Figures

Photos

Chapter 8. Accessible Trail Design

As outlined in Chapter 5, *Principles of Trail Layout and Design*, general trail layout and design principles are applied to trails for all user groups. However, the trails for each group have specific and unique design requirements to ensure they provide for safe enjoyment, protect the resources, and are sustainable. Meeting these requirements is one of the most challenging tasks faced by a designer. To every extent possible, all trails should have the highest level of accessibility. This chapter addresses the design criteria for "accessible" trails and trailheads, but does not include outdoor recreation routes, beach routes, shared use paths, public right-of-ways, or accessible routes for which separate guidelines would apply. This chapter also presents design and construction strategies for accessible trails developed by the Department.

Trail: As defined for the purposes of applying accessibility guidelines, a trail is a pedestrian route developed primarily for outdoor recreational purposes. A pedestrian route developed primarily to connect elements, spaces, or facilities within a site is not a trail.

Trailhead: An outdoor space that is designated to serve as an access point to the trail. The junction of two or more trails or the undeveloped junction of a trail and a road are not trailheads.

8.1. Federal Accessibility Standards for Trails

On November 25, 2013, the U.S. Access Board under the Architectural Barriers Act (ABA) issued new accessibility standards for outdoor developed areas on federal lands. These standards provide detailed specifications for accessible trails that apply to facilities that are built, altered, or leased on federal lands or with federal funds.

These standards originated from recommendations prepared by the Outdoor Developed Areas Regulatory Negotiation Committee, an advisory panel chartered by the U.S. Access Board.

Non-federal entities that construct or alter facilities on federal lands on behalf of the federal government are also subject to these standards. The federal standards will also apply to the following:

- Private entities that construct or alter trails on federal land pursuant to a concession contract or other arrangement with a federal agency under which the federal agency reviews or approves the design of the facility and has a property interest in the facility;
- State or local government entities that construct or alter trails on federal land pursuant to an agreement with a federal agency under which the federal agency reviews or approves the design of the facility and has a property interest in the facility; and

- Non-profit organizations and state or local government entities that enter into partnerships with a federal agency to construct or alter trails or viewing areas on federal land.

It is Department policy to follow these standards, which represent the best currently available information on designing and constructing accessible trails. These federal standards are also the basis for the *California State Parks Accessibility Guidelines* that should be followed for all state park projects, programs, and activities.

8.2. Applicable Trails

These standards only apply to trails designated for use by pedestrians only. Trails designated for use by mountain bikers, equestrians, off-highway vehicles, or a combination thereof are exempt from these standards.

These standards only apply to pedestrian trails directly connected to a trailhead or an accessible trail that substantially meets the technical requirements for an accessible trail. New or existing pedestrian trails not connected to a trailhead or accessible trail are exempt from these standards.

Following the design and layout process outlined in Chapter 5, *Principles of Trail Layout and Design,* will enable trail designers to determine if a proposed pedestrian trail can comply with the standards for accessibility and maximize the level of accessibility that can be achieved on a new pedestrian route. If the proposed pedestrian trail cannot meet accessible standards then the reasons for its non-compliance must be well documented.

These standards only apply to existing trails where the original design, function, or purpose of the trail is altered. **Trails that receive routine or cyclical maintenance that does not change the original design, function, or purpose of the trail are exempt from these standards**. (See Figure 8.1.)

8.3. Conditions for Exceptions

The ABA standards recognize the existence of constraints and limitations in the outdoor environment and allow for exceptions from specific provisions in the technical requirements where certain circumstances, referred to as “conditions for exceptions,” apply. When an entity determines that any of the conditions for exceptions do not permit full compliance with a specific provision in the technical requirements, compliance with that provision is required to the extent practicable. The phrase “to the extent practicable” means reasonably do-able under the circumstances.

The conditions for exceptions should be used only after all other design options are thoroughly explored. Where a condition for exception applies to only part of a trail, the rest of the trail must comply with all the technical requirements. (See Figure 8.2.)

