, types of uses on and adjacent to the site, and visual and physical accessibility of the site. The site selection will result in the most appropriate general location for each monument on the installation.

- A *site analysis* should identify factors critical to the proper development of a monument on a selected site. Many factors may be the same as those considered for the site selection, but they should be considered at a more detailed level in the analysis a particular site. These factors include existing development, adjacent uses, utilities, topography, views, and access. The site analysis will identify opportunities for and constraints to monument development and should influence both the site planning and the design of the monument.

- A *site plan* should be prepared that indicates the location of the proposed monument and includes sketches and/or elevations that illustrate its character and scale in relation to other site features. The plan should provide an effective display for the monument while achieving compatibility between the monument and the site within the context of the opportunities and constraints identified in the site analysis.

15.3 MONUMENT CRITERIA

The actual nature of a monument should be based upon the unique characteristics and circumstances at each installation, including its regional setting, history, architectural and site features, and other factors that will influence monument subject matter, design, and placement. Each installation should therefore establish its own design policies regarding monuments, but the following criteria are intended to help in the monument site development evaluation process. Two primary factors should be considered in establishing criteria for site planning for a monument: the monument itself and the setting.

While these criteria address primarily freestanding structural monuments, monuments may also be non-structural in nature. An individual tree, a grove of trees, a garden, or a park are examples of such monuments. Certain factors, including site relevance, scale, background, and view, may also be important considerations in the site selection and planning for non-structural monuments. Where relevant, the following criteria can be applied to the evaluation process for non-structural as well as freestanding structural monuments.

15.3.1 INTERRELATIONSHIP OF CRITERIA

The interaction between the monument and the setting presents areas of criteria that should help guide monument site development projects. These areas of criteria include the relevance of the site, the physical character of the monument, the placement of the monument, and the viewpoint of the observer.

Although these criteria are individually definable, their interrelationship is significant when planning and designing a monument. Therefore, while the size of a monument is one of its essential characteristics, the appropriateness of its scale can be determined only in relation to its setting. Likewise, the appropriate background treatment of a setting should be established based partly on the material and form of a monument, and a suitable placement for a monument should consider the level of detail and complexity in its design. Consideration of the setting should be guided by the purpose and design of the monument, just as the design of a monument should be influenced by its potential setting.

15.3.2 RELEVANCE OF THE SITE

Site relevance concerns the suitability of a monument for a site based on the subject matter of the monument and the uses or history of the site.

- A site may be directly related to a monument (e.g., it is the location of an event that the monument commemorates) or indirectly related (e.g., it is adjacent to the barracks of a unit whose exploits the monument celebrates). Sites that possess such relevance to a monument's subject matter should be strongly considered as the setting for the monument unless they are otherwise inappropriate.

- A site may be more appropriate or less appropriate as the setting for a monument based upon the uses within or adjacent to the site and the level of accessibility to the site. As an example, an administrative zone on an installation may be an appropriate setting for many types of monuments because of the kind of functions that occur there and the broad level of accessibility to the area. An industrial zone, however, would normally be an incompatible setting because of the types of activities present, the visual environment, and the general inaccessibility of the area.

- The subject matter of a monument may also influence the appropriateness of a setting. For example, a community commercial zone may be an appropriate setting for some monuments, but a memorial that conveys a solemn message may be better located in a low-activity area whose setting provides an opportunity for quiet reflection.

15.3.3 PHYSICAL CHARACTER OF THE MONUMENT

The site selection and site planning of a monument should be influenced by the monument's physical character, including its size, style, material and form, and level of complexity. Likewise, although monuments are often designed and selected with little regard for a potential setting, the physical character of a monument (i.e., its design) should be influenced by the opportunities and constraints presented by a site.

- The size of a monument should be determined in relation to the size and nature of the space it will occupy. To achieve an appropriate impact, monuments set in the outdoor environment should be large enough to be proportionate in scale to their surroundings, which may include large structures and/or open spaces. Monuments of inadequate scale in relation to their environment will lack impact. On the other hand, monuments set in enclosed spaces, such as courtyards, should not be so large that they overpower the space or are not easily viewed *(see Figure 15-1)*.

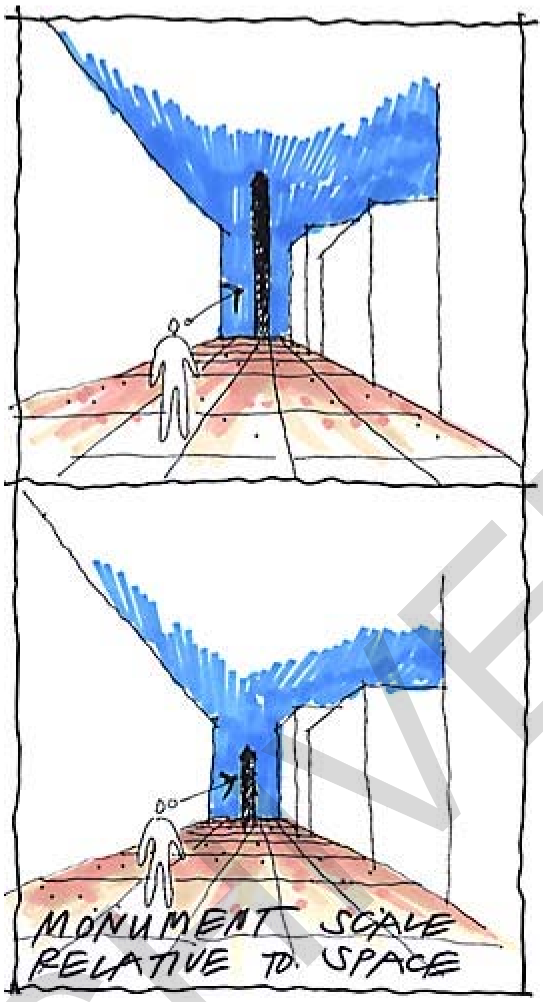

Figure 15-1: Monument Scale Relative to Space

- In addition to the relationship with the surrounding space, the relationship with the viewer must also be considered in determining the proper scale for a monument. This will depend, of course, on the intended viewpoint for the monument and its distance from the viewer. The importance of achieving adequate scale notwithstanding, a monument should be comprehensible from the intended viewpoint and not overwhelm the viewer with its size *(see Figure15-2)*.

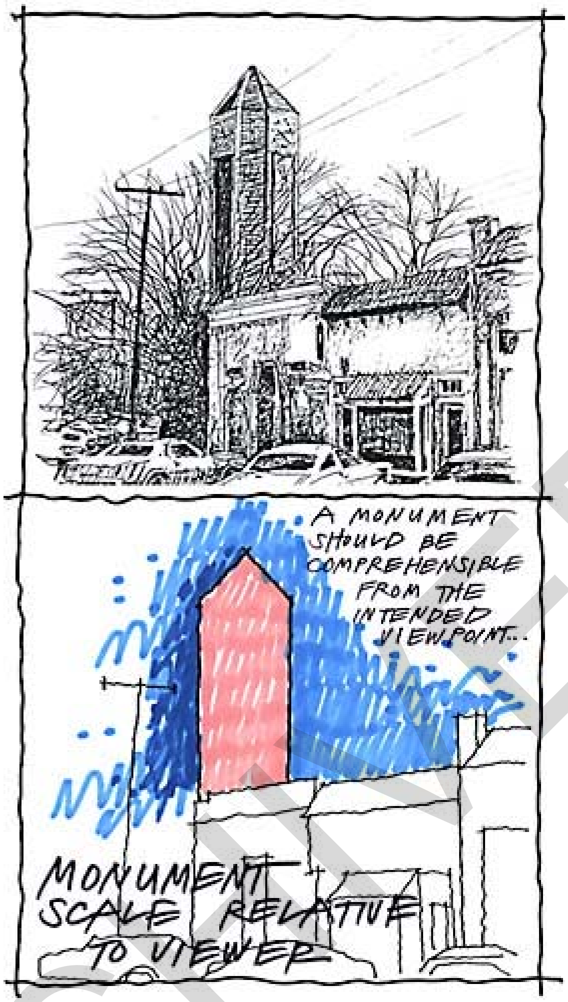

Figure 15-2: Monument Scale Relative to Viewer

- The style of a monument (i.e., whether it is a real object, a representational work, or an abstract work) should be a consideration in selecting the setting in which it is to be displayed. As an example, a modern abstract monument may be harmonious with a setting surrounded by contemporary buildings but may appear incongruous if located within an historic area of an installation. In some cases, however, this contrast between a modern abstract monument and a historic setting (or, conversely, a traditional representational monument and a contemporary setting) may actually create a desirable effect. Because each monument and setting is unique, no rules based on style can be applied to determine the correct relationship between them, but this relationship should be thoughtfully considered in each case.

- The material and form of a monument will affect its appearance and are therefore important considerations in relation to the scale, background, and other characteristics of a setting. Materials generally influence the form that a monument will take. Monuments made from traditional materials such as stone, concrete, or cast bronze generally achieve a volume that enhances their visibility in a setting. On the other hand, monuments created with materials such as narrow metal members may lack volume. While such monuments may be very successful when placed in a setting that enhances their form, placement in a setting with, for example, a busy and complicated background may render them virtually invisible.

- Physical complexity, which is related to qualities such as form and detail, will affect a viewer's ability to perceive and understand a monument. In general, monuments that are physically complex or intricate should be located only in settings that provide an opportunity for their proper appreciation. Monuments located in a setting where they are viewed at a distance or by viewers who are on the move, either in vehicles or on foot, should be relatively simple and readily understandable in their physical form.

15.3.4 PLACEMENT OF THE MONUMENT

Placement refers to locating a monument within a setting so it relates properly to site conditions and characteristics. This involves not only physical considerations but also visual considerations such as the monument as a focal point, the scale of the setting, and the framing, background, and foreground treatment for the monument. It is important to note that since a monument is three-dimensional and located in an outdoor environment, it can usually be viewed from many angles. Achieving a placement that properly addresses all visual considerations from all viewing angles may not be possible. Instead, it may be necessary to establish primary viewing angles based on such factors as the flow of traffic and existing development.

- As with any construction project, the physical characteristics of a site should guide the site planning and design of a monument. Physical characteristics that should be considered include existing and proposed development; circulation patterns and accessibility to potential settings; the availability of open space areas in relation to the size of the monument; existing vegetation, noise, wind, and even sun and shade patterns, which may enhance or detract from the monument setting.

- Since, depending on its size, a monument may require a large foundation, conditions below grade are also important considerations in the design and site planning process. Such conditions include soil types and surface and subsurface drainage patterns, which could affect both construction and maintenance costs, and underground utilities, which could be damaged during construction or become less accessible if a monument is built overhead.

- By their very purpose, monuments should be focal points on an installation. This should be accomplished not only by the selection of sites that locate monuments in visually and physically accessible areas on the installation but by a placement within a selected site that reinforces their prominence. This can be achieved by a number of techniques that focus the viewer's attention to the monument. These techniques include the scale relationship between the setting and the monument and the framing, background, and foreground treatment for the monument.

- Scale is not a measure of absolute size, but refers to the relative size relationship between the monument and the setting. A monument that is in scale with its setting will be visually apparent but will not overwhelm the space. A monument that is too large in relation to its setting will seem out of proportion and often will not be appreciated properly. The site selection process should exclude settings that are too small relative to a particular monument. A monument that is too small in relation to its setting may lack visual prominence. In such cases, the setting should be modified to reduce its scale and establish focus on the monument.

- Framing encloses the view to a monument and is an important consideration in creating proper scale relationships between the monument and the setting. It can be achieved by natural features such as plant material and topography or manmade features such as buildings and walls.

Depending on the scale of the monument and the desired viewpoint, framing can be minimal, as with a monument placed in a large grassy area, or it can clearly define the boundaries of a setting, as in a courtyard *(see Figure 15-3)*. Both background and foreground treatments contribute to framing a monument.

Figure 15-3: Framing of Monument

- Background provides the surface against which a monument is seen. It may consist of buildings, plant material, sky, or other elements. There should be contrast between the monument and the background to visually set off the monument. The background should not be overly complex, or it may compete with and tend to obscure the monument. The size of the monument and the position of the viewer should be considered in determining the appropriate height and width of the background. In some settings, the background may be a fixed condition that must be used in the most advantageous manner through the placement of the monument. In other cases, it may be possible to create an effective background where one does not exist with the introduction of plant material, walls, or other elements *(see Figure 15-4)*.

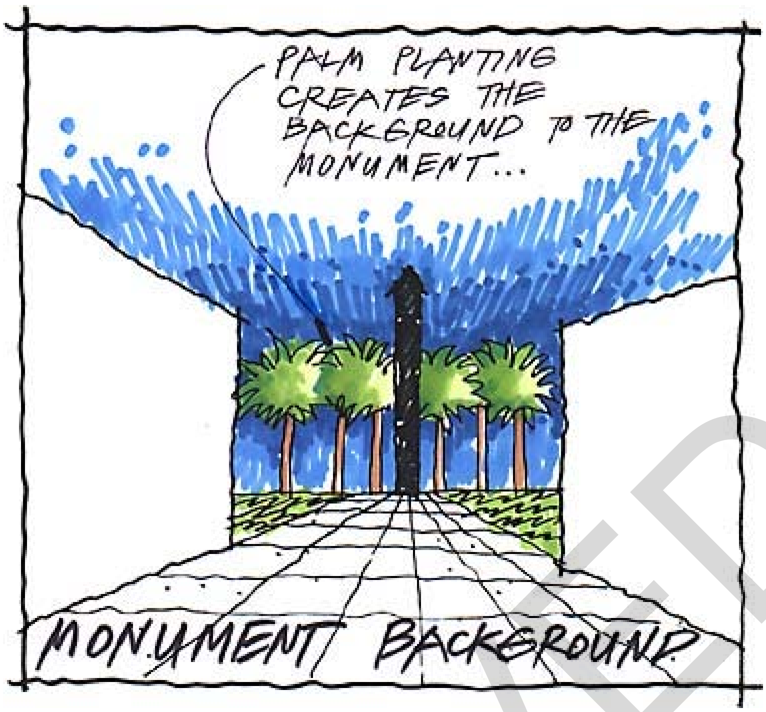

Figure 15-4: Monument Background

- Foreground provides features through or over which the monument is viewed. Foreground can consist of an open area such as lawn or water or include features such as trees that may partially screen the view to the monument. Foreground elements can be used to control the direction of view, the distance at which the viewer can see the monument, and the actual access to the monument *(see Figure 15-5)*.

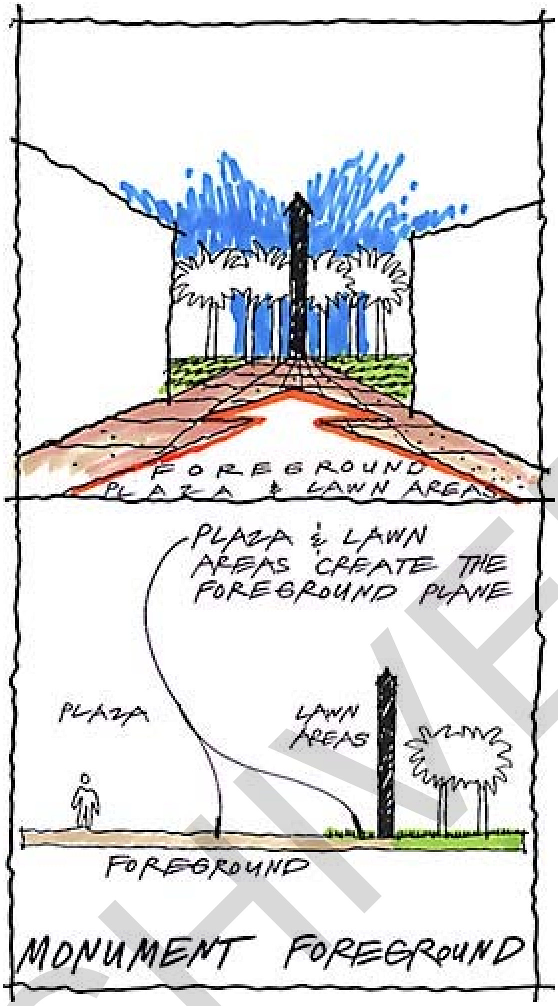

Figure 15-5: Monument Foreground

15.3.5 VIEW

The distance from which an observer can see a monument and the speed at which the observer is moving affect the view of the monument. While the designer may have limited control over the location and speed of observers, the physical characteristics of a monument and its placement within a setting can be controlled and are significant factors that influence view.

- In general, a monument should be seen clearly and in its entirety by an observer located at the intended viewpoint. A monument that is meant to be viewed from a distance should be large in scale, simple in form, and placed in an unobstructed setting.

- A monument that is meant to be seen from close range can be more complex and partially or totally concealed from locations beyond the intended viewpoint. It should be, in most cases, of a scale that allows a viewer standing nearby to comprehend the entire monument. There may be, however, cases where a monument is not intended to be fully taken in from a single place, but must be experienced from many angles and positions.

- An observer who is in motion will be less able to comprehend a monument than one who is standing still, and as speed increases, comprehension decreases. To compensate for the movement of observers in motion and the reduced time they have to appreciate their surroundings, a monument may need to be intelligible at a relatively quick glance. Thus, if a monument is intended to be viewed by drivers and passengers in vehicles moving along the main entry road, it should be large in scale and simple in detail. A relatively small scale and complex monument would be all but lost in such a setting and should instead be placed where it can be viewed by stationary observers.

- The placement of a monument within the normal direction and angle of view of an observer in motion will also tend to increase comprehension. As an example, a monument placed so that it can be seen out the windshield of a moving vehicle is more readily viewed than if it must be observed through a side window. The same concept applies, but to a lesser degree, to pedestrians on the move.

15.4 STATIC DISPLAYS

Because of their uniqueness as a type of monument, their special significance to the history and culture of an Air Force installation, and their potentially enormous size, static displays of aircraft and missiles deserve special attention related to criteria for their site development *(see Figure 15-6)*.

- Static displays should be sited in prominent locations on an installation where they can be readily viewed and accessed by installation personnel and visitors. Such locations would include areas near the main installation entry or in a central community/administrative area of the installation.

- Isolated static displays can be effective as focal elements if they are properly located and placed. Isolated displays should be placed in settings that relate to their history or function. Even an isolated display will generally require significant space, and if many isolated displays are contemplated, appropriately scaled settings may become scarce. If too many isolated displays are developed, they may appear scattered, and the impact of any individual display will tend to be diluted.

- If a number of static displays are anticipated, they should be consolidated primarily into a main exhibit area on the installation. Depending on the number of static displays, this type of exhibit area may require a large amount of land but may be generally more feasible than developing numerous isolated displays. The displays can also be integrated with other types of open space uses such as parks or quadrangles and located in association with an installation museum.

- A main exhibit area will place individual static displays in a context with other displays. The displays should be arranged in a clear and meaningful order that will assist in their interpretation (e.g., arranged chronologically or by type).

- An interpretive sign should be located at each static display to describe its use and history, including its past role at the installation or within the Air Force. The signs should be standardized in their design, made of durable materials, and installed in a permanent manner to maintain their appearance. They should be placed in a generally similar position at each static display so that they are readily viewed in relation to the display. The text on the signs should be legible and well organized in layout. The messages should be relatively simple and brief and, if possible, include supporting graphics to help convey their meaning.

- The static displays should be accessible for close viewing from a walkway system but surrounded by low barriers to prevent direct physical contact. The layout of the walkway system should reinforce the organization of the displays and allow for viewing from many sides. The display should be placed on a hard pad that may be integrated with the walkway system, or an aircraft's individual wheels should rest upon structurally adequate foundations. To decrease maintenance and maintain a clean appearance, the area beneath the static display, if it will not consist of a hard pad, should be paved with a soft material such as decomposed granite or mulch.

Figure 15-6: Static Aircraft Display

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15.5 REFERENCES

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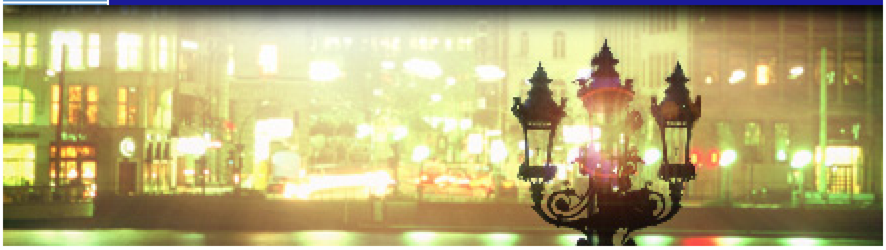
16 EXTERIOR LIGHTING



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16.1 INTRODUCTION

Exterior lighting on an Air Force installation performs numerous functions related to nighttime safety, security, orientation, and the illumination of features. To properly perform these functions, lighting systems must provide an appropriate and consistent level and type of lighting related to various functions and activities. Light fixtures that are coordinated in their appearance with each other and with other site furnishings contribute positively to the visual image of the installation. Fixtures that are efficient in terms of energy consumption and that have low maintenance requirements help assure the overall effectiveness of the lighting system. An exterior lighting system that is well planned in terms of these factors is important to support nighttime activity for both vehicles and pedestrians and to provide illumination for such features as landmarks, monuments, and landscape planting.

16.1.1 PURPOSE

The purpose of this chapter is to provide guidance related to the development of an exterior lighting system on an Air Force installation. This includes guidance for preparation of a lighting plan as well as guidelines for lighting equipment and the various applications of exterior lighting. Lighting design is a specialized discipline, and a qualified lighting professional should be involved in the selection of equipment and the development of a lighting system design. These guidelines are intended to address general considerations to help establish a uniform and coordinated lighting system that properly supports nighttime activity.

16.1.2 GOALS & OBJECTIVES

The goal for exterior lighting is to support and enhance nighttime activity by:

- increasing safety for drivers and facilitating the flow of traffic;
- providing for the safety and security of pedestrians;
- assisting with orientation for drivers and pedestrians; and
- illuminating features.

The objectives for exterior lighting that support achievement of this goal are to:

- provide a coordinated and uniform lighting system;
- provide lighting that is appropriate in character, scale, and level for each area and use;
- reinforce the vehicular and pedestrian circulation hierarchy;
- provide adequate lighting for safety and security; provide appropriate lighting for landmarks and landscape elements; and
- select fixtures for economy of operation, maintenance, and repair.

16.2 EXTERIOR LIGHTING SYSTEM PLANNING PROCESS

In order to establish adequate exterior lighting, the planning process for the lighting system should be logical and comprehensive and should include an *existing conditions survey*, an *adequacy analysis*, and the development of a *lighting plan*.

- An *existing conditions survey* should include written and mapped information on existing exterior light fixtures. This information should include the type, location, physical condition, and lighting level of existing light fixtures. This survey provides the physical data upon which an adequacy analysis will be based.
- An *adequacy analysis* should identify deficiencies in terms of the type, location, and condition of existing light fixtures. Areas with inadequate or excessive lighting levels should be identified. Nonconformance with design standards and potential safety and/or security issues should be noted. This analysis forms the foundation upon which the lighting plan will be developed.
- A *lighting plan* should be prepared to indicate all proposed improvements to the existing system. The plan should establish a coordinated and uniform system that provides appropriate levels of lighting for safety and security and reinforces the circulation hierarchy of the installation. The plan should indicate the type and location of all new fixtures to be installed and all existing fixtures to be repaired, replaced, removed, or relocated.

Narrative, tabular, and graphical information describing existing conditions, the adequacy analysis, and the lighting plan should be compiled and displayed within the installation's existing report and mapping framework and in accordance with applicable Air Force standards. Narrative information should be included in the Utility Systems Plan in the Infrastructure Component of the Comprehensive Plan. Graphical information regarding existing conditions should be compiled as a level or layer on the Existing Electrical Distribution Map. Graphical information locating proposed improvements should be compiled as a level or layer on the Future Electrical Distribution Plan. Non-graphical information that can be compiled in a tabular form should be attached, if possible, to the corresponding graphical map element.

16.3 EXTERIOR LIGHTING GUIDELINES

The development of an adequate exterior lighting system extends the use of the nighttime environment, increases safety and security, helps convey a sense of organization, and facilitates maintenance operations. This includes a coordinated approach to lighting equipment selection and a consistent use of lighting relative to its various functions on the installation.

16.3.1 EXTERIOR LIGHTING EQUIPMENT

To provide lighting that is appropriate for specific functions, equipment should be evaluated and selected based upon its characteristic advantages and disadvantages. The primary pieces of lighting equipment are the lamp (i.e., the light source), the luminaire (i.e., the enclosure in which the lamp is located), and the standard or pole. Light fixtures should be selected based on existing architectural standards of the installation and should reflect the installation's architectural character. Coordinating various fixtures in terms of types and materials will help visually unify the streetscape and other areas on the installation. Maintenance and repair of equipment will also be simplified because of the use of standardized parts and procedures.

Lamps

Many light characteristics, including brightness, color, energy efficiency, life span, and, therefore, suitability for a specific application, are determined by the type of lamp used in a light fixture *(see Figure 16-1)*. There are two broad families of lamps commonly used in exterior lighting. Incandescent lamps produce light from a filament being heated by an electric current. Electric-discharge lamps, including mercury vapor, high-pressure sodium, and metal halide, produce light by passing an electric current through a gas or metallic vapor.

- Incandescent lamps provide a color rendition that is warmer and more pleasing than most electric-discharge lamps. However, they are also less energy efficient and shorter lived than electric-discharge lamps. For these reasons, the use of incandescent lamps should be limited to areas where their color characteristics are more essential, such as pedestrian pathways and courtyards. Low-voltage incandescent lamps (12 volts) provide a simple and safe alternative to high-voltage lamps (120 volts), but they are not appropriate where high illumination is required and should only be used for low-level lighting along such areas as walkways and stairs.

- Mercury vapor lamps produce a color in the green to blue-green spectrum that is not flattering to many natural colors. Color-corrected mercury vapor lamps improve the color rendition, but where purity of color is necessary, they are still lacking. Mercury vapor lamps have the longest life but the lowest energy efficiency among electric-discharge lamps. They are recommended for use as street lighting in residential areas where somewhat lower levels of lighting may be desirable and color rendition is a secondary concern. Because mercury vapor lamps emphasize the green of foliage better than most other lamps, they are also a good choice for landscape accent lighting.

- Metal halide lamps provide better color rendition than mercury vapor lamps, have a higher energy efficiency rating, and are relatively long-lived. This type of lamp is recommended for general area lighting in public areas such as commercial and community centers.

- High-pressure sodium lamps are very efficient and relatively long-lived. However, they provide poor color rendition, producing light with a golden cast that is not flattering to many natural colors. High-pressure sodium lamps are recommended for primary and secondary roadway lighting and parking lot lighting where efficiency, reliability, and maintenance are critical and color rendition is a secondary concern.

