PORTLAND OFF-ROAD CYCLING MASTER PLAN

Task 3.3

Survey of Design, Planning and Management

Best Practices for Off-Road Cycling Facilities

DRAFT

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Overview

This report presents existing best practices for planning, designing and managing trails, trail systems, and riding facilities in major urban metro areas. Best practices are methods, techniques, or processes considered standard by an industry because they consistently result in desired outcomes.

The purpose of identifying off-road cycling best practices as part of the Portland Off-Road Cycling Master Plan is to support the plan's goal to lay a foundation for how off-road cycling is planned for in Portland; limit impacts on natural resources; and to promote the health, safety and enjoyment of trail and park users. As such, this Assessment of Off-Road Cycling Impacts examines the impacts, both negative impacts and potential benefits, of off-road cycling in three areas: the environment, health and safety of park and trail users, and the City's economic activity and tourism.

This document includes best practices from published sources, professional experts and case studies. The best practices included in this report are intended to inform the Portland Off-road Cycling Master Plan, and provide a framework for more detailed project- and context-specific best practices for the planning, design and construction of any future off-road cycling trails or facilities.

Summary of Planning, Design and Management Best Practices

Over the past 20 years, mountain biking has become recognized as a mainstream recreational activity. Park and recreation and land management agencies have responded to the popularity of off-road cycling on trail networks and in bike parks by actively managing, planning, and designing off-road facilities to maximize user benefits and minimize negative impacts to the environment in which they are sited.

The best practices listed in this document have become common practice among park and recreation and land management agencies and are based on an approach based in sustainability, from both an environmental as well as a social standpoint. Sustainable trail facilities are being planned and designed to meet multiple objectives: to meet the needs of the users and provide progressive experiences; to protect ecological health; and to be long lasting, low risk, require minimal maintenance and discourage unsanctioned trail building, which may cause degradation.

Ideally, trail planning, design, and management techniques are informed by research. However, the body of research pertaining to the impacts of off-road cycling is not entirely comprehensive. As such, this document forwards best practices intended to avoid or minimize impacts, based on both research and the experience of facility designers, builders and managers. These best practices, informed in part from established trails-specific practices and expert judgement from lessons learned, continue to be refined as riding styles and trends change over time, building techniques progress, and additional facilities are built. In addition, this document supports monitoring and adaptive management trail systems and facilities to ensure that any unintended impacts are accounted for and remediated.

Key Resources

The International Mountain Bicycling Association's books *Trail Solutions: IMBA's Guide to Building Sweet Singletrack* (2004) and *Managing Mountain Biking: IMBA's Guide to Providing Great Riding* (2007) are recognized resources of design and management practices to reduce user conflict, minimize environmental impact, manage risk and provide technically challenging trail experiences for riders of all levels. The U.S. Forest Service *Trail Construction and Management Notebook* (2007) references IMBA's guide as a trail construction resource. Another comprehensive resource for trails planning, design and maintenance is the Metro *Green Trails Guidelines for Environmentally Friendly Trails* (2016); though it has some limitations as it was not written explicitly for trails allowing mountain biking. The Minnesota Department of Natural Resources book *Trail Planning, Design and Development Guidelines* (2007) provides an additional resource.

Section 1: Best Practices for System Planning

The City of Portland strives to provide safe, equitably distributed recreational opportunities for all residents. The system planning process for this project aims to align with the Parks 2020 Vision, Portland Parks & Recreation (PP&R) strategic plan. The following best practices represent the core concepts embodied in Parks 2020, including providing a wide variety of recreation opportunities for all residents, developing a sustainable network of facilities to ensure PP&R's legacy for future generations, and preserving and protecting natural resources to provide "nature in the city".

The best practices for system planning described below should be used to guide the Portland Off-road Cycling Master Plan itself, as well as any future system plans for off-road cycling trails and facilities.

Community Outreach and Engagement

Early and effective community outreach and engagement with the local park users, including the off-road cycling community, park neighbors, and the general public is a critical part of successful off-road cycling trail and facility planning and development. In Portland, such engagement should follow the guidelines of the City's, Portland Parks & Recreation, and/or another appropriate agency's public involvement principles. .

Planners should pay concerted attention to early and meaningful involvement of stakeholders who are likely to be impacted by the plan or development, but may normally have little influence in the decision or outcome. This is particularly true for historically underrepresented communities, including communities of color, immigrant and refugee communities, and community members with disabilities, as well as youth.

Planning and development projects should also include outreach to affected public agencies, relevant City committees, and decision-makers. Coupled with traditional outreach mechanisms to reach the broad general public, such as open houses, community tabling events, online surveys, mailings and social media, partnerships with community based organizations can offer a mechanism to authentically engage those traditionally hard to reach communities and provide a voice to those whom may have a unique perspective to offer in terms of the project plans.

This type of comprehensive community engagement not only provides an opportunity for the project team to understand the community's needs and desires related to off-road cycling, it provides an opportunity for the public to weigh-in and influence the outcomes of the project in order to best meet the needs of the community. Engaging the community from the start with information and meaningful interactions forwards the development of a unified project vision and a high level of community coordination and collaboration.

Case Study

Cully Park: Portland, OR

The Cully neighborhood is one of Portland's most culturally diverse and park-deprived areas,

home to more than 13,000 residents with a mix of commercial and relatively dense residential development. In 2015, this underserved neighborhood opened its first park facility. A unique partnership between the City, Verde, and the Cully Association of Neighbors resulted in a collaborative design and master planning effort between Portland Parks & Recreation, the Cully community, and the Project Advisory Committee. This partnership resulted in direct community participation in the design, fundraising, and development of the park.