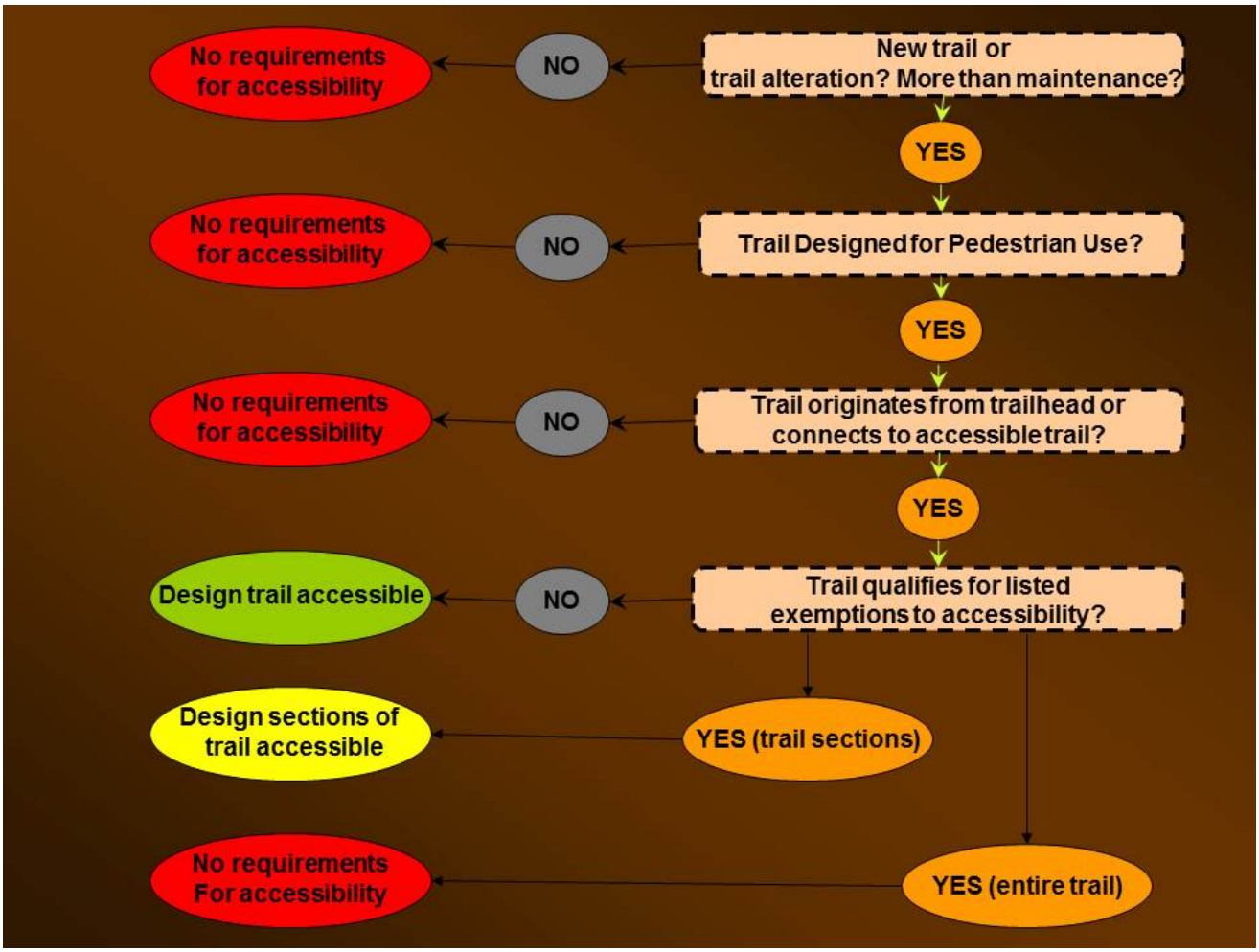

Figure 8.1 - Accessibility Compliance Determination Flow Chart

The following describes the four conditions for exceptions and provide examples of situations where they might apply.

8.3.1. Terrain

Compliance is not practicable due to terrain. An example of terrain that is infeasible to meet accessibility guidelines is a coastal descent trail where the elevation difference from the start to end points and a limited landbase for layout require the use of steeper grades or trail structures such as steps. These conditions also exist in areas where cliffs or steep terrain result in a substantial elevation difference between start and end points and a limited landbase for layout. In these circumstances, substantial control points prohibit the linear trail grade needed to comply with the accessibility guidelines and may require the use of trail structures that will serve as barriers to accessibility. (See Photo 8.1.)

Figure 8.2 - Portion of Trail Excluded from Compliance

8.3.1. Construction Practices

Compliance cannot be accomplished with the prevailing construction practices. An example of a construction practice that does not allow compliance is the exclusive use of unskilled volunteer labor to perform trail construction and maintenance. This labor force may not have the knowledge, skills, tools, or equipment to construct or reconstruct trails to meet the standards. (See Photo 8.2.)

Photo 8.1 - Infeasible Terrain

Photo 8.2 - Unskilled Volunteers Clearing a Trail

8.3.1.1. Change to Function or Purpose

Compliance will fundamentally alter the function or purpose of the facility or the setting. An example of altering the setting includes redesign and reconstruction of a trail designed for a primitive outdoor experience, such as access into a wilderness area or natural preserve. These trails are often narrow, have minimal structures, and provide the user with close contact to the surrounding environment. Widening and improving the trail tread and building additional structures to comply with accessibility guidelines will substantially alter the user's experience. (See Photo 8.3.)

Photo 8.3 - Trail Experience That Would Be Altered if Made Accessible

Another example of compliance that alters the purpose of the trail includes redesign or reconstruction of a trail that was intended to provide users with a rugged outdoor experience, such as a slick rock trail route in the southwest, boulder scrambling on the Appalachian Trail, or iron ladders ascending up rock faces in Acadia National Park. These trails are intended to provide visceral contact and experience with the environment. To comply with accessibility guidelines would require substantial widening, grade reduction, tread improvement, and trail structures. Again, the user experience would be altered or lost as a result of these changes. (See Photo 8.4.)

Photo 8.4 - Iron Ladder used to Assist Hikers Ascending a Rock Face

8.3.1.2. Existing Laws

Compliance is limited or precluded by law or by decisions or opinions issued or agreements executed pursuant to any of the following laws: Endangered Species Act; National Environmental Policy Act; National Historic Preservation Act; Wilderness Act; or other federal, state, or local law the purpose of which is to preserve threatened or endangered species, the environment, or archaeological, cultural, historical, or other significant natural features.

Examples of potential law violations include disturbance, removal, or alteration of pre-historic and historic cultural sites necessary to comply with accessibility standards. These sites include Native American middens, sacred sites, and ceremonial sites, and Euro American buildings, structures, historic sites, and religious sites. Typically these sites are listed or eligible for listing on national or state registers for historic places. (See Photo 8.5.)


Photo 8.5 - Cultural Features That Could Be Disturbed if Trail is Made Accessible

Other examples of potential law violations that would exempt a trail from compliance include the need to disturb, remove, or alter critical habitat for federal or state protected animal and/or plant species; the need to construct in fragile wetlands; the need to construct in animal breeding or rearing areas; and the need to remove or significantly alter natural features such as specimen trees, significant rock features, or viewsheds. (See Photos 8.6.)


Photo 8.6 - Listed Species - Spotted Owl (left) and Steelhead Trout (right)

8.3.2. Exceptions for an Entire Trail

When extreme or numerous conditions for exception make it impractical to construct a trail that complies with the technical requirements, the ABA standards provide an exemption for the entire trail. The exemption for an entire trail can only be used after applying the conditions for exception to portions of the trail. When determining

whether to exempt an entire trail, consider the portions of the trail that can and cannot comply with the specific provisions in the technical requirements and the extent of compliance where full compliance cannot be achieved. (See Figure 8.3.)

