Bidwell Park Trails Manual

Standards and Guidelines for Trail Management

Park Department
August, 1999

Approved by the Bidwell Park and Playground Commission June 28, 1999

Addendum
The Following Changes were approved by the
Bidwell Park and Playground Commission
11-15-00

1. The following paragraph be amended into the Bidwell Park Trails Manual:

Pruning techniques shall be used to provide variation and interest in trails. Methods such as directional pruning shall be used to provide desired clearance for passage but minimize vegetation removal. In addition, vegetation height on trail shoulders may vary (12 to 18 inches) in height depending on location. This particularly important for Class C trails.

As presented, the above paragraph would be incorporated into the Manual at the following locations:

a. Page 24 - Maintaining Existing Trails, Clearing Existing Trails, insert as new para. 5.
b. Page 27 - Insert on Figure 7.
c. Page 28 - Maintaining Existing Trails, Brushing Existing Trails, insert as new para. 6.

2. Section titled "clearing and Brushing for a New Trail, second paragraph be amended to read as follows:

"For protection against erosion, and to maintain the appearance of area, trees six (6) inches or less in diameter may be removed in conjunction with trail design and construction ~~all healthy trees over 12 inches in diameter should be left~~.
Where trees in excess of six (6) inches are encountered, alternative routing shall be considered. In the event alternative routes cannot be located, the tree(s) shall be flagged and the proposed removal(s) be reviewed and approved by the Director or his/her designee. Preference will be given to Butte County natives with non-Butte County natives removed where practical.

Background

Adopted in 1999, the Trails Manual provides the basic standards for improving and maintaining trails in Bidwell Park. Upon its adoption, the Trails Manual provides clear and concise guidelines which, from to time, require amplification or clarification. Staff is recommending clarification regarding amount of vegetation to be removed from shoulders of trail. Currently, the manual give the impression that all vegetation should be cleared. Staff is recommending that various techniques be used for specific applications and desired outcomes. Examples include directional pruning and graduated shoulder clearance to take advantage of natural features.

Table of Contents

Index of Figures

Introduction

Bidwell Park is the third largest municipal park in the United States with 3,670 acres of improved, semi-improved, and wilderness parkland. While a municipal park, Bidwell Park is also one of the largest regional parks in northern California. Visitors from throughout northern California come to recreate in Big Chico Creek, Caper Acres, its ball fields, and on its over fifty miles of trails. These trails allow (walkers, runners, hikers, horse riders, and mountain bike riders) access to every part of Bidwell Park; however, in the decades after the Park was established few formal/official trails exist while many informal/unofficial trails crisscross the Park.

THE PURPOSE OF THE BIDWELL PARK TRAIL MANUAL

Trails are one of the most important features in any park system. The creation and maintenance of a healthy and sustainable trail system provides quality recreational opportunities in the form of walking, hiking, mountain biking, horseback riding, and more, as well as access to the Park's points of interest without diminishing the natural resources of the Park or effecting future generations' ability to utilize these resources. The Bidwell Park Trail Management Manual lays the groundwork for a long-range trail program and reflects the vision contained in the Bidwell Park Master Management Manual of protecting park resources while providing enjoyable and safe recreational opportunities.

The Bidwell Park and Playground Commission and Park Department staff felt that after nearly a century of existence, the Bidwell Park trail system needed a formal plan to guide its next century of activities. The Park and its trails are under increasing pressure as the area population grows and people throughout northern California seek additional recreational activities and places to escape to. With the addition of the new park acquisition land, the Bidwell Park and Playground Commission (Commission) 0and staff want to be able to create a sustainable system of trails before they are randomly and haphazardly developed by people trying to gain access to new areas.

This document is a work in progress. Important components of the Manual will be developed over the next few years as resources allow. Trails have never been formally identified or their condition and need assessed. Trail maintenance has been conducted in a reactive rather than a pro-active manner and relies on the availability of volunteers. Limited trail development and maintenance standards exist in the Master Management Plan, but more are needed. Policies developed in the City's General Plan, Bicycle Plan, Bidwell Park Master Management Plan, and by the Commission have never been assembled into a single document for guidance.

The goal of this Plan is to incorporate all the information and policies that exist to date, develop a plan to properly assess trails and gather needed information, and produce a workable "Trails Manual" to guide the efforts of staff and volunteers in developing and maintaining a healthy, sustainable trail system as an integral part of an healthy, sustainable Bidwell Park.

As a living document, this Plan will be updated as policies are developed and information gathered. It is laid out to be easily expandable without having to reproduce the whole document. Chapter pages are individually numbered so that in chapters in which components (like BPPC policies) may be updated on a monthly basis changes can be easily inserted. The Trails Manual is included as an Appendix but it is also intended to be used as a "stand-alone" management and field tool for Park staff and volunteers. It provides general knowledge of overall trail management, outlines standards and guidelines for trail work, and describes how to construct a variety of trail features. By establishing well-defined procedures, the Trails Manual insures that the trail management program will be consistent. This manual is not intended to supplant trained, experienced, and skilled workers. It is intended to supplement their knowledge, and provide guidelines from which to operate.

Necessary Approvals and Environmental Review

This manual is not intended to supplant the need for discretionary approvals, environmental review, or permits from regulatory agencies, as established by the City's Municipal Code, the State Public Resources Code, or other applicable provisions of local, state, and federal law. Maintenance efforts in non-sensitive resource areas typically do not require review and approval outside the Park Department, but some maintenance activities within sensitive resource areas, and most new construction will require some level of environmental review, discretionary approval, or permitting.

Many of the activities discussed in the Trails Manual explicitly require the approval of the Park Director or his/her designee. Additionally, any activity for which the need for approvals, permits, or review is not clear should be referred to the Park Director for his/her consideration. As part of the responsibility for reviewing proposed actions, the Park Director or his/her designee will consult with such individuals as necessary to determine whether discretionary approvals, environmental review, or regulatory permits are required for the proposed action.

Components of a Healthy Trail System

A healthy trail system is created through the integration of a diverse staff, a strong resource base, an involved public, and a clear set of procedures. The trail management program for Bidwell Park involves a number of components, all of which must work together to be successful. A healthy trail system in Bidwell Park requires:

* Inventorying and monitoring the trail system,
* Determining and accessing needed resources,
* Maintaining, rehabilitating, and creating trails,
* Determining user need and assigning trail use,
* Educating trail users of opportunities and responsibilities, and
* Determining and enforcing trail rules and regulations

The Trails Manual provides background information and procedures for each of these components.

Public Support of the Trails Program

The success of the trails program for Bidwell Park relies heavily on the involvement of the public in a variety of ways. Volunteers are needed to provide labor for trail projects and routine maintenance. Trail users need to take it upon themselves to understand, respect, and follow all trail regulations and policies. And local businesses and community organizations need to donate money and resources for trail projects. In short, success depends on the public sharing in the work needed to create and maintain a healthy trail system in Bidwell Park.

Inventorying and Monitoring the Trail System

Managing resources without knowing their present state, and how they evolve over time, is both irresponsible and ineffective. To combat this problem, a comprehensive inventory and monitoring system is vital to any successful management program. The trail system in Bidwell Park is large, complex, and subject to frequent change. In order to have a healthy trail system, trail resources need to inventoried and monitored over time. Over the next several years, a formal inventory and monitoring system for Bidwell Park will be initiated under the guidelines outlined below.

Mapping and Surveying the Trail System

One of the first steps in a successful trail management program is the surveying and mapping of the existing trail system. This process involves the hiking of each trail with a rolatape wheel, tape measure, and trail log. As the inspection team hikes the trail, they should record every structure encountered into the log (e.g., bridges, puncheons, safety rails, retaining walls, steps, etc.). Each structure should be measured to identify its length or dimension. It should also be inspected to determine its structural integrity and general condition. Deficiencies should be noted and those structures requiring repairs, upgrade, or replacement entered into the log. As the inspection team hikes the trail, they should also survey the trail's bed and tread surface. Deficiencies, such as entrenching, drainage problems, exposed roots, and downed trees, need to be identified, measured, and logged. Through this process, a complete inventory of trail features and structures can be recorded, and every deficiency identified and quantified.

In addition to recording a complete inventory of trail features and structures, information on trail alignment, distances, and hiking times should be collected. Specific, definable reference points should be accurately located, and the trail's position should be plotted on a topographical map. In the near future, inventory data should be entered into a computer program (spreadsheet or other appropriate format), and the information describing the trails location used to place that trail into a GIS program.

Classifying Trails

Once the existing trail system is mapped and surveyed, each trail needs to be placed into a general group or class. The placement of trails into these classes is determined by using specific criteria with predetermined values (see figures 1a, 1b and 2). Using these criteria, each trail can be evaluated individually, as well as comparatively.

Placing trails into class categories allows for objectively assigning standards and work priorities to trails,

which are consistent with their primary function, environmental sensitivity, relationship to developed facilities, and visitor use. Class A trails are assigned the highest trail construction and maintenance standards. The maintenance standards for Class B and C trails are of decreasing priority unless extenuating circumstances dictate otherwise. The selection of trails for maintenance and rehabilitation work is also influenced by their classification. Assuming visitor safety, resource protection, and trail investment concerns are equal, those trails with the highest classifications should receive the highest priority.

The overall system for classifying trails, as well as individual sets of criteria for classification, is heavily influenced by existing trail resources in Bidwell Park. Until a complete and thorough inventory is done, the applicability and successful implementation of this classification system will not be known. Modification of the classification system may or may not be needed to create an appropriate inventory and monitoring program for Bidwell Park.

Acceptable Trail Classifications

	Acceptable Classifications		
Criteria	A	B	C
1. Disabled Accessible Trails			
2. Interpretive Trails			
3. Trails Within Visitor Facilities			
4. Trails Connecting Visitor Facilities			
5. Trails with Parking Access			
6. Destination Oriented Trail			
7. Trials Connecting to other Trail Systems			
8. Trails with Fragile Environments Restrict Use			
9. Trials with Special Safety Concerns Restrict Use			
10. Grade Limitations that dictate trail use.			
11. Bikes Use			
12. Equestrian Use			
13. Used by all - equestrian, hiking, biking			

Figure 1a

Definitions of Criteria for the Trail Classification-Survey

For this classification system, a visitor facility is defined as a developed picnic area, interpretive center, and so on.

Definition of Criteria

1. Trails designed as "all access" (i.e. accessible to wheelchairs and others with disabilities).
2. Trails with a series of interpretive signs or self-guiding pamphlets.
3. Trails that originate and stay within a visitor facility.
4. Trails that connect two, or more, visitor facilities.
5. Trails that start, pass through, or end at a parking lot (developed or non-developed).
6. Trails that lead to unique and/or significant scenic, historical, or recreational features.
7. Trails that are part of longer regional trail systems or connect to other agency trails.
8. Trails that pass through fragile environments. Fragile environments are defined as areas a trail passes through that are sensitive to disturbance because of endangered plant or animal species, unstable geology, etc..
9. Trails with safety factors to consider, such as trail structures, steep terrain, and/or precipitous drops.
10. Are there grades which limit type of use that should be considered.
11. Trails that are suitable for bike use.
12. Trails that are suitable for equestrian use.
13. Trails suitable for combined uses including equestrian, hiking and biking

Figure 1b

Trail Classification Survey

Trail Name: _____

Criteria		Check All Applicable
1. Disabled accessible trail		
2. Interpretive trail		
3. Trails within visitor facilities		
4. Trails connecting visitor facilities		
5. Trails with parking access		
6. Destination oriented trail		
7. Trials connecting to other trail systems		
8. Trails with fragile environments restrict use		
9. Trials with special safety concerns restrict use		
10. Grade limitations that dictate trail use.		
11. Bike use		
12. Equestrian use		
13. Used by all - equestrian, hiking, biking		

Surveyed by:_____

Date: _____

Figure 2

Class A Trail Design

Class A trails include disabled accessible trails, as well as some bike trails. The following specifications are required to be met and maintained for a trail to be classified Class A.

Drainage

In areas of trail trenching, trampling, or saturated trail beds, Class A trails must have gravel, water bars, turnpikes, or other structures for resource protection and visitor safety.

Trail Bed

The trail bed width for a Class A trail should be 36 inches to 60 inches, with a preferred width of 60 inches. Trail tread width and composition will vary depending on the surrounding terrain, vegetation, and assigned visitor use. Class A trails assigned "all access" (i.e. disabled accessible) must have a tread surface capable of accommodating wheelchairs, and be a minimum of 60 inches (5 feet) wide to allow two wheelchairs to pass one another.

Clearing Limits for Downed Logs and Tree Limbs

Trail clearing limits for downed logs and tree limbs must be 10.5 feet high.

Brushing Limits for Shrubs and other Smaller Plants

Trail brushing limits for woody brush and smaller plant species must be 10.5 feet high. Preferably, shoulders should be cleared back 12 inches.

Bridges, Puncheons, Steps, and other Trail Structures

Trail structures such as bridges, puncheons, and steps must have a minimum tread width of 48 inches, including a minimum 40 inch tread width between handrails and posts. A wider tread width may be desirable. Bridges for equestrians and/or mountain bikers must have a minimum tread width of 52 inches between safety rails.

Safety Railings

Safety railings must be present when the vertical drop from the tread exceeds 4 feet. The height must be 42 inches from the tread surface and a midrail diagonal must be installed.

Class B Trails Design

Class B trails include equestrian, hiking and some mountain biking trails that provide access into regions away from developed visitor use facilities. The following specifications are required to be met and maintained for a trail to be classified Class B.

Drainage

Structures, such as turnpikes or puncheons, are installed only in wetlands or areas of special concern (endangered plants/animals or culture resources).

Trail Bed
The trail bed width of a Class B trail should be 24 inches to 48 inches with a preferred width of 48 inches. Along a precipice or hazardous area it should be wider to provide greater user safety. Trail tread width will vary depending on the surrounding terrain, vegetation, and assigned visitor use. The trail tread must be composed of natural materials.

Clearing Limits for Downed Logs and Tree Limbs
Trail clearing limits for down logs and tree limbs is 12 feet.

Brushing Limits for Shrubs and other Smaller Plants
Trail brushing limits for woody brush and smaller plant species is 12 feet high. Preferably, shoulders should be cleared back 12 inches.

Bridge, Puncheon, Steps and other Trail Structures
Same as Class A.

Safety Railings
Same as Class A.

Class C Trails Design

Class C trails include lightly used hiking trails. The following specifications are required to be met and maintained for a trail to be classified Class C.

Drainage
Structures, such as turnpikes or puncheons, are best avoided, and installed only as a resource mitigating measure (i.e. controlling heavy erosion).

Trail Bed
For Class C trails, the trail bed width between 18 inches and 36 inches, with a preferred width of 36 inches. Along a precipice or hazardous area it should be wider to provide greater user safety. Trail tread width will vary depending on the surrounding terrain, vegetation, and assigned visitor use. The trail tread must be composed of natural materials.

Clearing Limits for Downed Logs and Tree Limbs
Trail clearing limits for down logs and major limbs must be 10.5 feet high. Preferably, shoulders should be cleared back 12 inches.

Brushing Limits for Shrubs and other Smaller Plants
Trail brushing limits for woody brush and smaller plants must be a minimum of 10.5 feet high.

Bridge, Puncheon, Steps, and other Trail Structures

Trail structures should be avoided by initial layout or relocation. If absolutely necessary, they will be the same as Class A.