Case Study

Community Engagement Planning: Minneapolis, MN

The Minneapolis Park & Recreation Board developed a Community Engagement Plan to codify the protocol for community outreach, noticing and engagement on new park projects. The plan included key goals and protocol for park planners that included:

- Identification of whom to engage on new projects: neighborhood organizations and other representative community groups and individuals.
- Promoting a culture of openness and learning.
- Providing opportunities for diverse ideas and information to influence the development and implementation of park projects.
- Use of available and emerging technology, including social media for outreach and engagement.
- Establishing a Technical and/or Community Advisory Committee.
- Public Noticing protocol including minimum number of days to send notices prior to meetings and minimum geographic area (e.g. citizens living within ¼ mile of the project area will be noticed).

Creating an Integrated System

Distribution of Facilities

Facilities should be distributed to meet citywide needs. Ideally, municipalities can provide local off-road cycling facilities to reduce barriers to use and allow for convenient bicycle or public transit transportation to the facility. Convenient access contributes to greater use of facilities which in turn supports a healthy and active community.

Distribution of Users

Off-road cycling facilities that are overwhelmed by users are an indication of demand and the need for additional facilities. Overuse of facilities, by off-road cyclists or a combination of multiple user groups, can cause environmental damage, increase maintenance needs, and result in safety hazards. Distributing users throughout a system of trails and facilities and/or among individual trails or bike park facilities typically results in greater social and environmental sustainability.

Providing a Range of Experiences

Facilities should provide a range of off-road cycling experiences for all ages and skill levels. This range of experiences can be provided within an overall trail and facility system or, ideally, within each trail

system and facility itself. The range and scale of experiences provided should be based on an understanding of the local user demand, need and regional trends in off-road cycling. These variables are critical to determining how to plan, design and manage facilities appropriately. Performing user surveys and community engagement are essential in understanding local demand, gaps and need. This is true for trail and bike park facilities.

Integrating into a Regional System

An off-road cycling system distributes facilities and users across the City, creating a network of sustainable off-road cycling trails and facilities to meet identified needs at a range of scales, from neighborhood-oriented to serving a broad area. In this way, the City's system integrates into a regional system, where facilities exist within and outside the City to provide a variety of experiences and riding opportunities for a range of cyclists. Ideally, these systems should be linked together through on-street bicycle facilities, off-road cycling trails, and/or public transit.

Site Suitability

Building on the core planning concepts above, the identification and evaluation of candidate sites for off-road cycling should be based on a citywide-scale opportunities and constraints analysis. The suitability analysis should address a range of criteria from ownership, land use, and zoning parameters and restrictions related to the ecological, historical, cultural resource characteristics on each site. The suitability analysis should also attempt to maximize opportunities to address community needs and reach underserved areas. This analysis process will likely require utilizing an interdisciplinary technical team of design and planning professionals, natural resource scientists and operations and maintenance specialists.

Section 2: Best Practices for Facility Planning

The following best practices address facility planning, which encompasses design, operations and programming planning. Once system planning is complete, these best practices guide site specific planning, development and management efforts for individual sites identified in the system plan. These best practices complement public involvement and master planning practices employed by Portland Parks & Recreation and other City agencies.

Site Assessment and Feasibility Studies

Successful park development begins with a thorough site assessment and feasibility study. Feasibility studies provide critical information used to determine a project's goals and objectives, opportunities and constraints, and conceptual design, costs and timeframe for development. This stage is critical to successful design, planning, construction and ongoing operation of the park. A feasibility study should include initial project meetings with park staff, local user groups, and other interested stakeholders. It should also include an assessment of environmental resources, constraints and capacity of the site; evaluation criteria analyses; and analyses of the project's strengths, weaknesses, opportunities and threats (risks) in order to be able to address any agency and community questions and concerns.

Site-specific Community Engagement

As discussed in the System Planning Best Practices section, early and effective community engagement is critical to successful park design and development projects. Site-specific community engagement efforts should follow engagement and equity principles and methods identified by Portland Parks & Recreation and other appropriate public agencies.

Stakeholder Identification

This process identifies the organizations and individuals who could be impacted by a proposed project, and the appropriate level of involvement. This step should also assess the need for specific outreach strategies to engage traditionally under-represented groups and/or balance stakeholder's power and influence. By clarifying who needs to be involved in the next steps of defining the project, this process helps to build the foundation for a successful communication and engagement strategy. Identifying all the stakeholders early in the process is critical to project success.

Park User Surveys

Conducting user surveys enables collection and analysis of usage patterns, demographic profiles, satisfaction indices, barriers to usage, and suggested park enhancements. This type of information informs the prioritization of park facilities and amenities.

Case Study

Trail Use Survey: East Bay Regional Park District, CA

The East Bay Regional Park District conducted a systematic park user survey in the Pleasanton Ridge Regional Park. The goal was to gain an understanding of existing usage patterns and desired park improvements prior to undertaking an update to the park's Land Use Plan. The survey results were combined with feedback received at community meetings and used to guide the development of a new Trails Master Plan. As a result, the Trails Master Plan and Land Use Plan were largely supported by the community and they are currently being actualized.

Public Notification

In addition to complying with City ordinances and Portland Parks & Recreation's public notification requirements, it is good practice to utilize a variety of methods for public notification and offer a variety of opportunities for stakeholders to provide comment. Newsletters (electronic or printed), project websites, flyers, meetings, public hearings, surveys, committees, etc., are effective tools to communicate with the public and gather input.