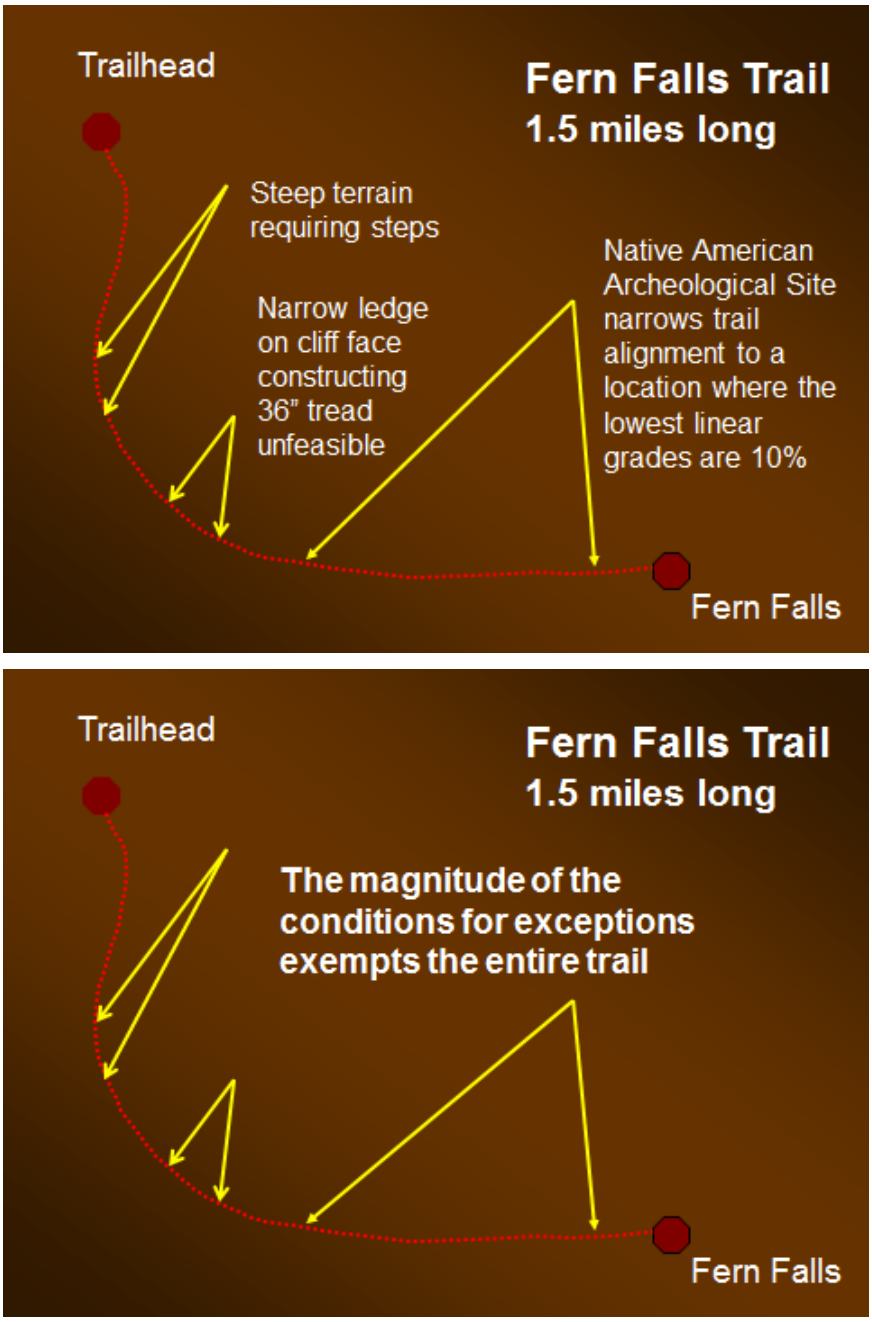

Figure 8.3 - Exception of the Entire Trail from Accessibility Compliance

8.4. Accessible Trail Standards

A summary of the ABA's standards for outdoor develop areas are provided below in Figure 8.4. See the Department's *Accessibility Guidelines* and the ABA *Accessibility Standards for Outdoor Developed Areas* for more details.

Summary of Accessibility Standards for Outdoor Developed Areas

Feature	Concrete, Asphalt, or Board Surfaced Trails	All Other Surface Types
Surface	Firm and Stable	Firm and Stable
A firm trail surface resists deformation by indentations. A stable trail surface is not permanently affected by expected weather conditions and can sustain normal wear and tear from the expected uses between planned maintenance.		
Clear Tread Minimum Width	36 inches	36 inches
If the trail is heavily used, a boardwalk, or otherwise not at the same elevation as the adjoining ground, consider providing either a minimum clear tread width of 60 inches, or, where the clear tread width is <60 inches, passing spaces at short intervals.		
Passing Space (Required Every 1,000 feet if tread width is less than 60 inches)		
Minimum Size	5 feet x 5 feet	5 feet x 5 feet
Maximum Grade	5%	5%
Maximum Cross Slope	2%	5%
Where the entire trail does not fully comply with these standards, a passing space that fully complies with the standards must be installed at the end of the trail segment to enable a person who uses a mobility device to turn around and return to the trailhead. The passing space shall be either: 1. A space a minimum of 60 inches x 60 inches; or 2. The intersection of two trails providing a T-shaped space, the base and the arms of which shall extend a minimum of 48 inches beyond the intersection. Where the passing space is the intersection of two trails, the intersection must be as flat as possible so that all of the wheels of a mobility device touch the ground when turning into and out of the passing space.		
Maximum Tread Obstacles	1/2 inch	2 inches
	(Tread obstacles on trails, passing spaces, and resting intervals are measured vertically to the highest point.)	
The vertical alignment of joints in concrete, asphalt, or board surfaces can be tread obstacles. Natural features such as tree roots and rocks within the trail tread can also be tread obstacles. Where possible, tread obstacles that cross the full width of the trail tread should be separated by a minimum distance of 48 inches.		

Figure 8.4 - Summary of Accessibility Standards for Outdoor Developed Areas

Feature	Concrete, Asphalt, or Board Surfaced Trails	All Other Surface Types
Openings		
Parallel	1/2 inch	1/2 inch
Perpendicular	1/2 inch	1/2 inch
Elongated openings should be placed so that the long dimension is perpendicular, or as close to perpendicular as possible, to the dominant direction of travel.		
Maximum Linear Grade		
5% or less	Any Distance	Any Distance
5% to 8.33%	200 feet	200 feet
8.33% to 10%	30 feet	30 feet
10% to 12%	10 feet	10 feet
Not more than 30% of the total length of a trail shall have a linear grade steeper than 1:12 (8.33%). The linear grade of any segment of a trail shall not be steeper than 1:8 (12%). Where the linear grade of a segment of a trail is steeper than 1:20 (5%), the maximum length of the segment shall be in accordance with the table above and a resting interval shall be provided at the top and bottom of each segment.		
Maximum Tread Cross Slope	2%	5%
Resting Interval between grades > 5%		
Linear Grade	2%	5%
Cross Slope	2%	5%
Where resting intervals are provided within the trail tread, they shall be at least as wide as the widest segment of trail leading to the resting interval. Where resting intervals are provided adjacent to the trail, the resting interval clear width shall be a minimum of 60 inches long and 36 inches wide. Where resting intervals are provided adjacent to the trail tread, a turning space shall be provided. Vertical alignment between the trail tread, turning space, and resting interval shall be level.		
Protruding Objects	Protruding objects on trails, passing spaces, and resting intervals can be hazardous for individuals who are blind or have low vision. Signs and other post-mounted objects are examples of constructed elements that can be protruding objects. The technical requirements for protruding objects do not apply to natural features, such as tree branches, rock formations, and trails that pass beneath rock ledges or through caves, because these are not constructed elements. Refer to the California Accessibility Guidelines Section 0.1, Accessibility Basics, VII Protruding Objects, for guidelines pertaining to constructed protruding objects.	