Safety Railings
Safety railings should be avoided by initial layout or relocation. If absolutely necessary, they will be the same as Class A.

Monitoring and Evaluating the Trail System

The trail system in Bidwell Park is not static. The system will change and evolve over time. In order to recognize changes, and then make provisions for them, the trail system needs to be periodically monitored and evaluated.

Inspecting Individual Trails in the Field

The trail system should be surveyed annually to determine work priorities for the year. Each trail within Bidwell Park, legitimate or not, should be walked its entire length. Any needs observed for that trail, be it tread maintenance, clearing and brushing, closure and rehabilitation, etc., should be recorded. Once all trails have been inspected, work priorities for the upcoming year should be developed. These priorities should be based on the current budget and available resources, trail classification, visitor use, and any other appropriate factors. See the section Determining Work Priorities for the Upcoming Year, under **Determining and Accessing Needed Resources,** for criteria to prioritize trail work.

Reclassifying Trails

The process of classifying a trail system should be performed at least once every three years. Facility developments, resource concerns, and visitor use are subject to change. Periodic reevaluation of classifications will ensure that assigned standards and work priorities reflect the current system's needs.

Reevaluating the Trail Management Program

The trails manual/program for Bidwell Park should be reevaluated every five years. Changes in budget and available resources, visitor use, and management philosophy may warrant the revision of the manual to reflect any differences. Trails are to be reclassified into one of the three classifications.

Incorporating New Data on the Trail System

Information is only as accurate and useful, as it is up to date and easy to access. As changes occur in the trail system, those changes need to be accurately recorded, and stored in a useful format that is easy to locate and access by all appropriate staff. Information from the field needs to be quickly entered into the current information storage system. Timely incorporation of new data will reduce errors and allow decisions to be based on the best available information.

In the near future, all information will be stored in a central location on a computer, and be connected to

the Bidwell Park GIS system. In addition, the next few years should see the adding of a staff person who is assigned, specifically, to the management of trails in Bidwell Park. Part of the responsibility of this staff person will be to organize and maintain the information system for the trails program.

Determining and Accessing Needed Resources

Determining Work Priorities for the Upcoming Year

All the individual trails in Bidwell Park, legitimate or not, should be inspected annually to observe and record any needs, such as repair to drainage structures, clearing and brushing, closure, and so on. Once all trails have been inspected, work priorities for the upcoming year need to be developed. These priorities should be based on the current budget and available resources, trail classification, visitor use, and any other appropriate factors.

All things being equal, trail work should be prioritized in the following way (listed from highest to lowest priority):

* Repairing damaged and unsafe trail structures, such as bridges, steps, etc.
* Mitigating soil erosion through the maintenance and building of drainage structures
* Closing and rehabilitating bootleg trails
* Clearing and brushing existing trails
* Repairing or upgrading tread on existing trails
* Relocating sections of existing trail around problem areas
* Building significant new structures (i.e. bridges, puncheons, etc.) on existing trails
* Building new trails

Accessing and Coordinating Resources for Trail Work

A healthy trail system in Bidwell Park requires a certain amount of maintenance and development. But no amount of trail upkeep and enhancement can occur without access to labor and materials. Coordination of park staff, recruitment of volunteers, and efficient use of materials is needed to create and maintain safe, enjoyable, and ecologically sound trails.

Acquiring Permission and Resources for Trail Work

Different trail projects require the involvement of different Park Department staff. Routine, day to day trail maintenance and smaller trail projects can be done by, or with the permission of, an appropriate Field Supervisor. Larger trail projects, which require high levels of labor and materials, need the permission of the Park Director in order to be done. If a park employee is unsure of who needs to be informed of proposed trail work, he/she should always take the time to seek out the appropriate

people, rather than start an unapproved trail project.

As noted in the Introduction, some activities may require environmental review, regulatory permits, or discretionary approvals outside the Park Department. New trails and capital improvement projects will require some level of environmental review, ranging from a categorical exemption, a simple process for projects which do not have the potential for adversely affecting the environment, to a more thorough initial study of environmental effect and public review process. Capital improvement projects within the Park may also require the approval of the Bidwell Parks and Playground Commission. Finally, certain activities within sensitive, regulated, habitats may require permits from the Army Corps of Engineers (wetlands), the U.S. Fish and Wildlife Service (habitat for federally-listed endangered and threatened species), California Department of Fish and Game (Streams and Lakes; habitat for state-listed threatened and endangered species), or the Regional Water Quality Control Board (wetlands). Any activity for which the need for approvals, permits, or review is not clear should be referred to the Park Director, who will provide clarification or refer the question to appropriate City staff or regulatory agency.

Additionally, the maintenance of drainage structures which are within Big Chico Creek, or within the portion of a tributary immediately upstream of Big Chico Creek, shall be approved by the Park Director or his/her designee prior to the commencement of the maintenance activity. Big Chico Creek provides breeding habitat for salmon, which can be adversely affected by sedimentation during critical portions of their life cycle. The Park Director or his/her designee shall select maintenance procedures which minimize sedimentation within Big Chico Creek and shall time maintenance activities in a manner which minimizes disturbance to the fishery.

Recruiting and Coordinating Volunteers

Trail crew leaders and field supervisors need to work closely with those staff that are in charge of recruiting and coordinating volunteers. Most trail maintenance and development can not be completed without the help of volunteers. Coordination between park staff, volunteers, and materials is critical to efficient and effective completion of trail projects.

Remember: When working with volunteers on trail projects, the highest priority of park staff must be the safety of those volunteers and any park users which might come in contact with trail work activities. If people take the time to volunteer, park staff must take the time to make their experience as safe as possible. It is the responsibility of park staff to clearly present to each volunteer any potential safety risk, from poison oak to ticks to sharp tools, and provide them with the information and skills necessary to participate in trail projects safely.

Working Safely on Trail Projects

A healthy trail system can not be achieved without a healthy work force. Every employee and volunteer working on trails in Bidwell Park must feel obligated to him/herself, park visitors, and to his/her fellow workers to use every safety precaution available to prevent accidents and promote safe work habits. It is expected that every person working in a trail crew will promptly caution their fellow workers of unsafe practices, including careless use of tools, lack of attention, and overconfidence or inexperience, which might result in an accident. Safety precautions should be taken in all situations, but when working in more remote locations, even greater care needs to be taken. Considering the time and difficulty of transporting injured victims from remote areas, it is imperative to have safety come first.

City employees working in remote or inaccessible areas need to be equipped with portable hand held radios. Radio communication capabilities should be investigated and identified during the field review of trail projects. For trail crews with no city employee present, cellular phones may be available. In the event that radios and/or cellular phones cannot be used due to availability or the work site's topography, a minimum of two people should be assigned to act as couriers. These individuals must be familiar with the area so they can go for help in case of an accident.

Once notified, park staff should assist with the treatment and/or transportation of injured crew members. The treatment and transport of outside agency crew members should comply with the emergency response policies of that agency. Only in situations where the park staff determine that such action would be detrimental to the health or life of the crew member should these policies be countermanded. Outside agency emergency response policies should be posted and disseminated to the appropriate park staff prior to the start of any trail project.

Remember: You can AVOID accidents by THINKING while you work.

Environmental Considerations

A variety of environmental conditions can occur when working in the outdoors. Trail crew workers should always be prepared for all types of weather, various types of noxious plants and animals**,** and more.

Windy Conditions

Working in forested areas of Bidwell Park requires special precautions during windy conditions. All

workers should be especially aware of winds that could shake limbs loose or blow trees down. No crew should enter forested areas during high wind conditions. If caught in the forest during a wind storm, every crew member should look up and listen for breaking sounds during wind gusts, and plan possible escape routes. The crew supervisor should evacuate the crew from a forested area when windy conditions develop.

A few basic guidelines to follow during windy conditions:
* The first storms of the winter may produce more windfall under mild wind conditions due to the accumulation of dead material during the relatively calmer summer and fall months.

* Gusting winds moving in different directions will have greater tendency to cause windfall and break out in the tops of trees.
* If working in one location for a significant length of time, identify hazardous limbs and trees, and their possible impact zones in the work area.
* If taking a rest or lunch break during windy conditions, everyone must continue to wear hard hats and stay aware of dangers.

Lightning

Lightning can be potentially hazardous to crews working on trails in certain areas. Crew members should be aware of these areas and avoid them, if possible.

A few basic guidelines to follow if lightning occurs:
* If caught on open ridges, seek a mid slope location with projections above you, or masses which are higher than where you are. Position yourself mid-range, and avoid projections and saddles.
* In dense forests, avoid groups of tall trees and seek clumps of shorter trees.
* If lightning strikes close enough to induce ground currents, then avoid gullies, depressions, overhangs, and caves, while keeping hands close to the body and off the ground.

Rain

All crew members must ensure that they have properly fitting and functional rain wear during rainy conditions. Keep in mind that wearing rain gear may reduce visibility and impair hearing.

A few basic guidelines to follow during rainy conditions:
* Always be aware of slippery footing, especially when crossing wood or rocks.
* Remember that when tools become wet, they are more difficult to control.

Even though it may not be cold, the crew leader must be able to identify signs of hypothermia, and be skilled in its treatment. Most cases of hypothermia occur when air temperatures are 30 to 55 degrees F, and can occur at temperatures above 55 degrees F. during windy conditions.

Noxious Plants and Animals

Noxious plants and animals, such as poison oak, ticks, and other insects, can exist in many work

locations. It is important that all crew members are advised as to their existence, and instructed on how to identify them. Infections caused by noxious plants and animals can be very uncomfortable and can even result in long periods of lost time.

A few basic guidelines to follow when around noxious plants and animals:
* The crew leader should be made aware of any crew workers who have a special sensitivity to noxious plants and animals, or have had previous adverse reactions.
* Avoid burning poison oak, as the smoke can cause respiratory and skin problems for many people.
* Always protect exposed skin areas by wearing gloves, a long-sleeve shirt with cuffs buttoned, long pants with cuffs closed around boots, and a face shield, if necessary.

* Avoid touching your face after handling noxious plants and animals, and always be sure to use cold, soapy water to wash skin when working in high risk locations. A soap designed specifically for this type of contact is recommended. When in areas suspected of ticks, the body should be checked for ticks frequently.

Visitor Safety

When working on trail projects, the safety of park users is as important as the safety of the trail crew. Whether the trail is open or closed, members of the trail crew must take precautions to ensure visitor safety.

Trail Closed During Field Work

Obvious advantages occur when park staff have the opportunity to completely close trails that need work. However, when this occurs, several tasks must be accomplished, including:
* Notification to Park Office - The Park Department must be notified of trail closures, so all appropriate park staff can be informed.
* Public Notification of Trail Closure - Every attempt should be made to provide users with advance notification of a closure. Public service announcements via radio and T.V. stations, newspapers, and park generated publications are all appropriate avenues for disseminating information. In addition, other appropriate agencies and related offices should be contacted, when appropriate.
* Signing of Trail Closures - All entry points onto a closed trail should be signed appropriately with standard Park Department signs. Providing an estimate of the reopening date should be included on a sign, when possible. All signs should be promptly removed when work is completed.

Example Sign: TRAIL CLOSED FOR MAINTENANCE
PLEASE DO NOT ENTER
Trail Likely To Reopen On _____

* Closure Enforcement - If staff patrolling or working on a closed trail observe someone using the trail, it is their responsibility to inform the users and request they immediately exit the trail.

Trail Open During Field Work

Many times trails are left open to the visiting public while crews work on trail projects. This has both advantages and disadvantages.
Benefits include:
* The public being able to continue to use the trail
* Allows the public to see how Park crews upgrade and maintain trails
* Requires less pre-posting and notification than closed trails.
Drawbacks include:
* Conflicts can arise between the productivity of the trail crew and public relations with the users
* Time lost keeping the trail safe for users

As with trails that are closed, those that remain open during trail projects require that several tasks be accomplished, including:
* Notification to Park Office - The Park Department must be notified of any trail work, so accurate information can be given to appropriate park staff and public inquirers.
* Public Notification - As with complete trail closures, every effort should be made to provide the park user with advanced notification of trail conditions.
* Signing of Trail Condition - All entry points onto the trail should be signed appropriately. Signs should be promptly removed when work is completed.

Example Sign: TRAIL CONSTRUCTION
Park Crew Currently Working On Trail
PLEASE USE CAUTION

Trail crew members must constantly be alert to the development of hazardous situations on the trail. Tools inadvertently left along the trail may cause a hazardous situation. Visitors entering the work site must be announced to crew members or escorted through the work site. If visitors are allowed to proceed on their own, they must be advised of safety precautions. Working conditions such as tree felling, cable rigging, etc., necessitate a higher level of security, including spotters at all approaches, temporary closure of the trail at safe distances, and other appropriate actions.

Equestrian use may require additional precautions for safe transit. Trail crew members should be alerted to turn off noisy equipment and avoid sudden movements as equestrians pass the work location. In addition, members of a trail crew should stand on the uphill side of the trail, as visible to a horse as possible, while it passes.

Using Materials for Trail Work

During trail construction or maintenance, various types of materials are often needed. Whether materials exist on site, or are brought to the location, certain procedures must be followed.

Using Native or On-site Material

Native or on-site materials are those construction material resources that occur naturally within the environment or land form that the trail passes through. Using native or on-site resources can reduce project material and labor cost, particularly in remote locations where material transport distances can be excessive. Native materials may also enhance the architectural appearance of structures, and minimize their visual impact in the surrounding environment. In choosing materials, their length of service shall be considered to reduce the long term cost and frequency of maintenance.

Resources such as trees, rock, gravel, soil, and vegetation can be used to construct trail features/structures when it has been determined that their use will not adversely affect natural or cultural resources. In some cases, the use of native or on-site materials in Bidwell Park may require permits, or other forms of notification, from a variety of county, state, and federal agencies. Be sure to check with all appropriate agencies before using any materials in question.

Recycled Materials

Recycled and used products shall be considered for use over new, virgin materials provided it meets the aesthetic and durability objectives for which it being used.

Soil

Soil is often needed for a variety of trail work, including tread maintenance and repair, turnpike and causeway construction, and more. Soil may be obtained for use in the following priority order (listed highest to lowest):

* Unwanted sloughs and berms
* Excavated soil from cleaning or constructing trail features
* Soil removed from restoring backslopes or berms

Every effort should be made to restore and blend the source area with its surroundings, and mask it from view.

Vegetation for Transplant

Rehabilitation of a disturbed area often requires the transplanting of native species. Transplanted vegetation should be selected and harvested from nearby areas abundant with desired species. When selecting and transplanting vegetation, care should be taken to notice soil types, drainage, and the amount of direct light and shade, so plants can be placed in similar conditions, if possible.

Attempts should be made to leave harvested areas in as natural an appearance as possible. To avoid excessive damage, do not repeatedly use the same access point when gathering transplants. Vegetation for transplants should be placed as they would grow naturally, and harmonize with the surrounding habitat. Types of vegetation for transplanting, and correct planting techniques, should be obtained from the Urban Forester.

Rock and Gravel

Rock and gravel are important materials for a variety of trail work, especially involving drainage features. Generally, sources of rock and gravel, in amounts up to one cubic yard from the same general location, may be used in the following priority order (listed highest to lowest):

* Rock removed from clearing and cleaning tread, maintaining ditches, and from restoring designated backslopes
* Rock from talus slopes
* Rock from streams or rivers (possibly dictated by a stream alteration permit)

The use of more than one cubic yard of rock must have the approval of the Park Director or his/her designee.