Case Study

Theodore Wirth Regional Park Master Plan, Minneapolis Park and Recreation Board, MN (2015)

An integral part of the master planning was the community engagement process that, through the work of an appointed Community Advisory Committee (CAC), set the vision for the regional park. The process included design charrettes, online surveys, study teams and focus groups, and the ability to receive comments via mail or email throughout the process. The notification process was robust: news releases were issued on a regular basis regarding planned public meetings, staff action, and plans for park improvements. Copies of these releases were sent to a targeted community and public relations group contact list. Postcards were mailed to residents within three blocks of Wirth Park prior to the first public meeting, charrette, and the public hearing. A project webpage was also created on the MPRB website with regular updates on the public process, dates for events, public impact, a project timeline, news releases, reports, plans, maps, project and park history, and staff contact information.

Design and Development

Conceptual Planning

Initial conceptual planning for a project helps establish the scope, scale, budget and complexity of a project and provides a visual representation of the potential layout of trails, riding facilities, site amenities and infrastructure such as parking and restrooms. A concept plan can be used during the initial community outreach and engagement process to share information with project stakeholders and the community at large by providing a visualization of the project.

Master Planning

Master planning is the process of designing a visualization of the proposed project, which is then used for environmental compliance, permitting, fundraising and the creation of detailed construction documents. The Master Plan integrates input and feedback from the site's owner and stakeholders. Working directly with the local community is essential to a successful Master Planning process. Engaging public agency partners, neighboring landowners, businesses, park advocates, and the local community from initial project envisioning through detailed master planning encourages a unified vision and successful implementation. The development of a detailed project budget, funding plans, construction document requirements, permitting and construction timelines, etc. ensures coordinated, timely and efficient project development. Master planning for staffing, maintenance, operations, events and park programming ensures the long-term sustainable management of the facility.

Environmental Analysis to Inform Design and Permitting

Environmental analysis includes assessment, compliance, and reporting to reduce and/or properly mitigate potential environmental impacts. The design approach should respond to the inventory and assessment of environmental resources developed in the planning stage, using the following prioritized approach:

1) Avoid impacts to significant natural resources;

2) Minimize unavoidable impacts; and

3) Fully mitigate for unavoidable resource impacts.

Sharing early design concepts with natural resource experts and planners can inform the design to better to respond to existing conditions and constraints, as well as help identify potential enhancement and mitigation opportunities. Laying out the existing documented environmental conditions as an integral part of the project baseline can anticipate and avoid design pitfalls and can streamline environmental permitting processes.

Construction Documents

The development of construction documents typically includes a multi-disciplinary design team with a bike park/trail designer; civil, structural and/or geotechnical engineers; landscape architects; and environmental and technical specialists. This design phase includes the production of detailed site plans, construction details, specifications, estimate of probable cost and bidding documents as required to construct the project.

Project Identity Development

Communicating a consistent project identity, vision, goals, milestones, and end user experience is critical to successful community engagement and project planning. Developing a project brand, including selecting an official project name and designing a project logo, provide clear and consistent messaging and enhanced content for websites, press releases, community outreach, marketing and fundraising campaigns, grants, and more.

Case Study

Creating a Public Awareness Campaign: Chattanooga, TN

Chattanooga, TN turned a regional goal of off-road cycling infrastructure development into a public campaign to garner public interest and gain support. They set a goal of developing 100 miles of singletrack mountain bike trails within a 10 mile radius of the City by 2010 and they named the campaign the "Singletrack Initiative". With key organizational partnerships to support the goals and consistent campaign outreach, the project gained community support and was successful.

Project Funding

Many projects require creative financing to secure capital funds; a portion of a project's costs may be raised through philanthropic foundations, grants and/or sponsorship sources. Developing a fundraising strategy for raising funds is important. The strategy should include the general information needed to raise funds, such as an outline of a fundraising proposal (project vision/description, budget, community need, community impact, etc.), identification of funding sources and eligibility requirements. It should also include fundraising protocols, such as sponsorship benefits. A consistent city-wide approach to sponsorship benefits will streamline the fundraising process and ensure a consistent aesthetic throughout the park system. For instance, it should be determined if sponsor logos are allowed on park signage, if parks are allowed to be given a top sponsor's namesake, and what benefits are available/appropriate to offer sponsors (e.g. sponsor logos/links on website).

Construction

Whether the park will be constructed by professional contractors, City or Park staff, volunteers or a combination of these resources, a specialty contractor (professional trail builder or bike park designer) should be on the team to ensure the proper construction of trails and installation of riding features, site amenities and infrastructure elements. This will result in the highest quality and lowest maintenance end product, and will ensure the ideal off-road cycling facility experience.

Facility Management

Operations Plan

An Operations Plan for each facility outlines an overall approach, protocols and actions to ensure the highest quality construction, maintenance, operation and management of the facility. Operations Plans should also ensure that comprehensive integrated risk management practices and protocols are established and maintained by all parties for the lifetime of the facility.

Budgeting for Maintenance

Off-road cycling facilities require regular, ongoing maintenance, and maintenance costs should be identified and factored into planning and operations budgets. Bike parks in particular require regular maintenance; annual maintenance costs can be estimated as approximately 10% of the capital construction cost. Maintenance costs are reduced if a bike park's dirt features are prefabricated with durable materials rather than constructed of dirt.

Maintenance

Ongoing maintenance is most successful when a Maintenance Plan establishes inspection and maintenance activity protocols, schedules, etc. Maintenance activities should be logged and tracked to become the basis for budget and resource planning. Over time, maintenance logs can help in identifying trail segments or riding elements with chronic functional problems or unacceptable environmental impacts, which need to be addressed.