Figure 8.4 - Sum. of Accessibility Standards for Outdoor Developed Areas, cont.

8.5. Accessible Trailhead & Trail Facility Standards

A summary of the ABA's standards for trailheads and trail facilities are provided below:

8.5.1. Trailhead Signage

Trail information signs at trailheads shall include the following:

1. Length of the trail or trail segment;
2. Surface type;
3. Typical and minimum tread width;
4. Typical and maximum linear grade; and
5. Typical and maximum cross slope.

New trail information signs are required at trailheads on newly constructed and altered trails designed for use by pedestrians to comply with the applicable technical requirements for trailhead signs, regardless of whether the trail is accessible. Contact the Department's Accessibility Section for additional information on accessible trail signage. (See Photo 8.7.)

Photo 8.7 - Example of an Accessible Trail Sign

8.5.2. Viewing Areas

Exception: In alterations, when an entity determines that site conditions will not permit full compliance with a specific provision, the viewing area shall comply with the provision to the extent practicable.

Clear Ground Space: A clear ground space shall be provided at each distinct viewing location. The clear ground space shall be 36 inches x 48 inches minimum and shall be positioned for either a forward or parallel approach to the viewing location. One full, unobstructed side of the clear ground space shall adjoin or overlap an outdoor recreation access route or trail, as applicable, or another clear ground space.

Viewing Space: Each distinct viewing location shall provide a viewing space adjacent to the clear ground space through which the point of interest is viewable. The viewing space shall be between 32 inches and 51 inches above the ground and shall extend the full width of the clear ground space.

Exception: Guards or similar safety barriers shall be permitted to obstruct the viewing space to the extent the obstruction is necessary for the guard or safety barrier to serve its intended purpose.

Circular Turning Space: The turning space shall be a minimum of 60 inches in diameter.

T-shaped Turning Space: The turning space shall be a minimum of 60 inches square with arms and base a minimum of 36 inches wide. Each arm of the T shall be clear of obstructions for a minimum of 12 inches in each direction and the base shall be clear of obstructions for a minimum of 24 inches.

Surface: The surfaces of clear ground and turning spaces shall be firm and stable.

Grade: The slope of the surface of clear ground and turning spaces shall not be steeper than 1:48 in any direction.

Exception: Where the surface is other than asphalt, concrete, or boards, grades not steeper than 1:20 shall be permitted when necessary for drainage.

8.5.3. Outdoor Constructed Features at Trailheads

When outdoor, constructed features are provided at trailheads, at least 20% but not less than one of each feature shall be accessible. (See Photo 8.8.)


Photo 8.8 - Examples of Accessible Trailhead Features

8.5.4. Outdoor Constructed Features along Trails

When outdoor constructed features are provided along a trail, at least 20% but not less than one of each feature shall be accessible. For example, if ten benches are located along a trail, then at least two of those benches need to be accessible. If one bench is located along a trail, then that bench needs to be accessible. (See Photo 8.9.)


Photo 8.9 - Examples of Accessible Trailside Features

8.6. Determining the Validity of Conditions for Exceptions Use

Only by following the trail planning, layout, and design processes discussed in Chapter 3, *Planning and Environmental Compliance,* and Chapter 5, *Principles of Trail Layout and Design,* can exceptions be validated. By following these processes, the trail designer discovers the applicable laws and regulations that prohibit compliance with

accessibility requirements. They will also identify any traditional design, trail use, and prevailing construction practices that may prevent compliance. During trail layout and design, the trail designers locate all natural, cultural, topographic, and designed control points. They also identify any trail conditions that qualify for exceptions. This information, along with maximum sustainable grades and linear grades between control points, will determine the feasibility of complying with accessibility standards. The process should be well documented and included in the environmental review documents. These documents are reviewed and approved by the Department's Accessibility Section.

Conditional departures and exceptions allow land managers to comply with applicable laws and regulations, protect natural and cultural resources, and retain long established traditions. They are not set up to avoid providing access to people with disabilities. It is the professional and moral responsibility of every trail designer to provide accessibility whenever possible.

8.7. Other Power Driven Mobility Devices

The U.S. Department of Justice amended the language in Title 2 of the Americans with Disabilities Act to include another category of mobility aids known as Other Power Driven Mobility Devices (OPDMD). (See Photo 8.10.) OPDMDs are any of a large range of devices powered by batteries, fuel, or other engines, whether or not designed solely for use by individuals with mobility impairments, that are used by individuals with mobility impairments for the purpose of locomotion, including golf carts, bicycles, electronic personal assistance mobility devices, or any mobility aid designed to operate in areas without defined pedestrian routes.

Photo 8.10 - Examples of OPDMDs

The revised law directs public entities to make reasonable modifications in its policies, practices, and procedures to permit the use of OPDMDs by individuals with mobility disabilities. To comply with the revised law and effectively address the legitimate needs of people with mobility disabilities while protecting the fundamental nature of our mission and programs, the Department has adopted the following policy in regard to the permissible uses of such devices.

OPDMDs may be used in any unit of the California state park system under the following conditions:

8.7.1. Types of OPDMD

Any OPDMD operated in California State Parks under this rule shall meet the following standards:

- **Size:** OPDMD shall not be wider than 36 inches or longer than 48 inches.
- **Weight:** The overall weight of the device and user(s) shall not exceed 550 pounds.
- **Speed:** OPDMD shall not be operated at speeds in excess of 5 miles per hour.
- **Noise:** OPDMD shall not produce noise levels in excess of 70 decibels.
- **Emissions:** OPDMD shall not exceed zero emissions during use.