Lamp Type	Color Rendition	Energy Efficiency (lumens/watt)	Life (hours)	Recommended Uses
Incandescent	renders colors well with emphasis on warmer tones	10-20	750-2,000	pedestrian areas, where natural color rendition is important
Mercury Vapor	green to blue-green; cannot render reds and yellows well	30-65	24,000	residential street lighting and accent lighting for planting material
Metal Halide	white light; renders colors well	75-125	15,000	general area lighting in public areas
High-Pressure Sodium	golden cast	75-130	20,000	primary and secondary roadway and parking lot lighting

Figure 16-1: Lamp Characteristics

Luminaires

The distribution pattern of light on a surface should vary depending on the specific lighting application. This pattern is controlled by placing the lamp in a luminaire that distributes light in a given direction by use of an enclosure, reflector, refracting lens, or a combination of these.

- A Type I luminaire distributes light in all directions from the light source at a distance of one to two times the mounting height of the lamp. It should be used for overhead lighting in areas such as parking lots, plazas, courtyards, and along walkways.

- Type II, III, and IV luminaries all distribute light to one side of the light source. These luminaries should generally be used for street lighting to direct light to the street side of the lamp but prevent it from shining into the building side. The difference in the three luminaries is in the ratio of the horizontal spread of the light to the mounting height of the lamp.

- A Type V luminaire concentrates the light beam to precisely control the direction and level of illumination. It should be used for such functions as recreation area lighting, for lighting landmarks, and for accent and decorative lighting.

- Cutoff luminaires place the lamp in an enclosure that restricts the light to a downward projection. With reflectors inside the enclosure, cutoff luminaires provide more light to the ground surface and prevent unwanted light and glare from escaping outward and upward from the fixture.

Poles

Light poles can be a significant visual element of the installation lighting system, especially in the daytime environment. They are available in a variety of shapes, materials, and finishes and should be selected according to short- and long-term costs, functional considerations, and aesthetic concerns. The variety of light poles used on an installation should be limited, and their selection should follow existing architectural standards.

- Concrete poles are available in a variety of finishes and are compatible in character with most settings, from roadways to pedestrian areas. Concrete poles are moderately expensive but require little long-term maintenance. They are appropriate for most applications but cannot exceed 50 feet in height. As they approach this height, their increased diameter may, depending on the setting, appear visually out of scale.

- Aluminum poles are also available in a variety of finishes and are appropriate in character for most uses and settings. They are relatively expensive but have low long-term maintenance requirements. The finish of an aluminum pole can be left natural but should be dulled to minimize reflection and glare.

- Decorative wood poles should be avoided because of high initial costs and high long-term maintenance requirements. Lights mounted on wooden utility poles should also be avoided because of aesthetic concerns.
- Painted steel poles, while relatively inexpensive, have high long-term maintenance requirements, and their use should generally be limited. Baked-on coatings help reduce this maintenance requirement but add considerably to costs.

- Weathered steel poles should be used for high mast applications exceeding 50 feet in height. They are inappropriate in pedestrian areas because of their scale and appearance and because the weathered finish can stain. Weathered steel poles are relatively expensive but are a practical, maintenance-free solution for high mast applications.

- Different types of poles can be used for different lighting applications, but they should be visually compatible. The same type of pole should generally be used for a similar application.

Other Equipment Considerations

The design, material, and scale of lighting equipment are factors that should be considered in the development of a lighting system. Exterior lighting should be integrated with the streetscape and other areas and should not visually dominate either the nighttime or the daytime environment.

- To help establish continuity, the variety of light fixtures used on an installation should be kept to a minimum. Light fixtures should reflect similar design, materials, and finishes throughout the lighting system.

- Fixtures should be used consistently in each type of application and should be appropriate in scale and character with the setting.

- Light fixtures should relate in appearance to other site furnishings.

- Light fixture materials such as poles and luminaire enclosures should have a matte or dulled finish to prevent glare and minimize their obtrusiveness.

- To reduce negative visual impacts, clutter, and potential conflicts with trees and other elements, lines supplying power to light fixtures should be located underground rather than overhead. Existing overhead lines should be buried in association with new construction or renovation projects.

- To minimize streetscape clutter, light fixtures should be integrated with traffic signs, street signs, and traffic control signals.

Economy of Operation, Maintenance, and Repair

The type, design, and location of lighting equipment can increase energy efficiency and help minimize the long-term operation, maintenance, and repair costs associated with the lighting system.

- The variety of light fixtures utilized in the lighting system should be minimized to facilitate maintenance and repair and the ordering and storage of parts.

- The highest-efficiency, longest-lived lamp appropriate to a particular application should generally be used. Incandescent lamps should be limited to pedestrian lighting where good color rendition is more essential and ease of access to the lamp can usually be provided.

- The placement of light fixtures should be coordinated with tree locations to prevent tree canopies from interfering with the proper distribution and level of lighting.

- Light fixtures and luminaries should be durable and resistant to vandalism and damage from accidents.

- The use of bollards as a low-level lighting source should be minimized because of the potential for damage and vandalism.

- The placement, height, and design of light fixtures should allow for easy access and replacement of lamps and luminaires.

16.3.2 EXTERIOR LIGHTING APPLICATIONS

Exterior lighting supports various functions on the installation, including the operation of vehicles, the activities of pedestrians, and the illumination of various features. Each of these functions has different requirements for lighting relative to purpose, intensity of lighting, light color, and maintenance *(see Figure 16-2)*. These requirements should guide the type of lighting employed in various areas.

Use	Foot-candles
Divided or wide primary streets	1.75
Narrower undivided primary streets	1.75
Secondary streets	1.0
Tertiary streets	0.5
Residential streets	0.2
Parking lots	0.5
Pedestrian facilities	0.5
Recreation areas	20.0

Figure 16-2: Minimum Recommended Illumination Levels for Various Uses

Vehicular Lighting

The primary purpose of vehicular lighting is to increase the safety and facilitate the flow of nighttime traffic by increasing visibility of the road and of potential hazards. Vehicular lighting also helps provide a sense of organization of the installation and orientation for the driver.

Safety and Traffic Flow

- Street lighting levels should allow drivers to clearly distinguish the alignment of the road and quickly discern signs, traffic control devices, obstacles, pedestrians, and other vehicles.
- Intersections, pedestrian and bicycle crossings, and other potentially hazardous locations, as well as curves, hills, and other areas with restricted visibility, should be illuminated at a higher level than other sections of the street.
- Street light poles should be located so they do not present an obstacle to pedestrians or a hazard to vehicles that may leave the roadway if a driver loses control. If a pole must be located where it could become an obstacle to a vehicle, a breakaway-type pole mounting should be used.
- Glare created by light fixtures should be minimized by the use of appropriate luminaires that direct the light in a manner that will not interfere with the driver's view.

Roadway Hierarchy

- Street lighting should be used to reinforce the vehicular circulation hierarchy on the installation by helping to visually differentiate between primary, secondary, and tertiary streets *(see Figure 16-3)*. To properly reinforce the hierarchy and lend a sense of organization, a consistent street lighting concept should be applied throughout the installation roadway network.

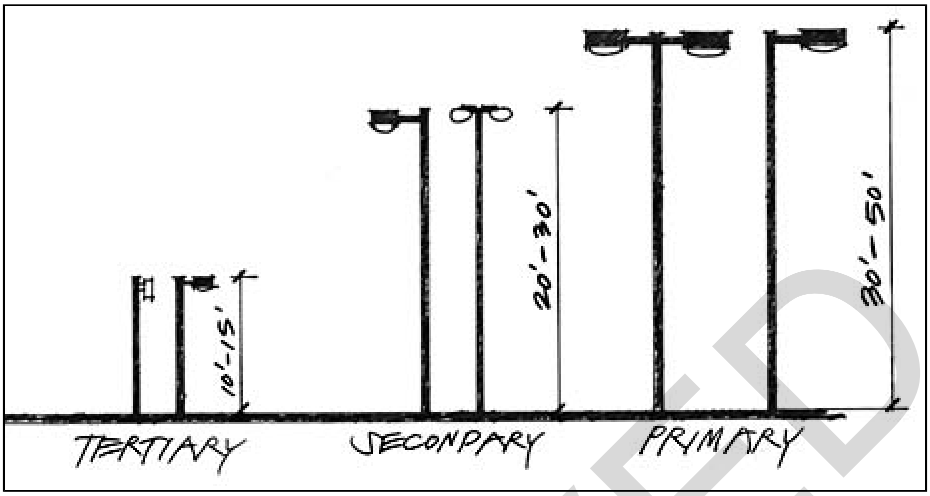

Figure 16-3: Primary, Secondary, & Tertiary Street Lighting

- The differentiation between various types of streets should be achieved not only by the level of lighting but also by the appearance of the light fixtures themselves. Appearance is influenced by such factors as the type, height, and mass of the fixtures, the spacing between fixtures, and the number of luminaires per fixture. Through their appearance, street light fixtures can reinforce the circulation hierarchy and lend a sense of organization even in daylight.

- Divided or wide primary streets should be defined by regularly spaced luminaires mounted approximately 40 feet high in an opposite arrangement along both sides of the street. Illumination levels should be maintained at 1.75 foot-candles.

- Narrower, undivided primary streets should be defined by regularly spaced luminaires mounted approximately 40 feet high along one side of the street. Illumination levels should be maintained at 1.75 foot-candles.

- Secondary streets should be defined by regularly spaced luminaires mounted approximately 25 feet high in an opposite arrangement along both sides of the street. Secondary streets with a median should be defined by regularly spaced, paired luminaires mounted approximately 25 feet high in the median. Illumination levels should be maintained at 1 foot-candles.

- Tertiary streets should be defined by regularly spaced luminaires mounted approximately 15 feet high along one side of the street. Illumination levels should be maintained at 0.5 foot-candles for nonresidential tertiary streets, and 0.2 foot-candles for residential streets.

- Luminaires for street lighting should generally be a directional type, projecting light downward to the road surface and away from the building side.

- The spacing between light poles and, therefore, the number of poles required should be determined by the level of illumination required.

Parking Lots

- Adequate lighting should be provided in all parking lots that will receive nighttime use.

- Light fixtures should be set back a minimum of two feet from circulation aisle and parking stalls. If possible, they should be located in raised islands or protected by wheel stops or other raised elements.

- Light fixtures should have luminaires mounted approximately 25 feet high. Illumination levels for parking lots should be maintained at 0.5 foot-candles. The spacing between light poles and, therefore, the number of poles should be determined by this level of illumination.

Pedestrian Lighting

The primary purpose of pedestrian lighting is to extend the use of the nighttime environment and provide for the safety and security of pedestrians. Pedestrian lighting can also help reinforce the hierarchy of the installation walkway network.

Safety and Security

- Lighting levels should allow pedestrians to clearly distinguish the edges of the walkway, changes in direction, intersecting walkways, and any potential obstacles or hazards.

- Street crossings, changes in grade, and other potentially hazardous locations should be illuminated at a higher level than other sections of the walkway.

- Light fixtures should be located so that they do not impede pedestrian traffic.

- To provide a sense of security, light fixtures should be located to minimize shadows and illuminate areas adjacent to the walkway.

Types of Pedestrian Lighting

- Low-level lighting refers to fixtures in which the lamp is mounted below eye level. It is generally used along the edges of walkways, ramps, and stairs to illuminate the pedestrian pathway. The lamp used in low-level lighting is generally incandescent, which typically provides low illumination in a small distribution pattern and is relatively short-lived. For these reasons, the use of low-level lighting should be limited. The use of bollards should be minimized because of their susceptibility to damage and vandalism. Of particular utility in lighting stairs, ramps, or walkways adjacent to walls are flush or semi-flush wall-mounted fixtures that direct light downward to the pavement *(see Figure 16-4)*.

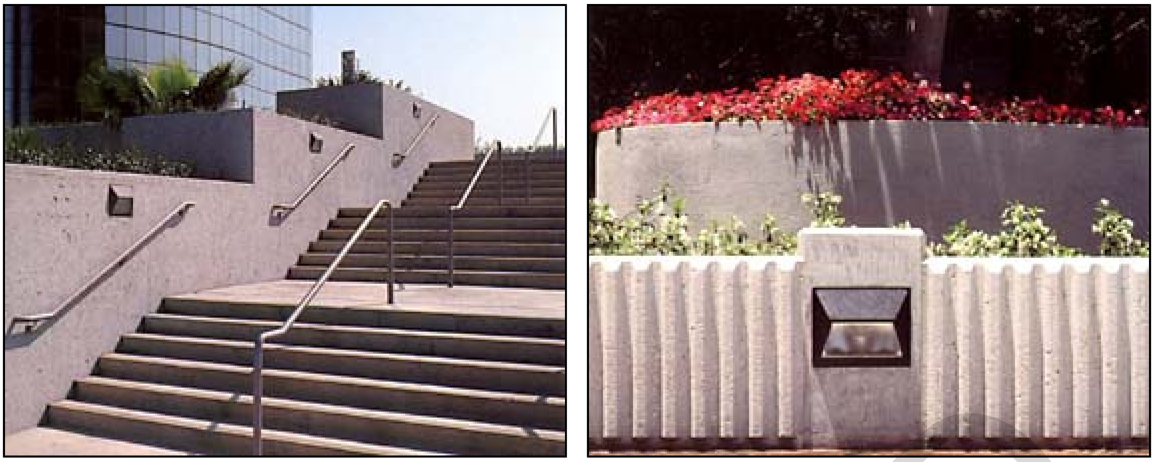

Figure 16-4: Step/Wall Light

- Light standards with the lamp mounted between 12 and 15 feet high should be the primary light fixtures used along walkways and in plazas, courtyards, and other gathering areas, such as commercial and community centers *(see Figure 16-5)*. These fixtures generally provide higher lighting levels and a broader light distribution pattern than low-level lighting, are less susceptible to damage, and are still in proper scale with the pedestrian environment. Metal halide lamps are recommended because they provide good color rendition and are relatively long-lived. The use of globe-type luminaires that cast light upward and outward as well as downward should be minimized because of their reduced efficiency.

Figure 16-5: Pedestrian-Level Light Fixture

- Bus shelters, telephone booths, kiosks, and other site furnishings should be adequately lighted for nighttime use for both security and functionality. Where possible, the light source should be incorporated into the structure of the furnishings.
- Where utilized at night, outdoor recreation areas such as ball fields and tennis courts should be provided with adequate lighting. These areas require a high level of lighting, with a minimum of 20 foot-candles recommended. Mercury vapor or high-pressure sodium lamps mounted 30 to 50 feet in height are recommended. Luminaires should focus the light onto the playing surfaces and prevent light or glare from intruding into adjacent areas.

Illumination of Features

The illumination of features involves using direct or indirect lighting to accentuate features or create a special effect. This differs from vehicular and pedestrian lighting, which involve using direct lighting for safety, security, and general area illumination.

Landmark Lighting

Illumination can be an effective tool to highlight landmarks and focus attention, which can also assist with nighttime orientation. However, care should be taken not to overuse landmark lighting, which may weaken its overall effectiveness and waste resources.

- Installation entry areas, monuments, static displays, architectural landmarks, and other such features should be lighted with floodlights or spotlights, creating patterns of light and shadow.
- The lamp should be directed away from viewers, and, if possible, the light fixture should be hidden.
- Lighting attached to buildings should be minimized and generally confined to entries.

Landscape Lighting

Landscape lighting achieves special effects by controlling the type, intensity, and direction of light to accent a landscape feature. As with landmark lighting, care should be taken not to overuse landscape lighting, which may weaken its overall effectiveness and waste resources. Several basic lighting effects can be used to accent landscape features *(see Figure 16-6)*.

- Installation entry areas, monuments, static displays, architectural landmarks, and other such features should be lighted with floodlights or spotlights, creating patterns of light and shadow.
- The lamp should be directed away from viewers, and, if possible, the light fixture should be hidden.
- Lighting attached to buildings should be minimized and generally confined to entries.

Figure 16-6: Landscape Lighting

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17.1 INTRODUCTION

Trees are the integral part of an urban forest and add beauty and character to an installation. Understanding the value of an urban forest is necessary to ensure its proper management. An installation's urban forest is vitally important and essential for social and environmental reasons. Trees can influence the environment by improving air quality and reducing energy cost as well as contributing to water and soil conservation.

This document provides basic discussion, understanding, and direction to implement and manage an installation's urban forestry resource.

17.1.1 DEFINITION

For most people, the word forest creates an image of rural areas covered with mile-after-mile of trees. It is important, however, to note that forests are not limited only to rural areas. Public awareness regarding the value of trees continues to increase as cities and military installations grow and populations expand. Both existing native trees in developed areas preserved through sensitive and creative site planning and design and those added as part of the landscape development define the urban forest. The management and care of these trees is urban forestry.

17.1.2 PURPOSE

The purpose of the Urban Forestry Guide is to provide information on analyzing and managing installation tree resources, developing a tree inventory, and maintaining the urban forest. This guide delineates the requirements specified in Chapter 11 of AFI 32-7064, Integrated Natural Resources Management.

17.1.3 GOAL

The goal of this guide is to assist Air Force personnel in their understanding of urban forestry and promote the development of management tools to sustain the quality of the installation's tree resources.

17.1.4 OBJECTIVE

The objective of this guide is to provide users with a logical process to develop an efficient Installation

Urban Forestry Management Program.

17.1.5 GUIDE ORGANIZATION

Trees

- Discussion of the importance and value of an installation's urban forest assets and providing for their life-long management and care

Urban Forestry Management Plan

- Discussion of the process necessary to implement and utilize a tree inventory while laying the foundation for managing an installation's urban forest

Conclusion

- Documentation of the actions necessary to efficiently manage urban forestry resources

Appendix

- Provide a sample Urban Forestry Management Plan Statement of Work

17.2 TREES

17.2.1 INTRODUCTION

A tree is a woody perennial plant, generally with one main trunk, having the potential to exceed three meters in height. Trees are an important resource. They provide much more than texture, color, and beauty to an installation's surroundings. They can modify the local environment and can give an installation a specific character and identity.

To gain the full benefit of what trees have to offer, they must be properly managed from selection and planting to a lifetime of maintenance. This chapter will address the following subjects:

17.2.2 BENEFITS

Trees can be a major part of an installation's natural resources. They have beneficial value both from a psychological as well as environmental standpoint. A tree's value applies and exhibits itself in the following categories:

Aesthetic

Trees add beauty through their shape, texture, color, and fragrance. They can soften the appearance of buildings, parking areas, and streets. Psychologically, trees create feelings of relaxation and well-being. They can provide privacy and a sense of solitude and security by their presence.

Figure 17-1: Trees Used to Soften Architecture

Figure 17-2: Trees Used to Soften Retaining Walls

Figure 17-3: Trees Used in Roadways and Parking Areas

Figure 17-4: Trees Used to Define Space and Provide a Sense of Solitude

Figure 17-5: Trees Used to Accentuate Building Entrance

Energy conservation

Studies have shown that properly placed trees can reduce energy consumption by shading building walls and windows. The shade and canopy cover from trees can alter surrounding micro-environments and reduce energy costs by cooling the facility. During winter months, trees can alter wind flow and drifting snow by blocking or redirecting winds to passively reduce winter heating costs.

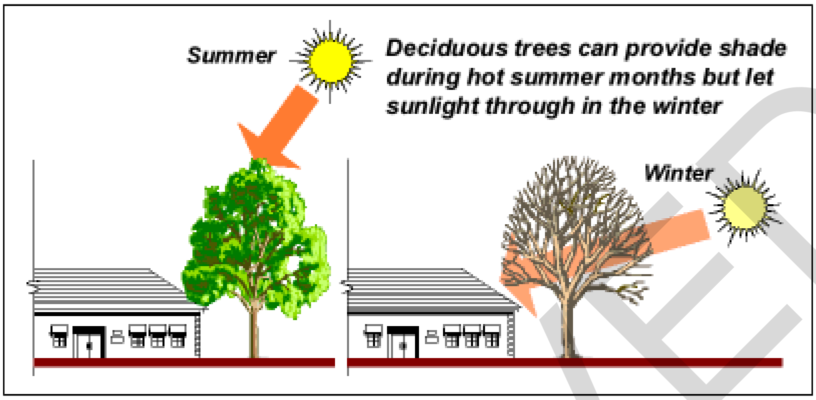

Figure 17-6: Solar Reduction and Gain

Natural resources

Trees can provide habitat and food sources for small animals and birds thereby enhancing the character of the environment. The tree inventory can be a useful resource to locate, improve, and preserve the habitat of wildlife species.

Environmental

Trees can influence climate, air quality, noise, and energy conservation. Trees reduce air pollution and serve as natural air cleaners by removing carbon dioxide from the air and releasing oxygen. Selectively placing a tree in the right location can reduce solar gain, glare, reflection, and noise; and provide sheltering from wind and snow.

Trees intercept rainfall to help control erosion of valuable topsoil. The tree's root systems help stabilize the soil and slow rainfall runoff by absorbing water before it enters a storm drainage system.

Taken as a whole, trees return overall benefits and value to the installation beyond the time and money invested in them for planting, protection, and maintenance.

Other benefits

Other benefits of developing and maintaining a current installation tree inventory are:

- Provides accurate information on the size, condition, and specie composition of tree resources
- Supports long-term maintenance budget requirements
- Provides detailed locations of trees for use in facility siting and landscape design
- Projects workloads, schedules, maintenance needs, and improvements to prioritize annual tree

management activities
- Monitors potential insect and disease epidemics and other problems
- Provides a baseline of the current condition of trees to aid decision making on what and how to manage these resources
- Promotes safety by controlling tree selection, planting, and removal in sensitive areas near or in the runway clear zones and flight paths

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17.2.3 MANAGEMENT CATEGORIES

Trees on an installation fall into four management categories:

Native forests

Most Air Force installations have naturally occurring trees. They are an important part of an installation's ecosystem and should be managed as a valuable natural resource. Native trees are usually found in undeveloped areas, located away from population centers. These trees should be managed as part of the commercial forestry program as described in AFI 32-7064, Integrated Natural Resources Management.

Native trees in developed areas

Native trees in and around developed facilities are also part of the urban forest tree management program. Once inventoried, they become part of the urban forest database and should receive regularly scheduled maintenance and care.

Planted

Trees planted as seedlings, transplants, or nursery stock fall into the planted category. Every planted tree on an installation which is not part of the commercial forestry program, should be part of the urban forest inventory and receive scheduled maintenance and care.

Airfield

An important task of an urban forest manager is the management of trees near the airfield. The airfield has unique airspace clearances that must be observed. AFJM 32-8008, Airfield and Heliport Planning Criteria (formerly AFR 86-14), provides specific height restrictions with respect to imaginary surfaces. Installations must comply with this criteria in managing the urban forest to ensure safe aircraft operations while eliminating the need to remove maturing, otherwise desirable trees from the urban forest inventory.

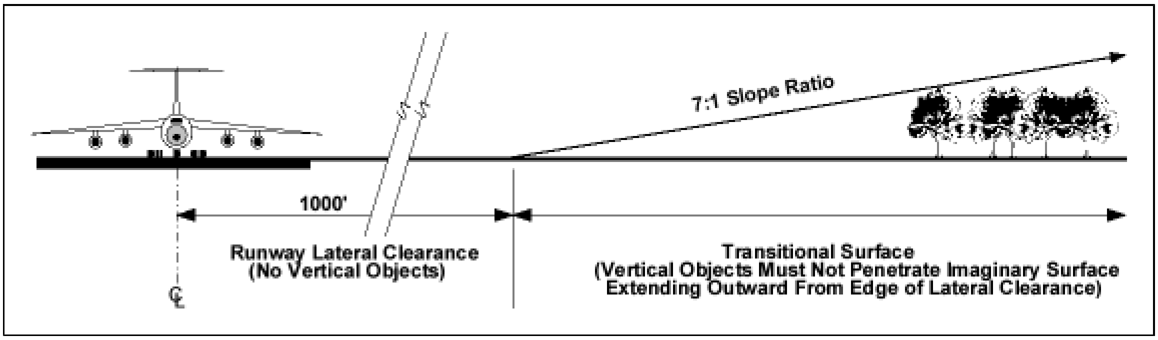

Figure 17-7: Trees Related to Airfield Safety Clearances

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17.3 URBAN FORESTRY MANAGEMENT PLAN

17.3.1 INTRODUCTION

The management of an installation's urban forest is an important task. Each tree species will generally require specific pest management, pruning, and fertilization to maintain its health and vitality. Identifying, quantifying, and understanding an installation's tree population is crucial to determining a comprehensive, long term approach to its well being. Trees will generally live longer and gradually require less intensive care with scheduled maintenance.

The tree inventory is an integral element of the Landscape Development Plan component of the installation comprehensive plan. This chapter provides an insight into the process of compiling an installation's urban forestry management plan to comply with the requirements of AFI 32-7064, Integrated Natural Resources Management. The process follows three phases:

- **17.3.2 INVENTORY**
- **17.3.3 ANALYSIS**
- **17.3.4 IMPLEMENTATION**

17.3.2 INVENTORY

The inventory is the foundation for formulating the installation urban forestry management plan. An inventory of installation trees provides detailed information for the manager and designer. Usually gathered in the field, inventory data must be systematically collected and stored for analysis. Installation natural resource managers or landscape architects can accurately forecast maintenance and replacement needs and budget for tree-related expenditures based on this information.

This data aids in developing long-range planning and design decisions such as new plantings, ensuring species diversification, and prioritizing maintenance actions.

Tree inventory information can be input into a computer aided drafting program (CADD) database and geographical information system (GIS) to build an integrated urban forest management plan and effectively maintain the installation's tree resources.

Trees vary considerably in life expectancy, growth habit, and maintenance requirements. It is important to record and maintain composite data on the various species found on the installation for the purpose of completing other requirements such as tree maintenance budgeting and personnel scheduling.

Data collection

The first step in accomplishing an installation tree inventory is to systematically collect and store data. Tree species, location, size, and overall condition of the installation's tree population are the primary data items collected. See Chapter 6 of the Landscape Planning Guide supplement of the USAF Landscape Design Guide for additional information.

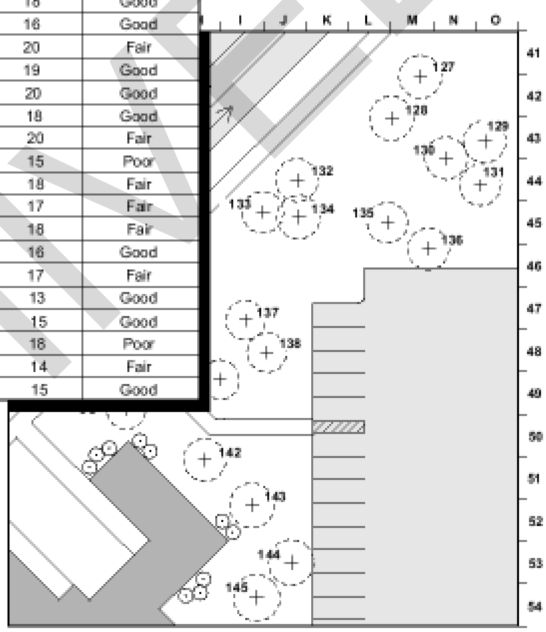
It is imperative that consistency and accuracy of the tree data be maintained throughout the inventory phase.