Typical maintenance tasks at bike park facilities include, but are not limited to watering, compacting, shaping and otherwise maintaining the dirt features. Tasks also include routine inspection and maintenance of signage, clearing potentially hazardous debris from fall zones, inspecting and repairing any damaged hardware on wooden structures, inspecting rock and wood features for structural integrity, and maintaining drainage control features and landscaping.

Typical maintenance tasks on trail facilities include, but are not limited to maintaining drainage features and encouraging proper drainage (e.g. deberming and maintaining the outslope, adding drainage features such as rolling grade dips); routine inspection and maintenance of signage; clearing potentially hazardous vegetation or debris along the trail corridor; and identifying problem areas that may need armoring, trail rerouting or reclaiming.

Maintenance can be conducted by staff, volunteers, professional contractors or a hybrid of these options. Ideally, maintenance staff of any kind should have experience or be trained in park maintenance and natural resource protection. Volunteer efforts should be supervised by a qualified and dependable manager.

Risk Management Plan

A Risk Management Plan, addressing both user risk and environmental risk, should be developed for each facility. The plan should establish effective management protocols and demonstrate an intent to manage the facility responsibly. The project owner's risk managers and/or legal department should review and approve the plan. Key elements of a Risk Management Plan for trails and bike park facilities include:

Design, Construction and Maintenance Guidelines.

- Signage Plan: a comprehensive signage program with specific rules and warning language approved.

- Incident and Accident Reporting Plan: a plan that will enable the project owner to record, monitor and respond to hazards in the bike park. Regular evaluation of incidents and accidents should take place to prioritize where maintenance and/or park design changes should take place to improve safety.

- Maintenance Plan: A plan of regular (daily/weekly/monthly/seasonal/annual) maintenance inspections and activities that can be tracked in a log and maintained in the project owner's records. This plan should include who is allowed to and responsible for performing maintenance activities. It should also identify thresholds for unacceptable environmental impacts and methods to address the impacts, such as adaptive management strategies (e.g. seasonal closures).

- Volunteer Activity Plan: Protocols may include requiring all volunteers participating in construction, routine maintenance operations or other special events to sign a liability waiver; requiring all volunteers to wear standard safety equipment (e.g. sturdy closed toed shoes, pants, gloves) during all construction and maintenance operations and activities.

Programming Plan

Land owners or operators of off-road trails and facilities should develop a plan for each facility that outlines the types of programming that are supported at the facility and associated protocols.

Case Study

Trips for Kids, Marin: Golden Gate National Park Conservancy, CA

Trips for Kids takes underserved youth on scenic day-long trail ride adventures in local, state and national parks where they learn bike skills, tips for leading a healthy lifestyle, and gain self-confidence and environmental awareness. The Golden Gate National Park Conservancy supports this effort and allows Trips for Kids to lead regular group rides and youth programming.

Partnerships with Trail Organizations and other Volunteer Groups

Successful partnerships with trail organizations or other volunteer groups can greatly increase a municipalities' capacity to design, construct and manage trails. However, such partnerships should be based on common expectations for performance, communication, and management.

A Memorandum of Understanding (MOU) is a tool for establishing a partnership between two parties to achieve a common goal or action. MOUs are a common tool for recreation facilities with considerable maintenance needs, such as off-road cycling facilities. An MOU is a formal document that establishes a framework of cooperation between the project owner and volunteer groups or organizations who will be assisting in the construction, maintenance and operation of the facility.

Case Study

Banks Vernonia Trail: L.L. "Stub" Stewart State Park, OR

This rails to trails project was spearheaded by a group of trails enthusiasts and eventually established as a state park. Oregon Parks and Recreation Department performs the typical daily maintenance functions of the trail system. Friends of Stub Stewart Park and the Banks Vernonia Trail provide support, under an MOU, to preserve and protect the recreational and educational opportunities of the park and trails, in order to promote use and appreciation of the park's cultural, historical, and natural resources.

Section 3: Best Practices for Protecting and Restoring Ecological Health

The placement and use of any trail by any type of user may have ecological impacts. The goal of this project is to create a sustainable system of off-road trails and facilities. A primary approach to achieving such a system is to site facilities to avoid ecological as well as historical and cultural resources, especially in sensitive areas.

As discussed in the 'Environmental Analysis to Inform Design' best practice, the mitigation hierarchy of avoidance of impacts, minimization of unavoidable impacts, and rehabilitation/restoration of resources through mitigation is the accepted best practice regarding protecting and restoring ecological health.

The best practices identified below are consistent with industry standards established by the U.S. Forest Service and International Mountain Bicycling Association. They also align with the design guidelines and standards for trail construction established in existing Portland Park & Recreation and Bureau of Environmental Services plans and policies.

Note regarding bike parks: The best practices in this section focus primarily on the siting, design and construction of trails, rather than bike parks. Bike parks tend to be sited more commonly in developed park and recreation areas (as opposed to natural areas) and as a result have fewer environmental constraints that demand best management practices. However, bike park design does need to take into account potential soil erosion, water resource requirements, and risk management best practices among others.

Summary of key research findings

The following key findings are based on the Assessment of Off-road Cycling Impacts, available under separate cover. The best practices identified in this section are intended to avoid, minimize, or mitigate these impacts.

Soils

- The available data indicate that off-road cycling, when limited to established trails, has a similar impact on soils to hiking, and a lower impact than horseback riding.
- Frequency of off-trail activity was the greatest cause of adverse soil and vegetation impacts.
- Trail design and landscape factors may have more potential to affect soils than the nature of the trail activity.
- Trails with slopes greater than 12% are strongly correlated with significant increase in impacts to soil and vegetation.
- Cross-slope trails have lower erosion and runoff potential than fall line trails.