Logs

Logs are used for a variety of trail structures. All standing trees and down logs selected for stringers, retaining structures, and split products must have approval by a field supervisor or their designate. As with any work in Bidwell Park, all signs of disturbance must be restored to a natural state. Sources of wood should be considered in the following priority order (listed highest to lowest):

* Trees cut when clearing a travelway
* Down trees, preferably off the trail and out of sight of park users (in some cases, they may be within sight of the trail, but removing them should leave minimal scars)
* Standing trees off the trail that are cut flush to the ground
* Non-native species

Down logs along a riverbank should not to be used without approval of the Park Director or his/her designate.

Using Non-native or Off-site Material

Trail construction materials imported to the worksite that are not identical to native, on-site building materials are considered non-native materials. The use of these materials is appropriate when native, on-site materials are unavailable or their removal would be ecologically detrimental, or when non-native materials are more cost effective and provide a safer, more durable, product. Prior to using non-native materials, their potential impacts on the natural environment should be considered carefully. Non-native materials should always be environmentally and aesthetically compatible with surrounding resources.

Rock, Gravel, Soil

Rock should be quarry or river run clean, and free of debris. Its minimum size should be 4 inches in diameter. Gravel should be crusher base, and mixed with sand or crushed shale for compaction. Soil should be free of large amounts of clay and contain no debris of any kind.

Milled Lumber

Milled lumber is often required for a number of trail structures, including bridges, puncheons, and more. Lumber used for trail projects should be pressure treated Douglas-fir or other appropriate material.

Hardware

All fasteners used for trail projects need to be hot dipped galvanized or zinc plated (except re-bar). Washers should be hot dipped galvanized or malleable iron. Rods should be cold rolled steel. Plate or sheet steel needs to be hot dipped galvanized. And any repair work to hardware should be coated with a cold galvanizing process.

Steel Cable

Wire rope, and other steel cable, needs to be pre-stretched, galvanized, and engineered for proper tensile strength. It should be of good quality, and of suitable size for the job. All metal components need to be rust resistant.

Paints, Sealants, Preservatives

Paints, sealants, and preservatives may be applied to wooden and metal components of trail structures, when appropriate, but should be avoided if at all possible. When treatment of trail structures is needed, experts in the use and application of such products should be consulted, unless adequate in-house expertise is available.

The use of wood preservatives is not recommended for use on trail structures unless warranted by insect of fungi infestations. In most cases, by using pressure treated Douglas-fir or other appropriate material, preventing earth-wood contact, and providing a proper air gap, preservatives can be avoided. If sealants and preservatives are needed, they should contain no Penta, Creosote, or other restricted substances.

Metal primers and paints should be avoided on trail structures, if possible. The use of pre-galvanized

metal or Cor-Ten steel will negate the need for primers and paint, and reduce the long term maintenance cost. If metal primers and paints are required, they should contain no lead or other restricted substances.

Geotextiles

Since their introduction in the construction of roads, geotextile fabrics have demonstrated their usefulness in trail construction and maintenance. Geotextiles are currently manufactured using a wide variety of fabrics, materials, and styles or designs. The geotextile industry is growing rapidly, and each year numerous new products are developed that improve or expand the application of this product. Presently the three principal uses of geotextiles for trail work are in the construction of turnpikes and causeways, drainage lenses, and retaining walls.

Turnpikes and Causeways

The most common use of geotextile fabric in trail maintenance is in the construction of turnpikes and causeways. Prior to building up the trail bed with soil or gravel, a course of non-woven, semi-impervious fabric is laid down. This material helps provide a stable base for the application of soil or gravel, and reduces the contamination of fill material by saturated base soils. This technique eliminates mucking through knee-deep mud and burying two thirds of your base material before the soil firms up. See figure 3. For further detail on turnpike or causeway construction, see the section Building Structures that Cross Streams or Wet Areas under **Creating New Trails or Relocating Existing Trails**.

Drainage Lenses

Another application of geotextile fabric is in the construction of rock drainage lenses. This technique eliminates the need for constructing puncheons or bridges when a trail is bisected by an ephemeral creek or spring. Geotextile fabric is incorporated into a drainage lens by first laying down a course of non-woven, semi-impervious fabric, and placing broken quarry rock on top of it. Next, a course of woven, permeable fabric is placed on top of the quarry rock and capped off with gravel or suitable native fill. This creates a relatively soil-free rock drainage lens that can easily accommodate low volume water flows. See figure 3. For further detail on drainage lens construction, see the section Building Drainage Structures under **Creating New Trails or Relocating Existing Trails**.

Retaining Walls

The third use of geotextiles is in the construction of small retaining walls. By using woven, permeable fabric, a slip out can be repaired quickly with minimal material cost. After a slip out has been dug down to firm soil, a layer of fabric (long enough to fold back over one half of its length) is placed across the bottom. Next, the area is filled with gravel or a porous native soil, and compacted. The extra fabric is then laid on top of the compacted gravel or soil. The next layer of fabric is then laid on top of the compacted gravel or soil, as well as the folded back bottom layer. This layer is stepped back to a minimum 1:1 ratio. This provides better weight transfer and greater stability to the wall. It also is filled, compacted, and folded back to one half of its length. This process is continued until the last layer of fabric is folded back its entire length and capped with native soil. The outer edge, or face of the wall, is also covered with native soil and compacted to prevent the fabric from being damaged from sunlight, or

torn by foot traffic. It also produces a more natural look to the retaining wall. See figure 4. For further detail on retaining wall construction, see the section Building Dry Land Structures under **Creating New Trails or Relocating Existing Trails**.

Maintaining Existing Trails

Creating the existing network of trails in Bidwell Park has cost a great deal of time, labor, materials, and money. As such, it is crucial to maintain existing trails in a healthy condition. Trail maintenance can include temporary closure, removing overhanging branches from trees and shrubs, resurfacing the tread, building and cleaning drainage structures, and more.

Opening and Closing Trails

Trails in Bidwell Park are often closed temporarily to protect against resource degradation. When wet, trails with natural tread surfaces (i.e. mineral soil) are often subject to severe damage from trail users, such as equestrians and mountain bikers. Horses and mountain bikes can leave depressions and ruts that can compact soil, and pool or channel water. For that reason, trails are usually closed until they dry out.

The temporary opening and closing of trails for resource protection is determined by Park Rangers. When Rangers investigate trails in the field and feel that trails are vulnerable to excessive degradation, they will close the trail system to use. Once Rangers decide that the potential for trail degradation is minimal, trails are reopened.

Clearing Existing Trails

In areas of Bidwell Park dominated by trees, the clearing of unwanted tree branches, roots, and woody debris is vital to a healthy trail. Unless maintenance crews are quick to remove obstructions from a trail, users will create detours above or below it. The end result is unwanted way trails that create resource damage and additional maintenance work.

Clearing maintenance includes removing windfall trees, uproots, leaning trees, loose limbs, and wood chunks from the travelway. See figure 5. The clearing dimension is determined by class.

Class A - Clearing limits must be 10.5 feet high. Preferably, shoulders will be cleared 12 inches back from the trail.
Class B - 12 feet for equestrian and/or mountain bike trails. Preferably, shoulders will be cleared 12

inches back from the trail.
Class C - Clearing limits must be 10.5 feet high. Preferably, shoulders will be cleared 12 inches back from the trail.

Downed logs which cross a trail should be cut back to the edge of the appropriate clearing limit (see figure 6). Down trees over 3 feet in diameter should be given special consideration. In some cases, it may be more appropriate to reroute a trail around a downed tree than remove the tree itself. When a large downed tree is encountered, the crew leader should be consulted. Tree limbs which fall within the appropriate clearing limit should be cut flush with the tree trunk, regardless of a tree's location. See figure 7. **NOTE: No projecting stubs should be left.** Downed logs and tree limbs that do not fall within the appropriate clearing limit, and are not obstructions, should be left in their natural state. In addition to the travelway itself, care should be taken to make sure that no logs, branches, sticks, or other debris block any drainage structure,
natural or constructed, that pass through, or near, a trail.
Logs, limbs, branches, and wood chunks on a trail, including those on the sidehill above the trail that could fall into the trail, should be moved clear beyond the margins of the travelway. Cut log rounds should be rolled off the downhill side of a trail until they can not be seen. Limbs and roots that are cut should be removed to the high side of a trail, out of sight. Cut ends and root wads left on a sidehill should be blocked or anchored so they will not fall into the trail in the future. All loose rock or soil in a disturbed area should be removed, and the trail tread restored to as close to the original as possible.

Brushing Existing Trails

As with downed logs and tree limbs, when brush grows or is forced into a trailway, damage often occurs due to trail users creating alternate paths to avoid the obstruction. Because of this, keeping trails free of overhanging shrubs and smaller plants is vitally important to maintaining a healthy trail. Routine brushing will increase user safety and enjoyment, and reduce long term maintenance costs.

Brushing maintenance consists of removing or mowing all shrubs and smaller vegetation from a travelway, as needed for resource protection and user safety. The brushing dimension is determined by class.

Class A - Brushing limits must be 10.5 feet high. Shoulders should extend 12 inches on each side.
Class B - Brushing limits must be 12 feet for equestrian and/or mountain bike trails. Shoulders should extend 12 inches on each side.
Class C - Brushing limits must be 10.5 feet high.

Brush removal is fairly simple. The key is to find the source of the obstruction. Often, many of the branches in a trail grow from a single stem. These can be easily located and cut off flush at the base of the shrub. By cutting the branch at the source, years of brushing individual branches can be avoided. Native, flowering, woody plants should be pruned instead of brushed whenever possible. Species that lack woody branches can be cut back to appropriate widths and maintained at that level every year.

Larger debris should be scattered above and beyond a travelway, out of sight. Cut ends or other loose material on an uphill bank that could possibly fall into the trail should be blocked or anchored so it will not fall onto the trail in the future. Smaller material (leaves, twigs, etc.) can be left on the trail tread. No debris should be disposed of in any drainage, natural or constructed.

A special application of brushing maintenance occurs at overlooks and vista points. Brushing of vista points and overlooks should be done as thoroughly as possible, down to the ground level. Leaving a brush barrier or low screen to block user access is ineffective. Hikers will continually try to breach a brush screen to get the best view. Instead, brushing should be completed to ground level and a rail installed. A rail provides a definitive barrier, as opposed to a brush screen. Vista points and overlooks are one of the most pleasing and surprising features to trail users and every effort should be made to keep them in excellent maintenance.

Maintaining Tread on Existing Trails

Tread maintenance consists of keeping a tread surface serviceable to park users, while maintaining its environmental soundness. Damage to a tread surface can manifest itself in a variety of ways, each requiring a certain set of procedures to return tread to a healthy and safe condition.

Maintaining Crown or Out Slope

Out slope is the method of grading a trail so that the outside edge of the trail is lower than the inside. This allows water runoff to follow its natural course across a trail and down the slope. Proper out slope will prevent a trail from becoming a channel for transporting the flow of water. Ideally, all trail tread should be out sloped, but due to certain physical restraints, this is not always possible. If an out slope is not possible, a crown should be maintained.

When a trail surface is durable, backslope stable, and traffic and vegetation light, an out slope or crown is easy to maintain. If not, a slough and berm often develops, or a trail becomes entrenched. Slough and berm deposits should be removed and spread over the tread to produce the correct drainage surface, in most cases being an out slope. In addition, backslopes need to be maintained or restored to the angle of repose. See figure 8.

An entrenched trail occurs when the tread surface is below the level of the ground surrounding the trailway. An entrenched trail can lead to the channeling of water and create severe erosion. To correct this problem, any soil berm deposits on the outside edge of a trail need to be removed and spread over the width of the trail. Any low spots in a trail tread capable of holding surface water should be drained (if necessary) and filled with mineral soil and/or rock to produce a crown or out slope. Any fill material that is needed should be obtained according to the guidelines outlined in **Using Materials for Trail Work**.

When an out slope is the correct drainage surface, it should be maintained between 6 and 10 percent, angled down slope. If the appropriate drainage surface is a crown, the crown should be approximately 2 inches in height. See figure 9.

Removing or Mitigating Exposed Tree Roots

Roots that are smaller than 3 inches in diameter, and protrude over 1 inch above a tread surface, should be removed to at least 4 inches beyond the margins of the trail and to a depth of at least 4 inches below tread level. Holes resulting from root removal should be filled and compacted with mineral soil and/or rock to create an appropriate tread surface.

Roots over 3 inches in diameter should not be cut to provide tread base. Any exposed roots that are larger than 3 inches in diameter, and determined to be a safety hazard or resource problem, should be covered with native or non-native materials until no longer a concern.

Restoring Tread After Damage From Uprooted Trees and Slides

If an uprooted tree or slide damages a section of trail, the trail should be reconstructed to the dimensions established for its classification (see the section Classifying Trails, under **Inventorying and Monitoring the Existing Trail System**, for guidelines on tread requirements). Care should be taken in layout of the reconstructed trail to avoid areas of active slide movement. A crew leader and/or trail supervisor should be consulted to discuss alternative trail routes, if necessary. See figures 10 and 11.

Adding or Restoring a Gravel Surface

Gravel surfacing of a trailway produces a durable, long lasting tread surface. If an existing gravel surface has eroded, or resource protection warrants the application of a gravel surface, the following procedures should be applied.

Gravel surfacing should extend over the full width of a tread surface. In poor soil conditions, the gravel should be underlaid with a geotextile fabric to eliminate loss of gravel into the trail bed. The trail bed should be covered with a layer of gravel at least 3 inches thick. The finished surface should be firm and uniform, and match the intended drainage design to facilitate water runoff. See figure 12.

Material used in gravel surfacing should be crushed shale or pit-run up to 1 ½ inches in diameter, and free of organic material. If on-site borrow areas or stockpiles are to be used, they need to be marked and designated. When work is completed, stockpile areas should be restored to a natural contour and appearance to the greatest degree possible.

Maintaining Tread on Turnpikes and Causeways

The tread surface of a turnpike or causeway should maintain a crown of approximately 2 inches higher than the rail logs. If fill material is needed to restore the crown of a turnpike, it can often be obtained during maintenance of parallel ditches existing along side the tread surface. Make sure approaches to turnpikes are smooth and consistent with the rest of the trail. See figure 13.

Maintaining Approaches to Puncheons and Bridges

Approaches to trail bridges and puncheon sections need to be maintained so that the tread surface remains level with the walking surface of the structure. If necessary, approaches at each end of trail bridges and puncheon sections should be restored with mineral soil and/or gravel (gravel being less than 2 inches in diameter). See figure 13.

Repairing and Maintaining Tread on Switchbacks

Over time and use, switchbacks lose their shape. Periodically, a switchback needs maintenance to reduce the need of costly reconstruction. Switchback maintenance involves reshaping of tread to the intended drainage, cleaning of the inboard ditch on the upper leg, maintenance of the landing between upper and lower legs, and rehabilitation of any short cuts developing between legs.

Reshaping the trail tread to the intended drainage normally involves removing the slough and berm on the lower leg in order to re-establish a 10 percent outside drainage. The upper leg may have been entrenched, thus blocking drainage into the inboard ditch. In such cases, regrade the tread surface to a 10 percent slope. See figure 14. If necessary, refer to Building Dry Land Structures, under **Creating New Trails or Relocating Existing Trails**, to understand basic switchback design.