This section will discuss the parameters for the following inventory data items:

- **Location**
- **Identification**
- **Size classification**
- **Overall condition rating**

NUMBER	GRID LOCATION	COMMON NAME	BOTANICAL NAME	SIZE (in. DBH)	CONDITION
127	M-42	Lemon-Scented Gum	Ecalyptus citriodora	18	Good
128	M-42	Lemon-Scented Gum	Ecalyptus citriodora	18	Good
129	O-43	Lemon-Scented Gum	Ecalyptus citriodora	16	Good
130	M-44	Lemon-Scented Gum	Ecalyptus citriodora	20	Fair
131	O-44	Lemon-Scented Gum	Ecalyptus citriodora	19	Good
132	J-44	Lemon-Scented Gum	Ecalyptus citriodora	20	Good
133	J-45	Lemon-Scented Gum	Ecalyptus citriodora	18	Good
134	J-45	Lemon-Scented Gum	Ecalyptus citriodora	20	Fair
135	L-45	Brazilian Pepper	Schinus terebinthifolius	15	Poor
136	M-46	Brazilian Pepper	Schinus terebinthifolius	18	Fair
137	I-47	Brazilian Pepper	Schinus terebinthifolius	17	Fair
138	J-48	Brazilian Pepper	Schinus terebinthifolius	18	Fair
139	I-49	Jacaranda	Jacaranda mimosifolia	16	Good
140	E-49	Jacaranda	Jacaranda mimosifolia	17	Fair
141	F-49	Jacaranda	Jacaranda mimosifolia	13	Good
142	H-51	Jacaranda	Jacaranda mimosifolia	15	Good
143	I-52	Canyon Live Oak	Quercus chrysolepis	18	Poor
144	J-53	Canyon Live Oak	Quercus chrysolepis	14	Fair
145	I-54	Canyon Live Oak	Quercus chrysolepis	15	Good

TREE PLAN DATA BASE



TREE LOCATION PLAN

Figure 17-8: Existing Tree Plan

Location

Individual tree locations can be determined by:

- Vistual extimate using aerial photos
- Detailed ground measurements
- Global Positioning System (GPS) survey

Each tree location is recorded on a map and assigned a number for entry into the database which correlates to Map L-2, Existing Trees as described in the appended Urban Forestry Statement of Work.

Identification

Individual trees are identified by common and botanical names (genus and species and cultivar). Number each tree in sequence. Be consistent with identification system used. This helps to determine the overall composition of the installation's tree population.

Size classification

Tree trunk diameter is an indicator of the relative age of the tree. Collectively, this information provides insight into the maturity distribution for each species. Diameter is measured at 4 -1/2 feet or 1.37 meter above the ground or diameter-breast-height (DBH). The following DBH size classes are used:

Trunk diameter: inches (DBH)	Trunk diameter: centimeters (DBH)
0 to 3	1 to 7.6
3 to 6	7.6 to 15.25
6 to 12	15.25 to 30.5
12 to 18	30.5 to 45.7
18 to 24	45.7 to 60.1
24 to 30	60.1 to 76.2
30 to 36	76.2 to 91.45
36 to 42	91.45 to 106.7
over 42	over 106.7

Overall condition rating

Condition addresses the current state of the tree's health, structural soundness, shape, and growth rate. Discoloration, decay, dieback, decreased internodal length, and/or disfigured or dead stems or roots are symptoms of poor condition.

Determine the overall health and condition of a tree by analyzing root characteristics, trunk and branch structure, canopy, foliage, and any presence of disease and pest pathogens. Classify and record the condition of each tree in one of the following categories adapted from the rating system established by the International Society of Arboriculture:

Excellent

Trees in this class are judged to be exceptional trees possessing the best qualities of their species. They have excellent form and very minor maintenance problems. There are virtually no dead branches, deformities, or nutritional problems. These trees are in an acceptable location and can be expected to achieve a full mature shape and life expectancy.

Good

Trees in this class are judged to be desirable and with proper maintenance can be returned to an excellent classification. They may be interfering with utility lines, planted in an overcrowded location, or have minor insect, pathogen, or nutritional deficiencies.

Fair

Most trees in this category have some or all of the following problems: large dead limbs with as much as one-half of the tree already dead, large cavities in the trunk, major deformities, girdling roots, obvious insect, pathogen, or nutritional problems. Immediate maintenance and proper care may be able to save the tree.

Poor

Trees in this group are in a very degraded condition with irreversible problems. They have over 50% dead branches, drastic deformities, and severe insect, pathogen, or nutritional problems. They will have to be removed as soon as possible.

Dead

Trees in this category are either already dead or in such very poor condition that removal is required. These trees have over 90% dead branches and have completely succumbed to either insects, pathogens, or nutritional deficiencies. It is important to conduct the installation tree inventory after spring growth has begun. This ensures that a dormant tree is not misidentified as dead.

17.3.3 ANALYSIS

One of the uses of a tree inventory is prioritizing maintenance tasks. Overall urban forestry maintenance requirements are determined by observing the condition of the trunk, large branches, and canopy of each tree as well as the tree's location relative to streets, sidewalks, overhead utilities, signs, and other traffic control devices. These conditions may necessitate pruning to maintain line of sight and avoid other problems.

Tree condition data should be used to develop cost-effective pruning and removal schedules, personnel or labor needs, and material requirements. The following areas contribute to establishing a viable maintenance program:

- **Species diversification**
- **Approximate age and life expectancy**
- **Removal and pruning requirements**

Species diversification

In general, no genus and species, (e.g., Quercus rubra), should account for more than 10% of the total tree population. Further, no single genus (e.g., Quercus) should comprise more than 30% of the total tree population. The total number of species comprising an installation's urban forest should not be limited unless a certain species is not on the Installation Plant List. See Chapter Three of the Landscape Planning supplement to this guide.

Having a large concentration of one species could lead to a large number of trees being lost if affected by insect or disease pathogens. An entire species of trees could be at risk as was the case of American Elm trees (Dutch Elm disease). In most regions, planting at least ten different species is desirable.

The following table is an example of identifying species population distribution:

Genus Species	Common Name	#	%
Acer ginnala	Amur Maple	686	17.3
Acer rubrum	Red Maple	208	5.2
Betula nigra	River Birch	534	13.4
Cedrus deodara	Deodar Cedar	294	7.4
All others	Miscellaneous	-	56.7

Approximate age and life expectancy

Tree species have different life expectancies and different diameters, heights, and crown spreads at maturity. It is, therefore, more useful to make general classifications of age such as young, mature, and overmature rather than actual years. The diameter of a tree measured at 4-1/2 feet or 1.37 meters above the ground (or diameter-breast-height-DBH) is the standard used to classify tree age.

As a general means of estimating the age of an installation's urban trees, use the following industry guidelines:

- *Young* trees are those considered to be 15 cm (6 inches) or less DBH
- *Mature* trees are those between 15 and 61 cm (6 to 24 inches) DBH
- *Overmature* trees are those greater than 61 cm (24 inches) DBH

The ideal age distribution of a species in the urban forest, and for the population as a whole, is 20% young, 60% mature, and 20% overmature. A high percentage of overmature trees could necessitate a massive, expensive removal and replanting program. Installations can achieve an appropriate age mixture by removing and planting a certain percentage of trees each year. Removals should never exceed plantings.

The following is an example of annotating approximate age data:

DBH Range	Number of Trees	Percentage of Trees
Young (<15 cm)	2,260	56.8
Mature (>15 to 61 cm)	1,499	37.7
Overmature (>61 cm)	215	5.5

Removal and pruning requirements

Trees lose vigor and die from natural causes such as disease and insect pathogens, weather conditions, and from physical injury due to vehicles, vandalism, poisoning, and root disturbance. Trees should be removed to:

- Reduce safety risk to persons and property
- Eliminate breeding sites for pathogens
- To improve site appearance

Tree maintenance requirements can be categorized in one of six categories as shown in the following table:

Maintenance Required	Number of Trees	Percentage of Trees
Removal-High priority		
Removal-Low priority		
Pruning-Immediate priority		
Pruning-High priority		
Routine pruning		
Training pruning		
Transplanting		

Removal-high priority

Trees categorized as high priority removals should be removed as soon as possible as their condition and location present risks to persons or property.

Removal-low priority

Low priority removals should be scheduled and accomplished when resources are available after high priority removals have been accomplished. These trees are generally located away from population areas and facilities.

Pruning-immediate priority

Like high priority removal, trees in the immediate pruning category present safety risks to persons or property. Trees in this category are characterized by dangerous broken branches and large deadwood. Pruning should be accomplished as soon as resources are available. All trees in this category should be examined closely during trimming operations for decay or severe dieback. If, upon closer inspection, these trees are severely decayed, they should be removed.

Pruning-high priority

Trees requiring high priority pruning should be attended to as quickly as scheduling will allow, starting with those presenting the greatest safety risks. These trees, like the immediate priority pruning category, have broken branches and areas of deadwood. The dead areas, however, do not present an immediate safety hazard to persons or property.

All trees in this category, too, should be examined closely during trimming operations for decay or severe dieback. If, upon closer inspection, these trees are severely decayed, they should also be removed.

Routine pruning

All other trees except young and recent plantings fall into the routine pruning category. They require removal of dead, dying, diseased, or obviously weak, heavy, or hazardous branches, and deadwood. Routine, ongoing pruning should be scheduled and programmed to ensure all tree pruning is accomplished on a minimum cycle of five to seven years. It is important to remember that low priority problems can become high priority if they are neglected for an extended period of time.

Thinning of tree canopies to reduce crossing or unnecessary branches should be accomplished routinely. This reduces the potential for wind and ice-induced branch breakage and increases sunlight and air circulation within the crown. Thinning of tree canopies reduces substantially the incidence of insect and disease related problems.

Training pruning

The final maintenance category is training pruning. Trees in this category are generally young, recent plantings. Minimum maintenance includes trimming root and trunk suckers, deadwood, crossing, diseased, or weak branches, and staking improvement or removal. Trees in this category need to be scheduled for maintenance and not neglected.

Generally, young trees should be pruned to reflect their species' natural growth pattern or to a single leader or a strong central leader to promote the development of strong scaffold limbs. Certain species do not develop single leaders, therefore, the strongest leaders should be selected and allowed to shape the tree canopy. It is important to remember that minor problems can become major if they are neglected for an extended period of time.

Transplanting

Trees within an installation's urban forest may be affected as the result of proposed construction. In these cases, the choices are to remove or transplant the tree. Trees in good condition under 20 cm dbh should be transplanted if expertise and equipment, and funding are available. The long-term benefits of transplanting a quality tree usually outweigh the transplanting costs.

Transplanting can be accomplished using a tree spade or by back-hoe and chain. A large, protected root ball and immediate replanting greatly improves transplant success. This will lessen transplant shock and dehydration greatly enhancing survival rates. In most regions, transplanting is most successful when performed in the fall. Transplanted trees must receive constant attention for at least six months or more depending on the season and climate. Extra irrigation, root stimulators, special fertilizers, and expert pruning contribute to the success and survival of a transplanted tree.

17.3.4 IMPLEMENTATION

As with all processes, the implementation phase is the most important. Properly collected and analyzed data provide the urban forest manager with information to begin formulating maintenance policies, schedules, and budgets. Proper tree care is an investment which can lead to substantial returns. Well cared for trees are attractive and add considerable natural resource value to the installation.

The following urban forestry management tasks can now be quantified:

- **Maintenance scheduling**
- **Planting recommendations**
- **Budgeting**
- **Database management**

Maintenance scheduling

Regular maintenance assures the urban forest continues to grow in value. Preventative maintenance should be the primary concern of the urban forest manager. An effective maintenance program includes regular inspection and on-going care such as pruning, mulching, insect and disease control, and fertilizing.

Pruning

Tree pruning should focus on removing dead, diseased, or insect infected branches, selecting and training good structural branches to develop strong branching habits. Tree trimming should conform to National Arborist Association Pruning Class I, II, III, and IV standards.

Mulching

Probably the most neglected tree care practice is mulching. Placing 6-10 cm of organic mulch over the entire root system reduces environmental stress, conserves moisture, minimizes mechanical damage from mowers and weedwhips, and reduces nutrient competition from weeds and turf. Although any organic matter can be used as a mulch, shredded leaves, pine straw, peat moss, and shredded or composted tree bark and chips are the most widely accepted. Care must be taken to ensure that a 3-8 cm wide ring around the tree trunk is maintained clear of mulch to guard against decay and other problems associated with excessive moisture.

Insect and disease control

Monitoring insect and disease infestations by regular inspections and responsive treatment will help to maintain the health and vitality of the urban forest. A certified arborist or highly trained urban forest manager can take steps to prevent or reduce the severity of future disease, insect, and other pathogenic problems through periodic inspections (at least once a year). By closely observing new leaves or buds, leaf size, twig growth, and crown dieback, these professionals can recommend treatment to prevent major problems from affecting urban forest resources. Signs of poor tree health include trunk decay, loose bark, and deformed growths.

Preventative maintenance and treatment for known regional pests will protect installation tree investments. Consult with local certified arborists for specific information. Use only licensed and experienced pest management professionals when treatment is required.

Fertilizing

Trees require certain essential elements and micronutrients to thrive. Since installation soils widely vary in their ability to provide adequate amounts of these elements, it may be necessary to supplement through the addition of balanced fertilizers. It is important to determine soil quality and add fertilizers based on need of the individual tree.

If done properly, a sound fertilization program can increase growth, reduce insect and pathogen susceptibility, and reverse declining health. Improperly done, fertilization can actually harm the tree.

Consult local nursery personnel, extension agents, and certified arborists to determine actual fertilization needs. Schedule this work to be accomplished at the right time of the year and continue program annually.

Planting recommendations

To assure continuous age distribution, the installation should replant about five percent of the total tree population each year. Successul tree planting is a combination of what, where, and how. The type of tree, its location, and method of installation are each vitally important.

What

The Installation Plant List should be used to determine which trees to plant. The urban forest manager should consult with local nurseryman and landscape architects to compile this list. If a list already exists, the manager should ensure urban forest objectives are met given the trees identified.

Certain species should not be planted on an installation because of undesirable features or disease susceptibility problems.

See Chapter Two of the Landscape Planning supplement to the USAF Landscape Design Guide for further information on the Installation Plant List. In addition, the following factors should be considered when making a tree selection:

- Shape and growth habit
- Mature height and spread
- Rate of growth
- Insect and disease susceptibility
- Expected lifespan
- Maintenance and irrigation requirements
- Litter

Where

Where a tree is planted affects aesthetics and function as well as overall maintenance requirements. See the Planting Design supplement of the USAF Landscape Design Guide for further information.

How

Proper planting of trees is also important. Inadequately sized planting holes, improperly placed and installed guy wires, and under or over watering are some of the causes for additional stress and even death of young trees. Urban forest managers should review tree installation details and specifications to ensure that proper methods are utilized.

As dead and dying trees are removed and new ones planted a systematic program of establishment and maintenance specifically for newly planted and young trees helps ensure the greatest chance of survival. Appropriate maintenance for these particular trees is paramount.

Budgeting

Successful implementation of an Urban Forestry Management Plan is impossible without proper programming and funding. The urban forest manager should estimate all costs required for establishing and maintaining the installation trees. Costs will typically be higher at the beginning because of initially higher removal and pruning requirements.

Long term costs should stabilize as maintenance becomes more routine. Recurring maintenance budget costs will include inspection, regular pruning, mulching, fertilization, disease and insect control, and replanting.

Potential storm damage cleanup and repair or epidemic insect or disease infestations should be considered in developing an annual budget.

Database management

To effectively manage the urban forest, the tree inventory database must be kept current and accurate. The tree inventory should be continually updated (at least annually) to reflect new plantings, removals, and maintenance required.

The tree inventory can be easily updated by creating and utilizing a computerized database. Several software products have been specifically developed for this purpose. Most generate schedules for recurring maintenance activities and cost estimates for budgeting and programming task proposed.

Urban forest managers should contact local tree care organizations, consultants, and certified arborists for information on suggested software.

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17.4 CONCLUSION

Effective tree care is an investment in the future. Healthy trees increase in value with age while providing both tangible and intangible benefits. Urban forest resources must be protected and preserved. New trees must be added to the inventory as a legacy of Air Force stewardship and concern. Installation leadership can make a contribution to the future by implementing a comprehensive and progressive Urban Forestry Management Plan.

17.4.1 ACTION ITEMS

Below are recommended actions to initiate and execute a comprehensive Installation Urban Forestry Management Plan:

- Develop an installation tree inventory to identify and assess the extent, condition, and needs of the urban forest
- Use a computer to effectively and efficiently manage and update tree database information
- Integrate the tree inventory with installation planning and design functions
- Enlist the education and experience of a certified arborist
- Follow tree care specifications exactly
- Consult with landscape architects in developing tree planting designs

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17.4.2 REFERENCES

Suggested further reading:

All About Trees, Editors, Ortho Books, 1992, The Solaris Group

City Trees, the City of Chicago's Guide to Urban Tree Care, Suzanne Malec Hoerr and Janet Ginsburg, 1995, City of Chicago Press

FORS/Map System, Forest Resource System Institute, 122 Helton Court, Florence, AL 35630, (205) 767-0250

Renewing the American City, Proceedings of the 1995 Annual Meeting and Expo American Society of Landscape Architects, 1995, American Society of Landscape Architects

Shading Our Cities, A Resource Guide for Urban and Community Forests, Gary Moll and Sara Ebenreck, 1989, Island Press

The Simple Act of Planting a Tree, Andy and Katie Lipkis, 1990, Jeremy P. Tarcher, Inc.

The Granite Garden, Anne Whiston Spirn, 1984, Basic Books

Trees in Urban Design, Second Edition, Henry F. Arnold, 1993, Van Nostrand Reinhold

Tree Manager Software, ACRT Inc, 2545 Bailey Road, PO Box 401, Cuyahoga, OH 44221, 1-800-622-2562

Urban Forestry in Arizona, David Hutchings, 1981, Cooperative Extension Service, University of Arizona

Urban Trees, A Guide for Selection, Maintenance, and Master Planning, Leonard E. Phillips, Jr., 1993, McGraw-Hill, Inc.

Urban Forestry - - Planning and Managing Urban Greenspace, Robert W. Miller, 1988, Prentice-Hall, Inc.

Assorted Brochures, International Society of Arboriculture, P.O. Box GG, Savoy, IL 61874-9902, 1995

17.5 APPENDIX

17.5.1 URBAN FORESTRY STATEMENT OF WORK

The following Urban Forestry Statement of Work can be used to contract for a tree inventory and management plan. *Italicized* sections are installation specific and should be filled in as appropriate.

Delivery Order (DO) Appendix Statement of Work (SOW) for (*Command/Installations*)

Contract Master SOW Reference: Landscape Development Project Title: Urban Forestry Management Plan Project Number: Delivery Order Number: Locations: (Attachment 1) Command & Installation POC: (Attachment 2)

1 Introduction

1.1 Master Statement of Work Cite: Services and materials will be described in the Master Statement of Work. Reference the Master SOW Chapter, Component L; Chapter 4, CADD/GIS and Global Positioning Survey (GPS); and Chapter 4, Map L. This Scope of Work is for study of urban forestry resources at the installations shown at attachment 1.

1.2 Purpose: The natural resource manager or landscape architect at each (*XXX Command*) Installation is responsible for the maintenance and upkeep of installation natural resources in compliance of Air Force conservation policy. Trees are a major investment. The urban forests at each (*XXX Command*) installation is a national as well as a physical and aesthetic asset. This work is to inventory these urban forest assets, and develop a cost effective plan for their continued vitality.

2 Scope:

2.1 The contractor will develop an Urban Forestry Management Plan, partly based on data provided by the government, but primarily contractor generated field data. The plan shall include an urban tree inventory and procedures and data to maintain the urban forest.

2.2 Consolidated Project

2.2.1 The contractor will perform work for (*installation*) as an individual customer. The work will be accomplished as a consolidated effort under the technical guidance of the Command Natural Resource Manager and/or Command Landscape Architect and Installation POC, and under the direction of the Contracting Officer.

2.2.2 Work will be programmed and directed for the listed installations to ensure a cost saving is realized by the command and installations, by the economy of scale. The contractor will assign labor in such a manner to avoid duplication of specialists and maximize benefit to the Air Force.

3 Specifications

3.1 Technical Requirements

3.1.1 The contractor shall use all available maps and reports as provided by the Contracting Officer to inventory and develop a management plan of the tree resources in the study areas as indicated below and other areas as identified by the Contracting Officer.

3.1.2 Attachment 2 provides installation points of contact (POCs) for Government Furnished materials (GFM), and assistance in scheduling site visits.

3.1.3 Study Area(S): The maps at attachment 3 show the location of the study areas the installation county and state location; and the acreage to be inventoried.

3.2 Contractor TASKS

3.2.1 TASK 1: Urban Forestry Management Plan: An urban forestry management plan for the study areas(s) will be prepared. The plan shall include tree survey information (Botanical and common names, size, relative age, condition, valuation, and maintenance needs), tree location reference points, maintenance/management recommendations, trends analysis, and method of scheduling personnel and equipment used to maintain the urban forest.

3.2.2 TASK 2: Automated Tree inventories will provide:

3.2.2.1 An accurate report of the number and condition of trees within each of the study areas.

3.2.2.2 An identity for each tree (name, location, diameter class, condition, and maintenance needs).

3.2.2.3 A method to efficiently schedule personnel and equipment used in the maintenance of the urban forest.

3.2.2.4 Information to be used in planning defensible urban forest budgets based on accurate quantifiable projections of the required workload.

3.2.2.5 Urban forest trends such as species not performing well or species which have been overplanted.

3.2.3 TASK 3: Map L-2, Existing Trees. Using Map M-1, Current Plan, 1" = 200' (or the installation equivalent), document the location and variety of each tree surveyed. All surveyed trees will be graphically represented based on size DBH (diameter at breast height - DBH) and keyed to the legend. The legend shall include genus, species, and common name for each tree.

3.2.3.1 Tree survey information points will be provided to run on a Personal Computer (PC) using an MS-DOS relational database which will be linked to CADD/GIS software applications to create Map L-2.

3.2.3.2 The data will be provided on CADD software (e.g., Autodesk's AutoCAD or Intergraph's Microstation) as specified by the Contracting Officer.

3.2.4 TASK 4: Management Plan Preparation. Ten (10) copies of the approved Urban Forestry Management Plan shall be provided to the Contracting Officer. The narrative management plan shall also be provided as a word processing document using Microsoft Word (most recent version). The Urban Forestry Management Plan shall not be distributed by the contractor to sources outside the Air Force without prior approval.

3.2.5 TASK 5: Map L-2 Preparation. Three copies of the approved final Existing Trees map will be provided to the Installation POC. The Map shall provide a format as specified in Part 5.L. of the Master Statement of Work. Three copies shall be provided on a compatible computer storage format most appropriate for the target host system (floppy disk, tape, Bernoulli) or as directed by the Contracting Officer.

3.2.6 TASK 6: Records Review and Data Collection:

3.2.6.1 The contractor shall review the current Installation Plant List, if existing, and provide recommendations regarding future tree planting. If there is no official Installation Plant List, the contractor shall create a tree list only that integrates USAF Landscape Design Guide requirements proposed for the installation prior to submittal of the Urban Forestry Management Plan.

3.2.6.2 Field Survey Visit. The contractor shall schedule and coordinate the data collection visit(s) with the installation natural resource planner and/or landscape architect. The field survey and evaluation will be based on a field examination of the tree resources by a certified Arborist or by personnel who possess a minimum of five years of recent experience in the fields of botany, arbor culture, dendrology and/or silviculture. Existing Natural Resources Management Plans, Landscape Development Plans and studies relating to the work effort will be provided to the contractor by the Contracting Officer.

3.2.6.3 All data collected shall be processed and provided to the installation using a software package designed for tree surveys and/or urban forest management, or an approved equal. The following are a few possible sources:

Tree Manager Software, ACRT Inc, 2545 Bailey Road, PO Box 401, Cuyahoga, OH 44221, (800) 622-2562 FORS/Map System, Forest Resource System Institute, 122 Helton Court, Florence, AL 35630, (205) 767-0250

3.2.7 TASK 7: Inventory

3.2.7.1 The inventory shall classify trees by location. Trees shall be classified to provide an easily identifiable location. The inventory shall as a minimum provide location definitions by zone, section and site number. All trees will be identified by the following characteristics:

3.2.7.1.1 Species. Identify by botanical and common name (genus, species, and cultivar).

3.2.7.1.2 Size/Diameter. The tree diameter shall be recorded to provide an estimate of the relative age of the tree. The diameter shall be measured in size classes at 1.37 meters above the ground (diameter at breast height - DBH).

3.2.7.1.3 Condition. The condition of each tree shall be recorded in one to the following categories adapted from the rating system established by the International Society of Arboriculture: Excellent, Good, Fair, Poor, Dead.

3.2.7.1.4 Maintenance. Maintenance data shall be collected to establish a basis for needed work. Maintenance needs shall be divided into the following categories:

3.2.7.1.4.1 Removal. Trees designated for removal are dead, stumps, and trees that are in poor condition or have hazard potential making them candidates for immediate action. Trees in the low priority removal condition are in good or fair condition, but are misplanted near living areas, species located near or under utility lines requiring regular pruning to keep lines clear, or are declining trees that will require removal in the next few years.

3.2.7.1.4.2 Immediate/High Priority Pruning. Trees in this category require pruning to remove dead wood and/or broken branches that pose a potential risk to personnel or property.

3.2.7.1.4.3. Routine Pruning. Trees in this category have characteristics that could become risks if not corrected.

3.2.7.1.4.4 Training Pruning. This category includes trees less than 20 feet in height with correctable structural problems or minor amounts of dead wood that pose little or no threat of injury to personnel or property.

3.2.7.1.4.5 Utilities. The inventory indicates whether overhead conductors or other utilities are present at the tree site.

3.2.8 TASK 8: Prepare a survey plan and submit the schedule of work to the Contracting Officer within 14 workdays following the notice to proceed. The Contracting Officer will provide written acceptance of the proposed work schedule prior to commencement of work by the contractor.