Vegetation

- All trail-based recreational activities have the potential to negatively impact vegetation, especially on unestablished trails.
- Most impacts occur with initial trail construction and use, with a diminishing increase in impact associated with increasing levels of traffic.
- Vegetation trampling/removal and soil erosion/compaction are closely linked impacts.
- Removal of vegetation is an inherent consequence in trail construction but that accelerated soil erosion becomes the primary impact once vegetation is lost.

Wildlife

- Wildlife disturbance can extend much further into natural landscapes than other forms of trail impacts, which tend to be limited to the narrow trail corridor.
- People riding bicycles cover more ground in a given time period than hikers and thus can potentially disturb more wildlife per unit time.
- The research on wildlife impacts focuses on a limited set of bird and mammal species, and the results appear to differ depending on the species studied.
- For some bird species, disturbance from mountain biking trail use on foraging and nesting behavior may be minimal, but fragmentation and alteration of habitat by mountain biking trails may reduce quality of nesting habitat.
- Wildlife impacts can be reduced by ensuring that trails avoid sensitive or critical wildlife habitats, including streams and wetlands.
- Additional studies of the impacts on wildlife habitat, including special status habitats and rare plant and animal communities are needed. There also is a gap in information on the cumulative impacts of recreational activities in natural areas, both urban and rural.

Water resources

- Trails can introduce soils, nutrients, and pathogens, increase water turbidity and sedimentation, and alter patterns of surface water drainage and divert water sources that serve important ecological functions.
- Very little research exists on the specific impacts of off-road cycling on water resources.

The following practices reflect both accepted and recommended best practices based on these key findings.

Trail siting to minimize resource and wildlife impacts

Mitigation hierarchy – Avoid, minimize, mitigate ecological impacts

Siting of trails and facilities should follow the mitigation hierarchy of avoiding, minimizing, and then mitigating negative impacts. The application of this hierarchy to a particular area should be based on that area's particular ecological function and value, the uniqueness of the resource within the City and region, and the area's use by resident and migratory species, particularly

Endangered Species Act listed species. In addition, the application of this hierarchy should also consider, and be balanced against, other City goals, including the City's goal to provide accessible recreational opportunities within an urban area.

The mitigation hierarchy should be applied at both the system planning and site planning scale. For example, a citywide assessment should consider potential impacts, and ways to avoid/minimize/mitigate these impacts at a high-level scale. Site planning efforts should take a more detailed and nuanced approach to avoid/minimize/mitigate impacts to individual features or species on a given site.

The City has mapped a variety of natural resources and habitat areas in documents like the Natural Resource Inventory (NRI) and Terrestrial Ecology and Enhancement Strategy (TEES). For example, the TEES defines special habitat areas as including oak woodland; interior forest; riparian, herbaceous and forested wetlands; and prairie. Various agencies and organizations have also identified fish and wildlife species of concern, including Endangered Species Act listed and threatened species, Special Status Species, and other at-risk species lists.

Where appropriate, the City should prioritize trail development on sites with existing disturbance, such as lower value natural areas that have been degraded, over development in higher value resources. Degraded areas offer a potential 'win-win' combination of environmental restoration and new compatible recreational access.

To limit overall environmental impacts in higher value areas or areas the City has prioritized for restoration, additional best practices can limit overall ecological impacts by minimizing overall trail density. These include the use of shared-use trails and 'east coast style' trail systems with tightly packed trails that minimize the overall area impacted.

Maintain habitat connectivity

Trail siting should consider impacts to overall habitat patch size, fragmentation and edge effects. While recreational trails do not have the same fragmentation potential as roads and other types of urban development, such impacts should be considered in site planning. Trails can be routed around particularly sensitive areas or narrowed (e.g. through use of a singletrack trail over a wide trail) to minimize impacts.

Water resources provide important wildlife habitat and habitat connectivity. Trails should avoid crossing streams, wetlands, and floodplain areas. Where no avoidance alternatives exist, the design and construction of trails in these areas should minimize impacts and follow applicable best management practices. For example, design of stream crossings should consider the potential use or retrofit of existing crossings, low impact designs such as bridges or boardwalks, and opportunities to restore disturbed habitat areas as part of the design. Minimize crossing lengths and avoid trails running parallel to streams. Targeted plantings or fencing may be used at crossings to deter trail users from venturing off-trail into sensitive areas.

Buffer sensitive ecological and hydrological systems

Establish habitat buffers to avoid or minimize impacts to sensitive ecological and hydrological systems. The City's Natural Resource Inventory recommends buffers of 100' to 600' depending on the type of resource and presence of wildlife species. Buffers should include migratory pathways that are seasonal in use (e.g. amphibian routes from wetlands to forest habitat). Trails should be located at habitat edges where possible, to minimize disturbance to intact habitats and potentially restore disturbed edge habitat by replacing invasive plants with natives.

Vegetation and clearing guidelines

Trail siting, siting, and construction should minimize tree and vegetation removal, particularly in areas where prevention of runoff and stabilization of the soils on steeper slopes may be an issue. Vegetation can serve useful trail purposes, such as working as "guide material" to define the edges of the trail, thereby preventing unsanctioned cut-through use. The U.S. Forest Services Guidelines acknowledge that vegetation can grow back quickly and become a nuisance or hazard to trail uses, especially trees close to a trail's edge. Tree removal may be prudent for safety reasons. Therefore, vegetation and clearing must consider a balance between natural resource benefits and trail user safety.