Narrowing Tread

Where trails exceed the standard width for their classification, they need to be narrowed to appropriate limits. There are two ways to narrow a trail depending on whether the trail is cut on a sideslope, or is constructed of fill material on more level ground.

For trails cut on a sideslope, part of the sidecast should be pulled back into the trail. If plants are present, they should be removed with their root ball intact, and then replanted in locations that help define the newly established trail width.

For non-cut and fill trails, the appropriate width should be reestablished by placing natural debris, such as downed logs, limbs, brush, and rock, along the trail's edge. Rock and logs should be partly buried with the weathered side facing up. Compacted ground should be loosened to aid natural seeding or the transplanting of native vegetation.

Building and Maintaining Drainage Structures for Existing Trails

There is no single factor with as much ability to damage a trail as the unchecked flow of water. Problems occur when a trail interrupts any of the natural drainage processes in the area it passes through. When this happens, drainage systems should be built to control or direct the flow of water either across, under, through, or around the trail.

A trail can intercept water flow in a number of different ways. On a sidehill, a trail can cut through a bank and expose subsurface flow that results in seepage. In a low lying area, a trail may encounter the water table near ground level. In many instances, trails can become entrenched and channel water themselves, leading to gullying. Unchecked, drainage problems surrounding trails can lead to soil compaction, erosion, trail widening, and other forms of resource degradation.

A number of drainage structures, including drain dips, water bars, culverts, and more, can be built to help mitigate drainage problems. However, before these techniques are used, drainage features of the area under consideration should be investigated. In addition, relocating or rerouting the trail should be considered, especially if the wet area is extensive.

New drainage structures and new or relocated trails may require environmental review or approvals, depending on the scope and scale of improvements, and should be referred to the Park Director or his/her designee for a determination. Additionally, the maintenance of drainage structures which are within Big Chico Creek, or within the portion of a tributary immediately upstream of Big Chico Creek, shall be approved by the Park Director or his/her designee prior to the commencement of the maintenance activity. Big Chico Creek provides breeding habitat for salmon, which can be adversely affected by sedimentation during critical portions of their life cycle. The Park Director or his/her designee shall select maintenance procedures which minimize sedimentation within Big Chico Creek and shall time maintenance activities in a manner which minimizes disturbance to the fishery.

In determining which drainage feature to use, the first question to ask is, "What is the source of the water?" The second question to ask is, "What is the intended use of the trail?" Once the source of water is determined, the user groups identified, and the site conditions considered (i.e. terrain features, soil characteristics, etc.), an appropriate drainage structure can be chosen.

Proper alignment and grade will vary for each individual trail, but some guidelines from which to work include:

Trails in General

* The alignment should follow the contours of the land.
* Sharp, angular turns over 50 degrees and long, straight stretches should be avoided.
* Grade should undulate gently to provide natural drainage and to eliminate monotonous, level stretches and long, steep grades that are tiring to the traveler.
* As a general rule, the grade should not exceed 10 percent (i.e. a 10 foot rise over 100 linear feet of trail). Grades of 1 to 7 percent are ideal.
* No grade should be so steep that erosion is a problem.
* Trails should not be located at zero grade. As a general rule, some grade must be provided to account for drainage needs.

Trails Intended for Mountain Bikers and/or Equestrians

* The trail should be aligned to provide adequate sighting distance for oncoming traffic.
* Switchbacks should be avoided, and climbing turns used whenever possible.
* As with most trails, an average maximum grade should be 10 percent, but short stretches (300 feet or less) of 10 to 15 percent are acceptable if the tread surface can be maintained without excessive erosion.
* The trail should be designed to avoid structures (e.g. water bars, steps, etc.) which would imped the travel, and reduce the safety, of mountain bikers and equestrians.

The drainage structure chosen should maximize trail health and visitor use, while minimizing disturbance to the natural environment. The following drainage structures run from the lowest environmental disturbance to the highest:

* Natural Channels
* Out Slope or Crown
* Drain Dip
* Water Bar
* Parallel Ditch
* Drainage Lens
* Culvert

Clearing and Maintaining Drainage Channels

Small stream channels that cross a trail can become blocked by logs, sticks, silt, or other debris. This can lead to the overflow or widening of the stream, or often cause water to flow down the trail. Clearing the drainage channel up and downstream of the crossing will help to consolidate and confine the flow to a smaller and more easily managed size. Some channels may be narrow and shallow enough to hop or wade, while wider channels may have a puncheon or bridge. If a trail structure crosses a channel, it's necessary to clean the channel leading up to, under, and away from that structure to assure a sustained and unobstructed flow.

Maintaining Out slope

One of the best ways to maintain good drainage off a trail is the maintenance of an out slope. See the section Maintaining Tread on Existing Trails for parameters of a proper out slope.

Cleaning and Maintaining Drain Dips

To function properly, drainage dips need to be maintained. Sediments and debris that build up in the trough must be removed and trail surfaces re-worked to restore their shape and out slope. Soil removed from the trough can be used to fill ruts and holes in the tread or to restore the fillslope. The outflow ditch below the drain point must be cleared of soil and debris. In addition, make sure energy dissipaters within the outflow ditch are intact. The trough should be maintained at a 30 degree angle, and the down slope at 15 percent, to insure adequate drainage and sediment transport. The out slope should be maintained at about 10 percent.

If a drain dip needs to be constructed to improve drainage on an existing trail, or for more information to aid in maintenance, see the section Building Drainage Structures under **Creating New Trails and Relocating Existing Trails**.

Cleaning and Maintaining Water Bars

A water bar must be maintained to function properly. Water bars can erode and become ineffective. If needed, the crown (i.e. top of the water bar) and angle of a water bar should be reshaped to allow for proper runoff. The outflow ditch below the drain point must be cleared of soil and debris. In addition, make sure energy dissipaters within the outflow ditch are intact. The crown of a water bar should, most often, be 1 foot in height. The angle will vary depending on the slope of a trail, but should be

somewhere around 30 degrees.

If a water bar needs to be constructed to improve drainage on an existing trail, or for more information to aid in maintenance, see the section Building Drainage Structures under **Creating New Trails and Relocating Existing Trails**.

Cleaning and Maintaining Parallel Ditches

Parallel ditches often become blocked by logs, sticks, silt, or other debris, and need to be cleared and maintained to function properly. If any areas of breech occur along a ditch, they need to be repaired. A ditch may need to be reformed if heavy damage has occurred. The width and depth of a ditch will vary depending on the amount of runoff expected. Make sure the outflow of a ditch is well beyond the trail surface.

If a parallel ditch needs to be constructed to improve drainage on an existing trail, or for more information to aid in maintenance, see the section Building Drainage Structures under **Creating New Trails and Relocating Existing Trails**.

Maintaining Drainage Lenses

Problems with a drainage lens most often occur when the rock drain becomes clogged with soil and other fine debris. This blocks the flow of water and can lead to erosion of the tread surface. Make sure the inlet and outlet of a drainage lens is free of dirt and debris. In addition, make sure the appropriate drainage surface (out slope or crown) is maintained.

If a drainage lens needs to be constructed to improve drainage on an existing trail, or for more information to aid in maintenance, see the section Building Drainage Structures under **Creating New Trails or Relocating Existing Trails**.

Cleaning and Maintaining Culverts

Culverts may often become blocked by logs, sticks, silt, or other debris. This can lead to the overflow or widening of the stream, or often cause water to flow across or down the trail. Culverts generally exist in areas with relatively large channel flow, and if not maintained, can cause serious damage to a trail and the surrounding environment. Debris should be cleaned from the mouth of a culvert, and woody debris should be cleared for a distance above stream of a culvert to avoid future blockage. The catch basin (inlet of culvert) and the splash apron (outlet of culvert) should be inspected for damage, and repaired if needed, to ensure proper flow and minimize erosion.

If a culvert needs to be installed to improve drainage on an existing trail, or for more information to aid in maintenance, see the section Building Drainage Structures under **Creating New Trails and Relocating Existing Trails**.

Maintaining Existing Structures that Cross Streams or Wet Areas

The construction of bridges, puncheons, and other structures that cross streams or wet areas is very

costly. Therefore, maintaining that investment, and extending the life of these structures is extremely important. Well maintained structures reduce long term costs and increase user safety.
As stated above, the maintenance of drainage structures which are within Big Chico Creek, or within the portion of a tributary immediately upstream of Big Chico Creek, shall be approved by the Park Director or his/her designee prior to the commencement of the maintenance activity. Big Chico Creek provides breeding habitat for salmon, which can be adversely affected by sedimentation during critical portions of their life cycle. The Park Director or his/her designee shall select maintenance procedures which minimize sedimentation within Big Chico Creek and shall time maintenance activities in a manner which minimizes disturbance to the fishery.

Maintaining Causeways

To maintain a causeway, make sure the rock walls are intact and maintain a height which exceeds the water height of a maximum flow event. In addition, make sure the tread surface is intact (see Maintaining Tread on Turnpikes and Causeways).

If a causeway needs to be constructed to increase resource protection and/or user safety, or for more information to aid in maintenance, see the section Building Structures that Cross Streams or Wet Areas under **Creating New Trails or Relocating Existing Trails**.

Maintaining Turnpikes

To maintain a turnpike, the drainage ditch must be cleaned to assure sustained flow. Ditch banks should be sloped at a 45 degree angle (ratio 1:1) to prevent sloughing. If material from a ditch is mineral soil or fine gravel, it should be used to restore crown to the surface of the turnpike (see Maintaining Tread on Turnpikes and Causeways). In addition, rail logs should be checked to see that they are secure, and free of extensive rot and decay.

If a turnpike needs to be constructed to increase resource protection and/or user safety, or for more information to aid in maintenance, see the section Building Structures that Cross Streams or Wet Areas under **Creating New Trails or Relocating Existing Trails**.

Maintaining Puncheon Structures

Maintenance of a puncheon structure includes both the structure itself and the drainage features around it. If a puncheon is to be safe and long lasting, both of these areas need to be maintained.

Drainage maintenance includes clearing any debris from under the puncheon, such as logs, sticks, gravel, and sand, which might lead to the damming of water. In addition, debris should be removed from the channel(s) for a short distance both up and down stream.

Maintenance of a puncheon also includes the clearing off of all accumulated debris, leaves, sticks, silt, and/or soil from the decking of the structure itself. These materials, if left on a puncheon, will accelerate the decomposition rate of the wood. Planks used to construct the tread should be inspected to ensure that they are secured tightly. Any loose, or otherwise damaged planks, need to be replaced or resecured. All other wood components of a puncheon should be inspected for rot and other structural

problems. See figure 15.

If a puncheon needs to be constructed to increase resource protection and/or user safety, or for more information to aid in maintenance, see the section Building Structures that Cross Streams or Wet Areas under **Creating New Trails or Relocating Existing Trails**.

Maintaining Bridges

Maintenance of a bridge is similar to that of a puncheon and includes both the structure itself and the drainage features around it. Bridges are one of the most expensive trail structures to build, so their maintenance is extremely important.

The channel which flows under a bridge needs to be cleared of any debris which could lead to the damming of water. Removal of debris should occur both under the bridge, as well as for a short distance up and down stream. Care should be taken when removing debris to minimize environmental impact to riparian habitat.

Maintenance of a bridge also includes the clearing off of all accumulated debris, leaves, sticks, silt, or soil from the decking of the structure itself. These materials, if left on a bridge, will accelerate the decomposition rate of the wood. Planks used to construct the tread, and wood used to build the handrails, should be inspected to ensure that they are secured tightly. Any loose, or otherwise damaged pieces, need to be replaced or resecured. All other wood components of a bridge should be inspected for rot and other structural problems.

If a bridge needs to be constructed to increase resource protection and/or user safety, or for more information to aid in maintenance, see the section Building Structures that Cross Streams or Wet Areas under **Creating New Trails or Relocating Existing Trails**.

Maintaining Fords

A ford is a section of stream that provides safe footing with which to cross. During storm events, a ford often collects woody debris, or other material, which creates an unsafe crossing area. Remove any debris and create a smooth stream bottom in order to provide safe passage.

If a ford needs to be constructed to increase resource protection and/or user safety, or for more information to aid in maintenance, see the section Building Structures that Cross Streams or Wet Areas under **Creating New Trails or Relocating Existing Trails**.

Maintaining Existing Dry Land Structures

The construction of steps, retaining walls, and other dry land structures is very costly. Therefore, maintaining that investment, and extending the life of these structures is extremely important. Well maintained structures reduce long term costs and increase user safety.

Maintaining Switchbacks

Over time, various parts of a switchback can show signs of wear and tear, and need light repair and maintenance. Switchbacks that are left in disrepair can lead to severe erosion and ecological damage. Routine upkeep can avoid both major reconstruction costs, and environmental degradation.

Over the normal process of sloughing and sedimentation, the inboard ditch on the upper leg of a switchback may silt in. Any sediment and woody debris should be removed to maintain a clean channel beyond the landing. Energy dissipaters should be checked to make sure they are still in place. And a proper in slope should be maintained to assure proper water runoff (see Repairing and Maintaining Tread on Switchbacks).

A landing, through erosion and slough, may loose its intended size. If so, re-establish the turning radius on the landing to two times the trail tread width of the approaches. The landing should incorporate an in slope (facing up trail), an out slope (facing down trail), and a crowned turning surface between both approach legs.

Log or rock barriers intended to deter switchback cutting may be inadequate and need modification. Necessary repairs should be made and more barriers added, if necessary. Possible barrier design may include a rock or wood retaining structure, or safety railing. Unwanted way trails must be closed and rehabilitated in such a way as to discourage passage by trail users in the future.

If a switchback needs to be constructed to increase resource protection and/or user safety, or for more information to aid in maintenance, see the section Building Dry Land Structures under **Creating New Trails or Relocating Existing Trails**.

Maintaining Steps

Steps are often subject to a lot of wear and erosion. If not maintained, steps can become very dangerous. Check any wood used to make steps for rot. Rocks used in the construction of steps should be checked to make sure they are securely in place. In addition, make sure fill material used in steps is maintained in such a way as to ensure the sheeting of water off step surfaces. Check barriers along the edge of steps to make sure they are intact and provide adequate determent to visitors who might want to go around the steps.

If steps need to be constructed to increase resource protection and/or user safety, or for more information to aid in maintenance, see the section Building Dry Land Structures under **Creating New Trails or Relocating Existing Trails**.

Maintaining Safety Railings

Over time, safety railings can come loose and show signs of other damage. If not maintained, a safety railing can quickly develop into a hazard. Safety railings should be checked to make sure all points of connection are secured tightly.

If safety railings need to be constructed to increase resource protection and/or user safety, or for more information to aid in maintenance, see the section Building Dry Land Structures under **Creating New**

Trails or Relocating Existing Trails.

Maintaining Retaining Walls

Earth movement, including slides, slips, and soil creep can weaken and damage retaining walls, making them unsafe and ineffective. Retaining walls should be checked to make sure they are sound and secure.

If a retaining wall needs to be constructed to increase resource protection and/or user safety, or for more information to aid in maintenance, see the section Building Dry Land Structures under **Creating New Trails or Relocating Existing Trails**.