3.2.9 TASK 9: Computer Software, Training and Support.

3.2.9.1 The contractor shall provide two (2) copies of all necessary software documentation required to utilize the collected data. The database and all associated software shall be installed by the contractor and shall be fully operational and functional prior to final acceptance by the Contractor Officer.

3.2.9.2 The contractor shall provide on-site training for two personnel as identified by the Contracting Officer. All personnel trained in the use of the computer program applications shall be provided with reference tutorials.

3.2.9.3 The contractor shall provide continuing technical telephone and/or fax support regarding the computer program's operation at an average of 20 hours per installation not to exceed an average total of 120 hours. The contractor will record technical support time spent on calls for and transmitted to the government on a monthly basis for a period not to exceed three (3) years from the effective date of the delivery order.

3.2.10 TASK 10: Work Requirements. Provide the necessary personnel, supplies, and equipment necessary to complete the field survey.

3.2.11 TASK 11: Permits. Obtain all permits necessary to accomplish the work in the areas as identified by the Contracting Officer.

3.3 Government Furnished Materials/Equipment (GFM/E)

3.3.1 The Contracting Officer will provide maps for each installation showing study areas.

3.3.2 The Contracting Officer will provide the contractor with any available copies of existing overviews of the base, such as records, maps, aerial photography, and other relevant documentation. The contractor shall protect the government materials provided for use and shall return each item in its original condition. Installation layout maps (e.g. Map C-1) will be provided by the Contracting Officer.

3.3.3 The Contracting Officer will provide, where possible, unsupervised access to survey areas and sites. Any required escorts will be provided by the Contracting Officer following a minimum of 48 hour notice of access requirement by the contractor.

4 Quality Assurance

4.1 Reports and Deliverables

4.1.1 Incremental Submittals: This work effort requires the contractor to make submittals for installation review. Prior to publishing the final Urban Forestry Management Plan, the contractor shall provide a preliminary draft which identifies the outline of the plan with a brief description of each section's contents (15% submittal). With approval of the Contracting Officer, the contractor shall continue on to develop of the draft management plan (65% submittal). The contractor shall incorporate all review comments into the final (100% submittal) management plan submittal.

4.1.2 Urban Forestry Management Plan: An urban forestry management plan which includes tree survey information. Eleven (11) copies.

4.1.3 Automated Tree inventories. One (1) copy per installation.

4.1.4 Map L-2, Existing Trees. Using Map M-1, Current Plan, 1" = 200' (or the installation equivalent), develop map document showing the location and variety of each tree surveyed. Three (3) reproducible copies.

4.1.5 Management Plan Preparation. Eleven (11) copies.

4.1.6 Records Review and Data Collection.

4.1.7 The contractor recommendations regarding future planting needs: local availability of plant materials on the Installation Plant List prior to submittal of the Urban Forestry Management Plan.

4.1.8 Field Survey Visit. The data collected and processed.

4.1.9 Software and data developed and procured, as part of the contract. 4.1.10 Survey plan and work plan.

4.1.11 Computer Software, Training and Support.

4.2 Government Reviews: The contractor shall make submittals to the Contracting Officer for review and approval. The Contracting Officer will provided review comments to the contractor within ten (10) workdays following receipt of each submittal.

4.3 Submittal Schedule: The submittal schedule is based on Government workdays from receipt of delivery order. The contractor shall assign personnel as necessary to provide submittals for each installation as follows:

Milestones	Calendar days from receipt of Delivery Order	Number and disposition of deliverables
Management Plan Outline	45	1 copy to each installation 1 copy to command
Government Review	60	Consolidated comments provided to the contractor
Draft Management Plan	90	3 copies to installation 1 copy to command
Government Review	120	Consolidated comments provided to the contractor
Final Management Plan	180	10 copies to installation 1 copy to command 2 copies to AFCEE

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18 EROSION CONTROL

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18.1 INTRODUCTION

Much of the erosion that occurs on Air Force installations results from construction, maintenance, or operations activities that disturb the soil and from a lack of appropriate management practices that effectively protect soil from the forces of water and wind. Insufficient erosion control measures can result in damage due to loss of soil and increases in sedimentation, waterborne suspended solids, and airborne particulate matter. Because impacts from soil erosion can be long term and far reaching, a number of federal and local regulations control runoff to adjacent properties and discharge into waterways and water bodies. Often, the damage resulting from erosion is more costly in terms of remedial actions needed and impacts to operational activities and environment resources than is the implementation of appropriate control measures.

18.1.1 PURPOSE

The purpose of this chapter is to provide guidance related to the control of soil erosion on Air Force installations. This includes guidance for preparation of an erosion control plan as well as guidelines for various methods of erosion control. These guidelines are provided for two distinct but interrelated levels of erosion control planning and design:

- overall strategies aimed at preventing or minimizing actions or conditions that might contribute to erosion; and

- specific measures aimed at stabilizing exposed soils and controlling runoff and wind.

18.1.2 GOALS & OBJECTIVES

The goal of erosion control is to minimize environmental impacts and long-term maintenance and repair costs by:

- reducing the loss of soil on a site;
- reducing sedimentation;
- reducing suspended solids in waterways and water bodies; and
- preventing slope failure and structural damage.

The objectives of erosion control that support achievement of this goal are to:

- minimize the disturbance of existing soil, topography, and vegetative cover;
- stabilize soils that have been disturbed; control the path and velocity of runoff to protect disturbed or exposed areas;
- deflect or filter wind in areas vulnerable to wind-related erosion; and

- reduce the amount of sediment entering or accumulating in waterways and drainage structures.

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18.2 CAUSES OF EROSION

Erosion is a natural process caused by the forces of water and wind. It is influenced by a number of factors, such as soil type, vegetation, and topography, and it can be accelerated by various activities that occur on an Air Force installation.

18.2.1 SOIL EROSION PROCESS

The soil erosion process involves the dislodging, transport, and deposition of soil particles. These forces are at work whether erosion occurs on a large flat surface, a slope, or in a drainageway or other waterway. The control or modification of these forces is the primary aim of erosion control planning and design.

- Soil particles are dislodged by the impact of falling rain (which lifts and shifts particles), by the overland flow of water (from precipitation, snowmelt, or manmade sources such as irrigation or construction activities), by wave action along shorelines, or by the action of wind.
- Dislodged soil particles are then transported by flowing water or the wind. As the flow of water increases in speed and volume, it transports particles either in rather uniform thin layers over a broad area (sheet erosion) or in concentrated channels (rill and gully erosion). Wave action and currents can transport soil and sand away from or along the shoreline. Wind can transport heavy particles in a low trajectory above the surface in which individual particles may continually strike the ground and dislodge other particles, thereby increasing erosion. Wind can also lift and transport lighter soil particles several thousands of feet into the air and many miles in distance.
- As the wind or the flow of water decreases, soil particles are deposited as sediment. In standing water, particles will settle to the bottom. The rate of settling is related to the movement of the water and the size of the suspended soil particles; as the water slows, particles begin to settle out, but fine particles may remain in suspension for long periods.

18.2.2 FACTORS THAT INFLUENCE SOIL EROSION

There are numerous factors that influence soil erosion, including soil characteristics, vegetative cover, slope, water, and wind.

- A complex set of characteristics determines a soil's erodibility (its vulnerability to erosion). These characteristics include the size of soil particles, the percentage of organic content, the structure of the soil, and soil permeability.
- Vegetation generally helps stabilize soil and control runoff. It protects the soil surface from the

impact of falling rain, slows the velocity of runoff, and can intercept water-borne sediment. Root systems usually act to bind soil in place and increase the absorptive capacity of the soil. Vegetation can also help lessen or deflect wind, intercept wind-borne sediment, and keep soils moist, which will make them less susceptible to wind-related erosion.

- Slope gradient and length affect the volume and velocity of runoff. As both gradient and length increase, the amount and rate of runoff become greater and erosion potential increases.

- As the frequency, intensity, and duration of water striking or flowing across the surface increase, the amount of runoff produced and, therefore, the erosion potential increase.

- As the frequency, intensity, and duration of wind increase, the potential volume of soil lifted into the air and the distance that soil is transported increase.

18.2.3 ACTIVITIES THAT CONTRIBUTE TO SOIL EROSION

Various activities that occur on an Air Force installation can contribute to erosion by exposing soils to the forces of water and wind. Impacts from erosion can often extend beyond the immediate location of these activities to surrounding areas.

- Construction projects can contribute to soil erosion both during and after the actual construction activity. Grading, clearing, and other activities that disturb the surface of the soil, alter existing topography, and remove existing vegetation can increase erosion potential during construction.

- Increases in the area covered by pavements and structures and a failure to incorporate into the construction design control measures that adequately stabilize slopes, reestablish cover on exposed soils, or convey runoff can increase erosion long after construction is completed.

- Grounds maintenance activities can contribute to erosion when appropriate consideration is not given to the protection of soil. These activities include irrigation practices that increase runoff by over-saturating the soil or allowing sprinklers to spray onto hard surfaces; the clearing of brush or other vegetation without replanting or otherwise protecting exposed soils; and snow removal activity that disturbs surface soils.

- Infrequent or inappropriate maintenance of drainage systems, plant material, and potentially erodible areas can also contribute to erosion. The failure to repair damaged drainage structures or regularly remove growth, debris, and sediment from channels, traps, and basins can increase flooding and runoff. Failing to control disease and pests can damage plant material, thereby increasing erosion potential. Neglecting preventive measures that stabilize slopes and protect barren areas can increase the exposure of soil to the forces of water and wind.

- Operational activities on an Air Force installation, such as those requiring expansive areas of airfield pavement or range training areas, can contribute to erosion by significantly increasing runoff and disturbing vegetation and soil.

- The use of natural resources on the installation for activities such as off-road vehicle recreation, grazing, and forestry can expose and destabilize soils, increasing the potential for erosion.

18.3 EROSION CONTROL PLANNING PROCESS

In order to achieve effective erosion control, a logical and comprehensive planning process should be followed that includes an *existing conditions survey*, an *erosion potential analysis*, and the development of an *erosion control plan*. While this process is commonly followed when developing grading and drainage plans for proposed construction projects, it should also be applied to an analysis of erosion potential throughout the installation to determine corrective actions for existing problems and preventive measures for potentially erosive conditions.

Existing Conditions Survey

- An existing conditions survey should include written and mapped information on existing conditions on the installation that may affect erosion. Such conditions include topography, drainage patterns, soil types, the extent and kind of vegetative cover, impermeable surfaces, and above- and below-grade drainage structures. This information should be combined on a single map to indicate areas of potentially overlapping concern. The survey should also document climatic information, including norms and extremes in temperature, precipitation, and wind, which will help define expected and unusual weather conditions that may affect erosion.

- The existing conditions survey should be conducted and maintained for the entire installation, but a similar and more detailed survey should be prepared for proposed construction projects, identifying site-specific factors that may affect erosion and influence project design. The existing conditions survey provides the physical data upon which an erosion potential analysis will be based.

Erosion Potential Analysis

- An erosion potential analysis should identify drainage, potential runoff, prevailing winds, and critically erodible soil areas. These critically erodible areas are determined based on a combination of factors including the types and exposure of soils and the steepness of slopes. Activities that might contribute to erosion should be noted to better define appropriate management strategies and maintenance practices. Drainage structures that require repair, renovation, or clean out should be identified. Areas currently subject to significant erosion should also be identified.

- As is the case with the existing conditions survey, the erosion potential analysis should be conducted for the entire installation, but a more detailed analysis should be prepared on a site-specific level for proposed construction projects. The erosion potential analysis forms the foundation upon which the erosion control plan will be developed.

Erosion Control Plan

- Based on the erosion potential analysis, an erosion control plan should be prepared to develop a program to correct existing erosion problems and prevent potential problems. The plan should identify erosion control construction projects and maintenance actions as well as establish a program to manage installation activities to help reduce or eliminate their creation or intensification of erosive conditions. Construction and maintenance projects should be prioritized based on the severity of existing or potential problems in terms of their impact to installation operations and maintenance or the environment.

- A separate erosion control plan should be developed for proposed construction projects that indicates new development and all existing and proposed grading, on-site drainage, and proposed temporary and permanent erosion control measures. Much of this information is commonly contained in the project grading and drainage plan, which is an appropriate vehicle to develop and communicate an approach to project-level erosion control.
- In developing the erosion control plan, the designer should be aware of governmental regulations that may affect erosion control actions. These include the federal Clean Water Act, which regulates the discharge of material into waters of the United States, and the Endangered Species Act, which regulates actions that may have an impact on rare plants and animals. Projects or actions that may require permits or approvals under these and other acts entail coordination with various federal agencies, including the U.S. Army Corps of Engineers, the Environmental Protection Agency, and the U.S. Fish and Wildlife Service.
- The designer should also be aware of state or local laws that may affect erosion control planning. Laws regulating such concerns as water quality or coastal zone management may simply endorse federal policy or may actually be more stringent. They may regulate activities within a relatively broad area, including complete watersheds or along the entire coastline of a state. These regulations vary from locale to locale and have different requirements relative to documentation or other procedures and the limitations placed on proposed actions. Early and thorough coordination with the appropriate agencies and jurisdictions may avoid needless setbacks in the erosion control planning and implementation process.

Narrative, tabular, and graphical information describing existing conditions, erosion potential, and the erosion control plan should be compiled and displayed within the installation's existing report and mapping framework and in accordance with applicable Air Force standards. Narrative information should be included in the Composite Constraints & Opportunities Component, the Infrastructure Component, and the Landscape Development Plan of the Comprehensive Plan. Graphical information regarding existing conditions and erosion potential should be compiled as a level or layer on the Opportunities & Constraints Composite Map and the Existing Storm Drainage Map. Graphical information locating proposed improvements should be compiled as a level or layer on the Future Storm Drainage Plan and Future Landscape Development Plans. Non-graphical information that can be compiled in a tabular form should be attached, if possible, to the corresponding graphical map element.

18.4 EROSION CONTROL PLANNING GUIDELINES

Advanced planning that seeks solutions to potential erosion problems before they arise is a significant aspect of an effective erosion control plan. Erosion control planning strategies address broad areas of concern, including *management practices*, *maintenance procedures*, and *site development approaches*.

18.4.1 MANAGEMENT PRACTICES

Based on conditions identified in the erosion potential analysis, management practices related to activities and situations on the installation that cause or contribute to erosion should be developed.

- Soils on the installation that are highly susceptible to erosion should be indicated on the erosion control plan in advance of any proposed actions. This information, along with other opportunities and constraints data, should be used to determine suitable locations for future development and activities that may contribute to erosion. If possible, highly susceptible areas should be avoided. If they cannot be avoided, advance identification should allow timely development of appropriate erosion control and mitigation measures rather than discovering potential conflicts during design or at the commencement of construction or other activity.

- The erosion control plan should be utilized to identify and manage potential far-reaching and cumulative impacts from erosion and runoff that could be caused by proposed actions. An installation-wide plan can provide information that may not be apparent on site-specific plans. This level of information could reveal potential impacts to adjacent sites and surrounding areas on the installation as well as to broader watershed areas or property outside the installation boundaries. In this manner, wider impacts from erosion should be avoided, controlled, or mitigated.

- The erosion control plan should be used to manage activities such as off-road vehicle use, grazing, and range training that may denude and otherwise physically affect soils. Management strategies should regulate the nature of the activity and establish any necessary limitations on its physical extent, duration, or time of year. Proper management of activities should also include requirements for appropriate erosion control measures on site and may entail periodic rotation of the activity to a different location to allow an area to recover or be restored.

18.4.2 MAINTENANCE PROCEDURES

The erosion control plan should establish a program of maintenance procedures related to erosion control. The program should include routine maintenance procedures that should be performed on a regular basis to prevent potential erosion problems from developing and the identification of specific maintenance projects that should be completed to arrest emerging problems and correct existing problems.

- Existing drainage structures should be regularly cleaned out to prevent backups or flooding and to allow systems to operate at full efficiency in terms of conveying runoff and capturing sediment. This includes the removal of sediment from detention basins and traps and the clearing of debris and unwanted growth from channels and catch basins. Drainage structures should be routinely inspected for wear or damage that might significantly impact their performance, and necessary repairs should be made in a timely manner. Existing structures should be adequately protected when nearby construction or other activities may temporarily increase sediment loads.

- Unstable soil areas, whether currently eroding or potentially subject to erosion, should be protected and stabilized. This may include regrading or retaining unstable slopes or providing vegetative cover on barren areas. Drainage channels and outlets where the erosive effects of water are concentrated may require protection with inert materials such as riprap or concrete.

- In areas where runoff is not adequately handled by existing drainage structures, projects for new or renovated structures may be required. This type of project should be considered a maintenance action, separate from the construction of drainage systems installed in association with the construction of new facilities such as buildings, roadways, or parking lots. These projects may involve the expansion of existing structures or the construction of additional structures to properly collect and convey runoff, and they include both surface drainageways and below-grade sewer systems. Maintenance projects may also include the installation of such structures as check dams or other grade control structures to reduce water velocity in channels or filtered storm drain inlets to trap sediment and pollutants.

- Properly maintaining plant material is an important means of stabilizing and protecting soils, slowing and intercepting runoff, and controlling wind. To allow plants to thrive and perform as expected, they should be selected and installed according to their environmental and physical requirements, including those of soil, water, light, climate, and space. Proper maintenance procedures, including pruning, thinning, mowing, and mulching, will increase plant health.

- Pests and disease can severely damage or kill plants, which can be particularly devastating if a single type of plant used exclusively over an area is affected. Pests and disease should be prevented and controlled through environmentally sound methods, including using resistant plant types and a mix of plants that is less susceptible to a single type of pest or disease.

- Irrigation should be utilized to help establish and maintain plants, especially during periods of drought. Plants should be irrigated in a manner that encourages vigorous root systems that will spread downward and outward to help bind the soil and improve plant health. Shallow watering will encourage shallow roots, which will decrease the plants ability to withstand stressful periods and be less effective in binding the soil, especially on slopes. Deep watering at intervals that allow the soil to dry between will encourage extensive root systems that will be more effective in binding the soil and protecting against erosion.

- Landscape irrigation systems that are appropriate to the circumstances should be installed and properly operated to help limit runoff. Spray systems should only be used where an even application of water over a broad area is required. The use of point source irrigation, such as drip or bubbler systems, should be considered in areas where individual plants are spaced well apart. Spray irrigation heads should be properly sized and located so that water is not applied over areas where it is not needed, including bare soil and hard surfaces such as walkways, parking lots, and streets.

- Care should be taken to control the watering time to limit over-saturation of the soil and runoff. Irrigation schedules should be adjusted to account for fluctuations in the weather and seasonal differences. Moisture sensors can be used to determine the water content of the soil and help limit the use of irrigation when the soil is already moist.

- Irrigation practices on steep slopes should provide a balance between too much and too little water. Over-watering can saturate soils, adding weight and lubrication that, under the effect of gravity, can lead to slippage. Under-watering can dry out soils, forming cracks that can become rills or gullies when runoff increases during storms.

18.4.3 SITE DEVELOPMENT APPROACHES

To reduce erosion and sedimentation, site development approaches aimed at avoiding or minimizing change to the natural site should be followed.

- The site development plan should minimize the amount of change to the natural grades and the clearing of existing vegetation required to accommodate the proposed project.

- High intensity development or use areas should be located in areas that are least vulnerable to erosion, and development should be avoided in critically erodible areas.

- The site grading plan should minimize the length and gradient of proposed slopes.

- Short-term construction activity, such as stockpiling of materials or parking of equipment, should be avoided in critically erodible areas.

- Clearing and grading should be phased such that they occur only on property that is needed for immediate construction and can be stabilized before clearing and grading another parcel.
- Control measures for stabilizing disturbed soils and slowing and/or redirecting runoff should be planned well in advance and included as part of the construction contract package. These include temporary measures, designed to control erosion and sediment directly related to construction activity, and permanent measures, designed to control erosion and sediment resulting from the proposed development.

- Construction activities that expose or disturb the soil should be scheduled during periods of low precipitation to limit runoff potential. Limiting construction to only dry periods may not be practical in some regions. Where the rainy season cannot be avoided, adequate measures, as discussed above, should be taken to protect exposed soils.

18.5 EROSION CONTROL MEASURES

Even with appropriate planning, some site-specific erosion control measures will be required to minimize the amount of erosion on an installation. These measures essentially serve to either control runoff or wind or stabilize soils. Measures will generally be permanent in nature, but they may also be temporary, specifically designed to control erosion during construction or other short-term activity.

18.5.1 APPROACHES TO EROSION CONTROL

Numerous factors, including existing and proposed site conditions, climate, available infrastructure, cost, maintenance practices, and regulatory compliance, will influence the appropriate approach to erosion control and, therefore, the specific erosion control measures that will be required for a given site. For water-related erosion, basic approaches to control involve either surface or underground drainage systems. For wind-related erosion, basic approaches to control involve providing either shelter from the wind or direct protection of the soil.

Surface Drainage Systems

Surface drainage systems collect and convey runoff from paved and unpaved surfaces in sheet flows or in open drainage channels.

- Primary considerations in selecting and designing a surface drainage system involve preventing on-site erosion where the flow of water is concentrated within channels or at drainage outlet points. These areas must be adequately designed, stabilized, and maintained, particularly where accumulated runoff flows at increased concentrations and velocities from large paved areas.

- Vegetation may help to slow runoff, but proper stabilization may require that some areas be lined with hard material such as riprap or concrete. On-site detention areas may also be necessary to slow the velocity of runoff. Unpaved areas subject to sheet flow should be stabilized with vegetation or inert materials.

- If on-site erosion can be adequately controlled with only a small percentage of the total drainage system lined with hard material, surface drainage may be a cost-effective approach to erosion control. Surface drainage structures are also generally more accessible than underground systems for maintenance, including sediment removal. Sites subject to large volumes or concentrations of runoff may not be well suited to a surface drainage approach to erosion control because the capacity of the system to adequately channel and remove runoff may be exceeded.

Underground Drainage Systems

Underground drainage systems convey site runoff in enclosed, below-grade storm sewers. Runoff is collected at storm drain inlets and can be released into the main installation or municipal sewer system or at a surface outlet.

- Primary considerations in selecting and designing an underground drainage system involve controlling the amount of sediment that enters the underground system, the availability of existing underground sewer systems with which to connect, and reducing the velocity of runoff released at surface outlets.

- The most effective means to reduce the amount of sediment entering an underground system is to protect erodible areas by diverting and channeling surface runoff and providing vegetative or other soil cover. Sediment carried by runoff to the underground system can be removed at either the inlet or the outlet to that system. Catch basins, traps, or filters can reduce the amount of sediment that enters the underground system, but they must be regularly cleaned out to maintain the system's capacity. Sediment can also be controlled at a surface outlet of an underground system by providing detention and settling areas.

- Because runoff collected in an underground system is conveyed in an enclosed pipe, it can attain higher velocities than in a surface drainage system. To avoid the potentially erosive impact of this runoff, new underground systems should tie into existing systems if lines with adequate available capacity are located reasonably close by. If runoff conveyed in sewer pipes must be released at a surface outlet, the velocity of the runoff should be reduced to non-erosive levels and the area around the outlet should be properly graded and stabilized to lessen erosion.

- If the accumulation of sediment and the erosion at surface outlets can be adequately controlled, underground drainage systems are an effective approach to erosion control. Underground systems can safely and efficiently convey higher concentrations of runoff than can surface drainage systems and significantly reduce on-site erosion. However, no storm drainage system can be entirely underground, since water must be conveyed overland to sewer inlets. An effective surface drainage plan is still an important aspect of any approach to water-related erosion control.

Windbreaks

Windbreaks can control the intensity of the wind over a specific zone. The feasibility and effectiveness of windbreaks to provide shelter for areas susceptible to erosion by wind is based on a number of factors.

- Because they are most effective when placed perpendicular to the direction of the wind, windbreaks should be used only where the direction of erosive-force winds is predictable. In most areas, winds blow predominantly from a single direction or a few directions on a daily or seasonal basis, making proper placement of a windbreak possible. If the direction of erosive-force winds is unpredictable or they come from many directions, windbreaks may not be an effective approach to erosion control.

- Windbreaks should be used if the soil area requiring protection is large enough to justify their installation and can be contained primarily within the zone sheltered from the wind. The sheltered zone is proportional to the height of the windbreak, extending in depth on the leeward side to approximately 30 times the height, depending on the nature of the windbreak. If the area requiring protection is either too small or too large, a windbreak may not be an appropriate erosion control approach.

- A windbreak itself must achieve a certain height, length, width, and density to effectively reduce wind, but it should also be compatible with the proposed site in terms of other factors, including space, functional, and aesthetic considerations.

Direct Protection from Wind

Wind does not possess the same erosive force as water and primarily acts over a broad area to move soil that is exposed and already loose. Wind speed decreases measurably the closer it gets to the ground surface, and even a strong wind cannot lift heavy soils such as sand more than a few feet above the surface.

- Protecting soil from the wind can be achieved by providing coverage for exposed areas. This approach can be used in combination with a windbreak or in situations where a windbreak may not be appropriate. Such coverage should also generally help lessen water-related surface erosion.
- Protection from wind should be provided with vegetation that establishes a low, dense, and continuous cover. Inert materials, such as stone, can also provide effective coverage but may be impractical or aesthetically unpleasing if used over large areas.

18.5.2 RUNOFF CONTROL MEASURES

The control of runoff involves diverting it from exposed soils or other vulnerable areas, slowing its velocity, and controlling the amount of sedimentation that leaves a site.

<u>Diversion Channels</u>

- Runoff should be diverted from exposed slopes and other vulnerable areas by means of a ditch, a dike, or a combination of both. These diversions should run laterally to and be located above the vulnerable area. Additional diversions should be located at intervals across a slope to reduce the slope length and divert runoff away from lower areas *(see Figure 18-1)*.