Designing trails for natural stormwater management

Trail design can minimize soil erosion and help protect water resources. The River View Natural Area Management Plan includes trail best management practices that are in line with the following BMPs:

Trail Alignment

Trails should be designed to avoid/minimize impacts, such as soil erosion, on streams, wetlands and other water resources through careful consideration and design of the stormwater flow path… First, avoid siting trails on level terrain and/or areas with incompatible soil types. Such precautions can prevent trails that easily become muddy, erosive, and challenging to users. Secondly, design rolling contour trails to enhance natural overland drainage and reduce soils erosion.

Tread Width

To reduce potential soil erosion, trail tread width should be kept to a minimum. This may be accomplished by constructing narrower trails or by narrowing existing trails to reduce the overall trail footprint. However, the width of a trail is a key factor that determines the associated recreational trail experience; as such, trail width, desired recreational experience, and soil suitability should all be considered in concert when siting trails.

Rolling Contour Trails

These trails are designed to follow the elevation contours of hillsides to encourage sheet flow of water across the trail. To minimize erosion, facilitate natural drainage patterns, and provide a fun trail experience, trails should maintain a 5-7% average running grade (i.e., the grade longitudinally along the trail)--or no more than half the grade of the side slope--and include frequent grade reversals. Grade reversals are short dips followed by a slight rise to allow water to drain off before it

can gain volume and speed. Trail tread (or cross slope) should tip downhill or outslope (about 5 percent). Blending the trail's "backslope" (uphill slope) to the hillside's angle of repose will further encourage proper drainage. Developing rolling contour trails (as opposed to fall-line trails that follow the shortest route down a hill) with the following characteristics is a key element in developing environmentally sustainable trails.

Full Bench-Cut Trail Construction

This type of trail involves cutting the trail tread into the uphill side of the slope and providing a solid, long-lasting and stable trail tread by retaining the lower edge without impacting native compact soils and existing well-rooted plants. Cut slopes soils should be broadcast thinly across the downslope over a larger area so as not to suffocate the roots of existing plants.

Slope rules - half rule and 10% grade, maximum grade

Trails should be aligned parallel to terrain contours, and a trail's grade should not exceed half the grade of the hillside or sideslope that the trail traverses (half rule). An average grade of less than 10 percent (ideally 5-7%) should be maintained (10% rule) to minimize erosion of the trail surface, accommodate undulations and to provide the majority of trail users with a rideable trail gradient. Maximum trail grade is typically 15 to 20 percent in relatively low-use areas (lower in high-use areas), however it is site specific and the trail should comply with the half rule and take into consideration variables such as soil type, user density, annual rainfall and difficulty level of the trail. In general, limit maximum grades and sustained grades, and include frequent grade reversals along the trail to provide frequent drainage relief.

Edge Protection

In general, edge protection may reduce sheet flow and increase erosion and trail maintenance. Edge protection should be provided only when conditions warrant it (steep drop off). If used, edge protection should use native vegetation and natural features such as rocks and logs that blend with the natural environment, installed in a manner to facilitate sheet flow.

Trail Hardening

Trails can be hardened to prevent erosion, stabilize steep sections of contour trail, cross low-lying muddy or sandy areas and to toughen high use areas. Each scenario may require a different trail hardening technique and considerations will include if the erosion is caused by users or water, available materials, access to the site and trail use patterns (e.g. high traffic vs. low traffic). The preferred technique is rock armoring, because it is long-lasting, uses natural materials and is aesthetically pleasing. IMBA's *Trail Solutions* describes each method of rock armoring. Commercial products used for trail hardening include chemical binders (i.e. liquid stabilizer), physical binders (e.g. crushed aggregate) and geosynthetics (e.g. geotextile sheets). The Minnesota *Trail Planning, Design and Development Guidelines* has a detailed description of these hardening techniques. Trail hardening in bike park facilities can prevent soil erosion and reduce maintenance requirements, but can also make it harder to update the layout and construction of park features over time.

Trail Construction

There are a number of ways to protect natural, cultural and historic resources during trail construction. Trail construction and maintenance should be performed (or managed) by qualified trail builders. During procurement, use a qualification-based selection process to select contractors based on highest quality work and value of services. Clearly define the boundaries of construction, resource protection areas, staging areas, etc. Manage construction activities to minimize exposure to disturbed earth during the wet season and near sensitive water resources. Work within seasonal work "windows" and build trails outside of breeding seasons for species using the site (i.e. avoid bird nesting season – see TEES Guidelines on Avoiding Impacts on Nesting Birds). Minimize the spread of ecological/invasive species by cleaning tools, boots and equipment prior to entering the project area and make sure imported soil is weed free.

Stewardship

Ongoing stewardship of trails and adjacent natural systems

Periodic monitoring and maintenance of trails are necessary to respond to trail surface and drainage issues before they affect water resources and natural habitats. Ensure environmental protection measures remain effective after trail construction is complete by having a stewardship program in place. As included in the River View Management Plan "implementation of the ecological prescriptions, including monitoring, baseline wildlife studies, long-term research and working with adjacent property owners to remove invasive species" will support the stewardship program. See also sections above on 'Maintenance' and 'Partnerships with Volunteer Organizations'.

Monitoring and Active Management

Monitor for unanticipated/unintended impacts such as excessive erosion, vegetation impacts, wetland/stream impacts, etc. and track maintenance activities including inspection, repair and emergency response with inventory forms. Relocate problem trail sections rather than performing continuous maintenance. Perform conditional closures (e.g. saturated soil conditions) as necessary and consider seasonal closures to protect wildlife (such as during migration or nesting periods). Decommission and restore unsustainable trail corridors.