Rehabilitating Closed or Abandoned Trails

A healthy park requires a healthy trail system, and a healthy trail system depends on park visitors using only safe, fun, and environmentally sound trails. Therefore, those trails that do not meet the highest standards of safety and resource protection need to be closed. When a section of trail is closed or is abandoned, steps need to be immediately taken to restore it to as natural a condition as possible. This timely action helps trail users avoid confusion as to which trail to use, eliminates sources of erosion, and restores the area to a more natural appearance.

Rehabilitating a closed or abandoned trail includes restricting access to the trail by park users, removing any trail structures (e.g. bridges, puncheons, steps, etc.), correcting any drainage problems to mitigate erosion, and revegetating the trail surface. Depending on the site, rock, brush, fallen timber, and transplanted vegetation may be used to help hide and rehabilitate abandoned trails. See figure 16.

Restricting Access to Closed Trails

Trails that are closed and slated for restoration must be blocked from use and, if possible, from being seen. This can be accomplished by laying logs, limbs, brush, and rocks across any and all access points to the closed section of trail. In some extreme cases, temporary fencing may be needed to prevent use. In addition, a sign describing the reason(s) for trail closure should be placed at the site to help inform trail users of Park Department decisions.

Removing Trail Structures

Trail structures are only safe when they are well maintained. Once a trail is closed and routine maintenance stops, trail structures along that trail will fall into disrepair. To avoid potential accidents to trail users which might find their way onto closed or abandoned trials, all trail structures, such as bridges and steps, need to be removed. When dismantling a trail structure, every effort should be made to recycle sound materials so they can be used again for future trail projects.

Correcting Drainage Problems

If a trail is subject to erosion, those drainage problems should not be allowed to continue even though

the trail has been closed. Where erosion has occurred, the resulting ruts and gullies need to be eliminated to prevent further loss of soil. This can be accomplished by filling in these channels with local soils and gravel, and returning the surface to its original shape and contour. Further stabilization can be accomplished by spreading natural materials such as rock and woody debris, or by using erosion cloth, burlap and/or straw to slow the speed of water runoff. Along those sections of trail built on a side slope in which sidecast was used as fill for the outer edge of tread, that sidecast should be pulled back into the cut and the original slope restored.

Revegetating the Tread Surface

Once cuts and gullies have been stabilized, vegetation needs to be reestablished to protect and enhance surrounding resources, and restore the natural view scape for park users. In order for new vegetation to grow on a closed or abandoned trail, the tread surface needs to be scarified in order to break up compacted soils. The type and distribution of new plants should blend in with the existing vegetation in the area. Information on the appropriate species, and correct planting techniques, should be obtained from the Urban Forester.

Creating New Trails or Relocating Existing Trails

When routine maintenance of existing trails is ineffective, or trail user demand dictates the need for additional trails, the relocating or construction of new trail may be needed. Building new trail is costly and resource intensive, and should only be done when necessary. The construction of new trail should be well planned and well built to ensure a safe, enjoyable, low maintenance, and long lasting addition to the trail system of Bidwell Park. New trail construction may require environmental review, discretionary approvals, or permits from state or federal regulatory agencies. Please refer to **Determining and Accessing Needed Resources** for a discussion.

Sound trail planning and design techniques should show respect for ecological and historical integrity, appropriate visitor opportunities, and sustainable practices. Trails should minimize conflict between users and have minimal environmental impact. Trails that employ "Best Practices" possess the following qualities: pleasing aesthetics, solid construction using acceptable materials, informative offerings, and safety. They are provided with a wise and efficient use of resources. These trails are in scale with, complementary to, and appropriate for their natural and cultural surroundings and Park Zones.

ELEMENTS OF A WELL-DESIGNED TRAIL

There are many factors which go into a well designed trail; here we will only look at the elements

required from a maintenance perspective.

Gradient

Generally, the linear gradient of a trail should be less than 10%. The term "gradient" refers to the ratio of the rise over the run. In other words, an elevation gain of 2 feet in 20 horizontal feet represents a 10% gradient.

Ten percent is a good standard, but circumstance may warrant a greater or lesser gradient.
In highly erosive, sandy soils, a 5% slope may be excessive. Granitic soils are more forgiving and can allow long sections of trail to be constructed at 13 to 15%. It is best to look at existing trail conditions and measure gradients to determine what maximum gradient works best in each unique condition. However, it should be noted that trails less than 10% are far more comfortable to hike and ride. The soils may allow for a trail that exceeds 10%, but the users might not!

Relationship to Existing Contours

In map jargon, a contour is a line of points that are at the same elevation. If you walk precisely parallel to a contour, you are walking at a level (0%) grade. If you walk perpendicular to a contour, you are walking either straight uphill or straight downhill. A well-designed trail is laid out to traverse a hillside, closer to parallel than perpendicular to the contours.
The figure below shows two proposed trail routes to the top of the hill. Although Trail A stays within a gradient of 10%, it is the poorer route because it travels perpendicular to the contours. When a trail runs perpendicular to the contours, water runs down the middle of the trail, causing trenching, even at a 10% gradient. The only way to get water off the trail is for the route to **traverse** the natural slope (Trail B), because then there is always a lower side of the trail. When there is a lower side of the trail, it becomes a simple matter to redirect water across and off the trail, rather than allowing it to cut a channel down the trail's centerline.

Outslope

A well-designed trail should be constructed to have a 3% to 4% cross-slope to get the water off the trail as soon as possible. This explains why it is difficult to construct an effective trail in a flat meadow. You can not merely cut out sod and call it a finished trail. It will always be easiest to construct an outsloped trail if the original trail alignment traverses the natural slope as in Trail B, above.

Avoid Switchbacks

A "switchback" is any place where the alignment of a trail traverses a slope in one direction and then abruptly "switches back" toward the opposite direction. Switchbacks are often used to run a trail up a steep slope in a constrained location. Although switchbacks are often the only solution to the problems of rock outcrops and steep slopes, they should be avoided where possible. Unless they are perfectly designed and constructed, switchbacks present an irresistible temptation to shortcut the trail and cause erosion over a web of indiscriminately created volunteer routes.

Determining if Relocation of an Existing Trail is Needed

If the reason for new trail construction is to relocate an existing trail due to ecological concerns or excessive maintenance, several considerations need to be taken into account. Generally, relocations

should only be done when there can be a substantial improvement in trail conditions on the new section. This assumes that the relocation will replace a substantial piece of trail. Short relocations around a wet area may be appropriate, but the best long-term solution is usually to close and replace a long section of trail, or reconstruct the original trail to correct the problem(s).

When deciding whether trail relocation is needed, ask and answer the following questions.
1. *Will the new section of trail have the same environmental conditions and the same design as the damaged section being replaced?*
Often the answer to this question is "yes" which means that the same steep slope or boggy soils have to be traversed by the relocated section of trail. If this is the case, more often than not it is best to stick to the old location, rather than build a new section of trail that will deteriorate in the same fashion. Only if the problem area can be avoided, or at least crossed in a more effective way, should relocation be considered.

2. *Will the old section of the trail be too difficult to close and rehabilitate?*
If the section of trail being replaced is the most obvious location in a given landscape, such as along a stream or on a pronounced ridge, then hikers naturally tend to assume its existence and will use the trail even after a relocation is installed and the section in question has been closed. In these cases, again, it is best to stick to the old location. Sometimes in situations like this, a relocation can actually hasten environmental degradation by becoming confused with the old location so that hikers begin using both routes interchangeably. When this happens problems with both locations can develop, as well as with any unplanned crossover trails that may develop because of hikers' confusion. Older sections of trail should only be abandoned and relocated if they can be effectively closed and rehabilitated.

Factors Influencing New Trail Construction

The construction of a healthy and safe trail is generally controlled by two factors. The first factor is the intended use of the proposed trail. For example, if the new trail is intended to accommodate mountain bikers as a user group, then it must be constructed to meet all the specifications required of mountain bike trails. The second factor is the character of the land itself. All land areas have an inherent ability to sustain certain types and levels of recreational use without suffering damage to soil, vegetation, and water resources. If a particular piece of land cannot support the type of trail desired, then an alternate location for the trail must be found. Both factors need to be addressed in order to create a trail that will provide enjoyment for park users, be cost-effective to build and maintain, and protect surrounding resources.

Locating New Trail Routes

Once new trail construction has been approved in Bidwell Park, a route for the new trail needs to be found. The location of a trail is vitally important to meeting the general objectives set for a particular trail. A successful trail location is one that produces a minimum impact on the land, is visually pleasing, requires minimum maintenance, and provides for the intended use.

The individual(s) assigned to locating a route for a proposed trail must have a "feel" for the as-

constructed trail as they survey potential areas. This "feel" is gained through experience in laying out trails, seeing them built, and critiquing the final product against the original criteria or objectives.

The locator(s) must be aware of adjacent terrain, vegetation, soil types, and moisture conditions. In addition, the trail worker(s) need to know the intended use, and thus classification, of the trail, and all of the minimum requirements that classification entails. All of these factors will directly influence where the trail should be located, and subsequently how well the constructed trail will function.

Selecting a General Area for the Trail Corridor

The initial step in determining a specific route for a new trail in Bidwell Park is to first select a general area(s) in which a trail corridor could exist. Through the use of maps, aerial photos, and limited field reconnaissance, along with the following criteria as a guide, select those areas which fall within the constraints of budget, intended trail use, and available materials and labor.

General

* New trails should incorporate existing trails as much as possible.
* Trails should be located to avoid extreme changes in terrain and elevation.
* The location of a trail should be suitable for both winter and summer activity to the degree terrain and climatic patterns will accommodate it.
* Trails should be located to take advantage of scenic panoramas, historical and cultural resources, and ecological points of interest, when appropriate.
* Most trails should be located in such a way as to disperse visitors away from fragile, or heavily used, areas.
* Trails should be located in such a way as to avoid heavy-use roads.
* Trails should be located to avoid areas of extensive downed woody debris.
* Trails should be located in such a way as to allow loop systems, as well as access at varying distances along the trail, so users can choose trips of varying lengths.
* Trails should be located to avoid talus slopes or rock slide areas.
* Trails should be located to avoid areas with concentrated numbers of snags.
* Trails should be located to avoid areas with high wind and potential for lightning.

Flora & Fauna

* Trails should be located to avoid animal wallow areas.
* Trails should be located to avoid areas with endangered species.

Soils

* Trails should be located on stable soils, except where short sections can be structurally contained and/or a relocation would create more environmental damage.
* Trails should be located around extended bedrock areas.

Water

* Trails should be located to provide a balance of experience by locating different sections of the trail that both overlook streams and lakes and also follow along the water's edge.
* Trails should be located to provide water access to users, as well as horses, where appropriate.
* Trails located adjacent to bodies of water should avoid fragile riparian habitat.
* Trails should be located to take into consideration the stream crossing needs of the intended users, be they equestrians, mountain bikers, and/or hikers.

River, Highway and Railroad Crossings

* Trails should be located to avoid bridge crossings, if possible.
* Trails should be located in areas that provide adequate visibility at road crossings.
* Trails should be located in areas where natural or existing features can be used as easy and quick crossings.

Determining Trail Alignment and Grade

When the general location for a new trail route has been found, the next step is to find an alignment and grade that will "fit" the trail to the ground. An appropriate alignment and grade is influenced by the intended use/classification of the trail and the ecological characteristics of the area. Both of these influences need to be well understood before parameters for alignment and

grade can be set. For example, if the trail is intended to be accessible to wheelchairs, an alignment and grade must be set so as to constrain the trail along a route in which a 5 foot tread width, and a slope never exceeding 3 percent, can be maintained.

Proper alignment and grade will vary for each individual trail, but some guidelines from which to work include:

Trails in General

* The alignment should follow the contours of the land.
* Sharp, angular turns over 50 degrees and long, straight stretches should be avoided.
* Grade should undulate gently to provide natural drainage and to eliminate monotonous, level stretches and long, steep grades that are tiring to the traveler.
* As a general rule, the grade should not exceed 10 percent (i.e. a 10 foot rise over 100 linear feet of trail). Grades of 1 to 7 percent are ideal.
* No grade should be so steep that erosion is a problem.
* Trails should not be located at zero grade. As a general rule, some grade must be provided to account for drainage needs.

Trails Intended for Mountain Bikers and/or Equestrians

* The trail should be aligned to provide adequate sighting distance for oncoming traffic.
* Switchbacks should be avoided, and climbing turns used whenever possible.
* As with most trails, an average maximum grade should be 10 percent, but short stretches (300 feet or less) of 10 to 15 percent are acceptable if the tread surface can be maintained without

excessive erosion.
* The trail should be designed to avoid structures (e.g. water bars, steps, etc.) which would imped the travel, and reduce the safety, of mountain bikers and equestrians

Layout and Flagging

When the general location for the travelway has been determined, and parameters for alignment and grade set, the next step is to layout and flag the exact route. The layout can be either very precise using a transit and grade stakes, or it can be as simple as using an Abney level and flagging. The method used is determined by the intended use of the trail. For example, a paved trail which can accommodate wheelchairs will require more precision than a simple hiking trail.

The first step in layout is to make a field reconnaissance of the terrain between the proposed starting and ending locations of the trail. It is important to determine whether an appropriate trail corridor exists given the criteria selected for that trail. Record a series of reference points along the proposed trail corridor which express the general direction of the trail route.

When a trail corridor is finalized, the specific route is then determined by at least a two person team, most often using an Abney level and a selection of different colored flagging. After insuring it is set to show level, the Abney level is sighted at the other person to obtain a reference point that will be used consistently throughout the operation. This calibration must be done on known level ground to be accurate. A rod with a fixed marking can also be sighted on, if so desired. See figure 17.

After finding the reference points to be used, the Abney level is generally set at the maximum allowable grade, either up or down. The person being sighted by the Abney moves up or down slope within the selected range of grade until a section of trail, meeting all set criteria, is determined. That section of trail should then be flagged with a single color of flagging. Several different routes should be investigated, and a different color of flagging used for each potential route, until the most feasible route is selected. Upon selecting the most feasible route, it is important to remove all unnecessary flagging immediately in order to eliminate confusion when ground construction begins.

As mentioned in the previous sections, it is very important for the layout team to follow the natural topographic contour and drainage patterns of the terrain. See figures 18 and 19. The team should always layout a trail that will minimize the need for structures and costly maintenance.

Some key points to layout and flagging:
* Flagging should be spaced close enough to insure that there is no confusion during construction.
* Curved linear alignment should be adhered to as much as possible.
* The route selected should eliminate the need for as many structures as possible.
* Deviation from the maximum grade, in some cases, may be made for short distances to avoid obstacles and the building of structures.

Once the trailway has been flagged and the route finalized, clearing and brushing for the new trail can begin.

Clearing and Brushing for a New Trail

Clearing and brushing limits for a trail are determined by the trail's classification. Once the intended use for the proposed trail has been determined, and the trail has been classified, refer to the section Classifying Trails for the appropriate clearing and brushing limits. Clearing and brushing beyond those limits may be desirable and acceptable if done so to provide additional recreation opportunities or increase safety. For example, clearing and brushing should be increased at stream crossings, resting places, and scenic points.

For protection against erosion, and to maintain the appearance of the area, all healthy trees over 12 inches in diameter should be left. In sparsely timbered country, no healthy trees should be removed, unless they interfere with trail traffic and the trail cannot be relocated to eliminate the interference.