8.7.2. Areas of Authorized Use

OPDMDs that meet the above criteria are allowed in the following locations within state park units:

- Class 1 designated trails that are either designated accessible or multi-use;
- Exterior routes of travel designed for pedestrian use within developed public use areas; and
- Controlled access roads such as fire roads.

Park staff should be prepared to inform visitors where they may use OPDMDs. Park staff should review park brochures and maps to identify the areas where OPDMDs may be used. It may be helpful to visitors to highlight on a map the areas where visitors may go with an OPDMD. In addition, remind visitors that the OPDMD must not exceed 5 miles per hour. It is anticipated that people with mobility disabilities will endeavor to use OPDMDs on recreational routes and will be primarily interested in where use is allowed on hiking trails and fire roads. However, where appropriate, the use of OPDMDs should be allowed on access routes within campground and picnic areas, such as accessibly designed routes between campsites and restrooms.

8.7.3. Deviations to Allowable Use

OPDMDs that do not meet the criteria for the types of devices that are allowed shall not be allowed in any state park unit outdoor facility or route until a formal written request for OPDMD deviation is submitted to the district and written approval of that request is granted. Similarly, OPDMDs that do meet the criteria for type but whose use is being requested in a location not listed under the areas of authorized use will not be allowed to use the state park unit outdoor facility or route until a formal written request for change of use is submitted to the district for which the use is desired and approval of that request is granted. The OPDMD deviation process shall be implemented in making these determinations.

8.7.4. Implementation Guidelines

The implementation of this policy will be through the use of the District Superintendent's Order, pursuant to Public Resources Code §5003, and Title 14 of the California Code of Regulations (CCR) 4326. Park staff should be aware of the policy and contents of the Superintendent's Order regarding the use of OPDMDs in their parks. Further, staff should be prepared to advise visitors with disabilities where they may use their OPDMDs as well as the procedures for submitting a formal request for an OPDMD deviation.

8.7.5. Posting Information

The Superintendent's Order, including information about types of OPDMD allowed and areas where they may be used, is to be posted at visitor information areas, on park web pages, and in district and sector offices. Once a Superintendent's Order is posted in accordance with Department policy, copies of the order, including information on specific routes where OPDMDs are allowed, should be transmitted to the Department's Accessibility Section so that accurate information can be provided to visitors who call the Department's Accessibility Hotline.

8.7.6. Validating Mobility Disabilities

A mobility disability is a condition that prevents, inhibits, or restricts a person's ability to move about. This type of disability is not always obvious because a heart condition, diabetes, or other invisible condition can limit a person's ability to walk. Mobility disabilities differ from other types of disabilities such as hearing impairment or mental or cognitive disabilities. All users of OPDMDs may be asked to provide credible assurance that the mobility device is required because of their disability. "Credible assurance" includes a National Park Service or Federal Recreational Lands Access Pass or any state's valid disabled parking placard or card assigned to the person who will be using the OPDMD. However, if a person does not have a state-issued placard or card, employees must accept as a credible assurance a verbal representation, not contradicted by observable fact, that the OPDMD is being used for a mobility disability.

8.7.7. Verifying Device

After staff have assurance that a visitor with an OPDMD has a mobility disability, they should verify that the OPDMD meets the criteria for types of devices allowed. Staff should use common sense when determining the appropriateness of the device; it is not necessary or reasonable to go to extensive lengths to weigh the device or measure noise output. If staff have concerns that the device does not meet the criteria for allowable use, they should contact a State Park Peace Officer who will make the final determination.

Wheelchairs are manual or power driven devices that are designed primarily for use by individuals with mobility disabilities for the main purpose of indoor and outdoor

locomotion. Wheelchairs should not be scrutinized under this policy and are permitted to be used wherever pedestrians are allowed. (See Figure 8.5.)

Mode	Examples
Wheelchair	• Manual or battery powered wheelchair • Three or more wheeled electric chair • Three or more wheeled electric scooter
OPDMD	• Segway • All-Terrain Vehicles (ATV) • Golf Cart • Combustion engine powered mobility devices • Two wheeled scooter • Powered bicycle

Figure 8.5 - Examples of Wheelchairs and OPDMDs

8.8. Additional Trail Design Considerations

Understanding the needs and limitations of the intended trail user is critical in designing trails. There is a broad range of potential mobility problems from severe ambulatory restrictions that require specialized breath-activated powered wheelchairs, to less severe impairments that make it difficult to walk up or down steps, steep grades, or rough, irregular ground. Users with visual impairments and no ambulatory restrictions may have difficulty negotiating trails with protruding objects and irregular tread or other barriers. Accessible trail design provides a reasonable level of independent access for trail users with a variety of disabilities.

Users with disabilities want the same outdoor experience as other trail users. Highly developed asphalt or concrete trails located on flat ground behind the visitor center or in the campground may be desirable for some users with a disability, however, these types of accessible trails are designed and constructed using traditional methods of the “built environment”. They often do not provide access to the primary resources that visitors are seeking. The building materials, colors, textures, and defined edges of these paths contrast with the surrounding environment and perceptually separate the user from that environment. The challenge for the designer is to develop an accessible trail that provides intimate access to high quality resources in a fashion that is seamless with the environment. (See Photo 8.11.)

The common hospital-style wheelchair provided by health care organizations to people with mobility impairments is very functional in the built environment, but limited in the outdoor environment. These chairs have narrow, smooth tires that limit their flotation and traction on soft, smooth, or slick surfaces. Their suspension consists of a single axle for the rear wheels and small castors in front. This suspension design causes the chair to pull toward the downhill side of the trail, and the user must correct this pull by turning the chair toward the upper side of the trail. Once it reaches the upper side, the chair straightens until it is gradually pulled to the downhill side of the trail and the

process begins again. This zigzag motion requires more trail width and more effort from the user. (See Photo 8.12.)

Photo 8.11 - Accessible Trails that Provide an Intimate Experience

Photo 8.12 - Wheelchair Pulled to the Outside of the Trail

When the trail combines linear grade, cross slope, and a change in direction, the wheelchair is pulled even more to the outside edge of the trail. The user in the wheelchair has to keep it from drifting to the edge of the trail. (See Photo 8.13.) This condition can be offset by widening the trail tread, improving the trail surface, or installing edge protection.