Environmental Interpretation and Education

Interpretation deepens a user's outdoor experience and appreciation for their surroundings. Interpretive signage is often limited to short walking trails, however providing interpretation on a scale relative to a mountain biking experience provides an opportunity to share a greater amount of information on a larger scale. It also indicates that some trail users may be stopping and reading the interpretation and that riders should ride at an appropriate speed. Interpretation can also encourage 'leave no trace' equivalent practices.

Section 4: Best Practices for User Experience, Health and Safety

Designing facilities for an intended use or target user provides a positive user experience for riders and other users. This is one of the greatest challenges (along with balancing natural resource constraints) and one of the greatest opportunities to meeting the community needs and supporting a healthy and active community.

Summary of key research findings

The following key findings are based on the Assessment of Off-road Cycling Impacts, available under separate cover. The best practices identified in this section are intended to maximize positive benefits and minimize or avoid negative impacts or risks.

- Participation in outdoor recreation, including off-road cycling, can improve participants' physical and mental health. A positive recreational experience can inspire more use and benefit.
- Bicycling is a top gateway activity that results in an increase in outdoor activity.
- The frequency of injuries in mountain biking is comparable to that in other outdoor sports and the majority of injuries are minor. Riding within one's ability level, using properly maintained bicycles, and wearing helmets and other protective equipment can reduce the risk and severity of injuries.
- Actual and perceived conflicts between different user groups, such as off-road cyclists and hikers, is a potential impact of shared-use trails. Trail education and awareness reduces perceived and actual conflicts between user groups.
- Off-road cycling trails, along with other site improvements, have been successfully used to reduce or eliminate nuisance activities on public properties. Such uses can contribute to real or perceived health and safety threats.

The International Mountain Bicycling Association's (IMBA) book *Trail Solutions, IMBA's Guide to Building Sweet Singletrack* is an essential resource of best practices on sustainable multiuse trail design, trail building and trail maintenance. The following are core design concepts that include techniques described in IMBA's guide and best practices utilized by professional trail builders and adopted in communities across the country.

Trail Use Policies: Shared Use, Preferred Use and Single Use

Determining if a trail should be managed as shared use (used by multiple user groups), preferred use (designed and managed for a specific user) or single use (one user type allowed) is site specific. When determining allowable uses, consider three key factors: safety, impacts on natural and cultural

resources, and public input/need. When creating a trail use plan these considerations should be kept in mind:

Shared use trails:

- Can accommodate the needs of most users.
- Are more cost effective to design, build, maintain and manage.
- Can minimize overall trail density and potential ecological impacts
- Typically disperse users across a trail system.
- May lead to conflicts between users of different speeds or modes.

Preferred and Special Use Trails:

- Can respond to community needs while also alleviating conflict/pressures at other facilities.
- Require a well-designed and managed signage plan.
- Do not eliminate conflicts between users of different speeds or modes.

Single use trails:

- Concentrate users to fewer trails.
- Can provide specific experiences desired by off-road cyclists (e.g. flow trails, downhill trails) and alleviate these pressures on the traditional shared use trails.
- Can limit conflicts between users.

Case Study

Competitive Tracks (preferred use/special use areas): Phoenix, AZ

The Maricopa County Regional Park system now includes three competitive trail loops designed for mountain bikers. The trails are designed for training and to accommodate higher speeds and racing events. The three competitive trails are designated as multiuse and are used by cross country runners and endurance equestrians, however they were designed for and are used primarily by mountain bikers. To reduce potential risk of injury the trails are managed as one-directional trails.

McDowell Park offers 3 competitive loops totaling 15 miles, including a beginner level loop, intermediate loop and advance/expert loop. Estrella Mountain Regional Park includes 3 competitive loops totaling nearly 16 miles with a short "Junior Loop", "Long Loop" and "Technical (advanced) Loop". The Sonoran Loop Competitive Track is a stacked loop trail system with 9.3 miles of trail and a 1 mile technical segment designated for experts only.

The three competitive tracks are geographically distributed in the County, so there is a track in close relative proximity to each community.

Effective signage is an important risk management practice at these tracks. Each park map includes this caution: This TRACK is for high speeds, challenging one's skills and racing. Use TRAILS elsewhere in the park for leisurely traveling. The maps also stipulate that slower users shall yield to faster users.

Case Study

Concrete Bike Park (single use): Fresno, CA

The City of Fresno's Parks, After-School, Recreation and Community Services Department developed a 30,000 square foot concrete bike park named Mosqueda Bike Park; it is the largest concrete BMX-only bike park in the country. The park was designed and developed to meet the needs of the BMX community who wanted a concrete bike park experience designed specifically for the BMX user group. The goal was also to disperse BMX use from the other skatepark in the City.

User Experience

Progression

Skills progression is one of the most important aspects in designing dynamic, long-term off-road cycling facilities (trails and bike parks). Progression-based facilities provide opportunities for developing new skills and techniques and minimize risk by providing riders opportunities to incrementally improve their skills through repetition. Progression-based facilities can be designed to provide compelling experiences for all levels of users from novice to advanced. They should be designed to promote a community of learning and advancement while providing safe, fun and exciting experiences.

Stacked Loop Trail System

In a stacked loop trail system, trails are 'nested' or 'stacked' within each other. In such a system, there may be a short loop near the trailhead, a moderate loop extending partway into the site, and a long loop extending even further. Stacked trail systems provide a looped trail options that accommodate many skill levels and provide a variety of riding experiences. Shorter loops, beginner level trails, and denser sections of trail should be sited near developed areas or trailheads to enhance accessibility and separation of user skill levels for safety.