If tree roots interfere with grading, remove the appropriate trees and stumps. All trees and shrubs that are completely removed should be cut flush with the ground. See the sections Clearing Existing Trails and Brushing Existing Trails, under **Maintaining Existing Trails**, for more information.

Tread Base Construction

Tread base construction may or may not require grading. If the trail is to be built on a sidehill, it will usually require grading a bed. If the trail is built on an existing surface that is relatively flat, and provides a suitable tread, it should be left undisturbed. Regardless of whether grading is required, all debris should be removed before building a tread base.

When grading is necessary, it should start on the upper slope and be carried down to the finished grade. The usual procedure is to "scratch" a continuous line along the upper slope using a pulaski. Any excess duff should be removed at this time. Excavation should begin along the scratch line using a mechanical grader, hand tools, light tractor, or other means. Fill slope and back slope should be constructed to the native materials' angle of repose (see figures 20 and 21).

The trail bed should always be out sloped, if possible, to ensure good drainage. If terrain features or other trail characteristics do not allow an out slope, a crown or in slope may be required. See the section Maintaining Crown or Out Slope, under **Maintaining Tread on Existing Trails**, for more information.

When building trails for equestrian use, a rock or log barrier may be used for safety if the side slope is 80 percent or greater. These barriers will help keep the horse from walking on the outer edge of the trail. In addition, the trail base width should be widened to provide adequate tread area for horse and barrier. Remember, if rock or log barriers are used, more frequent maintenance is usually required to keep the barrier intact.

Side slope trail construction often requires cribbing for initial excavation and to provide soil retention during fill slope development. Cribbing consists of placing manageable sized logs, roots, and woody debris into a toe trench excavated below the trail grade at the foot of the fill slope. This provides any needed soil containment without the use of a more elaborate retaining structure. Trail cribbing is designed to decompose, so it should not be used in an area that will slump once decomposition occurs.

Tread base construction on mild slopes should be done by building up, rather than cutting down. Soil, gravel, and vegetation residue can all be used to help build up an adequate base. When building up a tread base, try to avoid excessive disturbance. This will reduce erosion and future maintenance.

Tread Surfacing

The depth and width of surfacing is determined by the quality of the native material and the class of the trail. Normally, the native soil used to construct the trail base is adequate to carry most user traffic. For trails which have certain ecological features, or are designed for heavier visitor use, alternative tread surfacing materials may be needed. Remember, importing tread surfacing material can be very costly, and should only be done when absolutely necessary.

A variety of materials can be used for tread surfacing, including asphalt, gravel, and vegetation residue. To determine the correct tread surface, user requirements, ecological conditions, and construction and maintenance costs must all be considered. When tread surfacing is required, native material should be used first, if possible. If no native material is available, then importing material can be considered. Because of the relatively high labor cost in transporting material for trail work, the source location is of greater importance than the quality of material. In other words, from a cost standpoint, a poorer, but still suitable, material nearby may be more desirable than higher quality material farther away.

Pavement

For trails designed to be "all access" (i.e. accessible to both disabled and able people), it may be appropriate to surface the trail with pavement. When pavement surfacing is required, experts on its use and application should be consulted, unless adequate in-house expertise is available.

Gravel

Under certain circumstances, it may be appropriate to cover a trail with a gravel surface. If the trail tread is to be covered with gravel, it should be at least 3 inches thick. In poor soil conditions, the gravel needs to be underlaid with a geotextile woven fabric to eliminate loss into the trail bed. The tread should be crowned when a trail is at, or near, 0 percent grade, and out sloped on side hill construction. For trails designed for mountain bikes and/or equestrian use, the gravel surface needs to be compacted firm, where possible. See the section Adding or Restoring a Gravel Surface, under **Maintaining Tread on Existing Trails**, for more information.

Vegetation Residue

Under certain circumstances, it may be appropriate to surface a trail with some form of vegetation residue (i.e. wood chips, plant mulch, etc.). Trails surfaced with vegetation residue should be covered to a minimum of 3 inches thick. In poor soil conditions, vegetation residue should be underlaid with a geotextile woven fabric to eliminate loss into the trail bed. The tread surface should be out sloped on side hill construction, and crowned when the trail grade is at, or near, 0 percent.

Building Drainage Structures

Drainage structures are built in order to direct water around, under, or away from a trail. Drainage control on a trail relates to two primary types of water flow -- surface and subsurface. Surface water is

the water from rain or snow that before the trail was built flowed in a sheet along the natural ground surface, but is now cut off and channeled into the trail. This water will flow along the trail, and if allowed to accumulate above a certain critical combination for soil type, slope, and velocity, will erode the trail surface.

Methods of diverting surface water include drain dips, water bars, parallel ditches, and more. Any provision for the discharge of surface water must include precautionary measures that will prevent silting, erosion, or gullying of areas off the trail. Rock placement at the discharge point will help dissipate water runoff and stop erosion. Perhaps the most troublesome drainage problem in trail construction is subsurface water. Occasionally, trail construction on an apparently dry hillside will open up subsurface water in the form of springs. A small amount of water is not a problem, provided the trail base and tread will not become boggy. If the amount of water is excessive, the best solution is to relocate the trail and bypass the trouble. If this is not practical, the next best solution is to construct drainage features to divert water away from the trail and permit the trail surface to dry out sufficiently to support the expected trail load. As a last resort, puncheons, turnpikes, or other similar structures should be constructed to cross these areas.

Constructing Drainage Dips

In a situation where the volume of surface water runoff is in excess of what a normal out slope design can accommodate, a drain dip may be required. Drain dips are an exaggerated out slope that terminates in a shallow trough. Drain dips should be located where they will be the most effective. Features such as natural contours, side slope, and trail grade must be studied closely to determine where the largest volume of water can be intercepted and diverted from the trail. Soil characteristics, vegetative cover, and down slope steepness must also be considered when selecting the location of the drain point.

A drain dip begins on the up trail side with a normal out slope. The out slope is gradually increased (4 to 10 percent) as the trail grade is cut and lowered to the trough and drain point. The terrain and volume of water encountered usually determines the length and degree of out slope used in the drain dip. Generally, steeper terrain and higher flows require longer drain dips with more out slope.

The trough is dug across and down the trail at a 30 degree angle. It should also be dug with a 15 percent down slope to insure adequate drainage and sediment transport. From the trough, the down trail side sharply rises to the original trail grade and out slope. This angle must not be too steep, or that portion of the trail will be worn down or scuffed into the trough by hikers. Below the drain point, a ditch or drainage channel must be provided to allow water to escape from the trail and fill slope without creating significant erosion. This channel is sized according to the volume of water generated by the drain dip. The channel may also require armoring with rock to reduce scouring and bank erosion. See figure 22.

Constructing Water Bars

A water bar is a physical structure across a trail which turns and directs water to the downhill side of a trail. Water bars are made of soil, wood, or rock, with rock the material of choice because of greater

longevity and strength.

When studying a trail for possible water bar placement, look at the natural drainage of the area. If the water crosses a trail naturally, the water bar will reinforce this pattern. If the trail has altered the natural drainage pattern and the water runs down the trail, determine the natural, most direct drainage pattern, and build the water bar to emphasize that pattern. Try to observe the trail with water on it during spring runoff or during a cloudburst, and the drainage requirements of the trail should be more evident.

To determine the final location of a water bar, look for natural anchor points, especially large rocks embedded alongside the trail. These make excellent keystones for water bars. In addition, trees may occasionally be used when well located. Once the site of the water bar has been determined, dig out a trench in which the water bar will be laid. Dig the trench deep enough, and large enough, for the water bar to be well anchored and low in height. A water bar should be constructed to a minimum height across the trail tread which will accommodate the amount of water it will receive in a cloudburst type of storm, yet not high enough to interfere with the ease of travel by park visitors. Usually a water bar can be lower than most are inclined to make it. The best water bars are subtle, low structures that are barely noticeable. The up slope and down slope ends of a water bar must be designed to fully cross the trail bed to prevent a hiker, biker, or equestrian from going around it.

The angle of a water bar across a trail depends on the gradient of the trail, the amount of water runoff, and the off-trail terrain. Typically, the angle is 15 to 40 degrees from a perpendicular line across the trail. Water bars at less than 15 degrees may dam up and require frequent maintenance, and water bars of more than 40 degrees may promote erosion and undercut water bar rocks or logs. The ideal drainage occurs at a point where the flow of water off a trail keeps the water bar clear of sand, soil, and debris. This self-maintaining type of water bar is the objective for any water bar construction, but may not always be possible. An approximate rule-of-thumb to determine the angle of a water bar across a trail is to begin with 15 degrees and add a degree for each percent of grade. In other words, a trail of 15 percent grade would require a water bar at an angle of approximately 30 degrees. See figure 23.

Building a Rock Water Bar

When selecting rock for water bars, look for rocks with uniform surfaces and at least one 90 degree angle. Lay the rocks with as much contact between them as possible. The lower portion of the rocks should be buried by the water bar tray and chinked tight. See figure 24.

Care should be taken so points of contact overlap with the flow of water, rather than providing an entry for water to erode between rocks. Lay rocks in their most stable position with the main portion of their weight down and in the trench. It is important to lay a rock with the weight low, otherwise it may have a tendency to be kicked out.

Fill behind the water bar and chink it tight. If needed, lay a rock tray in front of the water bar to provide a non-eroding surface for water to pass over. The final construction step should be to clean up the work site and bury the water bar on the down trail side.

On sections of trails of more than 10 percent grade, heavily used trails, or sections of trails that see a heavy amount of runoff, it may be advantageous to construct a "backed" water bar. A backed water bar is essentially a step which is installed across the trail less than two feet below (or down) the trail from the water bar. Crushed rock and other fill is placed between the water bar and the backing retainer bar until level with both the water bar and backing retainer. See figure 25.

Backing a water bar provides a more solid "dam" to effectively turn water off the trail, and it minimizes the large step-over created by bigger water bars. Try to minimize the height of the step-up on a backed water bar. A large step-up is not necessary. A rise of 8 inches is all that is needed. Grade the trail tread material to conform to the existing trail grade and drainage surface.

Constructing Parallel Ditches

A lateral or parallel drainage ditch is constructed adjacent to a trail to catch surface water sheeting from the tread surface and divert it away from the trail. Generally, parallel ditches are used in low, flat areas. The width and depth of a parallel ditch is a function of the amount of water runoff expected from a particular trail. In addition to increasing its width and depth, a parallel ditch built for larger runoff levels should be armored with rock to prevent soil erosion. Excess soil removed from constructing a parallel ditch should be used to backfill eroded areas and restore tread.

Constructing Drainage Lenses

Occasionally a trail will be bisected by an ephemeral spring or seep. These low volume flows saturate base soils creating a muddy, unstable trail bed. A simple and effective solution to this problem is a rock drainage lens. See figure 26.

The proper installation of a rock drainage lens begins with the excavation of the trail bed to the depth of the saturated soil. This excavation usually extends beyond the trail bed into the back slope and fill slope. Once fully excavated, the void should be filled with large angular quarry rock. The bottom course should consist of the largest quarry rock, with each progressive layer becoming smaller. When placing the rock, it should be laid point to point. This insures that sufficient crevices are available for the water to pass through. The rock lens should extend to the original height of the trail bed, then be capped with a layer of fine aggregate, or suitable native fill, until level with the adjacent tread surface.

When saturated soils are exceptionally deep, or base soils are difficult to stabilize, the use of geotextiles is recommended. By “sandwiching” the rock lens between two layers of geotextile fabric, a stable base is established for the lens, and the rock is less contaminated or plugged by soil. For more information on the use of geotextile fabric in the construction of a drainage lens, see the section Geotextiles under **Using Non-native or Off-site Material**.

Constructing Culverts

Culverts are installed when larger drainage channels cross a proposed or existing trail location. Culverts should follow the natural watercourse whenever possible. If not, the culvert should be built to drain in such a way as to allow an unobstructed flow of water. Constructing a culvert consists of excavating a trench across the trail, placing the culvert in the trench, backfilling the trench, and compacting soil

around and above the culvert. The size of a culvert should be sufficient to adequately carry the maximum peak flow of water anticipated, and promote self cleaning.

A culvert trench should be dug 30 degrees from perpendicular, and provide the culvert with a minimum down slope of 2 percent over its entire length. Excess soil removed from the trench should be used to backfill adjacent eroded areas, and/or restore trail tread.

A culvert should be bedded in an earth foundation of uniform density and carefully shaped to fit the lower part of the culvert exterior. Where a firm foundation is not encountered at the grade established, due to soft, spongy, or otherwise unstable soil, all such unstable material needs to be removed and replaced with rock, or other suitable material, to form adequate support.

Culvert pipes should be of sufficient length so that the top portion of the ends will be exposed. The extent of the exposure should be approximately equal to the pipe's diameter. The exposed ends should then be concealed with rock.

The culvert should be buried a minimum of 6 inches below the trail tread surface. Backfill material within 2 inches of the pipe should contain no rocks greater than 2 inches in diameter. Compacting the backfill and leveling to grade should extend from head wall to head wall.

A head wall and catch basin should be constructed at the inlet end of the pipe. A head wall, energy dissipater, and escapement channel should be built at the outlet end of the pipe. These structures will prevent erosion and help obscure pipe ends from view along the trail. Rocks that are at least 12 inches in one dimension should be embedded in the embankment across the top of both ends of the pipe. Rocks should protrude at least 4 inches beyond the ends of the culvert pipe. See figure 27.

The channel which leads to and from a culvert needs to be cleared of any debris which could block the ends of the pipe and result in the damming of water. Removal of debris should occur a short distance both up and down stream. Care should be taken when removing debris to minimize environmental impact to riparian habitat.

Culvert materials and design include corrugated steel, wood, or rock. Head wall and energy dissipater materials may be rock, concrete, wood, or a combination of the three.

Metal Culverts

Metal culvert pipe should be corrugated, galvanized metal, or aluminum alloy. Corrugations may be annular or helical. Corrugated, metal pipe should be a minimum of 16 gauge. See figure 28.

Wooden Culverts

A wooden culvert should be constructed of cedar or redwood planks, with all sap wood removed. The planks should have a thickness of at least 3 inches, and possibly more depending on span and size. The culvert walls should be spiked onto a sill plank, and a cap plank spiked onto the walls. This design will help prevent the collapse of the culvert from trail compaction. In addition, guide holes should be bored for the spikes to prevent splitting of the wall planks. See figure 29.

Rock Culverts

Rocks or stones used in the construction of rock culverts should be sound and durable. Those used to form the top should be reasonably flat, with a minimum thickness of four inches; side wall rocks should have at least one flat side, be even across one end, and 18 inches long.

Sufficient excavation needs to be done to provide a firm foundation for supporting the sidewalls. The sidewalls should be placed in accordance with lines and dimensions necessary to provide the required opening. Rocks selected should fit together snugly and be placed so as to have firm bearing on adjacent and underlying stones. Small stones can be used to fill voids. All space back of the sidewalls should be completely filled and firmly compacted. See figure 30.

Closed Rock Culverts

Stones used to form the top of rock culverts should be flat and of sufficient dimension to bridge across from one sidewall to the other. They should have firm bearing on the sidewall stones and form a base for the trail tread. Their placement should be sufficiently close to prevent gravel and soil from sifting through the top of the culvert and into the drain. In some cases it may be appropriate to place geotextile fabric over the cap stones before fill is placed on top to form the tread surface. If geotextile fabric is used, the tread layer above it should be at least 6 inches.