Photo 8.13 - Combination of Linear Grade, Cross Slope, and Change of Direction

The braking system on hospital wheelchairs consists of the user grabbing the rim of the rear wheels and applying pressure with their hands. This system is a poor braking method on steep grades.

Many Americans with disabilities do not have the financial resources to purchase another style of wheelchair with better outdoor capabilities. Designers must account for how the common hospital-style wheelchair performs on trails.

The accessible trail standards have some commonalities with resource protection and sustainable trail design discussed in this handbook, including:

- Curvilinear alignment to produce a sustainable trail and a moderate linear grade.
- A moderate linear grade for less erosion, greater sustainability, and higher accessibility potential.
- A firm, stable, and uniform tread surface to promote sheet drainage, reduce tread deformation and soil saturation, and improve access.
- A tread surface with a high coefficient of friction for a safe and pleasurable user experience and improved accessibility.

Coefficient of friction is the ratio of frictional force between two surfaces in contact with each other. On accessible trails, a high coefficient of friction creates better traction between the wheels of the mobility assistive device and the trail tread. The tread

surface needs to be firm and stable and have a rough texture to provide this level of traction, especially when the trail surface is wet or covered with leaf litter.

There are also several conflicts between accessibility, resource protection, and trail sustainability requirements. A summary of these conflicts is outlined in the table below. (See Figure 8.6.)

Trail Design Criteria	Accessibility Concerns	Resource Protection Concerns	Trail Sustainability Concerns
Linear Grade	Steep linear grades are difficult to traverse depending on the assistive device.	Low linear grades require long trail alignments and more land disturbance.	Low linear grades may require engineered structures and increase construction and maintenance costs.
Trail Width	Narrow trail widths (less than 36") do not accommodate most wheeled assistive devices.	Wide tread widths increase the size of the trail's footprint .	Wide trail widths increase trail construction and maintenance costs.
Trail Tread	Trail tread with a low coefficient of friction does not provide traction necessary for many assistive devices.	Hardened tread surfaces may impact vegetation, change the character of the land or the user's experience.	Hardening the tread surface increases construction and maintenance costs.
Trail Edge	A steep drop-off along the trail's edge may create a safety issue.	Edge protection may interrupt sheetflow and change the character of the land or the user's experience.	Providing edge protection increases costs, inhibits sheetflow, and causes surface erosion.
Linear Grades & Cross Slopes	Steep linear grades, when combined with high cross slopes and a change of direction, cause wheeled assistive devices to track off the trail.	Low linear grades, wide tread widths, engineered structures, and hardened tread surfaces increase the trail's impact on the resources.	Low cross slopes and edge protection reduce sheetflow and increase erosion and trail maintenance.

Figure 8.6 - Conflicts Between Accessibility and Resource Protection

Trail Design Criteria	Accessibility Concerns	Resource Protection Concerns	Trail Sustainability Concerns
Trail Structures	Traditional trail structures such as steps, water bars, and open culverts represent barriers to accessibility.	Engineered structures and hardened tread surfaces increase the trail's impact on the resources.	If the original trail layout did not follow proper curvilinear alignment, then removing drainage structures could result in an accelerated deterioration of the trail unless the trail alignment is rerouted to correct drainage problems.
Trail Obstacles	Obstacles in the trail tread such as roots and rocks may create barriers to accessibility. Vertical obstructions such as tree limbs and overhanging trees may create barriers to accessibility and hazardous conditions.	Removing all overhead limbs may sterilize the trail and reduce its character and aesthetic appeal.	Removal of obstacles in the trail tread or covering them with aggregate/soil may improve the trail's sustainability by improving surface drainage and impacts to roots of adjacent vegetation

Figure 8.6 - Conflicts Between Accessibility and Resource Protection, cont.

When redesigning an existing trail or designing a new trail to meet accessibility requirements, the designer should follow this process below.

1. Thoroughly research and evaluate the landform for potential trail routes, resource concerns, boundary issues, land use capabilities, and political constraints. (See Chapter 3 *Planning and Environmental Compliance,* and Chapter 5, *Principles of Trail Layout and Design.*)

2. Evaluate the existing trail to determine if the initial layout and construction was fundamentally sound. Trail conditions with resource damage and sustainability problems reflect poor trail design and construction. These problems are due to an incomplete understanding of the landbase, and its capabilities and limitations. Neglecting to layout a trail that accommodates major and minor control points (locations the trail has to connect to or avoid), ignoring curvilinear alignment

principles, and constructing trails that disrupt the surface and shallow groundwater flows will lead to future maintenance problems. These deficiencies need to be corrected as a standard practice in trail design and reconstruction. Designing to incorporate and anticipate resource protection and sustainability issues significantly enhances a trail's potential for accessibility.

3. Once major and minor control points are established, the linear grade between those control points is identified and compared with the maximum sustainable grade for the landform and the linear grade required by accessibility standards.

4. If no conditions for exception apply and if linear grades between the control points are within accessibility standards and the maximum sustainable grade, the trail can be realigned between the control points. New trail alignments and reroutes will incorporate curvilinear layout and maximize hillside construction. All abandoned trail segments are fully rehabilitated by re-contouring the trail bed and re-vegetating the former tread and excavated area with plants salvaged from the new alignment.

5. If the linear grade between control points is in excess of accessibility standards, evaluate minor control points to determine if they can be modified to reduce the linear grade. Examples of potential modifications include: (1) constructing a retaining wall under a large tree (minor control) to allow the trail to pass under and reduce the linear grade; (2) lengthening a bridge at a stream crossing (minor control) to elevate the approaching trail grade and reduce the linear grade; or (3) excavating the trail bed through a rock outcrop to keep the linear grade within compliance. (See Photos 8.14 and 8.15.) If minor controls cannot be modified without encountering one of the conditions for exception, evaluate the landbase to determine if additional linear grade can be achieved through the use of properly placed topographic turns, climbing turns, or switchbacks.

6. If minor control point modifications or turns cannot be achieved to reduce the linear grade, the segments of trail that do not comply with the accessibility standards will meet the "not feasible due to terrain" condition for exception. However, every effort should be made to achieve the lowest linear grades possible for these segments and they still should be constructed or reconstructed to comply with the standards that can be met (e.g., tread width, cross slope, tread firmness and stability, and overhead clearance).