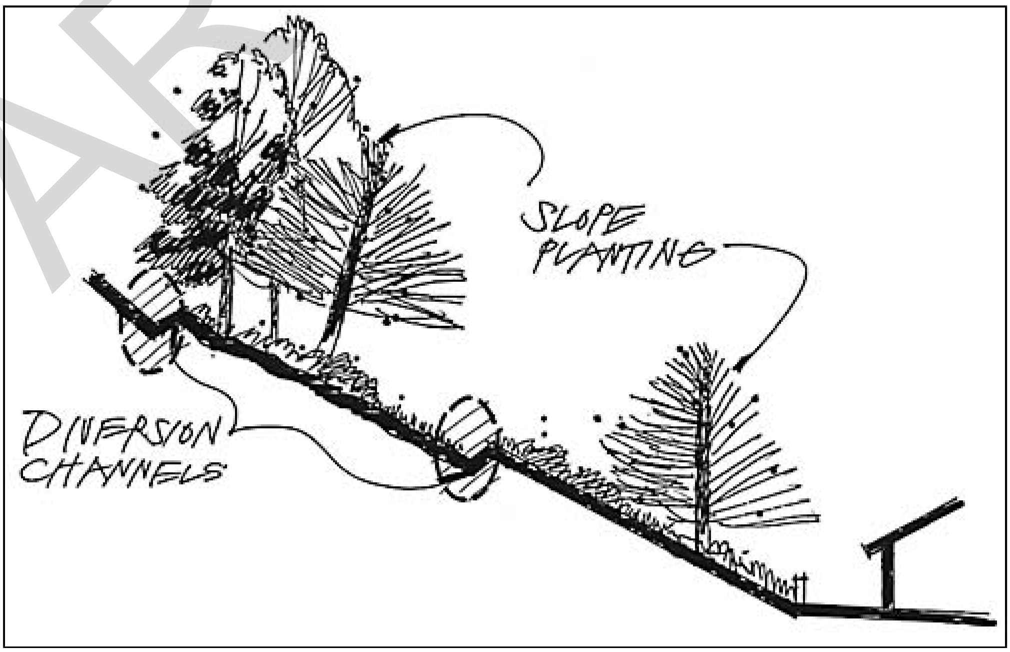

Figure 18-1: Diversion Channel

- Diversions should be sized appropriately to collect and convey runoff that may enter them. Depending on the erodibility of the soils in a diversion itself and the amount and velocity of runoff to be conveyed, the diversion should be planted with vegetation or lined with hard material such as riprap.

- Because of the concentrated volume of runoff in a diversion, there should be a stabilized and appropriately sized outlet to reduce the erosion potential. If adequate area exists, this may be achieved simply by gradually widening and reducing the gradient of a diversion channel to reduce the force of the water.

Slope Drains

- When runoff cannot be intercepted laterally in a diversion channel, a drain that runs the direction of the slope may be necessary. These drains can be located on the surface as an open channel or can be placed below the surface as an enclosed pipe (*see Figure 18-2*).

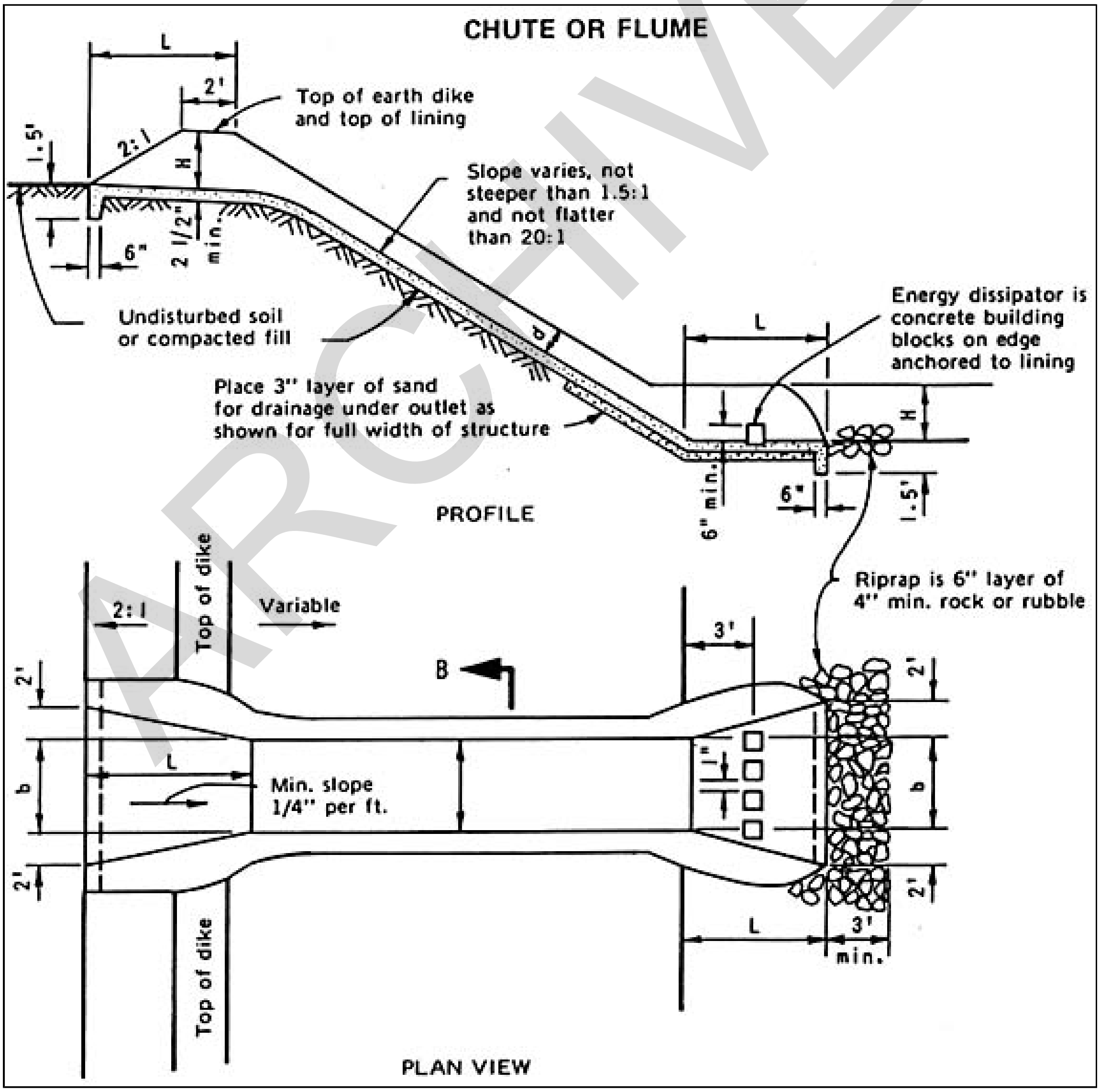

Figure 18-2: Slope Drain

- Like diversions, slope drains should also be sized appropriately to collect and convey the runoff that may enter them. Depending on the amount and velocity of runoff to be conveyed, a surface slope drain can have a soft surface, such as grass, or a hard surface, such as concrete or riprap.

- Because of the concentrated volume of runoff in a slope drain, there should be a stabilized and appropriately sized outlet to reduce the erosion potential. Energy dissipators, such as riprap, may also be required to slow the velocity of runoff at the outlet of a drain to a non-erosive level.

Grade Control Structures

- To lessen the velocity of runoff in a drainageway or channel, a grade control structure may be necessary to reduce the gradient of the flow. By reducing gradient, the grade control structure helps dissipate the energy of flowing water and lessens erosion potential (*see Figure 18-3*).

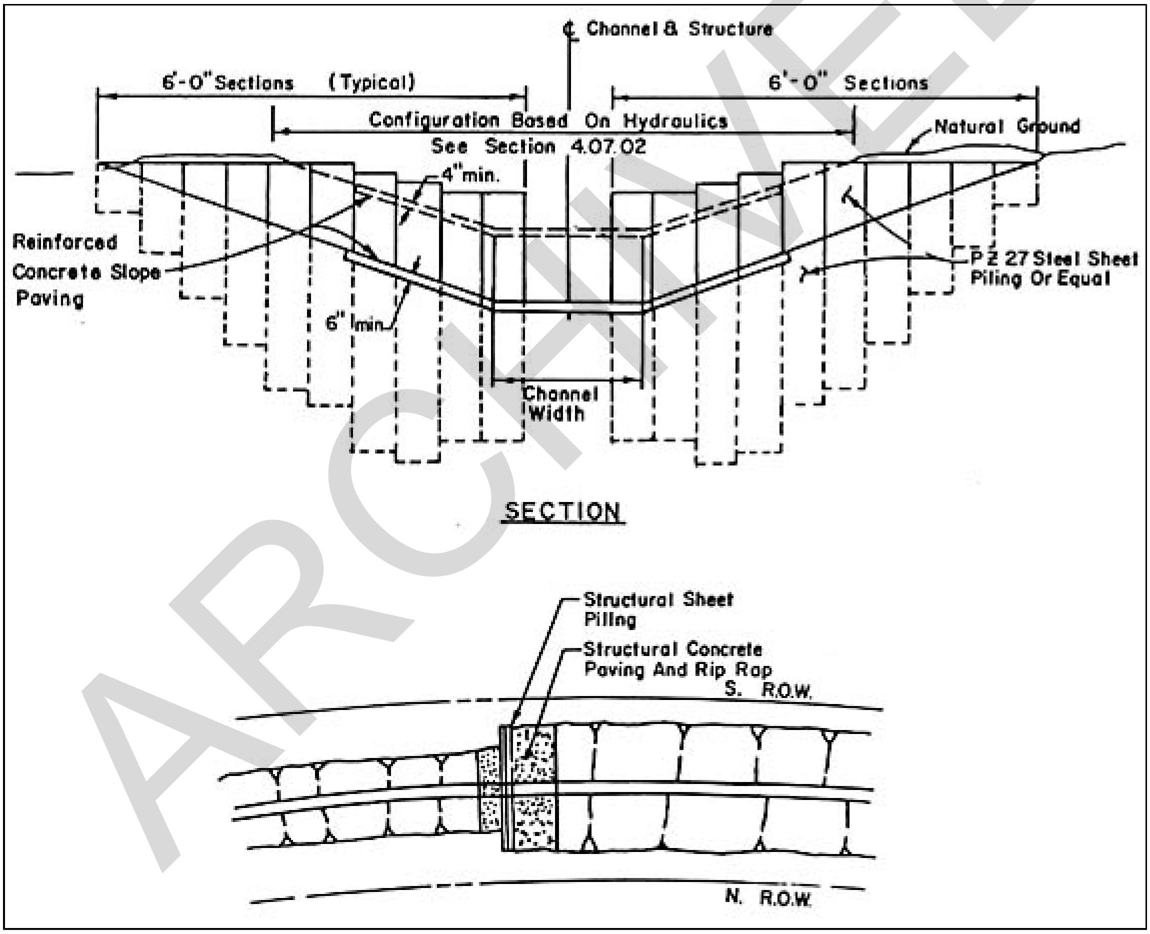

Figure 18-3: Grade Control Structure

- Grade control structures include check dams, weirs, and drop spillways. These structures can be temporary or permanent, depending on the long-term need. Permanent structures should consist of a hard material, such as concrete.

- The velocity and volume of the water, and therefore its erosive potential, is concentrated at the grade control structure drop. Additional stabilization of the channel bottom and sides is often required at the grade control structure to prevent undercutting and erosion of the channel sides.

Storm Sewers

- When diversions, surface drains, and channels cannot adequately handle the volume or velocity of runoff, storm sewers may be necessary. These systems can be designed to convey large volumes of runoff at relatively high velocities.

- Because storm sewers are underground and enclosed, most concerns related to erosion from water flow are reduced. However, the flow of sediment into the sewer system must be controlled to allow the system to operate at full capacity. Catch basins provide a sump that allows sediment and debris to settle out before storm water flows into the drain pipe, but they should only be employed where regular maintenance will be provided to clean out the sump and control mosquito breeding. Drop inlets do not have a sump and allow storm water to flow directly into the pipe. Traps or filters located at the inlet will reduce the amount of sediment that enters the underground system, but these must also be regularly cleaned out to maintain the full capacity of the system. Sediment can be controlled at a surface outlet point of an underground system by providing detention areas that will allow it to settle out before runoff is again released.

- Because of the relatively high volume and velocity of runoff in a storm sewer, proper controls are necessary at an outlet to minimize erosion. If an existing storm sewer of sufficient capacity is reasonably close, the new system can be tied into it. If such an existing system is not available, an on-site surface outlet, such as a detention basin, may be required. This basin should be large enough to handle the volume of flow, and it should be stabilized sufficiently to resist eroding. The rate of release from the sewer should also be controlled or dissipated to reduce erosion potential.

Runoff from Impermeable Surfaces

- Streets, paved parking lots, roofs, and other impermeable surfaces allow no infiltration of runoff and provide little resistance to flow. Runoff draining from these surfaces can be highly concentrated and moving at a velocity greater than runoff flowing over an unpaved surface. This runoff must be removed, but soils must be protected from its erosive force.

- Where a storm sewer system is available, curbs and gutters can be installed on streets and parking lots to capture runoff and convey it directly to sewer system inlets. In this way, paved areas themselves serve as drainageways.

- Where curbs and gutters are not economically feasible, paved areas should be designed to minimize the distance that runoff will travel before leaving the surface. This will reduce the accumulation and velocity of runoff. Areas at which the runoff leaves the paved surface should be properly stabilized to reduce the potential for erosion.

- At airfields, the accumulation of runoff from runway, apron, and taxiway pavements can be considerable. Measures to control this runoff must be implemented such that they themselves do not interfere with airfield operations activities. The preferred approach from an airfield operations viewpoint is to surface drain pavements to areas outside designated aircraft routes. These areas may be located within paved surfaces, in which case runoff should be directed to storm sewer inlets. Areas at which runoff drains from the pavement surface should be properly stabilized to channelize runoff and reduce erosion and potential damage to the pavement edge. If underground drainage structures must be placed within the airfield pavement, they must be airfield rated for structural strength and should be located to minimize impacts to airfield operations during required maintenance and repair activities.

- Storm runoff flowing from roof downspouts directly onto the ground can severely erode the soil adjacent to a building. To avoid this, roof drains can be connected directly to an adjacent street or other drainage system that can safely convey the runoff. If roof drains cannot be directly connected to an external drainage system, surface areas that receive runoff should be properly stabilized. Splashblocks or pavement should be placed beneath downspouts to protect soil, dissipate runoff, and direct it away from the building.

- If buildings do not have a gutter or drain system, the ground below the roof eaves should be properly stabilized and protected with vegetation, stone, or other material to prevent erosion along the drip line.

Detention

- On-site detention of runoff is often required to protect adjacent property from erosion, and to prevent sediment from discharging off site. Detaining runoff allows suspended soil particles to be filtered or settle out before the runoff is released.

- Detention can be achieved with vegetation that can slow the velocity of runoff and act as a filter to intercept sediment suspended in the runoff. Vegetative buffers or strips should be planted between areas of potential erosion and sensitive zones, such as streams, to reduce the discharge of sediment.

- Sediment traps can be constructed across drainage channels to detain runoff for a sufficient time to allow sediment to settle to the bottom. These traps should be cleaned out periodically, removing sediment from the trap basin.

- Detention basins can also be used to detain runoff and allow sediment to settle to the bottom. After sediment has been trapped, runoff can be released from the basin at controlled rates to reduce erosion potential. Detention basins can be constructed by excavating a depression or building an impoundment. If appropriate, they can be integrated into a site development as a permanent pond (*see Figure 18-4*).

Figure 18-4: Detention Basin

- Although Air Force planning guidance permits water areas within runway clear zones and accident potential zones, the designer, based on local experience, should consider the possible impacts to flight operations from potential bird air strike hazards (BASH) when siting open detention areas. Mosquito abatement may also be required where there is open water. Underground structures, such as cisterns, may provide an alternative to open water detention.

18.5.3 WIND CONTROL MEASURES

Wind control involves blocking, deflecting, or filtering the wind to reduce its erosive impact on a given area. This control is achieved essentially with windbreaks, which can provide some degree of shelter for soils that are susceptible to wind erosion *(see Figure 18-5)*.

- The size and degree of sheltering from the wind that can be achieved is based on an interrelated set of factors, including the permeability, height, width, and placement of the windbreak. The characteristics of trees and large shrubs make them one of the most effective elements for windbreaks.

- The amount of wind that is deflected up and over an object depends on the solidness of the object. A solid element, such as a wall or a building will deflect all wind, but in the process it tends to create turbulence on the leeward side, effectively reducing the depth of the area of shelter that is provided. Windbreaks consisting of permeable elements, such as trees, reduce this turbulence and actually provide a larger area of shelter. This occurs because the wind that is allowed to pass through the trees keeps air pressure on the leeward side more constant, inhibiting the formation of eddies. Studies have shown that the optimum density for a windbreak is about 50 to 60 percent surface coverage facing the wind. At higher densities, leeward turbulence is increased. At lower densities, too much wind is allowed to pass through.

- The depth of the sheltered area is based largely on the height of the windbreak. The depth of the area that receives some degree of shelter will extend 30 to 40 times the height of the windbreak. Within this sheltered area, the extent to which wind speed is reduced will vary, with the greatest reduction occurring at a distance from the windbreak equal to about five times its height. As distance from the windbreak beyond this point increases, the degree of reduction in wind speed within the sheltered area steadily decreases.

- Plants make effective windbreaks because they can achieve heights greater than most other elements found on an installation. A 40-foot-tall tree will provide, theoretically, five times the shelter area provided by an eight-foot wall or fence. Trees that have low branching characteristics should be used for windbreaks because as trees grow taller, the open zone beneath the canopy becomes larger. If this zone becomes too large, increased wind speeds could result as air is forced through the openings around the tree trunks.

- The depth of the sheltered area will also increase as the width of the windbreak increases in a direction perpendicular to wind flow. Thus, wider windbreaks will provide a proportionally deeper zone of protection. The depth of the windbreak itself has little effect on the reduction in wind unless increased depth is required to achieve a desired density of coverage. A single row of trees that achieves the desired density is as effective as a windbreak consisting of many rows with the same overall density.

- To successfully reduce erosion with a windbreak, erosive force winds must come from primarily one direction, and windbreaks should be placed perpendicular to that direction. As the angle between the windbreak and the direction of the wind becomes more acute, the area of protection becomes narrower.

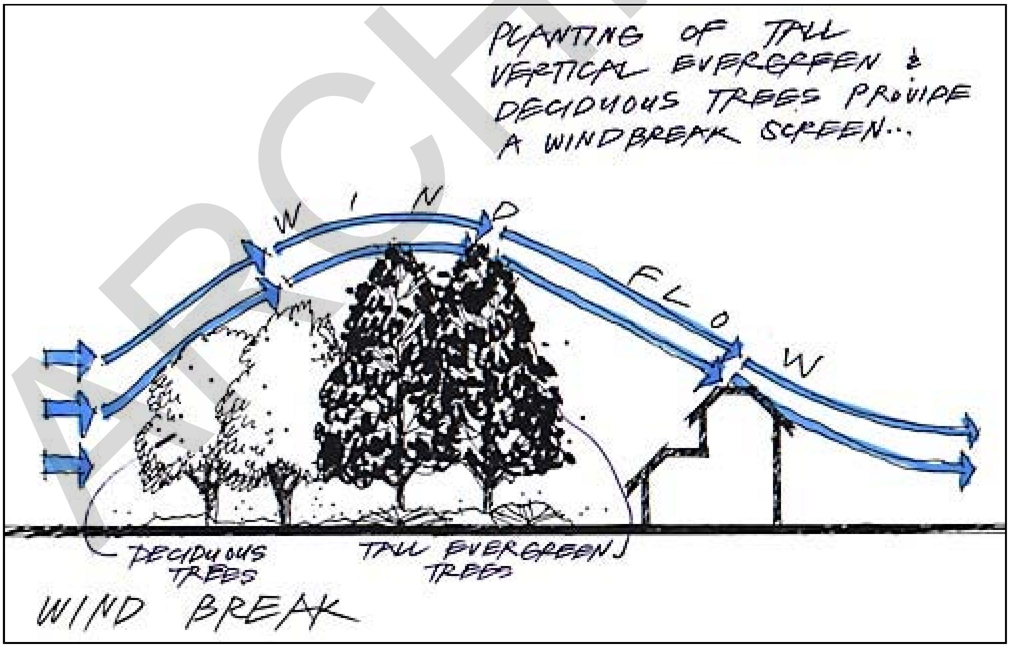

Figure 18-5: Windbreak

18.5.4 STRUCTURAL SOIL STABILIZATION MEASURES

Structural soil stabilization measures involve the physical control of a potentially unstable condition. This includes the modification of site grades and the use of structural elements to retain or provide cover for soils.

Slope Reduction and Compaction

- Reducing the gradient of a slope will decrease erosion by slowing the rate of runoff, lessening the effects of gravity, and making the slope more plantable. In general, the horizontal distance required to accommodate a vertical change will increase as the gradient of a slope decreases. The distance required to accomplish slope reduction must be available unless retaining walls or other structures are employed.

- As a slope becomes flatter and longer, a larger surface area is exposed to the effects of erosion. Diversions located at intervals across a slope can help decrease the length of the slope.

- Compaction of soils will lessen the vulnerability of exposed surfaces to erosion, but it is relatively short-lived and should generally be employed as a temporary control until permanent stabilization measures can be completed. Compaction will also increase runoff potential, which may accelerate erosion where the runoff is discharged.

Retaining Walls

- Retaining walls can be used to stabilize steep embankments where the potential for severe erosion or slope failure is high. A retaining wall can also be used to reduce the gradient of a slope where the area available is not sufficient to allow for regrading and lengthening the slope.

- Retaining walls should be used to preserve areas of existing mature vegetation that would otherwise be subject to loss from the effects of erosion or need to be cleared in order to regrade an unstable slope. Retaining walls can also be used to create flatter areas to facilitate the establishment of new plantings (*see Figure 18-6*).

Figure 18-6: Retaining Wall

Soil Coverings

- Slopes, embankments, and other unstable areas can be covered with a hard surface that will stabilize exposed soil and protect it from erosion. Because of cost and esthetic considerations, large areas of hard cover should be used only where slopes cannot be regraded and are too steep to be vegetated. A variety of materials can be used for cover, including riprap, masonry, and boulders. Interlocking concrete systems that have voids allow for the establishment of vegetation while providing stabilization.

- Revetments should be used to protect streams, drainage channels, and shorelines from erosion. They are particularly important where the channel takes a sharp bend, increasing the force of the water on the outside bank. Revetment materials include riprap, concrete, and gabions *(see Figure 18-7)*.

Figure 18-7: Revetment

- Concrete headwalls and endwalls should be used where a channel enters and exits a closed conduit to reduce bank erosion.

- Netting and erosion control blankets provide temporary but quick coverage for exposed areas. Netting made of jute or other biodegradable material is often used to anchor mulch, such as straw or wood chips, that might otherwise be washed or blown away. Together, the netting and mulch reduce erosion and can protect seeds until they can germinate. Pre-fabricated blankets made of paper or other biodegradable material can be rolled onto the surface and staked in place. They provide protection from rainfall and runoff and have perforations to allow water to seep into the soil.

- Liquid binders that are sprayed on, soaking into and hardening the soil, are a temporary measure to protect exposed surfaces from water and wind.

18.5.5 VEGETATIVE SOIL STABILIZATION MEASURES

Vegetative stabilization measures employ plant material to protect soil exposed to the erosive forces of water and wind. The designer should be aware of and respond to local conditions that may influence the development of vegetative stabilization measures. As with any planting design, climate, maintenance practices, the availability of plant material (including native species), and many other factors will influence such considerations as plant or seed mix selection, installation methods, and project scheduling.

Vegetative Stabilization Applications

In general, vegetation above the surface reduces the impact of precipitation, provides direct protection of the soil from wind, intercepts and slows runoff, and removes water from the soil through evapotranspiration. Below the surface, vegetation helps to bind the soil and increase the infiltration of runoff. However, the appropriate type of vegetation and its specific function will vary depending on where erosion occurs, including slopes, channels, large flat areas, areas impacted by wind, and lakes or ponds.

- On slopes, the goal of vegetative stabilization is not only to reduce surface erosion but also to prevent slope failure. Vegetation should provide dense coverage to protect soils from the direct impact of precipitation and help intercept runoff. A variety of plants should be used to provide root systems that are distributed throughout all levels of the soil, increasing slope shear strength and giving plants a greater ability to remove soil moisture. Uniform mats of shallow rooting plants should be avoided because, while such plants may increase runoff infiltration, they cannot remove soil moisture beyond the surface level, leaving slopes potentially saturated and prone to slippage. Shallow, interlocking root systems may also increase the size of a soil slippage by holding together and pulling down a larger area of slope after a small section has given way. Large trees that have become unstable may also pull down slopes and should be removed. Using plants with low water requirements can reduce the potential for soil saturation from irrigation.

- On channels, the goal of vegetative stabilization is to prevent erosion within the channels themselves, where runoff is concentrated and flows at higher velocities. Where necessary, vegetation with deep root systems should be planted above the channel to help maintain the channel edge. Within the channel, dense, uniform vegetation, such as grass, should be planted to help slow runoff to reduce its erosive force.

- On large flat areas, the goal of vegetative stabilization is to reduce the loss of surface soil from sheet erosion. Vegetation should provide complete coverage to reduce the force of precipitation, which can shift soil particles to seal openings in the soil, reducing infiltration and increasing runoff. Vegetation should also provide many stem penetrations to slow runoff and increase infiltration. Deep rooting plants are less critical for erosion control in flat areas than on slopes because soils are not subject to the same forces that may cause slippage on a slope. However, trees and shrubs can increase infiltration, lessening the buildup of runoff, and transpire large volumes of water, reducing soil saturation.

- In areas susceptible to wind erosion, the goal of vegetative stabilization is to establish direct protection of the soil. Vegetation should provide dense and continuous surface cover. Binding the soil deeply is generally not a requirement. The ideal vegetation for this purpose is grass, which forms a mat of protection. In developed areas of the installation, grass generally has high maintenance requirements. In less developed, open areas, unmown grass, including perennial native species, can be used to provide protection.

- In lakes and ponds, the goal of vegetative stabilization is to prevent erosion of the shoreline. Wetland plants anchor the bottom of the lake or pond adjacent to the shore and help dissipate the erosive energy of waves. An important consideration in planting along shorelines is the need to establish favorable conditions for plant establishment and growth. These include the proper grading of side slopes and the control of upland erosion to prevent the buildup of silt and pollutants in the water. The designer should maintain an awareness of any regulatory guidelines that may influence vegetation projects in a wetland environment.

Planting Methods

Providing vegetative stabilization can be achieved primarily through seeding or planting pre-grown stock, each of which has characteristic advantages and disadvantages related to particular applications.

Seeding

- Plants grown from seed are naturally adapted to their environment because they experience their complete development in that environment. Seeded plants develop deep and extensive root systems, which are generally important for erosion control. Seeded plants also exhibit vigorous growth and may often quickly exceed pre-grown stock in size. Seeding is a relatively inexpensive method of planting and should be used to provide cover over a broad area and to stabilize areas that must be quickly protected from erosion. Seeding should be done at the proper time of year relative to weather and the species being seeded. This will vary in different regions. Mulching and water are important to assure seed germination.

- Broadcast seeding, where seeds are spread directly on the soil, should be used where broad coverage is required, but it is not recommended for steep slopes because the seed will tend to wash away.

- Hydroseeding, in which seeds are mixed in a slurry consisting of water, mulch, fertilizer, and chemical soil binders, can be used to cover large areas quickly and to vegetate slopes that are too steep for other planting methods. Seed mixes can contain nurse crops of quick-germinating seeds to provide temporary erosion control while permanent plant species can establish. The hydroseeding slurry provides protection for seeds while they germinate and can provide temporary protection for exposed soil areas until plants take root.