Open Rock Culverts

For an open rock culvert, cap stones are not put into place, and a safe step-through drain is constructed. The width of an open rock culvert should never be less than 24 inches, and the depth should be a minimum of 8 inches. Open rock culverts deeper than 8 inches need to be stepped down.

Building Structures to Cross Streams or Wet Areas

If an area cannot be drained, or for environmental reasons should not be drained, and if relocation is not feasible, then the building of structures to cross streams or wet areas may be necessary. These structures offer dry passage for hikers, and constrain traffic on a hardened surface, thus protecting adjacent plants and animals. The use of structures to cross streams or wet areas should be held to a minimum. Extensive effort should be made to avoid building new structures. In addition, when existing structures need extensive repairs, relocation or redesign of that section of trail, in order to avoid needing such a structure, should be considered. Those structures that are built should be designed to blend in with their natural surrounding. The attention of the trail user should be focused on the natural scenery, and the intended activity, not on trail structures themselves.

Constructing Causeways

A causeway is built primarily in flat areas that are wet, or become wet during the rainy season. A causeway is designed to raise the trail base above the wet area. A causeway should be built to the minimum height, width, and length needed to bridge the problem area during a maximum flow event. Causeway walls should be laid so as to create a near level and uniform surface. Lay the rock so that a good edge faces outside to present an aesthetic appearance. The inside face is not as important as it will be buried with crushed rock and mineral soil used to build the tread surface. The rock walls should be stuffed and chinked from the inside before any rock is crushed or tread constructed. Geotextile fabric can be used as underlay if necessary (see the section Geotextiles under **Using Non-native or**

Off-site Material).

Once the walls are laid and chinked, the tread should be built up with rock and gravel. The causeway should be filled with rock and gravel to within no more than 4 inches of the top of the walls. The remainder should be filled with mineral soil, and the tread surface crowned to allow for compaction and proper drainage. See figure 31.

NOTE: Before building a causeway, make every effort to locate the trail around the problem area.

Constructing Turnpikes

Similar to a causeway, a turnpike is used primarily in flat areas that are wet, or become wet during the rainy season. A turnpike is designed to raise the trail base above the wet area and carry water away. A turnpike should be built to the minimum height, width, and length needed to bridge the problem area during a maximum flow event.

Construction of a turnpike should begin by setting two curb logs parallel to the trail tread. The curb logs should be anchored together with heavy gauge wire. Once the logs are in place, the space between them should be filled with rock or gravel to within 2 inches of the top of each log. This material should then be capped with mineral soil, or another appropriate material, and crowned. A parallel ditch should be constructed on the outside of each curb log to divert water away from the trail. See figure 32. Geotextile fabric can be used as underlay if necessary (see the section Geotextiles under **Using Non-native or Off-site Material**).

NOTE: Before building a turnpike, make every effort to locate the trail around the problem area.

Constructing Puncheons

A puncheon is a log or timber structure built close to the ground (3 feet or less). A puncheon is used to cross a small drainage, wet area, or other place where a turnpike or causeway is not effective. It usually consists of mud sills, stringers, and wood decking. In addition, if a puncheon crosses a depression of more than 3 feet in depth, safety railings are required.

Construction of a puncheon consists of setting two 10 inch by 10 inch mud sills, 6 feet long, into the soil until buried to 1/3 their diameter. These sills should be spanned by two 4 x 8 inch stringers, and then decked. Generally, stringers should be placed to allow a deck tread width of at least 40 inches, although the width may vary depending on the class, and intended use, of the trail.
Stringers should be fixed to the sills with 5/8 inch drift pins, or notched and spiked. Decking material should be at least 3 inches thick, and installed using #50 & #60 galvanized nails (at least 4 per plank). Each end of a puncheon should have a soil dam spiked on to prevent soil or fill from eroding out. A puncheon should not exceed 12 feet in length (sill to sill). See figure 33.

The approach to a puncheon should be level and flush with the walking surface, or stepped up at 8 inch

intervals. All brush and debris should be removed from the drainage channel(s) on both sides of the puncheon, and disposed of out of sight.

Puncheon Structures for Equestrian Use

While the basic structural design is the same for hiking/mountain biking and equestrian puncheons, there are some design modifications to accommodate equestrian traffic.

In order to accommodate the additional weight associated with horse traffic, the number of stringers should be increased to three 4 x 8 inch timbers. The stringers should be anchored with 3/8" x 8" galvanized wire spikes. The decking material must be a minimum thickness of 4 inches, and create a tread width at least 60 inches (52 inches between bull rails). A bull rail should be attached directly over the outside stringers on both sides of the puncheon. The bull rail should be raised at least 2 inches from the decking surface to allow drainage. Approaches to both ends of the puncheon should be level, if possible. See figure 34.

NOTE: Before building a puncheon, make every effort to locate the trail around the problem area.

Constructing Bridges

Whether a bridge is needed depends upon the type of use expected, the season of use, and the nature of the stream or crossing. Visitor safety is the primary consideration, while visitor convenience may or may not be important. For example, on a more remote trail which is used by more experienced visitors, hopping from stone to stone, and the possibility of getting wet feet, is part of the experience. On the other hand, a high use trail that is visited by a wide variety of people (many in street shoes and with little hiking experience), may need a bridge to provide both convenience and safety.

When it is determined that a bridge is needed, the specific location of the crossing should be determined by the:

* Availability of bridge materials
* Length of span
* Character of banks
* Range of high water
* Alignment of stream bed
* Accessibility of the site

Care must be exercised in the selection of a bridge site. The ideal site is one requiring little or no trail relocation, where an abundance of suitable material exists, the stream is narrow, the channel straight, and the banks high, even, and solid.

Designing and Building a Bridge

Bridges are large and complex projects, and will usually require an outside consultant to help design and build, unless adequate in-house expertise is available. The type and location of each bridge should be done on a case by case basis.

NOTE: Before building a bridge, make every effort to locate the trail around the problem area.

Constructing Fords

In some situations, fords are preferred to bridges for stream crossings, provided the velocity and depth of the water is acceptable during the normal season of use. The use of fords eliminates the expensive construction and maintenance costs associated with bridges.

Fords are not normally constructed, but are selected from natural crossings. Desirable natural features include: gentle approach grades (not more than 10 percent), firm streambank soil (not susceptible to erosion), shallow, low velocity flows (less than 24 inches in depth), and stable, even stream bottoms (no stones larger than six inches). Modifications to these natural crossings may be required if all these criteria cannot be met.

Prior to performing any in stream work, the chosen location must be inspected thoroughly to determine what effects any needed modifications may have on the stream's morphology. Stream bank irritability, both upstream and downstream, should be evaluated to ascertain what effects increased stream depth might have. Upstream banks and side slopes should also be evaluated to determine if landslide activity is present. In addition, the stream bed should be evaluated to determine if it is actively aggrading or cutting. Any of these conditions, depending on their severity, can effect the success of an established ford.

If the desired ford is too swift, its velocity can be reduced by constructing a small stone dam just downstream from the crossing. This structure will increase the depth of the ford, reduce its velocity, and catch and retain aggregate, producing a smooth and level ford tread. When constructing this dam, it should be keyed into the stream bank a minimum of 12 inches on both sides. The bottom course of the dam should be laid below the streams known scour depth or 18" below the existing stream bed if the scour depth is unknown. Rocks used in the dam should be no smaller than 12 inches in diameter. Stepping stones should also be incorporated into the dam for pedestrian use. These stones should be no smaller than 24 inches in diameter and be spaced no further apart than 24 inches. The tops of the stepping stones should be a minimum of 6" above the stream's high water mark.

The stream bed at a ford crossing should have a minimum down slope of 3 percent. This will reduce the deposition of unwanted silts and excessive aggregates.

The approaches to a ford should have a minimum tread width of 36 inches (for a distance of 10 feet on either side of the ford), and a minimum down grade of 10 percent. In addition, the approaches should have a graveled surface. This will help armor them so they maintain their shape and resist erosion. The prevailing trail grade should be a minimum of 1 foot above the high water mark where it joins ford approaches. See figure 35.

Building Dry Land Structures

The use of dry land structures should be held to a minimum. Extensive effort should be made to avoid building new structures on existing, and future, trails. In addition, when existing structures need extensive repairs, relocation or redesign of that section of trail, in order to avoid needing such a structure, should be considered. Those structures that are built should be designed to blend in with their natural surrounding. The attention of the trail user should be focused on the natural scenery, and the intended activity, not on trail structures themselves. In general, construction of most structures should be avoided, if there are alternative solutions. Following initial construction, they become a major maintenance item and if not carefully maintained can be a hazard to trail users.

Building Switchbacks

When they are needed, switchbacks should be located in such a way as to utilize natural topography and vegetative screening. The distance between switchbacks should be varied to introduce variety. Repeated and visible switchbacks create excessive disturbance to vegetation and soil, and severely scar the landscape. They also introduce monotony by repeatedly presenting the same view to the user.

Construct the turns as flat as possible. On side slopes of less than 30 percent, treat a switchback as a climbing turn. If this results in the center line grade being steeper than is desirable, shorten the radius and design a step section. Tread width on sharp switchbacks should be at least double the trail width on landings. Where the outer trail tread margin is along a very steep slope or cliff, the trail tread may be 4 feet wide and over. The upper and lower 20 foot approach sections, and the turn section, should be constructed to have at least a 36 inch tread width. In addition, the tread on the approach sections, and on the turn section, should not exceed the prevailing grade of
the trail, and have no surface rocks over 2 inches in diameter.

The upper leg of the switchback should be constructed as a full bench (see figure 19 within the section Tread Base Construction). Cut banks of the approach sections should be uniform with the adjacent trailway excavation. Bank gouging and excessive back slope excavation is not permitted.

A gutter type ditch, 8 inches deep and 12 inches wide, should be constructed along the bottom of the cut bank (on the upper leg) and extend up from the spill point for a distance of 20 feet. The trail tread paralleling the ditch should have a 10 percent in slope that will drain water from the tread into the ditch. The tread surface on the lower leg should be constructed with a 10 percent out slope for a distance of 20 feet. See figure 36.

Material encountered in the excavation of the approach sections of a switchback should be conserved and used for fill to make the required embankment. The embankment should be constructed in conformance with the grade line, cross section, and slope stake markings. To provide a stable base for an embankment on a steep side slope, the surface of the natural slope should be trenched or stepped.

Formation of the embankment for the landing should be done by layering fill material. Fill material should be placed in a series of layers, each approximately 24 inches thick, and compacted after each layer. At least 25 percent of the fill material should contain rock to help add stability. An 8 inch shoulder should form the top edge of the embankment.

Near the turning point, or landing, a log or rock barrier should be installed along the outer edge of the upper leg to prevent hikers, bikers, and/or equestrians from crosscutting the switchback. The barrier should be a minimum of 14 inches high, and extend up the trail from the landing for at least 15 feet.

Building Steps

For trails with low to moderate grades, steps are needed infrequently. However, on trails with steeper ascents, they can be critical to soil stability and retention. The basic purpose of steps is to provide a stable vertical rise on the trail, while permitting lower average grades between steps. This trail design slows water and helps retain soil. For trails designed to accommodate equestrians and/or especially mountain bikers, extensive effort should be made to avoid the use of steps. Steps need to be thoughtfully placed on the trail to ensure that hikers will use them. If not, hikers will bypass steps and create increased soil erosion. Steps must be in the most appropriate place to walk and have evenly spaced rise and run, otherwise, they will be avoided by trail users.

If visitors are tired and going uphill, even steps that are well placed are often avoided. To prevent this, screen one or both sides of the trail with dead wood or stones, leaving the steps in the middle or along one edge. In addition, a drainage ditch, usually on the out slope of the trail, may be needed to collect water and channel it down alongside the steps to a drainage spot where it can be removed from the trail.

In placing steps, it is generally best to work up from the bottom of a slope. This procedure makes it easier to determine the best step placement, and the optimum mix of stabilization techniques. The tread width of most steps should be the same as the width of a bridge designed for the same trail user group. For visitor safety, handrails should be installed on all stairways with more than four risers.

Step Calculations

To have properly designed steps, a series of calculations are needed. Begin step calculations by measuring the total height gained and the total run. Next, determine the number of steps by dividing the height by a 7 inch rise. Once the number of steps is determined, subtract that number by 1 to find the number of landings. Finally, divide the total run by the number of landings to determine the landing width. See figure 37.

For safe and easy to use steps, the landing width should be at least 13 inches and no more than 18 inches. When calculating a long series of steps, it may be appropriate to make separate calculations for a series of smaller sections. In addition, when calculating a long section of steps, allow for a few larger landings so trails users will have areas to rest.

Wood Steps

The standard materials for wood steps are 4 x 8 inch split or milled redwood. Two holes should be drilled through the step, one 3 inches from each end. A trench should be dug for the step to set, and then pinned to the ground with 5/8" x 36" rebar. The length (i.e. tread width) of wooden steps should be at least 48 inches. See figure 38.

Once a wood step is secure, the uphill side can be backfilled with soil. When steps are placed in a

series, the bottom of the upper step should be just a bit lower than the top of the lower step, with the steps slightly in or out sloped. This will ensure proper drainage and prevent puddling behind the step.

Rock Steps

If the setting is appropriate, rock steps are aesthetically pleasing and will last longer than wood steps. Suitable rock for steps is often difficult to find, but the additional effort required to obtain building materials may be justified due to the longevity of the structure.

The proper weight and shape of rocks is critical. Look for keystone rock shapes, i.e., long rectangles with flat tops and 90 degree angles. Rocks should weigh between 25 and 100 pounds; smaller rocks tend to work loose and lead to frequent maintenance.

Develop an adequate bed to lay rocks on. By doing this, it will reduce the chances of "rocking." Make sure exposed faces of rock are face to face with good contact. Lower portions of rocks in the trail bed can be chinked and back filled to provide good contact and stability. On steep sections of trail, rock steps should be overlapped. Larger flat slab-type rocks should be used with rock ends anchored in the trail bed. See figure 39. In some locations, lack of quality rock, or high use by park visitors, will require the use of mortar to build rock steps.

Interlocking and Cribbed Steps

Ordinary step construction may be unsuitable for some sites. In some locations, the ground may be full of large rocks or roots which make excavation impossible, or the site may be too steep to allow installation of wood or rock steps. In cases such as these, partial crib steps may be needed.

Partial crib steps, also called interlocking steps, are useful in sections constructed on steep side slopes where holding fill material in the steps may be a problem. This type of step consists of a side wall or walls built to become its own free standing two or three walled box. Fill material is then placed into the step until the step surface is compact and level.

In most cases, the step requires a crib only on the out slope. The step and the crib piece are notched so they fit together flush on the top and are secured with a galvanized wire spike. The rear of the crib should be secured with a 3 foot piece of 5/8 inch rebar. See figure 40. In some cases, a full crib section may be required.

Equestrian Steps

When laying out an equestrian trail, every effort should be made to avoid grades or situations where steps are required. Although capable of traversing steps, many horses, and their riders, prefer not to climb them.

When equestrian steps are needed, the same procedures as those used in pedestrian wood, rock, or cribbed steps should be followed. The only difference is that the landings need to be a minimum of 48 inches long. The extra length of the landings allows horses to have at least half of their bodies on a step at one time. This spacing minimizes the tripping and stumbling that may occur while ascending or

descending steps.