7. Trail redesign and reconstruction efforts should focus on the simplest solution and graduate to the more complex, as needed.

Photo 8.14 - Use of Retaining Walls to Maintain Linear Grade and Protect Trees

Photo 8.15 - Use of Bridges to Maintain Linear Grade and Span Low Areas

8.8.1. Tread Width and Surface

Trail segments with minor bench and surface deficiencies are reconstructed to obtain a uniform linear grade and outslope. Locations where the tread surface fails to meet firmness and stability requirements are augmented with trail hardening techniques that produce a firm and stable trail surface that closely matches the color and texture of the native soils. The material should also provide a good coefficient of friction during wet conditions, as well as when the trail is littered with organic material. It should allow water to percolate through and evaporate off to minimize seasonal resource impacts. The material should be simple to install, long lasting, sustainable, and easy to maintain. (See Photo 8.16.)

8.8.2. Obstacles in the Tread Surface

Remove rocks and small roots from the tread surface to provide a uniform and smooth trail tread. Large roots are covered or capped with crushed rock and native soil to bridge over the obstacles ("turnpiked"). (See Photo 8.17.)

Aggregate installation

Completed trail surface

Photo 8.16 - Installing Crushed Aggregate with Native Soil to Harden Trail Tread

Exposed roots prior to aggregate and soil installation

Trail surface after aggregate and soil installation over roots

Photo 8.17 - Bridging Over Roots with Crushed Aggregate and Native Soil

8.8.3. Vertical Clearance in the Trail Corridor

Protruding limbs or trees spanning the trail corridor are removed if they do not comply with accessibility guidelines and their removal does not adversely impact the resource or the user experience. Slight trail realignments can be made instead if adjusting the trail route a few feet provides the proper clearance. Raised edges are installed or vegetation is used along the side of the trail to guide users with visual

impairment along the trail. When possible, edges are elevated to allow sheet drainage to flow underneath the edging. The trail should be rerouted when a significant number of downed trees are encountered, if a route can be identified that still provides the user with an up-close, tactile experience wherever possible. (See Photo 8.18.)

Photo 8.18 - Aligning Trail to Provide Required Overhead Clearance

8.8.4. Combinations of Linear Grade and Cross Slope

Where the linear grade is steep (8% to 10%) and the cross slope is 4 to 5%, consider widening the trail between 48 and 60 inches where possible, and hardening the trail surface to increase the coefficient of friction. (See Photo 8.19.)

Photo 8.19 - Example of Widening and Hardening Trail Tread

8.8.5. Combination of Linear Grade, Cross Slope, and Change of Direction

Consider widening the trail tread to between 48 and 60 inches where possible; improving the tread surface by using a hardening technique to increase the coefficient of friction; and installing edge protection along the radius of the turn if site conditions dictate. (See Photo 8.20.)

Photo 8.20 - Installing Edge Protection on Outside of Turn

8.8.6. Edge Protection

Edge protection consists of an elevated barrier to prevent users from going over the edge of the trail. Consider edge protection at locations where there is (1) a steep hazardous drop-off along the outer edge of the trail; (2) a steep linear grade, cross slope, or a precipitous drop-off; or (3) a combination of steep linear grade, cross slope, and change of direction. Site specific evaluations will determine potential safety risks and recommend proper design solutions. Consistent treatment of safety issues should occur along the trail. Edge protection may consist of native vegetation (if strong enough to restrain the user); logs or large tree limbs securely fastened to the ground; large rocks firmly attached to the ground or incorporated into a multi-tier retaining wall; or a combination of horizontal rails, diagonal rails, and bull rails on bridges and puncheons/boardwalks. All edge protection is installed to allow for overland sheet flow and to blend in with the natural surroundings. Edge protection is only installed where it is needed and its application is uniform and consistent across the trail system. (See Photos 8.21 and 8.22.)

Photo 8.21 - Native Vegetation (chemise and manzanita) for Edge Protection

Photo 8.22 - Using Native Materials to Provide Edge Protection

8.8.7. Watercourse Crossings

Small watercourses can be traversed by installing armored crossings (cobblestones), drain lenses, or culverts (See Chapter 14, *Drainage Structures*). (See Photo 8.23.) Low volume perennial watercourses are crossed using puncheons or boardwalks. Bridges are constructed to cross large perennial streams. These structures must be designed to have a final elevation at trail grade and meet linear grade, cross slope, tread obstacle, and clear space opening requirements. Puncheons and bridges should have edge protection. When the trail grade approaching a watercourse crossing is too steep to comply with accessibility standards, puncheons, boardwalks, and bridges can be elevated and lengthened to reduce the approaching trail grade and bring it into compliance. (See Photo 8.24.)

Photo 8.23 - Armored Crossing (top left), Culvert (top right), and Drain Lens (bottom)

Photo 8.24 - Puncheon (top left), Boardwalk (top right), and Bridge (bottom)

8.8.8. Aesthetics

During construction, every attempt is made to match the building materials to the natural environment and local architecture. Native materials such as rocks, logs, and soil are used to the extent practical. If synthetic materials are used (cellular confinement and geotextile fabric), they are covered by native soil and vegetation. Applying the principles of curvilinear alignment, the trail should have an element of sinuosity, and its edges should be irregular and non-linear. Every attempt is made to create a finished trail that is seamless with the natural environment, providing a quality outdoor experience. (See Photo 8.25.)

Photo 8.25 - Use of Sinuosity and Soft Irregular Edges

8.9. Firmness and Stability

An important requirement for accessible trails is that the tread surface be firm and stable. This requirement is essential because trail surfaces that are soft and easily displaced require more effort to traverse, are more difficult to maintain to standard, and have a higher safety risk. Users with disabilities expend substantially more energy traversing loose and unconsolidated soil than firm and stable soil. A loose and unconsolidated surface, when combined with a moderate linear grade and cross slope, is also slippery and difficult to negotiate. These conditions can cause one to fall or lose control of a mobility assistive device. The U.S. Access Board defines a firm and stable trail as follows.