- Seed mixes used in broadcast seeding and hydroseeding offer limited control in the precise placement of individual plant types, and some species may not be appropriate to these methods of planting. They can, however, be combined with other planting methods, such as direct seeding or planting pre-grown stock, that offer a broader plant palette and more control of the placement of materials.

- Direct (or drill) seeding, where seeds are placed in holes and covered with soil, provides greater protection for seeds and can be accomplished by hand or mechanically. It is a good method for planting woody species with seeds too large for broadcasting or hydroseeding and provides greater control for the precise placement of individual plant types.

Planting Pre-Grown Stock

- Depending on regional preferences and plant species, pre-grown stock is available in a variety of forms, including bare-root, balled and burlapped, and container-grown materials. Planting pre-grown stock allows for precise placement of specific plants, which may be important to providing stability in certain circumstances, such as on slopes or in the installation of a windbreak. Planting pre-grown stock also provides control over plant characteristics that may not be possible with plants grown from seed. Additionally, certain species must be planted from pre-grown stock because they cannot be successfully established in field conditions from seed.

- Planting from pre-grown stock may provide a more immediate effect than does planting from seed, but care should be taken that plants do not become rootbound, which could affect their long-term health and their ability to successfully control erosion. Planting with smaller material will provide plants that are more adaptable to their environment and more able to develop healthy root systems.

Planting Grass

- Grass can be planted by laying pre-grown strips to provide immediate results where necessary. More cost-effective methods include planting with seed, sprigs, stolons, or plugs.

- Given the relatively high water and maintenance demands of grass, it should be planted selectively as an erosion control vegetation. Turf is most appropriate and effective on large flat areas that are susceptible to wind or large amounts of runoff and require a dense and continuous coverage to reduce surface erosion. In some areas of an installation, unmown grass may be an appropriate erosion control planting that requires little maintenance.

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18.6 REFERENCES

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19.1 INTRODUCTION

Hydroseeding is a cost effective method of erosion control and soil stabilization. It can be used on a wide variety of locations from moderately steep slopes to low swales providing an excellent vegetative cover and soil protection. Hydroseeding protects valuable, nonrenewable soil resources from wind and water erosion.

19.1.1 DEFINITION

Hydroseeding is the mechanical process of applying turfgrass, wildflower, or native grass seed either separately or in blends to an area requiring vegetative groundcover.

19.1.2 GOAL

The goal of the Hydroseeding guide is to provide information on the various aspects of hydroseeding and the benefits of soil and erosion control. This will be accomplished by increasing awareness and understanding of the numerous issues facing landscape architects when designing and specifying hydroseeded areas.

19.1.3 OBJECTIVE

The objective of this guide is to provide a framework for the successful implementation of hydroseeding and soil erosion practices to areas requiring soil vegetative covering and stabilization.

19.1.4 GUIDE ORGANIZATION

Hydroseeding

Provides insight into the materials and application methods used in the hydroseeding process.

Soil Stabilization

Provides information on the various materials available for preventing erosion and stabilizing soil.

Conclusion

Lists hydroseeding do's and don'ts and References.

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19.2 HYDROSEEDING

Hydroseeding is a diverse and effective way to apply vegetative seed to an area requiring herbaceous groundcover. There are several groundcovers ideally suited for hydroseed application as well as two methods of application. The groundcovers and application as well as two methods of application. The groundcovers and application methods will be discussed as follows:

19.2.1 TURFGRASS

Turfgrasses are relatively inexpensive and serve as a durable landscape ground cover. Turfgrass provides a lush, green, low, ground carpet effect. Turfgrassed areas provide an appealing, eye-catching addition to any landscape situation. Numerous turfgrass species can be applied using hydroseeding methods. Turfgrass is the number one product applied by hydroseeding. The recommended application rate for turfgrass is 2.2-4.4 kilograms of seed per 93 square meters.

Benefits

The benefits of turfgrasses can be grouped and described as functional, recreational, and aesthetic. A brief description of each follows:

Functional

Functionally, turfgrasses prevent soil erosion and minimize dust, dissipate heat, abate noise, reduce glare and nuisance animal infestation, and help control air pollution.

Recreational

Recreational benefits include a low cost, safe surface for sports, games, and outdoor use.

Aesthetic

Aesthetic benefits of turfgrasses include beautification of surroundings, improved quality of life, community pride, increased property values, and as a compliment to trees and shrubs in a landscaped environment.

19.2.2 NATIVE GRASSES

Often a project will specify hydroseeded native grasses as a soil stabilization herbaceous ground cover. Native grasses are usually specified when large, open areas require hydroseeding. Native grass seed is relatively inexpensive and easily applied requiring minimum maintenance. Native grass species for a region can be supplied by the local USDA extension agent. Native grass seed is readily available from wholesale nursery product distributors.

Several native grass species do extremely well when hydroseeded. Side Oats, Blue Stem, Blue Gramma, and Millet are just several species that provide excellent native grass groundcover and soil stabilization. The recommended application rate for native grass seed is 2.2-4.4 kilograms per 93 square meters.

19.2.3 WILDFLOWERS

Wildflowers are another option for hydroseeded soil stabilization and erosion control. Species of wildflowers suited for the region are available from the local USDA extension agent. Wildflower seed is readily available from wholesale nursery product distributors. Wildflowers are very effective in controlling soil erosion and add color and nutrients to the soil. Most wildflowers will easily reseed and emerge annually providing continual herbaceous ground cover. The recommended application rate for wildflower seeds is 1.1 kilograms per 93 square meters.

19.2.4 MIXTURES

Another option available for large, open areas is to hydroseed a mixture of native grasses and wildflowers. This will provide an excellent groundcover of grass and colorful wildflowers. The application rates for the native grasses and wildflowers in the same as if applied individually.

19.2.5 METHODS OF APPLICATION

Paper Pulp Mixture

The most common method of applying hydroseed is the paper pulp method. Shredded newspaper colored with green dye, fertilizer, a tactifier, and water is the normal paper pulp mixture.

The fertilizer added should be based on regional requirements and application time of year. A mixture of 13-13-13 or 15-15-15 applied at 5-7 kilograms per 836 square meters would provide an adequate worldwide fertilizer dosage. Recommend consultation with an area agriculture extension agent for further guidance.

Tactifier is a glue-like substance adhering the hydromulch to the soil surface. Follow manufacturers guidelines for application rates based on degree of slope and hydroseed mixture dosage.

The amount of water added to the mixture should be enough to maintain a loose, uniform consistency allowing the slurry to be easily applied.

The recommended paper pulp mulch application rate is 22.7 kilograms per 836 square meters. When applying turfgrass, use .5-1.0 kilograms pure live seed (pls) per 836 square meters. Wildflower mixtures should be applied at .5 kilograms pls per 836 square meters.

Following the application process, the entire area should be immediately and regularly watered to ensure desired germination.

Hay mulching

Hay mulching is another application option. It follows the exact same quantities as the paper pulp mixture method only without the paper pulp.

Application begins by disking the soil to a depth of 10 centimeters. Machine broadcast fertilizer over the application area. Apply desired seed using a drill-seeder pulled behind a tractor. Finally, a hay-mulcher mounted on a trailer or pulled behind a tractor applies a layer of hay over the entire treated area. The depth of applied hay is usually 2-4 centimeters. Generally, 907 kilograms of hay per acre on a flat surface and 1814 kilograms of hay per acre on sloped areas is an acceptable specification.

Following hay application, a hay crimper is towed behind a tractor to complete the process. A hay crimper has teeth to push the hay into the soil. On slopes, an over-spray of water and tactifier should be applied to the hay surface to assist in holding the entire application in place.

Following the hay application process, the entire area should be immediately and regularly watered to ensure desired germination.

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19.3 SOIL STABILIZATION

Proper soil stabilization prevents erosion. Not all erosion is the same. Variables such as soil type, length of slope, moisture availability, fertility, and degree of slope are all factors to consider when planning erosion prevention and soil stabilization measures. Erosion control and soil stabilization is best achieved with permanent herbaceous vegetation.

When vegetation is unavailable or unfeasible, there are several man-made product options available to assist in stabilizing soil. These products assist in moisture retention, help control soil surface temperature fluctuations, conform to the terrain, protect against sun burnout, and break up rain drops to help stop erosion.

19.3.1 FIBER

Wind, rain, and dryness can destroy or carry away unprotected grass or wildflower seeds before germination. Fiber mulch seed covering provides protection and allows an excellent environment for germination. Fiber mulch is made from wood fibers and can be substituted for paper pulp in any hydroseed mixture.

Advantages of using fiber mulch is its durability and ability to interlock and cling to the soil, forming a web-like network that holds seeds in place. This mulch covering also acts as a second layer of soil helping to deflect wind and rain and insulates the seeds. Fiber mulch is an excellent option on steep slopes and in areas near running water. It also retains moisture and gradually decomposes and contributes nutrients to the soil, but only after seed germination and initial cutting.

Fiber mulch is more expensive than paper pulp. The advantages and disadvantages should be weighed before deciding which mulch to use in a hydroseed mixture.

19.3.2 EROSION CONTROL BLANKET

Another man-made soil stabilization option is a variety of erosion control "blankets." These "blankets" are actually rolled up "mats" constructed from straw, coconut fiber, and synthetic fibers meshed and held together by loose, biodegradable netting. They are rolled out and stapled together right over the soil. Erosion control blankets are ideally suited for a variety of slope and run off situations.

Erosion control blankets should be installed immediately following hydroseed application. The blanket assists in soil stabilization, moisture retention, and run off control. The seeds will germinate and grow through the blankets and together provide excellent soil stabilization.

These blankets come in a variety of grades and uses. They are a highly reliable and effective way to stabilize soil and an option available to designers. They are expensive and the advantages and disadvantages should be weighed before deciding on their use.

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19.4 CONCLUSION

This guide promotes hydroseeding components, application techniques, and soil stabilization options available to installation landscape designers. There are numerous "Do's and Dont's" that should be adhered to ensure minimum environmental impacts while maximizing long term value.

19.4.1 HYDROSEEDING DO'S:

- Always refer to regional hydroseed experts for additional guidance.
- Always use certified seed per directions and viability date on attached product tag.
- Ensure the specified seed is checked and correct prior to adding to the hydroseed mixture or broadcast over the soil.
- Ensure fertilizer is certified and not date expired prior to use.
- Apply desired seed at the correct pure live seed percentage.
- Always use clean, fresh, unmolded hay when hay mulching.
- Always conform and adhere to the highest application safety standards and practices.
- Ensure personnel utilize the following equipment such as hard hats, goggles, gloves, long pants, and boots.
- Hydroseed mixtures should be mixed at the application site due to the weight involved and possible mixture breakdown during transit. Site mixing also allows for the inspection of the mixture products and correct quantities.
- Protect materials enroute to the site by covering paper pulp, seed, and tactifier bags, and hay with a tarp.
- Allow mixture to thoroughly mix on site at least five minutes prior to application.

19.4.2 HYDROSEEDING DON'TS

- When watering a hydroseeded area, do not allow water to pool and run-off resulting in erosion and seed run-off.

- Do not allow any type of traffic on a newly seeded area for at least three weeks.
- Do not accomplish first mowing of a hydroseeded area until the grass is at least ten centimeters high.
- Do not allow hydroseeded grass to grow unmowed past ten centimeters due to seed light competition resulting in weak, leggy grass plants.
- Do not over apply seed due to competition dieout.

19.4.3 REFERENCES

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20.1 INTRODUCTION

Plants often fill an emotional and spiritual need within people. Indoor plants were once considered to play only an aesthetic role as a "nice looking green mass." Today's trend of open offices without permanent walls places increased importance on indoor planting. Plants can control traffic flow, screen views, and reduce glare. They can enliven any indoor setting and be environmentally beneficial by filtering and purifying the air.

This guide provides basic guidance and direction to enhance building interiors through interior planting design.

20.1.1 DEFINITION

Interior planting can be described as the use of selected plant material in an indoor setting. Hardly an office or workcenter in the Air Force is without plants. The use of plants extends from entry foyers to individual offices or cubicles.

20.1.2 GOAL

The goal of this guide is to assist Air Force personnel by providing information on how to use, select, and maintain plants in interior design.

20.1.3 OBJECTIVE

The objective of this guide is to provide users with information and procedures on developing and implementing an interior planting design and maintenance program.

20.1.4 GUIDE ORGANIZATION

Design

- Discusses the interior planting environment and the orderly and logical process of selecting and arranging plants and containers

Maintenance and Care

- Identifies numerous interior planting environmental requirements and maintenance procedures necessary to sustain healthy and appealing indoor plants

Conclusion

- Delineates actions necessary to efficiently manage interior planting resources and practices to follow or avoid

Appendix

- Provides recommended interior plant lists and an interior planting glossary

CATEGORY	APPEARANCE	EXAMPLES
Mass	*Oval, spreading*	• Rosa hybrids and miniature
	Rounded	• Pittosporum tobira • Cyclamen persicum
Line	*Linear, upright*	• Sansevieria trifasciata
	Linear, spreading	• Philodendron x wend-imbe • Asplenium nidus
	Linear, curved	• Spathiphylum clevelandii • Dracaena fragrans • Howea forsterana
	Cascading	• Sedum morganianum • Nephrolepis exaltata bostoniensis
Exotic	*Weeping*	• Ficus benjamina
	Picturesque	• Coccoloba uvifera • Chamaedorea erumpens • Monstera deliciosa

Figure 20-1: Interior Planting Material Types

20.2 DESIGN

20.2.1 INTRODUCTION

Interior planting design should be aesthetically appealing and organize the prescribed space. Interior designs should be based upon sound principles and an understanding of the different aspects considered in the design process. This chapter will address the following subjects:

20.2.2 BENEFITS

Interior plants have beneficial value both from a psychological as well as environmental standpoint. Studies show that workcenter employees with interior plantings are more content, comfortable, and healthier. People should be able to enjoy the space they occupy and work in. Planted interior spaces are more aesthetically pleasing and perceptually stimulating as plants add warmth and color. There is a vitality and visual excitement to an attractively landscaped interior setting. An interior plant's value applies and exhibits itself in the following categories:

Aesthetic

Interior plants and their arrangement add beauty to an environment through their shape, texture, color, and fragrance. They can soften the appearance of entryways, walls, and openspace. Psychologically, interior plants create feelings of relaxation and well-being. They can provide a sense of privacy, solitude, and security to their surroundings. Studies have shown that areas with interior plants have more contented employees with higher morale and reduced absenteeism.

Engineering uses

Interior plants reduce large areas to human scale by softening harsh architectural surfaces such as solid walls and lengthy corridors. Plants can reduce light glare or may be placed in a manner to control and direct traffic. Interior plants aid in reducing sound by deflecting sound waves resulting in a quieter work space.

Environmental

Interior plants reduce air pollution and serve as natural air cleaners by removing carbon dioxide from the air and releasing oxygen. Interior plants also help cleanse the air by absorbing harmful pollutants such as benzene, trichloroethylene, and formaldehyde found in virtually all indoor environments.

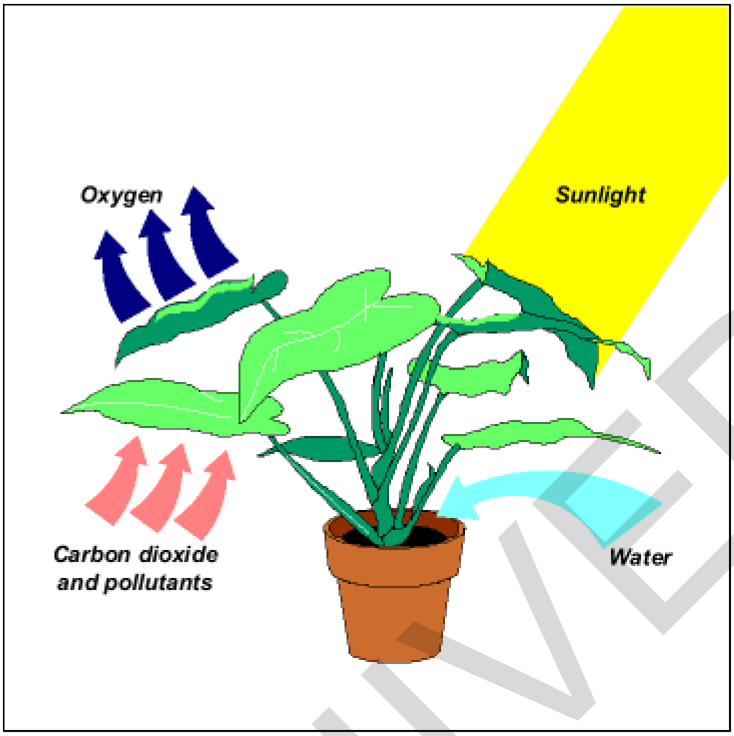

Figure 20-2: Environmental Benefits of Plants

20.2.3 LIGHT

Light is the major determinant of plant growth and development, influencing many plant processes and design decisions. Each interior design situation will have requirements unique to itself with lighting being the most challenging to handle. Interior plant lighting will be discussed as follows:

- **Intensity**
- **Plant response**
- **Sources**

Intensity

Intensity refers to the brightness, or level of light. In most instances, it is the limiting factor in growing and maintaining interior plants. Indoor light intensity will vary depending upon the source(s) of the light, obstructions, and reflections. Natural sunlight may provide most, some, or none of the light for a building interior. The intensity of sunlight varies with the season of the year. Natural light is influenced by cloud cover and composition, atmospheric pollutants, the amount of moisture in the air, and haze.

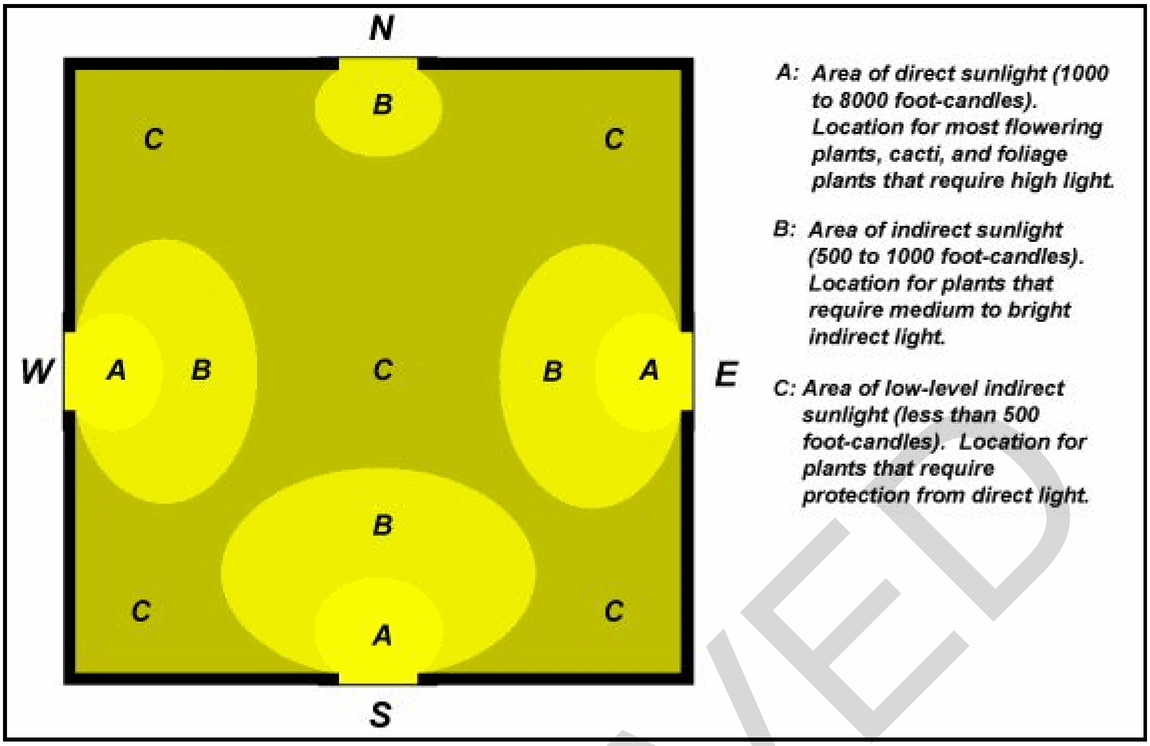

Figure 20-3: Light Intensity

The amount of natural light entering a building will also be influenced by the area and exposure of glass surfaces, the presence of outdoor trees and shrubs, roof overhangs, window screens and awnings, and the color and cleanliness of the glass. For example, a .64 cm thick pane of bronze glass allows 21% visual light transmission; gray, 41%; and clear, 89%.

Inside, the amount of natural and/or artificial light available for the plants will be affected by curtains and blinds, surface textures, and reflectance from wall coverings, draperies, and furniture. For example, white surfaces reflects about 90%; mirrors, 80-90%; gray-beige paint, 50%; and draperies, 35%. When properly designed, an artificial supplemental lighting system would provide the most uniform and desirable lighting intensity.

Measurement of the light intensity on the area where interior plants are to be used should not be guesswork. An accurate light meter should be used to measure the light level. If natural or a combination of natural and artificial light is used, several readings should be taken at various times of the day and at different seasons. An average of these values will be the light intensity for the area.

Light intensity may be expressed in any of several units. Foot-candles and the lux are the two most commonly used. A foot-candle (fc) is the unit of illumination equivalent to that produced by a standard candle at the distance of one foot. Lux is the international unit of illumination and is the amount of illumination received by a surface at a distance of one meter from a light source whose intensity is taken as a unit. One lux is equal to 0.09 foot candle.

The simplest way to measure light intensity is with a direct-reading light meter. Several hand-held models are available permitting light readings from one to 10,000 foot-candles.

Average Light Intensities for Selected Locations	

Location	Foot-candles of Light
Outdoor sunny day	to 10,000
Outdoor cloudy day	500-2,000
Office conference room	20-30
Office workroom	40-50
Office drafting room	50-100
Office foyers	15-30
Office hallways	10-25

Plant Response

There is a minimum light intensity required for plant viability and maintenance. The level of light required for interior plants is:

- Related to the native habitat of the plant
- The light intensity at which it was produced
- The degree of acclimatization it has experienced

Plants indigenous to tropical rain forests will have a lower light requirement than those which normally grow in full, open sun. Plants with colored and variegated leaves require higher light intensity than green-leafed forms. Flowering plants require brighter light to flower. Other plant responses include:

Adequate light

- Generally speaking, if a plant is maintaining leaves, the light level is adequate.

Too bright

- If the light is too bright, leaves may scorch and the leaves may be small, bleached, and curled.
- At light intensities above the minimum (see table below), new leaves will be produced. Intensities higher than the preference levels will cause the plants to grow faster and more pruning will be necessary.
- Increasing the light intensity will increase photosynthesis and reduce the number of hours of light the plant must receive each day.

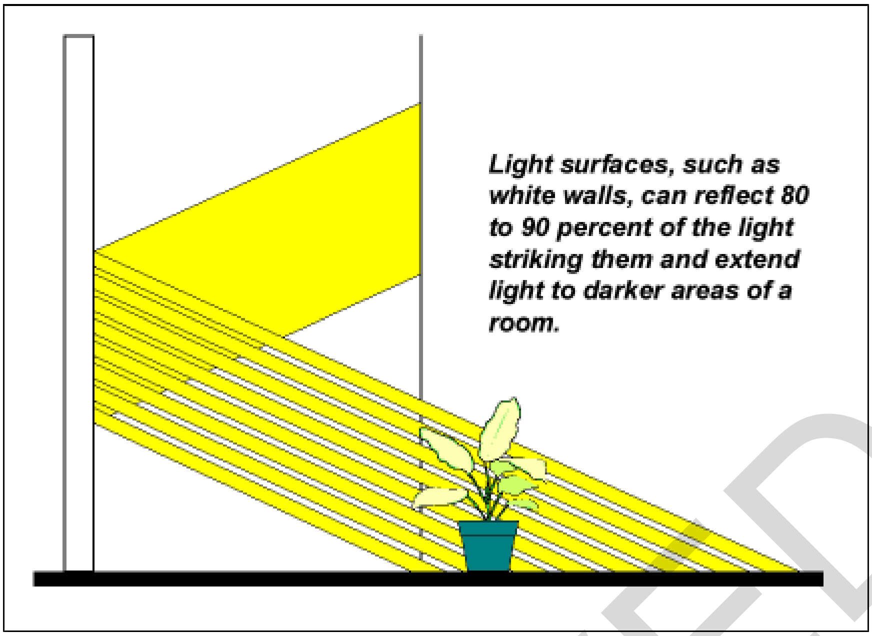

Figure 20-4: Reflected Light

Too low

- If the light intensity is too low, leaves may yellow and drop from the plant. New growth will be leggy, with weak, elongated stems and wide internodes. New leaves will be small, too.

Uneven

- If the plant receives light from only one side, it will bend toward that side. The plant must be turned to facilitate straight growth.

Suggested Light Intensities for Maintenance of Foliage Interior Plants		
Requirement of a Particular Species	Minimum foot-candles	Preferred foot-candles
Natural, low	12	35-100
Natural, medium	35	100-250
Natural, high	100	250
Natural, very high	500	>500
Artificial, low	25	75-100
Artificial, medium	75-100	200-500
Artificial, high	200	500
Artificial, very high	1000	>1000

Sources

Interior plants receive their light from two sources, the sun and artificial lighting. The sun is an incandescent source meaning light is produced by thermal radiation. Where practical, as much natural light as possible should be used for interior plants since it saves on energy costs. Natural light levels fall off very rapidly with distance from a window, with usable light generally not penetrating beyond 15 feet from the glass. To maximize natural window light, plants should be placed within a 45 degree area from the top of the window.

Artificial light may be used as a supplement to natural light or as the sole source of illumination. As a supplement, the amount required will depend upon the varieties of plant material used and the level of natural light available. Artificial lighting may serve a dual role: room lighting and plant lighting. General room lighting will not be adequate for plant maintenance. Additional supplementary light specifically provided in the area where the plants are located should alleviate the lighting problem.