Additional features that should be added to equestrian steps are erosion resistant backfill material, and barriers along the trail's edge. The hooves of horses rapidly scuff and scrape soft soils creating depressions or ruts. If steps are backfilled with erosion resistant materials such as shale, base rock, or a suitable mixture of rock and soil, the durability of the steps will be significantly improved. To avoid having horses walk to the side of steps, barriers such as rocks and logs should be placed on both sides of the trail, but in such a fashion as to not impede drainage. These barriers should be so imposing that horses will not be tempted to go out of the trailway.

Building Safety Railings

Safety railings are built to help delineate trails, protect vegetation, and assist trail users in negotiating structures such as steps and bridges. Safety railings are comprised of vertical posts and horizontal (and/or diagonal) rails. Lumber used to build safety railings should be construction heart redwood to provide the structure with strength and longevity.

Safety railings should be constructed by first placing 4 x 6 inch posts in the ground at a depth of at least 24 inches. Posts should be spaced about every 8 to 10 feet, and spanned by two 4 x 6

inch rails. Both the top and diagonal rails should be notched for a firm fit and fixed to the posts with #30 or #40 galvanized nails. Splices in rail should be made at a post to assure a firm splice. The top of the completed railing should be 42 inches above the trail tread, and be placed no closer than 2 feet from the tread center line. See figure 41.

Building Retaining Walls

Retaining walls are structures of wood or stone designed to stabilize soil on a side slope. A solid foundation on earth or rock is needed to obtain a strong and safe retaining wall. Native logs or lumber should only be used if rock is not readily available.

Log or Wood Retaining Walls

Excavation of an adequate sized footing is the key to a stable wall. The footing width should be slightly larger than the timber used for wall materials. The footing foundation should be at least 8 inches below grade, and in stream side applications, 18 inches below the lowest point on the stream profile.

All wing, facer, and tie logs should be construction heart redwood or pressure treated Douglas-fir, and be at least 4 inches thick (if using logs, the minimum all heart diameter should be 6 inches at the small end). Tie logs should be spaced not more than 8 feet apart and be at least 48 inches long. All components should be notched and fastened with 3/8 inch diameter spikes or drift pins. Facer and wing members should be fitted with 1 inch spaces between courses. All ends of the retaining wall should be keyed into native soil which is not experiencing mass movement. See figure 42.

Tie logs are installed either by digging a trench to the necessary depth and length for the log or burrowing to the necessary length. Tie logs must be angled down approximately 10 degrees toward the fill side and firmly seated.

Aggregate soils or drain rock (less than 4 inches in diameter) should be used as backfill to promote drainage. Backfill material should be compacted and measures taken to avoid fill material sifting out.

When the length of the wall is greater than 12 feet, and two retaining wall pieces are spliced together, additional anchor posts need to be placed on each side of the splice. If possible, the splice should be a lap joint splice or full notch.

Rock Retaining Walls

A retaining wall constructed of rock provides an aesthetically pleasing, long-term solution that will withstand the rigors of many winters, as well as heavy use by hikers, bikers, and horses. However, dry wall rock work (rock laid without mortar) takes time, experience, and is labor intensive.

Planning a rock wall, as with other structures, requires taking into account natural features of the work site. Rocks and bedrock that are in place should be used as anchors and keystones, whenever possible.

Selected rock and stones should be sound, durable and have at least one or more uniform surfaces (which can be used as an outside face). The rock shape should allow the rock to be laid with the bulk for the rock's weight set back into the wall. The header stone's length should span the full thickness of the rock wall. Fifty (50) percent of the stones in the wall should be greater than one cubic foot.

Look for rocks of reasonable size; it is not worth the time and effort to place smaller rocks. If the project is large and the number of rocks needed are many, they will unsafely jam up the work area and block the trail to users. A rock stockpile which is too large is unsafe and slows production. Gather only the number of rocks that a stockpile area will comfortably hold yet still provide an adequate selection.

As with a wooden retaining wall, excavation of an adequate sized footing is the key to a long lasting, stable wall. The excavation for the foundation width should be 1 ½ times the wall height. The entire footing should be in undisturbed native soil. At least one third the wall height should be below the ground line. Foundation rocks should be laid with no overhang protruding beyond the footing. Each foundation rock should be firmly set with a 3 percent batter into the wall. See figure 43.

Begin laying rock at the lowest point in the wall. Continue to lay rocks in tiers of roughly equal height. All stones should be laid with their greatest dimension extending into the wall. At least one quarter of the outer face rocks should be header rocks (header rocks span the thickness of the wall). In general, stones should decrease in size from the base of the wall to the top. The top of the wall should reflect the trail bed drainage design and have at least a 4 inch thick tread.

Make face to face contact on all rock to rock placement. Trim the rock, if practical, to achieve

adequate contact. Offset the joints of rocks on succeeding tiers similar to brick laying. Lay rock faces so their outer face does not overhang the wall surface. The wall face should batter 3 percent back into the slope. Place the rock so its weight is transferred down into the wall. (See figures 44 and 45).

Once the rocks are laid in position, stuff small rocks and soil around each rock in the tier to strengthen its placement and secure it in position. After the rocks are stuffed and chinked, backfill behind them with permeable aggregate fill. Fill each tier as the wall is built.

Building Additional Trail Structures

Not all trail structures have been outlined in this manual. If a structure is needed for a trail, and it is not described in this manual, independent research by appropriate Park Department staff will be required.

Determining Public Need and Assigning Trail Use

The ability of the trails system in Bidwell Park to accommodate trail users is finite. The strain on trail resources, and the conflict between different user groups, will only rise as the demand for trails increases. Steps need to be taken to minimize resource degradation and user frustration, now and in the future.

Minimizing User Conflicts

Equestrians, mountain bikers, and hikers all have desires and needs associated to trail use in Bidwell Park that may or may not be compatible. When these different trail user groups recreate on the same trails, it often leads to concerns over safety. Equestrians frequently voice concern that mountain bikes may cause their horses to react in such a way as to injure the horse and/or rider. Mountain bikers often express concern over the possibility of being injured by a horse. And hikers share similar concerns with respect to both mountain bikers and equestrians. These, and other user conflicts, need to be assessed and solved.

In order for user groups to accept conflict solutions, they need to be a part of process to create those solutions. With that in mind, a Trail Advisory Group may be established in the near future. The Trail Advisory Group should be made up of people who represent all user groups. The goal of the advisory group should be to develop useful dialogue between user groups and create solutions to user conflicts.

Assigning Visitor Use to Trails

As of now, nearly all trails in Bidwell Park are open to all user groups (i.e. equestrians, mountain bikers, and hikers). In the future, as demand for trails increases, it may be necessary to assign a single use to some trails. Decisions such as these should be made by Park Department management in conjunction with the Bidwell Park and Playground Commission and any other appropriate participants.

Public Surveys and Questionnaires

Currently, the use of surveys and questionnaires to determine public opinion with regard to trail use and management are not an established part of the trails program for Bidwell Park. However, with an increase in user demand and conflict, surveys and questionnaires may become an integral part of trail management. Although, a formal system for public inquiry is not in place, all forms of citizen comment regarding the trail system are welcome and given due consideration.

Educating Trail Users of Opportunities and Responsibilities

For a healthy trail system to exist in Bidwell Park, trail users have to want, and support, a healthy trail system. In order to help in creating and maintaining a successful trails program, park visitors need to be provided with the information necessary to be educated participants. Most trail users that degrade trail resources do so out of ignorance. Very few trail users make a conscious effort to participate in activities which damage trails. It is the responsibility of park staff to provide easily understandable and accessible information to those trail users that want to learn how to become active participates in protecting and enhancing trail resources.

Educational Resources Available to Trail Users

There are a number of ways that trail users can currently access information about their opportunities and responsibilities regarding trail use, and several additional ways that are being developed for the future. At present, trail users can access information in a variety of ways, including handout materials, the Park Department voice mail system, signs at many trail heads, and the Chico Creek Nature Center. All of these resources should be maintained, and enhanced if possible.

In the near future, a number of additional and improved ways to disseminate information to the public may be developed. With the continued increase of access to the Internet by the public, the Park Department web site will grow in importance as a means to post information. When resources become available, the Park Dept. web page could provide access to trail maps, status on the closure of trails due to weather or maintenance activities, trail/park rules and regulations, volunteer opportunities, and more. Also, new and improved trail maps are a priority for the future. These maps will provide

information, both visually and verbally, on legitimate trail location, intended use, travel time, degree of difficulty, and more. In addition, the future of Bidwell Park may see the building of kiosks and a visitor center in and around the Park. These areas, among other things, will be locations to receive written information on trails, gathering places for interpretive walks and talks, and more.

Determining and Enforcing Trail Rules and Regulations

For a healthy trail system to exist in Bidwell Park, trail users need to take it upon themselves to understand, respect, and follow trial policies and regulations. Extensive patrol and enforcement of trails in Bidwell Park is neither possible, nor effective. Trail users must regulate their own actions and behavior for the trails program to be successful.

In general, few trail users make a conscious effort to participate in activities which are against park policy. Of those users that do break trail rules and regulations, many do so out of ignorance. Therefore, it should be the responsibility of park staff to provide easily understandable and accessible information about trail rules and regulations to those trail users that want to know. In this way, education and enforcement go hand in hand.

Determining Policy for Trail Use

Rules and regulations regarding the use of trails in the park are governed by Title 12 of the Municipal Code for the City of Chico. Any additions, deletions, or modifications to park rules must be done by the Bidwell Park and Playground Commission in accordance to the guidelines outlined in the Municipal Code.

Enforcing Trail Rules

At present, two Rangers are on staff with the Park Department to patrol and regulate park activities, including trail use. In addition, seasonal help is employed, usually during the high use months of summer. During high use months, more effort is taken to patrol trails to increase resource protection

and user safety. In the future, as user demand increases and budgets allow, additional focus will be placed on the patrol and enforcement of trail rules and regulations.

Glossary of Terms

Abutment: Foundation at either end of a bridge that supports the mud sill and stringers

Backslope: The bank along the uphill side of trail, usually sloped back a varying degree, depending on bank composition and slope stability

Batter: The angle which an abutment or rock wall is constructed off plumb (< 90 degrees)

Borrow Material: Soil, gravel, or rock materials taken from approved locations away from the trail

Brushing: Removing shrubs and smaller plants from the travelway

Classification: The designation of trails to indicate intended use and maintenance specifications

Clearing: Removing windfall trees, uproots, leaning trees, lose limbs, wood chunks, etc. from the travelway

Culvert: A drainage structure composed of rock, metal, or wood which is placed approximately perpendicular to and under the trail

Drain Dip: A reverse in the grade of the trail bed accompanied by out slope which diverts water off the trail

Fillslope: Area of excavated material cast on the down slope side of the trail cut

Ford: A natural stream crossing modified to provide a level surface for safe traffic passage.

Full Bench: Where the total width of the trail bed is excavated into slope and the trail bed width is not made of compacted fillslope.

Hazardous Tree: An unstable tree 5 inches or greater in diameter at breast height which is likely to fall across the trail.

In Slope: Where the trail bed is sloped downward toward the backslope of the trail.

Mineral Soil: Soil or aggregate that is free from organic substance and contains no particles larger than two inches in greatest dimension.

Mud Sill: Foundation on which a bridge is built.

Out Slope: The trail bed is sloped downward toward the down slope side of the trail.

Parallel Ditching: A lateral drainage ditch constructed adjacent to the trail tread to catch surface water sheeting from the tread surface and divert it away from the trail. Generally this drainage system is used in low flat areas or areas where multiple entrenched trails have developed.

Pier: Intermediate bridge support located between two adjacent bridge spans.

Pre-field: Performing a physical examination of the project worksite in order to evaluate solutions to trail deficiencies, select the appropriate course of action, formulate the design, and quantify the material, equipment and person hour requirements.

Puncheon: A log or timber structure built to cross a wet area. Usually consists of sills, stringers and a deck.

Retaining Wall or Crib: Log or rock construction to support trail tread or retain backslope.

Safety Railings: Horizontal or diagonal structural members which are attached to vertical posts for the purpose of delineating trails, protecting vegetation, providing safety barriers for hikers at overlook areas, and assisting hikers in negotiating trail structures such as bridges and steps.

Sideslope: The natural slope of the ground measured at right angle to the center line of the trail.

Slide: Material which has slid onto the trailway from the backslope and possibly beyond in quantities sufficient to block the trail.

Slough (Sluff): Material from the backslope that has been deposited on the trail bed and projects

higher than the center of the trail tread.

Slump: When the trail bed material has moved downward causing a dip in the trail grade.

Specifications: Standards to which trails and trail structures are built and maintained according to class.

Stringer: A log or timber that rests on the mud sill and spans a water course, muddy area, etc. Supports the tread surface.

Switchback: A turn which is constructed on a slope of more than 30 percent when measured between the exterior boundaries of the trail 120 to 180 degrees. The landing is the turning portion of the switchback. The approaches are the 20 foot trail sections upgrade and downgrade from the landing.

Trail Bed: The portion of trailway between hinge point of the back slope and the hinge point of the fill slope.

Trail Log: An item by item record of trail features and facilities along or adjacent to a trail.

Trailway: That portion of the trail within the limits of excavation and embankment.

Travelway or Corridor: Includes tread surface and clearing limits.

Turnpike: A structure built to raise the trail bed above wet, boggy areas by placing mineral soil between parallel side logs. Usually includes parallel ditches.

Water Bar: A device used for turning water off a trail, usually made of logs or stones.

Water Course: Any natural or constructed channel where water will collect and flow.

Way Trail: A non-legitimate trail used by park visitors

Appendix

Employee Training Tips

Things That Employees Should Not Do When Working On Trails

1. Don’t work close together with cutting tools, axes, and saws.

2. Don't use two people on a saw without using two handles.

3. Don’t watch a wedge being driven or a cable being cut.

4. Don’t walk behind a person carrying a saw.

5. Don’t watch others drive spikes, drift pins or wedges.

6. Don’t leave axes sticking in trees or logs or a saw lying around your work.

7. Don't throw axes, files or saws.

8. Don't carry your axe over your shoulder.

9. Don't stand in front of a person using an axe or any other cutting tool.

10. Don't try to lift or move a load that is too much for one person -- ask for help.

11. Don't take any chances while driving and always leave your vehicle in gear and chocked while parked.

Things That Employees Should Do When Working On Trails

1. Do look for obstructions, overhead and around your feet, before swinging your axe.

2. Do keep on the upper side of logs being sawed or moved.

3. Do keep away from moving cables and timbers.

4. Do look before rolling a rock from a switchback.

5. In transporting explosives -- one person carry the powder and another person carry the caps.

6. Do watch your saw while bucking. Keep your legs back as you finish cuts. Wear chaps.

7. Call "TIMBER" three times before falling a snag or tree.

8. Do have a good solid grip on all tools before trying to swing or chop.

9. Do divide up the tools while carrying them to and from work.

10. Always carry a FIRST AID kit with you.

11. Do have person flagging out, and the danger area clear, before explosive charges are set off.

12. Do wear your safety helmet.

13. Do wear safety goggles while splitting timber, drilling rock, and so on.

14. Do wear all designated safety equipment.