> *A firm trail surface resists deformation by indentations. A stable trail surface is not permanently affected by expected weather conditions and can sustain normal wear and tear from the expected uses between planned maintenance.*

During construction it can be difficult to determine whether these conditions have been achieved. A more precise method for determining the firmness and stability of the trail tread is to test it with a rotational penetrometer. (See Photo 8.26.)

Photo 8.26 - Rotational Penetrometer

"Firmness" refers to the penetration of the surface when a foot or mobility assistive device applies downward force on the trail tread. "Stability" refers to the displacement of the surface when a foot or mobility assistive device rotates on the surface. Measurements conducted with a penetrometer must be performed during different seasons to ensure that tread conditions do not change as a result of soil moisture variations. The recommended penetration depths for firmness and stability are a maximum penetration of 0.3 inch or less for firmness and 0.5 inch or less for stability.

8.10. Soil Stabilizers and Hardeners

Some native soil may comply with accessibility standards, but most will not. Native soil rarely has the combination of fractured rock, rock gradation, and soil plasticity to provide year-round durability and cohesion, and meet the firmness and stability requirements for accessible trails. Furthermore, soil types frequently vary along the trail alignment, and not all soil will meet the requirements. The designer must often augment or replace native soil with stabilizing or hardening material. Selecting the appropriate stabilizer or hardening application requires an understanding of the various soil types. The designer evaluates products and methods using the following criteria.

8.10.1. Installation

What level of knowledge, skill, equipment, environmental conditions, and logistic support are required to install the stabilizer? The designer must match the stabilizer to the trail program and workforce capability. Some products can be installed by unskilled labor such as volunteer, youth program, or inmate crews. Others require skilled crews or contractors. Equipment support for most stabilizers is as simple as

a wheelbarrow, hand tools, and vibratory plate compactor, while others require a batch plant, hopper/mixer, loader, powered toter, paving machine, and roller. Some products can be installed in almost any weather conditions, while others have temperature and moisture limitations. Some products can be installed a long distance from the trailhead, while others are more limited due to short curing times and transportation issues.

8.10.2. Product Limitations

Regional climatic conditions and vegetation types affect the performance of stabilizers. Freeze-thaw, frost heave, dry-arid, and low humidity or high rainfall/humidity can influence the behavior and sustainability of a soil stabilizer. Vegetation growing next to the trail will also affect a stabilizer's performance. Rigid products will crack and buckle when exposed to frost heave conditions or roots pushing underneath the trail bed. Stabilizers are also subject to damage in wet-freezing conditions. Other products can lose their cohesiveness when exposed to dry-arid or wet-humid weather.

8.10.3. Cost of Installation

The cost of installing stabilization products varies considerably. The total cost includes materials, labor, and equipment. Material costs include the stabilizer itself, imported soil or aggregate, and cribbing. Labor and equipment costs vary with installation protocols.

8.10.4. Resource Impacts

Application of stabilizers can be detrimental to surrounding resources. Non-permeable products stop the percolation and evaporation of water through the trail tread, which affects the roots of adjacent trees by eliminating mycorrhizal fungus in the soil and causing roots to wither and die back. Some stabilizers leech into the surrounding soil, changing the pH and adversely affecting vegetation.

8.10.5. Maintenance Requirements

Frequency and ease of maintenance vary among stabilizers. Some require frequent application of seal coats to maintain performance. Other products are difficult to repair once they fail because the entire defective segment must be removed and replaced. These repairs can be unsightly, as the new color and texture may not match the rest of the trail. Other products can be repaired relatively easily by de-compacting problem areas, adding new material, and reshaping/compacting the repaired area without changing the color or texture of the trail tread.

8.10.6. Appearance and Aesthetic Appeal

When used with native soil, stabilizers can closely match the color and texture of the surrounding environment. Without native soil, stabilizers can present a stark contrast to the surrounding environment and distract the user, which does not provide a quality outdoor experience.

8.10.7. Product Performance

Traditional methods of stabilizing trail tread, such as rip rap, turnpikes, causeways, boardwalks, and aggregate, have been widely successful. Soil cement, lime base treatment, concrete, and asphalt have also been used to stabilize trail tread for many years. These products have had mixed results and are used on short accessible trails near developed areas.

Over the past 20 years, the number of soil stabilization products has increased. There are dozens to choose from, but most of them have not been around long enough to evaluate their performance. Although these products each have their own individual chemistry, they can be loosely grouped into pine tar resins, polymers, latex polymers, enzymes, and polyurethanes. Many of the modern stabilizers have been removed from the market or reformulated due to poor performance. Several studies have evaluated the performance of these stabilizers. For the most part, they conclude that these products are difficult and expensive to install, have geographic and climate limitations, require more maintenance than native material, and lack durability. Several do, however, blend in well with the surrounding environment. (See Figure 8.7.)

	Install			Limits			Cost			Resource			Maintenance			Durability			Aesthetics		
Stabilizer	P	M	G	P	M	G	P	M	G	P	M	G	P	M	G	P	M	G	P	M	G
Stone Pitching/Rock Armoring	x				x		x					x			x			x			x
Causeway/ Turnpike		x			x			x				x		x				x			x
Aggregate (crushed rock)			x		x			x				x			x			x			x
Boardwalk		x				x	x					x		x			x			x	
Soil Cement	x			x			x			x			x			x				x	
Lime Base		x		x				x		x				x		x					x
Concrete	x			x			x			x				x				x	x		
Asphalt	x			x			x			x				x				x	x		
Pine Tar Resin	x				x		x			x			x			x					x
Polymers	x				x		x			x			x			x					x
Latex Polymers	x				x		x			x			x			x					x
Enzymes		x			x			x			x			x			x				x
Polyurethanes	x				x		x			x			x			x					x

Rating Legend

P = Poor (*Installation* : difficult; *Limits* : limited applications; *Cost* : expensive; *Resource* : potential resource impact; *Maintenance* : high; *Durability* : low; *Aesthetics* : poor.)

M = Moderate (*Installation* : somewhat easy; *Limits* : works in most applications; *Cost* : moderate; *Resource* : few potential impacts; *Maintenance* : moderate requirements; *Durability* : good; *Aesthetics* : fair.)

G = Good (*Installation* : easy; *Limits* : works in all applications; *Cost* : low; *Resource* : no potential impact; *Maintenance* : low; *Durability* : good; *Aesthetics* : good.)

Figure 8.7 - Stabilizer Performance Comparison Chart