All artificial light sources can serve as plant lamps. The types include tungsten filament incandescent lamps, and gas discharge lamps such as fluorescent, mercury, metal halide, and sodium. The lamp or lamps for the interior planting setting must be selected with considerations of the specific responses wanted; for example, control of stem elongation, branching, flowering, or foliage color. The following information on various lamps and plant responses is provided:

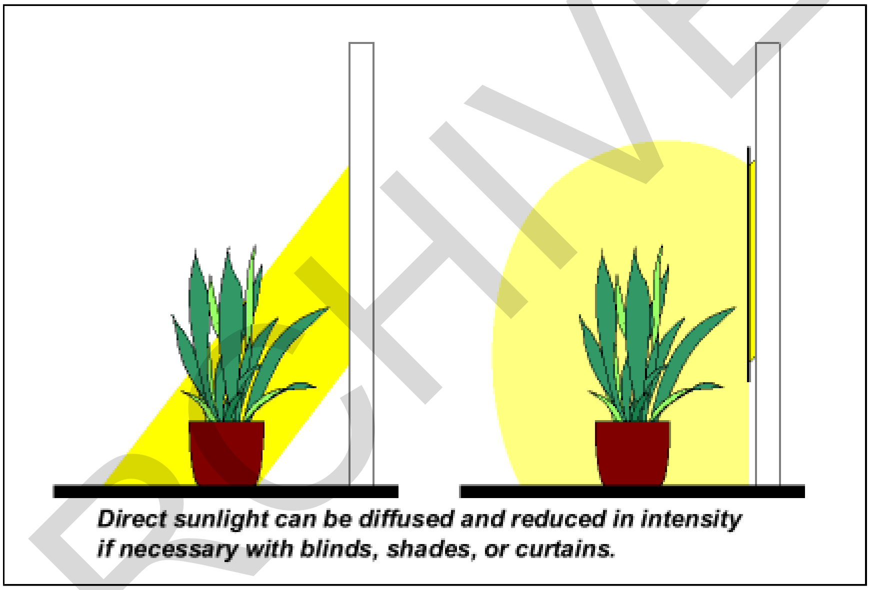

Figure 20-5: Diffused Light

Fluorescent lamps, cool white (cw) and warm white (ww)

- Green foliage expands parallel to the surface of the lamp
- Stems elongate slowly
- Multiple side-shoots develop
- Flowering occurs over a long period of time

"Narrow light spectrum" plant lamps

- Deep green foliage expands larger than on plants grown under cw or ww light conditions
- Stems elongate very slowly and become extra thick
- Multiple side-shoots develop
- Flowering occurs late and flower stalks do not elongate

Wide "balanced color spectrum" plant grow lights

- Light green foliage which tends to ascent toward the lamp
- Stems elongate rapidly, large distances between leaves occur
- Suppressed development of multiple side-shoots
- Flowering occurs soon, flower stalks elongate and and plants mature and age rapidly

High-density discharge Mercury or metal halide lamps

- Green foliage expands evenly
- Stems elongate slowly
- Multiple side-shoots develop
- Flowering occurs over a long period of time

High-pressure sodium

- Deep green foliage expands often larger than on plants grown under mercury or metal halide
- Stems elongate very slowly and thicken
- Multiple side-shoots develop
- Flowering occurs late and flower stalks do not elongate

Low-pressure sodium

- Extra deep green foliage which is bigger and thicker than on plants grown under other light conditions
- Stem elongation is slowed
- Multiple side-shoots develop, even on secondary stems
- Flowering occurs normally and flower stalks do not elongate

Incandescent and incandescent Mercury lamps

- Foliage pales and is thinner and longer than on plants grown under other light conditions
- Stem elongation is excessive
- Side-shoot development is suppressed and plant expands in height only
- Flowering occurs rapidly and the plant matures quickly

For the long-term, cool-white fluorescent lights produce the best results for interior planting situations. Studies have shown that long tubes are more efficient than short, as the last three inches of the lamp produces very little light. Thus, two 122 cm tubes end-to end produce less light than one 244 cm tube. When installing fluorescent illumination, use the longest lamps practical. Additionally, it is desirable to use two or more lamps side by side rather than single lamps, as the light intensity at any distance from the lamp will be greater.

All lamps should have a reflector to direct the light at the interior plantings. Avoid up-lighting from the ground with spot-lights as leaves are adapted for utilization of light from their tops.

20.2.4 TEMPERATURE

Plant growth depends upon both light and temperature. Temperature influences every physiological process in plants and must be carefully controlled to maximize the longevity of high quality interior plants. There is no one temperature at which interior plants grow best, but rather an optimal range for each plant species. For most tropical interior plants, a temperature range of 18 to 24[ring]C is satisfactory.

A 3[ring]C reduction of temperature at night is desirable but not absolutely essential. In an effort to conserve energy, heating and cooling systems in offices and workcenters may be turned off at night and on weekends, resulting in cold temperatures in winter and excessive heat during the summer. These temperature fluctuations may be harmful to plants. Quality may decline, necessitating more frequent replacement. Interior plants will survive short periods of higher or lower temperatures, but slower changes tend to be less harmful than rapid changes of the same amount. Temperatures below 4.5 to 7.2 [ring]C may be harmful to interior plants. Symptoms include defoliation, discoloration, spotting, bending, and curling of leaves, poor growth, and death. Conversely, temperatures above 32.2 to 35[ring] C may be harmful to plants by causing excessive transpiration, resulting in wilting and death of tissues. Respiration increases, causing a depletion of stored food and leggy, rapid growth.

20.2.5 ATMOSPHERE

The surrounding atmosphere around interior plants is another important consideration when selecting material. Atmosphere consists of gasses surrounding the plant, in the growing medium (soil), and within the plant tissue. The air inside an average building consists of:

- 79% nitrogen (N)
- 21% oxygen (O_2)
- 0.03% carbon dioxide (CO_2)
- Other gasses, water vapor, dust, dirt, microorganisms, and pollen

The atmosphere around interior plants will be discussed as follows:

Air movement

Interior plants should not be subjected to drafts of hot or cold air. Extreme temperatures may harm the plants, and the air movement may cause excessive transpiration with potential wilting, injury, and even death of plant tissue.

Relative humidity

Most interior plants have been produced in an environment where the relative humidity ranges from 85-95%. This is far in excess of the 40% or lower relative humidity of most building interiors. Although most tropical foliage plants thrive at humidity greater than 30%, they will survive in the low-moisture atmospheres of building interiors if they are properly acclimatized.

Grouping plants will increase humidity. As water is transpired from the leaves and evaporates from the planter medium, a microclimate of higher humidity is created. The larger the grouping, the bigger the change. The practice of misting plants every day is futile in increasing the relative humidity.

Air pollutants

Air pollutants are present in any interior atmosphere, and at times may present problems. Ethylene, a bi-product of hydrocarbon combustion, may be produced by the heating and cooling system. Atmospheric fluoride, a product of industrial processes, also adversely affects interior plants.

Unless air is filtered, the air in buildings will contain dust and dirt particles. These dust particles will settle on plants and detract from their beauty as well as hinder their physiological life processes. Dust should be removed periodically. Regular use of a simple feather duster or a light water spray will remove the dust and dirt.

Avoid using commercial plant shine spray as it will build up on the leaf surface, doing more harm than good. Proper room and building ventilation will reduce the pollutants and dust affecting interior plants and the people around them.

20.2.6 DESIGN CONSIDERATIONS

Whether in permanently installed planters or in individual moveable containers, the selection and design layout process requires careful consideration and planning. These planted areas must be attractive and decorative and provide the proper growing environment for plants. The interior designer should create moods and organize the space compatible with the surrounding area.

The designer must analyze the different features of the interior plants available and design the plan accordingly. For example, is the plant oval and spreading, or is it upright and rounded? Does it have fine or coarse texture; is it fragrant or have an unpleasant odor?

The designer must be aware of the relative size of the interior plants and their scale in relationship to humans. If a plant is too large, it can overpower a setting. If the plants are too small, they are ineffectual and lack scale.

When placing containers in an interior setting, avoid sharp or sudden height or texture changes. Strive for interesting and appealing placement of same or similar objects and plants.

Repetition of the same species may lead to monotony. Use massing and clustering of containers to frame an area or route traffic flow through or around an area. Avoid straight-line container placement.

Interior plants can provide vistas and gradually reveal a setting or object just by the placement of the plants and their containers. Refer to Appendix A for further information on plants for various design situations.

When selecting plants for a large, permanently installed planter, arrange species in a layered technique starting with the smallest and gradually working inward with progressively larger types ending with vertical specimens planted in the center. This presents a formal, layered look that provides an appealing scale to the surrounding area. Using inert material such as river-run rock adds additional texture and scale to the planter, too.

Another design idea is to gradually berm the planting medium inward and mass plant with the layered technique. This provides some necessary vertical relieve and character to any planter.

Figure 20-6: Plants in Permanent and Moveable Containers

Figure 20-7: Use Plant Material Appropriate in Scale to the Space

Figure 20-8: Repetition of Elements

Figure 20-9: Arrange Plant Species in Layers from Small to Large

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20.2.7 PLANTERS

Nearly any container may be used or adapted to grow interior plants. They range from very expensive such as brass to those that are quite reasonable such as clay. Planters are available in different sizes, shapes, colors, and textures. They may be portable or built-in, with or without drainage holes. It is important to consider the practical and aesthetic qualities of the choices when selecting planters for interior use.

For ease of replacement, it is generally better to keep the plant in its original container and place it inside a decorative planter or box rather than directly in soils. After placement in the planter, an organic mulch or bark-chip cover should be placed over the planting medium to cover the plastic pot lip and help retain moisture.

The following factors should be considered when choosing a planter for interior plants:

- **Plant needs**
- **Aesthetics**

- **Cost and availability**
- **Strength and durability**
- **Weight**
- **Drainage**
- **Material**

Plant needs

Suiting the needs of the plant is the most important consideration when selecting a planter for interior plants.

- If directly planted, (not left in the plants plastic pot), it must be sufficiently large so as not to restrict the root system
- All planters should be in proportion to the height and width of the plant
- In general, tall plants look and perform better in
- a tall container, while broad, shrub-like specimens should be placed in a lower, wider receptacle
- Shallow pots are used to proportion the planting and de-emphasize height and is ideal for low, massed groupings

Aesthetics

The decorative value of the planter must also be considered.

- Its style, color, texture, and proportions will be determined by the plant chosen and where it is to be placed
- The decor of the area--room, office, foyer--will influence the choice
- Custom-made planters are also available. If the planters are a part of a grouping, it is best that they match
- A plant displayed by itself may permit use of a planter that is "one of a kind"

Cost and Availability

Cost of a planter is undoubtedly a design consideration.

- While price may not be important when one or two planters are involved, they represent a sizable investment on larger projects
- Planters must be readily available and when selected and ordered must be delivered prior to the arrival of the plant material to avoid stress and loss

Strength and durability

Planters must be durable and sufficiently strong to hold the plant material and the growing medium.

- It must be able to withstand normal wear and tear without cracking or chipping as well as colorfast

Weight

Weight is also important.

- Avoid heavy containers as they will be difficult to move and rearrange when planted
- The concentrated weight of containers need to be considered when placing them above the ground floor

Drainage

Planters are available both with and without drainage. If holes are provided in the base, some provision must be made to catch the excess water. If not done, damage to floors, carpets, and furniture will result. Setting the containers on nonporous trays or saucers will solve the problem.

Where no drainage is provided, the planters are usually used as decorative containers or jardinieres, holding the plants in the plastic pots they were grown in. These plastic pots have drainage holes and are just placed inside the container and not planted. The plastic pot should be raised by setting it on a brick to prevent it from sitting in pooled water in the bottom of the jardinieres if just placed in the container. The plastic pot can be placed in the container filled with 10-15 cm of small pea-gravel and surrounded by growing medium and covered with organic mulch or bark chips, too.

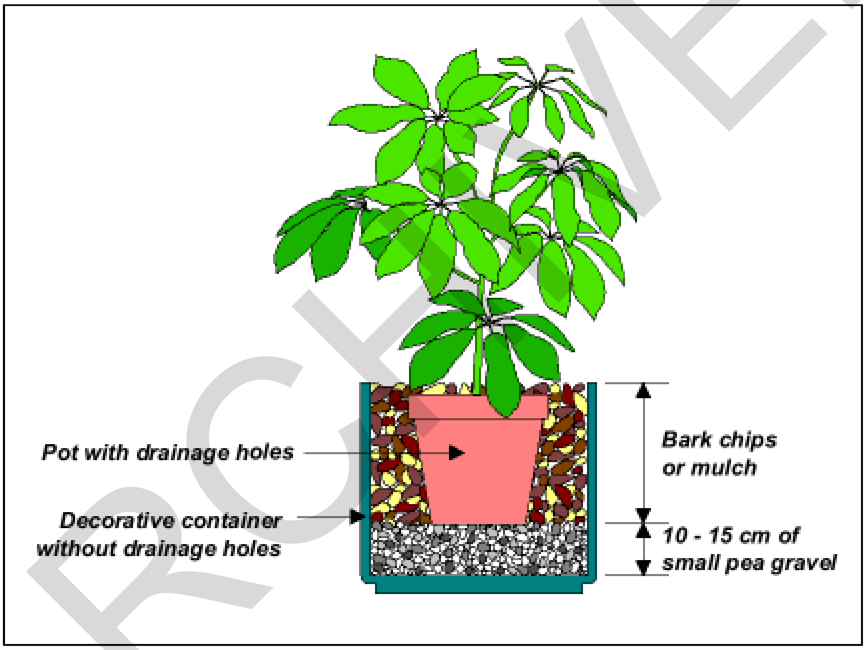

Figure 20-10: Planter drainage

Planting directly inside a container without drainage is possible although not recommended unless provision is made for the excess water. One technique is to line the bottom of the container with washed pea-gravel sized rock. Place the growing medium over the rock and then direct plant. Watering must be enough to maintain plant vigor without allowing standing water to rot the roots.

Material

Planters may be constructed of various materials including wood, clay, plastic, fiberglass, ceramic, concrete, and metals including brass, aluminum, and iron. Design considerations for these different types of planters are discussed below:

Wood

- Wooden planters consist of tubs, boxes, or barrels mainly constructed from cedar, cypress, and redwood
- All wooden planters are subject to eventual decay and may be flammable

Clay

- Clay planters are porous and permit evaporation of water. The soil dries quickly, necessitating more frequent watering. As much as 50% of applied water will evaporate directly through the sides of clay pots
- Clay pots foster better soil aeration and reduce the potential of overwatering. They are heavy and subject to breakage and deterioration

Plastic and Fiberglass

- Plastic and fiberglass planters are considered non-porous because their sidewalls are water impervious. Evaporation is reduced and they require less frequent watering.
- Light-weight and usually less expensive than metal. Strong and reliable although they do become brittle with age.

Ceramic

- Ceramic planters are attractive and come in many colors. Heavier than plastic and, unlike clay, evaporate little water. Subject to breakage, however.

Concrete

- Portable concrete planters are not well suited for use indoors because of their extreme weight. Amendments to the growing medium such as vermiculite or perlite should be added to reduce weight.

Metal

- Metal planters are rarely used in commercial interior planting due to cost and possible toxicity
- The copper from brass planters is toxic to plants. Utilize a plastic, non-porous lining placed inside the container to overcome the threat
- Metal containers, especially aluminum, make excellent jardinieres

20.3 MAINTENANCE

20.3.1 INTRODUCTION

No matter how beautiful and functional the interior planting design, and no matter how nicely the plant material was grown and cared for, it all comes down to maintenance. Improper handling and neglect will undo all the initial success in a very short period of time. The proper maintenance of interior plants is not difficult. Knowledge of the basis for plant growth about the interaction of plants with environmental factors are important. The most important factor, however, is recognizing the symptoms the plant is displaying and then acting accordingly. The following maintenance areas will be discussed:

20.3.2 SOIL

Interior plants require a constant supply of water and minerals for normal growth. Almost all of the water and minerals absorbed by the plant enter through their roots. A suitable growing medium must not only provide sufficient porosity for the plant to acquire water and essential micro-nutrients, but must also provide an environment suitable for the growth and function of the root system.

The following soil characteristics will be discussed:

Growing Medium

Natural soil is not the best choice for interior plant use. Organic materials such as sphagnum moss, sawdust, or bark as well as coarse inorganic aggregates in the form of sand, vermiculite, perlite, or clay may be added. Interior plant growing medium must be light and not too heavy or coarse which restricts water infiltration.

Soil pH

The pH of the growing medium for interior plantings is a very important factor for indoor planters. pH is an index of the acidity or alkalinity of the medium and ranges from 1.0 which is extremely acid, to 14.0 which is alkaline. A pH of 7.0 is considered neutral. Interior foliage plants generally prefer a slightly acidic medium of 6.0 to 6.5. The pH of the medium is important because it will affect the absorption of all the mineral elements required by the plant.

The pH of the growing medium gradually changes over time as fertilizers are used and residues of water accumulate. To raise the pH, use ground limestone. To lower the pH, add sulfur.

20.3.3 WATER

Virtually all of the water used by the plant is absorbed by the roots from the growing medium. An adequate supply of water must be available at all times. Over-watering is probably the most serious problem confronting plants in an interior setting. Watering will be discussed as follows:

- **Frequency**
- **Quantity**
- **Quality**

Frequency

Determining when to water is one of the most difficult aspects of maintaining interior plants. The growing medium should be watered when it needs it, not according to a predetermined schedule. Always err on the side of dryness, not wetness.

How often water should be applied depends upon many factors, including:

- The physical environment which includes the light, temperature, relative humidity surrounding the plant
- Plants in bright light require more frequent watering than those in low light
- Plants in cool rooms require less water than similar plants in a warm location
- Not all plant species have similar water requirements. For example, Cacti withstand a drier medium than do leafy interior plants and should be watered less frequently
- Large plants are usually grown in larger pots and containers which hold a larger volume of soil medium and require less frequent water
- Pot-bound plants of any size generally require more frequent watering
- The type of planter has a profound influence on watering frequency. Water rapidly evaporates through the walls of porous containers such as clay pots meaning the plants need more frequent watering
- Plants in non-porous containers such as plastic or ceramic require less frequent watering
- The use of peat, bark, or other organic mulch on the medium surface will reduce the watering frequency, too
- Older plants can withstand less frequent watering

Quantity

Apply a sufficient quantity of water to thoroughly wet the growing medium from top to bottom with some drainage from the growing container. This drainage permits soluble salts to be leached from the soil medium. Small quantities of water applied at frequent intervals will not disperse evenly throughout the entire soil medium mass.

In planters without drainage, care must be exercised so excess water will not collect in the bottom. Lift out the containered plant and dump out the excess water. In planters without drainage, cover the bottom with gravel, install organic material, and set the plant material still in their original containers within the organic material and cover with mulch or bark.

Quality

Regular city tap water is suitable for interior plants provided it is neither high in fluoride nor softened. Some plant species suffer leaf death if the fluoride level is too high. Water from softener systems is often high in sodium. The soluble salt level is increased and injury may occur. Use tepid or room-temperature water to avoid root damage and leaf spotting.

20.3.4 FERTILIZER

Interior plants require certain essential minerals for proper growth. In order to maintain an attractive interior setting with high-quality, long-lived plants, careful attention to plant nutrition must be followed. Sixteen elements are required by interior plants for growth and chemical processes. Most of these elements come from the growing medium and scheduled nutritional applications.

A well-managed feeding program for interior plants should provide adequate nutrition at all times. Deficiencies or excesses of any one element may be harmful or fatal to plants. Excessive nitrogen, for example, causes an overabundance of vegetative growth which create spindly and weak plants. When large quantities of fertilizer are used, soluble salts may accumulate causing injury or death. Insufficient amounts of elements may cause yellow, stunted, or curled growth.

Interior plants should be fertilized with a "complete" mixture of nitrogen, phosphorus, and potassium. Nitrogen and phosphorus are used in greater quantity than other elements and should be applied in higher amounts. The other elements are considered "trace" and are usually available in the soil medium. Fertilizers are available in dry or water-soluble forms. The type of fertilizer is not critical as long as it provides the needed elements. Dry fertilizers are not normally used with foliage plants as the time involved with measuring and applying small amounts to many individual containers is generally time consuming and not as effective.

Water-soluble fertilizers simply dissolve in water and are applied during scheduled watering times. Whether fertilizer is applied in dry or in liquid form, it should be used at the directed rate. Most interior plant fertilizers are applied quarterly or semi-annually. Infrequent small doses may not provide adequate nutrients, and high levels will cause injury or death. Fertilizers should always be applied to moist soil, and dry fertilizers should be immediately watered after application.

20.3.5 PRUNING

Pruning is the selective removal of a portion of the plant done for one of the following reasons:

- To control the overall size of the plant to remain effective in the space allotted
- To remove dead or injured leaves, branches, or shoots
- Assist in developing and maintaining the desired shape of the plant

Interior plants grow under conditions where they may not be as dense and full as similar plants grown outdoors. Thus, maintaining a tight, full crown or a desired shape may be difficult.

Periodic light pruning and shoot removal is better than infrequent, severe pruning. When a portion of a leaf is dead, remove the entire leaf rather than just the injured portion. When a small branch or shoot is removed, the cut should be made close to the main branch.

20.3.6 INSECTS

Various problems with insects and disease can be encountered when growing plants indoors. Plants should be examined regularly and treated immediately should any problem become evident.

There are relatively few serious insects pests affecting indoor ornamental plants, however, they can do significant damage if undetected. It is important to identify the pests, and treat accordingly. There are primarily seven insect species commonly found on interior plants:

- **Aphids**
- **Fungus Gnats**
- **Mealybugs**
- **Scale**
- **Spider Mites**
- **Thrips**
- **Whitefly**

Aphids

Aphids are soft-bodied, pear-shaped insects that are either winged or flightless. They are usually less than .4 cm and come in shades of green, brown, and red. Aphids damage plants by sucking plant sap and reduce plant vigor. They also cause curled and distorted leaves which may transmit viral diseases when feeding. Control by washing plants with a weekly spray of 1 teaspoon phosphate-free soap in 3.7 liters of water directly on the insects.

Fungus gnats

Fungus gnats are dark-colored, delicate flies less than .3 cm long. Adult fungus gnats do not damage the plant, but large clouds of flies appear when the infested plant is disturbed. The larvae stage of the gnat damage plants by feeding on organic matter (including roots) in the growing media. Diseases may enter damaged plant tissue. Symptoms of infestation are overall decline of plant appearance, stunting, yellowing, and defoliation. Control fungus gnats by allowing the growing media to dry-out and move the plant to a brighter location.

Mealybugs

Mealybugs are six-legged insects with a flattened, oval body. A white, waxy secretion covers the insect. Mealybugs pierce stems and leaves and feed on the sap. Disease may enter through the wound. Control by pruning out infested branches and spray a mixture of rubbing alcohol and water directly onto the insects.

Scale

Scales are piercing-sucking feeders, related to mealybugs. Most females have no legs, feeding during their immature life-stage. The winged males have legs, but no mouth parts and do not feed. Scale insects damage plants by sucking sap from tender growing parts of the plant, reducing plant vigor and appearance. Control by pruning off infected branches and mist or hose off the plant to remove and dislodge insects. Wipe-off or spray insects with a rubbing alcohol and water mixture.

Spider mites

Mites are an eight-legged species related to spiders with bodies less than .05 centimeter with oval bodies. Mites damage plants by sucking sap leaving gray or yellow stippling of upper leaf surfaces producing a mottled appearance. Control by removing all visual areas of plant-stress and moving the plant from hot, dry areas. Spray at 7-10 day intervals with a water and a phosphate-free soap mixture

Thrips

Thrips are winged insects, .5 cm in size, usually tan, black, or yellow. Thrips scrape plant tissue and suck sap from the wound. Diseases may develop on damaged areas. Plants lose vigor and appearance suffers with thrip infestation. Control thrips with a spray of phosphate-free soap and water and increase humidity level.

Whiteflies

White flies are tiny winged insects about .16 centimeter in size. Adults are covered with a powdery wax. Whiteflies suck plant sap resulting in plant wilting, yellowing, and loss of vigor. Control by vacuuming off winged adults or spray with a phosphate-free soap and water mixture.

12.3.7 DISEASE

A controlled environment and proper maintenance generally keep interior plants healthy and vigorous. When infectious diseases do develop they are caused by a disease pathogen; a living agent such as fungi, bacteria, or virus is present. Pathogens do not have the opportunity to get established when the following practices are introduced into an interior planting disease prevention program:

- Use healthy, disease-free plant stock
- Use sterilized potting media
- Don't crowd plants; allow air to circulate freely around the plants
- Water plants without splashing the leaves
- Routinely disinfect tools and hands with alcohol or bleach
- Remove and destroy infected plants, media, and top dressing
- Maintain correct environmental conditions such as light, temperature, and water
- Remove standing water from bottom of containers

Three disease pathogens commonly attack interior plants:

Fungi

- Fungi spores are fluffy, moldy looking growth on the surface of the plant causing spotting, holes, yellowed, and withered leaves resulting in poor plant health
- Control by trimming out infected portions and apply an interiorscape/indoor fungicide

Bacteria

- Plant diseases caused by bacteria are less common than fungal diseases, but when they do occur, they are potentially quite damaging since bacterial infections spread quickly
- Bacterial pathogens usually enter the host plant through a wound or natural opening
- Bacterial infections thrive in moist, humid conditions
- Bacteria often appear as oily, greasy, or water-soaked spots on leaves or as rotting, sour smell, cankers, and wilting
- Control by promptly removing and destroying infected plant or plant parts as well as disinfecting all tools that come into contact with the bacterial infection
- Spraying a bactericide labeled for this use may be required for control

Virus

- Viruses cannot penetrate an intact host, instead they enter a plant through an opening caused by injury, pruning or grafting, by insect feeding, or by worker's hands or tools
- Symptoms of viral infections are diverse and can easily be mistaken for other causes.
- The most common clue to viral infection is the sudden onset of symptoms
- Some viral symptoms are stunted growth, mosaic pattern on leaves, distorted leaves, yellow-streaking or curling of leaves
- Currently, there is no chemical control for virus

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20.4 CONCLUSION

This guide promotes interior planting design principles and maintenance techniques which minimize environmental impacts while maximizing long term value and efficiency.

20.4.1 INTERIOR PLANTING DESIGN DO'S AND DON'TS

Do's

Follow these principles for efficient and attractive interior planting design solutions:

- Consult local extension agents and nurseries on the suitability and availability of interior plant material provided in the Recommended Plant Lists
- Require that all designers, design agents, and tenants comply with installation interior landscape development and design policies
- Use only qualified, experienced landscape architects or interior designers on contracted interior planting design projects
- Always factor all facility, site, user, and environmental considerations into the final design solution
- Specify the minimum installation sizes of plants and containers required to satisfy initial aesthetic desires and needs
- To ensure interior plant beauty and viability, establish a watering and fertilizing schedule and keep plants free of dust, pests, and disease
- Ensure interior plants are healthy and disease and insect free and have been planted in sterilized soil
- Ensure trimming and maintenance tools are routinely disinfected with alcohol or bleach
- Quickly remove and destroy insect and disease infected plants, media, and mulch top-dressing
- Ensure indoor environmental conditions are maintained appropriately to maintain plant viability
- Remove any standing water from planter saucers

Don'ts

- Do not fertilize new interior plants for 6-12 months as they have been well cared for at the nursery or greenhouse
- Do not crowd interior plants; allow air to circulate freely and provide light around the entire planted area
- Do not allow water to splash the leaves when watering

20.4.2 REFERENCES

Suggested further reading:

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20.5 APPENDIX

20.5.1 RECOMMENDED PLANT LISTS

The following lists provide information on plants for various design situations.