Designing for Riding Experience

Each rider's preferred off-road cycling experience is unique, however there are a number of experiences that are almost universally desired in a trail setting. A flow trail is one of these; it is designed for maximum flow and minimal pedaling and braking using grade, banked berm turns and consistent rolling terrain. Another is providing diverse trail experiences and an opportunity for challenging lines (either mandatory or optional). Intermediate to advanced off-road cyclists generally desire longer distance routes, and narrow or singletrack trails with flowing banked climbing turns (as opposed to switchbacks). Similarly, there are riding features and erosion control features that are not compatible with off-road cycling, such as stairs and water bars.

Bike park facilities offer a great opportunity to design for desired riding experience, because they are typically single-use facilities, are purpose-built and can be updated to reflect changing community needs.

Stakeholder engagement is key to understanding the local trends and desires in a local and/or regional community. Designing for riding experience is easiest when designing new trails or bike facilities.

Natural and Prefabricated riding features

Many off-road cycling facilities now incorporate prefabricated skills features as an alternative to site-built features or features constructed of dirt. While the upfront cost is higher for prefabricated features, the benefits include increased lifespan of the feature, reduced maintenance requirements and reduced liability. The drawback is that they are more permanent in nature. A facility that is intended to be redesigned and updated periodically to accommodate user's changing needs may be better suited using dirt and/or locally sourced materials built onsite.

Recreational and/or Competition Use

If races or competitions are allowed in a park, develop a protocol for frequency of events allowed, which provides an equilibrium between these uses that is appropriate for the park users and the local community. For example, competitions could be limited by size of participants and/or frequency of events allowed per month or per year.

Shared Trails

Shared use trails require careful planning and design to ensure they provide a quality, enjoyable recreation experience for all intended users. This requires understanding the existing and/or intended user groups, usage patterns and user desires. Key factors of design and management include:

Sight Lines

Sight lines improve safety, especially on bi-directional trails, shared use trails and before approaching trail junctions. The wider the trail (and the faster the potential user speed) the longer the sight lines should be. The more twisty the trail (and the slower the potential user speed), the shorter the sight lines can be. On bi-directional trails, blind corners should be designed to rise at both approaches so users meet at slower speeds.

Directionality

On high use multiuse trails that are experiencing user conflict that cannot be managed through trail design or maintenance, consider instituting an opposite direction of travel for different user groups (i.e. hikers and bikers will travel in opposite directions along the loop and pass each other head-on) to maximize sight lines and visual interaction (hikers are less likely to be startled).

Passing/Regrouping Areas

Passing areas are wider sections of trail that allow riders to safely pass other riders or trail users. Passing and regrouping areas should be designed throughout a trail system to prevent users from straying off the trail and impacting the surrounding habitat. Installing a skills feature at regrouping areas encourages groups of riders to regroup at that point rather than elsewhere along the trail.

Signage & Wayfinding

Clear and consistent signage is at the core of successful off-road cycling facility design and management. Signage should enhance the user experience and minimize risk by informing users of trail conditions including park rules, trail difficulty, enhanced terrain and technical features, trail etiquette, riding technique, appropriate safety equipment and emergency medical services. In the context of a bike park or skills trails, providing recreational interpretation, which shares riding techniques promotes progression and skills improvement and will improve user experiences and safety. Well-thought out signage and wayfinding materials can also improve accessibility for those using handcycles or other adaptive features.

Activating Negative Use Areas

Negative use areas are undeveloped areas that are predominantly used for nuisance and negative activities such as dumping or drug activity. Activating these areas with recreational opportunities can displace the negative use with positive use.

Case Study

Seattle, WA

The City of Seattle, WA has supported two projects that provide accessible off-road cycling and recreational experiences to the community and displace negative activities. The 7.5-acre Colonnade Bike Park was developed under Interstate 5 and resulted in activating the area with positive, family-friendly outdoor activities. The Cheasty Greenspace project includes the restoration of a 43-acre remnant forest in south Seattle. The Greenspace suffered from invasive plants and garbage dumping and was home to multiple illegal encampments. Work will be done in stages, and include the construction of mountain biking trails, as part of a pilot effort that will assess the impacts of restoration and recreational trails on the environment and community. (Cheasty Greenspace)

Risk Management

A number of techniques can be used to reduce rider risk, maintain a safe facility and minimize losses from lawsuits. These can include sequential skill progression, particularly in bike parks, where riders can find features appropriate to their skill level. Signage that communicates the technical difficulty of trails and features; filters that require riders to overcome an obstacle (such as a rock garden) at the beginning of a trail segment; and optional lines that allow riders to opt-out of challenging natural or manmade obstacles, can all help ensure riders choose trails appropriate to their ability. Adequate sight lines, which allow riders to see what is ahead, and fall zones can reduce the likelihood and severity of falls. Finally, performing regular maintenance on all off-road cycling facilities in compliance with maintenance plan protocols can ensure trails and facilities remain in a safe, rideable condition appropriate to its technical difficulty.

Monitoring & Adaptive Management

Monitoring and adaptive management can reduce safety risks and improve overall user experience. Monitoring including logging incidents and accidents, assessing overall patterns, and identifying high

priority risks. This is followed by inspecting recurring problem areas and making site-specific trail or bike facility modifications. These modifications could include increasing sight lines, adding wayfinding signage, improving the flow of a turn, etc.

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