The most common plants

Botanical Name	Common Name	Remarks
Aglaonema spp.	Chinese Evergreens	Very hardy interior plant with attractive leaf patterns, slow growing, and bushy
Aspidistra eliator	Cast Iron plant	Very slow growth and very hardy with long, dark green leaves
Chamaedorea elegans	Neanthe Bella palm	Very hardy indoor palm with attractive fronds easy to maintain
Chlorophytum comosum	Spider plant	Ideal plant for hanging baskets which sends out numerous 'plantlets' on long, slender branches. Comes green and variegated
Croton variegatum	Croton	Very striking, colorful large-leafed plant
Dracaena marginata	Red-margin Dracaena	Very graceful red-margined member of the dracaena family with an upright, angular form
Dracaena massangeana	Corn plant	For size, beauty, and durability, this plant is #1 for most interior situations
Epipremnum aureum	Golden Pothos Ivy	Outstanding hanging basket or wall cascade plant with striking golden-green foliage
Fatsia japonica	Japanese Aralia	Very striking, large-leafed plant well-suited for interior settings
Ficus benjamina	Weeping Fig	The best tree for interior use. Easy to maintain with graceful, weeping branches

Ficus lyrata	Fiddleleaf Fig	Large, deep green leaves are shaped like a fiddle. Best when planted three per container
Philodendron spp.	Philodendrons	Philodendrons are excellent performers indoors. They can be bushy or be used in hanging baskets
Phoenix roebelenii	Pygmy Date Palm	For its size and bushiness, this is the top performing palm for interior settings
Sansevieria spp.	Snake plant	Slow growth up to .9-1.22 M, requiring very low water and light
Schefflera actinophylla	Umbrella tree	An outstanding large tree for interior use with large, deep green leaves
Schefflera arboricola	Hawaiian Schefflera	A top interior performer with small, deep green, oval-shaped leaves used as a shrub or a small tree
Sedum spp.	Sedum	Attractive family of succulents that can be used upright, as a groundcover, or in hanging baskets, often with colorful flowers
Spathiphyllum spp.	Peace lily	Small, bushy plant with long, oval leaves producing a beautiful white flower stalk
Syngonium podophyllum	Arrowhead plant	An outstanding interior plant that can be used as a bush or in hanging baskets with arrow-shaped variegated leaves

The best low light plants

Botanical Name	**Common Name**	**Remarks**
Aglaonema spp.	Chinese Evergreens	Very hardy interior plant that is slow growing, bushy requiring as little as 35 foot-candles
Aspidistra eliator	Cast Iron plant	Very slow growth and very hardy in as little as 10 foot-candles
Chamaedoreas spp.	Bamboo	Very hardy and most live comfortably in as little as 20 foot-candles

Dracaena marginata	Red-margin Dracaena	Very graceful red-margined member of the dracaena family requiring at least 30 foot candles
Dracaena massangeana	Corn plant	For size, beauty, and durability, this family is #1 for low light situations
Ferocactus spp.	Barrel cactus	Cacti love full sun, but their efficiency in water storage allows them to survive in less than 30 foot-candles
Philodendron spp.	Philodendrons	Most philodendrons are good low-light plants with leggy growth at 25 foot-candles, but normal over 40 foot-candles
Rhapis excelsa	Lady palm	For its size and bushiness, this is a top performing palm requiring as little as 45 foot candles
Rumohra adiantiformis	Leather Fern	No other fern performs in low light situations as well as this fern, requiring as little as 30 foot-candles
Sansevieria spp.	Snake plant	Slow growth up to .9-1.22 M, requiring very low water and all thrive in as little as 20 foot-candles

The toughest plants for heavy traffic and high use areas

Botanical Name	Common Name	Remarks
Aspidistra, Clivia, and Sansevieria spp.	Stiff-leafed lilies	Hardy, well-rooted plants which can take abnormal abuse without showing damage
Chamaerops and Livistona	Fan palms	All fan palms are extremely tough and durable with small, stiff fronds, short stems, and thick trunks
Ficus benjamina	Fig tree	Durability, flexible branches, and fast growth make this tree the #1 choice for well-traveled areas
Hedera and Ficus spp.	Woody vines	These are the two best performers for heavy traffic areas as they have woody stems and stiff leaves
Leea coccinea	Hawaiian	Very rapid growth with an

	Holly	almost succulent appearance
Podocarpus macrophyllus	Yew pine	Very graceful plant featuring long, flexible stems and small, flattened needles
Rhapis excelsa and humilis	Lady palms	Both species are very tough and difficult to damage with slim stems
Rumohra and Cyrtomium spp.	Leathery Ferns	Although most ferns bruise easily, leathery ferns are tough and durable and hard to damage
Spathiphyllum wallisii	Peace lily	Although it has soft foliage, this plant produces new foliage very quickly and is quite hardy
Yucca elephantipes	Yucca	A superior interior yucca with soft, downward curving leaves that is extremely durable and hardy

The best plants for hot, bright, and dry conditions

Botanical Name	**Common Name**	**Remarks**
Aeschynanthus spp.	Lipstick Vine	Heat does not bother this hardy vine and it can adapt to nearly every harsh condition
Aspidistra and Sansevieria species	Stiff-leafed lilies	These lilies have no difficulty storing water and are very tough and hardy
Beaucarnea recurvata	Bottle Palm	Bottle palms are very hardy and have a large bulb with numerous growth stalks emerging
Cactus genera	Cacti	Cacti withstand heat and dryness well and will flower quite readily in these conditions
Chamaerops humilis	European Fan Palm	Palms are hardy, rarely dry out, and have soft, grass-like fronds
Dracaena reflexa	Reflexa Dracaena	This species of dracaena does the best in harsh, dry conditions
Ficus benjamina	Fig tree	Figs easily adapt to the heat and thrive if water is regularly provided
		Philodendrons are slow to wilt

Philodendron selloum	Philodendron	and thrive in hot, dry conditions
Succulent types	Succulents	Leather-leafed succulents endure heat and low humidity quite well and flower proficiently
Yucca elephantipes	Yucca	Yuccas thrive in high heat and have rapid growth and flowery white spikes

The best plants for cool and damp conditions

Botanical Name	Common Name	Remarks
Asparagus varieties	Asparagus Ferns	All ferns stand up well in cool, drafty areas but asparagus ferns do best due to their tough, hard needles versus soft fronds
Araucaria heterophylla	Norfolk Pine	Norfolk pines grow well in cooler conditions due to their woody structure and low moisture content
Livistona chinensis	Fan Palm	These palms are virtually indestructible and can survive cool temperatures down to freezing
Aspidistra eliator	Leathery Ferns	Aspidistraís will survive nearly all difficult interior situations, even cool and damp conditions
Cactus genera	Cacti	Cacti stand up well to all weather conditions but will grow much slower in cooler conditions
Ficus elastica 'Decora'	Rubber plant	The rubber plant stands temperatures down to freezing and is very tough and durable
Hedera helix	English Ivy	Ivies prefer cooler temperatures and thrive in interior condition
Pandanus spp.	Screw Pine	Quite a durable dracaena-like plant that is hardy and tolerant of cool conditions
Pittosporum tobira	Mock Orange	Mock orange is usually an outdoor plant that can adapt to interior conditions
Succulent spp.	Succulents	Most succulents will tolerate some cold and damp temperatures

The best interior plants that stay short and bushy

Botanical Name	Common Name	Remarks
Aglaonema spp.	Chinese Evergreen	Very hardy but slow growth to 1.2 M content to produce new stalks from its base rather than increasing its height
Chamaedorea elegans	Neanthe Bella Palm	Attractive dwarf palm with very slow growth to 1.5-1.8 M although it usually levels off at 1.2 M
Clivia miniata	Clivia lily	Very showy flowers as well as hardy and durable to a height generally less than .6 M
Phoenix roebelenii	Pygmy Date Palm	Very slow growth with an attractive head of fronds with a stout, hairy trunk making it appear dwarf
Aspidistra eliator	Cast-Iron plant	Very hardy and slow growth to .6-.9 M
Chamaerops and Livistona spp.	Fan Palms	Fan palms grow very slowly and produce only 2-3 fronds per year
Crassula argentea	Jade plant	Very hardy and slow growth at a rate of about one foot per year
Cycas revolta	Sago Palm	Superior performer that is hardy and a very slow grower with extremely stiff foliage
Sansevieria trifasciata	Snake plant	Very slow, controlled growth to about 1.2 M
Schefflera arboricola	Hawaiian Schefflera	Very hardy, small-leafed plant that remains small and controlled

Outstanding average-sized plants

Botanical Name	Common Name	Remarks
Agave spp.	Agave	A virtually indestructible plant with heavy, long spiked foliage, needs sun
Beaucarnea recurvata	Bottle Palm	Very hardy and slow growth to 1.5-1.8 M with a mass of long, whip-like foliage
Cereus peruvianus	Peruvian Cactus	This hardy cactus has a smooth-ribbed exterior, and does not have dangerous needles

Chrysalidocarpus lutescens	Areca Palm	A delightful plant with gracefully arching leaves that looks best when massed
Dracaena fragrans massangeana	Corn Plant	1.2-1.5 M is the most popular size for this hardy and decorative ramrod-straight cane which will grow under most interior conditions
Ficus elastica ëDecoraí	Rubber plant	A very neat and tidy plant with a thick, stout trunk and branching limbs
Leea coccinea	Hawaiian Holly	This is a hardy, cheerful, undemanding plant
Nephrolepis exalta ëBostoniensisí	Leathery Ferns	An extremely attractive mass of long, graceful fronds make the Boston fern an eye-catching interior plant
Philodendron selloum	Selloum	A very hardy, spreading plant which may have over thirty large, fan-shaped leaves at one time
Spathiphyllum ëMauna Loaí	Spathiphyllum	This is the largest peace lily and is a hardy, striking plant with dark, long green foliage

Outstanding large-sized (over 2.1 M) plants

Botanical Name	Common Name	Remarks
Brassaia actinophylla	Schefflera	A large-leafed interior plant that has a rounded, controlled look
Chamaedorea erumpens	Bamboo Palm	A hardy and graceful large interior plant that will grow in most settings
Dieffenbachia spp.	Dieffenbachia	A strikingly beautiful specimen with long, narrow leaves will grow in most bright locations
Dracaena fragrans massangeana	Massangeana Cane	Slow growth to 2.1 M for this hardy and decorative ramrod-straight cane make this an excellent choice that will grow under most interior conditions
Dracaena marginata	Red-margin Dracaena	A towering, multi-branched specimen of D. marginata is a graceful and delicate addition to an interior setting

Ficus lyrata	Fiddle Leaf Fig	A striking, large plant with large, fiddle-shaped leaves
Kentia belmoreana and K. forsterana	Kentia Palms	Kentia palms level off at 2.1-2.4 M indoors then start to spread making a strikingly beautiful impression
Podocarpus macrophyllus	Yew Pine	A hardy, graceful looking plant which has coarse foliage and upright growth
Rhapis excelsa	Lady Palm	A large plant making an instant impression with finely structured leaves and large trunk
Yucca elephantipes	Yucca	An impressive, large-cane yucca has nice straight stems with graceful, curved leaves

Outstanding larger-sized (over 3 M) plants

Botanical Name	**Common Name**	**Remarks**
Araucaria excelsa	Norfolk Pine	An attractive large tree with spiked needles and long, gracefully drooping branches
Beaucarnea recurvata	Bottle Palm	The 3 M bottle palm is truly a strikingly beautiful and unique interior plant with itís massive trunk and graceful branches
Caryota urens and C. mitis	Fishtail Palms	A large and delicate palm with a large , smooth trunk and graceful branches
Chrysalidocarpus lutescens	Areca Palm	Large specimens have leathery fronds supported by a thick trunk
Cibotium schiedei	Tree Fern	A truly unique tropical plant with large frond-like branches that uncurl from the center
Dizygotheca elegantissima	False Aralia	Unique, very dark narrow leaves on long branches make this an attractive interior plant
Dracaena reflexa	Reflexa Dracaena	A stout-trunked plant with dense leaves that is an instant impact
Ficus benjamina	Fig Tree	Fig trees have so many uses that it has become the #1 most frequently specified, big interior plant with long, drooping branches

Ficus elastica Decora	Rubber Plant	A thick-trunked plant with numerous large, oval-shaped leaves
Ptychosperma elegans	Alexander Palm	Really best when at least 3 M tall with a smooth, strong trunk and thick, glossy foliage glossary

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20.5.2 GLOSSARY

The following terms are commonly used in interior planting discussions:

Acclimatization - The process required to cause physiological changes within a plant system that will enable the plant to adapt (in the most attractive state) to the change from the nursery or outdoor or native environment to the purely human interior environment without exhibiting severe damage or death.

Aerial roots - Roots formed above ground from Ficus species, Selloum, and Boston Ferns.

Axil - The angle formed between the petiole and the stem.

Axillary bud - A bud produced in the axil of a leaf.

Bacteria - One-celled, non-spore forming microscopic organisms usually entering the host plant through wounds or natural openings.

Balled and burlapped - Refers to a foliage plant which has been field grown and dug from the ground with its root-ball contained in burlap wrapping.

Basal - Growing from the base of a stem.

Biological controls - A pest control strategy that uses living organisms to control another less desirable living organism.

Chemical controls - Pesticides and least toxic chemicals such as rubbing alcohol and phosphate-free soap used to control pests.

Chlorosis - An abnormal condition of plants in which the green parts lose their color or turn yellow as a result of disease or lack of nutrition.

Clump-form - A plant form resulting from a massing of major and minor stems issuing from the soil mass from a common origin.

Compacted root ball - Tight; there are more roots than soil.

Compound leaves - Leaf blade which is composed of two or more separate parts (leaflets) which are connected by a petiole.

Contract - A specific agreement by two or more parties for their mutual benefit.

Cork mat (acrylic mat) - Used for protecting finished surfaces from planter damage.

Cultural/mechanical controls - Techniques used to change the plant's physical environment, the condition of the host plant or the behavior of the pest in order to prevent or suppress the pest.

Direct planting - The Planting process whereby the nursery growing container is removed from the root-soil mass of the plant prior to the plant being "planted" in the soil media which fills the planter.

Double-potting - The Planting process whereby the growing container is left around the plant root/soil mass and the unit is placed in a decorative planter which contains soil media or drainage fill material surrounding the nursery container to aid in restricting root-growth spread and future plant removal convenience. In double-potting installations, the surrounding mediums main objectives are the support of the growing container, to promote drainage from the growing container to provide additional surface for increased humidity around the plant.

Fertilizers - A combination of minerals needed by a plant to produce carbohydrates during photosynthesis.

Flowers - The plant's reproductive organs.

File-top planter - Any decorative planter small enough or specifically designed to fit on top of a filing cabinet.

Fixed planting bed - A permanent, non-movable planting area which is built into a building's construction (at grade level or at-finished-floor level or slightly above grade). Recommend that water supply and a means of adequate drainage of excess water be provided in each bed, as well as waterproof electrical power.

Floor planter - Any decorative planter, either basket, fiberglass, metal, ceramic, clay, etc. type of container that is designed and scaled to sit on the floor and is usually movable (except where tied to an electrical junction box in floor for uplighting in planter or affixed mechanically to the floor to prevent movement).

Flower rotation - The cyclical process whereby potted flowers are placed in an interior landscape for "color" under contract with an account at agreed upon intervals for either a set or variable price.

Foliage plant - Living green plant forms that are commercially grown in containers for their form, texture, and growth habits instead of their flowers or blooms and that are capable of living indoors for long periods at relatively constant temperatures and under low light intensities (i.e., lower than they were used to in production).

Foot-candles - The units of light received by an object (plant) from a specific direction and source of variable distance. The measurement is based on light from one candle received by an object at a fixed distance.

Fungus - Any of a large group of the thallophytes, including molds, mildew, rust, and smut, which are parasites on living organisms or feed upon dead organic material, lack chlorophyll, true roots, stems, and leaves, and reproduce by means of spores.

Gall - Tumors made of root tissue, indicative of nematodes, bacteria, or fungi.

Glaucous - A thin coating of bluish or whitish waxy granules, easily rubbed off by hand or cloth, may be eliminated by a very dilute solution of leaf shine. Glaucous is often seen on Ficus, Grape ivy, and Schefflera.

Growing media - A combination of media particles, water, and pore space. The media used by most tropical plants contain no soil (referred to as a soilless media), and is a combination of organic matter such as peat moss and bark mixed with inorganic materials like perlite, vermiculite, or styrofoam pellets,

Guaranty - Agreement made between the Contractor and the Owner for a specified time period (recommended period of one year) which states that the Contractor shall replace any plant which is not in a healthy and an attractive condition, excluding damage or loss of the plant due to conditions over which the Contractor had no control. These exclusions are usually spelled out in contractor's terms and conditions.

Guttation - The loss of liquid in the form of droplets from plant leaves. Often seen at the base of Ficus leaves on the lower side.

HVAC - Construction industry terminology for an integral unified system for heating, ventilation, and air conditioning.

Hanging basket - A plant with trailing and/or spreading growth habit grown in a shapely tapered plastic or wire/moss growing container with a wire hanging apparatus.

Hanging planter - Any planting installation whether a wire basket, plastic basket: self-watering container or of special design; designed and scaled primarily to be hung by wire, rope, or chain.

Holding period - Time duration in which plants should be held by the Contractor following their arrival from the growing nursery and prior to their installation at the job site. The objective of this holding period is extended acclimatization of the plants, yet is different from and additional to the acclimatization period usually implemented in a facility in which lighting, humidity, and temperature can be controlled.

Honeydew - Secretion from pests, usually insects.

Infectious diseases - A disease caused by a living pathogen such as a fungus, bacteria, or virus.

Installation - Delivery, placement, and planting of interior landscapes.

Integrated Pest Management - A method of pest control that combines cultural, mechanical, biological, and least toxic chemical solutions.

Internode - Part of the stem between the nodes.

Latex - A milky plant secretion.

Leaching - The process of flushing the growing medium (i.e., soil mass within a nursery container or planter) with clean, pure (low in dissolved slats) water so as to wash out dissolved soluble salts which might otherwise "burn" the plant roots, causing subsequent foliage deterioration and plant ill health.

Leaf scar - The distinctive cork-covered scar left on a stem when a leaf drops off.

Lease/Management - An account which is leasing (rather than buying) plants and/or planters and materials with maintenance and warranty services.

Lease Purchase/Maintenance - Lease of plants with sale of planters.

Leasing - A long-term rental of duration greater than or equal to one year.

Lenticel - A small, usually raised, soft, porous spot in the cork layer of stems permitting gas exchange between the living tissue and the surrounding air.

Less Than A Load (LTL) - Applies to shipping materials, planters, and plants less than a load via "common carrier" trucking; LTL is more expensive than ordering a fully loaded tractor trailer.

Light duration - Refers to the total number of hours of light a plant receives in a day (also called photoperiod).

Light intensity - Refers to the brightness of light. It is measured in footcandles.

Light quality - Refers to the different wave lengths of colors that make up the visible (white) light.

Liner - A waterproof "inner" non-decorative shell to contain a nursery pot within a porous planter or an alien soil environment.

Macro nutrients - The major nutrients that plants need for growth. They include carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur. Called macro nutrients because the plant uses them in large amounts.

Micro nutrients - Micro or trace elements needed in small amounts for plant growth. The micro nutrients include iron, zinc, boron, copper, manganese, molybdenum, and chlorine.

Midrib - The large main-vein, usually in the middle of the leaf.

Multi-stem tree form - A woody plant that produces three or more main trunk (issuing from the soil line) and a more or less distinct and elevated foliage crown.

Node - The point or level on the stem which is capable of producing leaves, flowers, and sometimes roots. Make all pruning cuts at the node, not the internode.

Noninfectious diseases - A disease that develops from abiotic or non-living disease agents. noninfectious diseases can develop due to incorrect environmental conditions, poor maintenance practices, or aging media.

Overall Height - Average overall height including the growing container.

Overall width - Average overall width of the tree or plant.

Pathogen - A disease-producing organism.

Petiole - The basal stalk of a leaf, supporting the blade; buds are usually present in the upper axils of petioles.

Petiolule - The stalk of a leaflet; buds are never present in the axils.

pH - The symbol used to establish the degree of acidity or alkalinity of 1.0 -14.0. A reading of 7.0 is neutral, a higher reading of 7.1 to 14.0 is increasing alkaline and a lower reading of 6.9 to 1.0 is increasing acid.

Phloem - The food-conducting tissues of plants with vascular systems (higher plants). Phloem is found in both leaves and stems.

Phytotoxic reactions - An adverse reaction to a chemical or pesticide.

Photosynthesis - The chemical process by which plants use light, CO_2, and water to manufacture sugar. Oxygen is a by-product.

Phototrophism - The movement of a part of the plant toward or away from a light source.

Pinching plants - A technique that involves removing the growing tip (apex) of a plant to promote lateral branching

Plant Height - Overall height of a plant from base of nursery growing container to top of major foliage. Outstanding branches, not visually a part of the foliage massing, are to be discounted from height measurement.

Plant replacement warranty - A promise by the interior landscaping contractor made as part of an agreement between the Contractor and Owner for a specified time period which states that the Contractor shall replace any plant which is not healthy and an attractive condition; excluding damage or loss of the plant due to conditions over which the Contractor had no control. These exclusions are usually spelled out in Contractor's terms and conditions of sale.

Plant width (spread, foliage mass size) - Overall width of foliage measured across main foliage body. Outstanding branches, not visually a part of the foliage massing, are to be discounted from width measurement.

Planter - A decorative planter, hanging planter, or fixed planting bed.

Plants per pot - Designation indicating the number of individual rooted cuttings, rooted canes, etc. planted together to form a single plant.

Pot - Nursery growing container.

Prune - Removing dead or living parts from a plant to improve the form or remove necessary growth.

Purchase order - A multiple part order form used to convey the intention of a firm to purchase specifically itemized products from a specific supplier at stipulated prices and terms. Initiates an authorization to disburse a firm's funds to acquire products and/or services for resale or internal use.

Rental - A "using" of products for a duration of less than one year in return for monetary consideration.

Respiration - The process by which a plant releases energy stored in carbohydrates to maintain life processes.

Rhizome - An underground stem, usually horizontal, which produces roots and upright stems such as Bamboo palms, Aspidistra, etc.

Root hairs - A line of single cells which extend out into the soil from the main root body. These hairs are responsible for water and mineral absorption for the plant and are very sensitive to moisture content in the soil.

Rotation (rotational planting) - The cyclical process by which plants are removed from an installation site to a back-up greenhouse facility for rejuvenation, simultaneous to a replacement plant being taken from the greenhouse to the installation site so that the number of plants on a job always remains intact and plant aesthetics and health remain high. Rotating may also take place between plants of highly differing environmental settings on the same job.

Runner - A creeping or tailing stem. Runners are relatively independent of the main plant, sending out their own roots as they run.

Separator - A porous fabric used to separate soil from drainage fill when direct planting.

Service (Horticultural Services, Maintenance) - Performance of professional duties pertinent to keeping interior foliage plants in a continuously attractive and healthy state. Services are usually based on a guaranteed maintenance contract renewable every year.

Sessile - Without a stalk or petiole leaves or flowers. All Dracaenas have sessile leaves.

Shade level - The terminology used by greenhouse "skin" producers to indicate the percentage factor of direct sunlight reduction. Commercial shade cloth and horticultural fiberglass are available in numerous shade levels. A 47 percent shade lever cloth, for instance, blocks out 47 percent of the direct sunlight penetration and yields 53 percent actual sunlight transmission. A 47 percent shade cloth on a clear Florida summer day of 10,000 foot-candles intensity would permit 5,300 foot-candles to penetrate to the plants.

Site contact - Primary person on the job or project who the Contractor relates to for regular installation or maintenance operations.

Soil line (or level) - Average top surface of growing medium (i.e., soil mass).

Soluble salts - The total dissolved material present in the growing medium (i.e., soil mass) at any time. Soluble salts are measured as parts (of salts) per million of water (ppm) utilizing a solubridge meter.

Sori (Sorus) - Fern spores.

Spadix - A fleshy spike of tiny flowers, usually enclosed in a spathe.

Spathe - A modified leaf, like a bract, that often is brightly colored and draws attention to a spadix.

Special Service Order - A multiple part form used by the contract service department to initiate work at an "account" other than regular weekly maintenance.

Specification(s) - A complete and detailed description of a project; including all pertinent plans and drawings, plant lists, procedures, and contractual information.

Specification and Price Breakdown sheet - A form used to specify initially or itemize an existing inventory of plantings at an account.

Spore - Organism or cell that can develop into a new individual, such as found on ferns or fungi.

Standard tree form - A woody plant that produces one main trunk and a more or less distinct and elevated foliage crown.

Stolon - A running shoot that produces roots along its stem.

Stomata - Pores through which gasses pass.

Subirrigation - Subirrigation or self-watering containers are systems that supply moisture to a plant on a regular basis. A reservoir of water is located at the bottom of the container. Plants draw up moisture as they need it.

Substitution - Term used in installation and maintenance operations to convey authorization that plant or planter, etc. other than exact kind, size, shape specified, or on site can be employed if the original is not in stock or appropriate.

Sucker - A branch or cluster of leaves, usually undesirable, arising from the trunk or crown of a plant. Although not necessarily harmful to a plant, a sucker can damage a plant's overall symmetry.

Top watering - Adding water to the top of a container.

Translocation - Movement of water and minerals through the plant.

Transpiration - The process by which a plant cools its leaf surface.

Triple potting - The process of placing a plant and its nursery growing container into a second watertight container or liner of slightly larger diameter and then placing this entire unit with a third planter (decorative pot, fixed planting bed). This process is used to facilitate situations such as flower rotations where replacement is frequent and/or a minority of plant species have vastly differing water requirements from the surrounding plants.

Transpiration - The release of moisture in vapor form through plant leaves.

Trim - Cutting yellow, brown, and torn tissues from a leaf, recreating the natural leaf shape.

Turgidity - Term used to describe the leaf condition either as being firm and full of water (turgid) or weak and lacking in water (not turgid, wilted).

Vector - An insect or other organism transmitting germs or other agents of disease.

Viruses - Microscopic pathogens consisting of a single strand of DNA and a protein coating. They can enter a host plant through injuries or insect damage.

Xylem - The supportive, water-conducting tissue of plants. Located toward the center of stems, xylem often hardens and becomes what is commonly referred to as wood.