



# Literature Review: Best Management Practices in Trail Construction, Maintenance, Planning and Design for VMBA's Bike Optimized Trails

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## Introduction

The vast majority of literature and guidance available for trail construction and stewardship activities exist as general guidelines, “how-to” manuals, or standards for specific trail types. Very few guidance documents exist for best practices to employ for those engaging in the activities of trail planning, design, construction, and maintenance specifically in order to mitigate impacts from these activities on soil, air, water, vegetation, wildlife, cultural resources, and trail user safety and experience.

The goal of this project is to compile a working version of BMPs for Vermont Mountain Bike Association (VMBA) Chapters to follow in developing, maintaining, and managing high-quality, low-impact mountain bike-optimized trails. The resulting practices and their resources will serve as a living document to be updated and modernized as the landscape of VMBA Chapter activities shifts over time.

Many of the best practices integrated into the various guidance documents reviewed are utilized regularly throughout Vermont, however they are not currently clearly documented. This compilation of best practices is intended to serve as a common understanding and documentation of activities known to develop and maintain high quality bike optimized trails in Vermont, as derived from the various current available resources and expert experience.

Leading up to the kick-off of this project, a specialized review committee representing VMBA chapters was established to provide feedback, review, and recommendations at various points along the process. Resources were compiled through various search means and the initial list was reviewed and expanded upon by the BMP review committee. Resources were solicited from VMBA chapters, through the Professional Trail Builder Association member page, and extensive online searching and outreach to ensure the most up-to-date resources were included, as well as the classics upon which much of the following literature was built upon, namely the IMBA Trail Solutions series and Whistler Trail Standards.

The process by which these BMPs came to be is outlined below following the general steps of an in depth literature review, individual practices extracted, cross referenced, compiled, and then reviewed for applicability in the Vermont landscape. The resulting list was reviewed by the VMBA BMP working group and exists as the first version of a living document to be updated as is necessary.

Of the 28 useful and accepted guidance resources reviewed in detail, only five or fewer are titled as “Best practices” and contain clear guidance on the actual practices that are necessary to achieve sustainable and high quality trails in Vermont or Northern New England.

The remainder of this document outlines the process by which the Best Management Practices (BMP) and their supporting details were created, drawing from respected resources near and far and curated to fit the landscape of bike optimized trails in Vermont.

## Literature Review

### Process, Findings and BMPS

Few guidance documents exist for best practices to employ for those engaging in the activities of trail planning, design, construction, and maintenance specifically in order to mitigate impacts from these activities on soil, air, water, vegetation, wildlife, cultural resources, and trail user safety and experience.

After searching relevant written resources and publications related to best trail management practices, the list was curated to 34 sources and publications to review for this project. They range from internal documents from some of the highest quality trail networks in Vermont to the foundational classics that laid the basic guidelines for mountain bike trail building and management from International Mountain Bike Association and Whistler, to standards, guidelines and practices from a full variety of organizations: federal, state, municipal, non-profit, mainly from the US, Canada, and Australia.

Most resources were built upon the core foundations of the IMBA Trail Solutions series (2004, 2007) and the *Whistler Trail Standards* (2003), which were then expanded upon and further modernized to be inclusive of various newer ways of thinking about mountain bike optimized or multi-use trails and approaching practices. Examples of these are the guidance documents from Parks Canada , Minnesota Department of Natural Resources and *Western Australia's Mountain Bike Management Guidelines* (2019).

For this project each resource was reviewed and noted “practices” in a variety of areas were extracted, cataloged, compiled and sorted for cross referencing. The annotated bibliography compiles the resources that were included, and the resource compendium links to where these references can be found for more information (except in the case of organizations internal documents, or other documents not publicly available at this time.)

The area of Trail Planning was found to have significantly fewer existing resources, guidelines, supporting manuals and documented existing practices. One very recently released document provides the majority of trail specific planning guidance available to the industry at this time. The *Trail Competency Framework* (2024) being developed by the Trails Skills Competency Committee of the Professional Trail Builder Association and American Trails includes a framework of trail planning skills and levels of competency that would be shown by trail planners and has been used to cross reference and augment the other available planning resources in this review.

Also notable, Australia's *Western Australia Mountain Bike Guidelines* (2019) is one of the most recent and creatively modern publications on the topic, rich in the newest ways of thinking about trail planning and design, yet built upon the same classics and principles.

Natural resource and regulatory guidance documents specific to Vermont were also reviewed and integrated and/or documented where applicable to Best Management Practices. The existing guidance

focused on ecological function, riparian areas, stormwater, wildlife and wetlands, though only half of these documents focus on trail development, maintenance or management activities specifically.

### **Best Management Practices**

The Best Management Practice that resulted from this process are a product of both this compilation of existing best practices as shown in the existing literature, as well as place-specific aspects to these activities that are more unique to Vermont than some other regions of the country or world.

For each section of BMPs, the specific references and resources from which they were initially drawn are listed following the section. See Appendix for the resource matrix for each BMP section, as well as each BMP.

### **Permit and Approval Processes for Trail Projects**

There are a number of potential trail permits and/or approvals that may apply to any trail construction or maintenance project, depending on the scale of the project, location, and type of trail or activity occurring. Below is the list of potential permits and/or approvals.

1. Stormwater
  - a. Construction- Jurisdiction: based on square acres of ground disturbance.
  - b. Operational (ADA trails)
2. Stream Alteration and Crossing
  - Jurisdiction: Mainly perennial streams (greater than .25 square miles drainage area) and their buffers
3. Natural Heritage
  - Jurisdiction: Rare, Threatened or Endangered Species
4. Wetlands
  - Jurisdiction: Class 1 and Class 2 Wetlands and their buffers
5. Floodplains
6. Act 250
  - Projects larger than a certain size
  - Parcels under jurisdiction due to existing Act 250 permits
7. NEPA
  - Federal Land
8. Local Zoning
9. US Army Corps
  - Jurisdiction: Wetlands, rivers and streams
10. Coast Guard
  - Navigable waterways

## 11. Historic Preservation

### Summary

Of the many existing trail management activity guidance documents, few provide precise best practices to employ for those engaging in the activities of trail planning, design, construction, and maintenance specifically in order to mitigate impacts from these activities on soil, air, water, vegetation, wildlife, cultural resources, and trail user safety and experience. However, when examined closely as a body of work, they each contain elements of more precise best practices that have been extracted and compiled to create the basic elements of guidance necessary for the resulting Best Management Practices for VMBA's Bike Optimized Trails.

### Annotated Bibliography

Appalachian Trail Conference. (2003). *Appalachian Trail Fieldbook: Maintenance and Rehabilitation Guidelines for Volunteers*, 2nd ed. Harpers Ferry, VA.

This pocket-sized fieldbook is designed for use in the field and to accompany the larger "how-to" manual that preceded it (see below). It is simple, clear and portable, with glossaries of vocabulary and bulleted lists. While it is designed to be used for activities on the Appalachian Trail, (a pedestrian trail), it contains applicable useful information on general maintenance, bridges, and signage, along with some less applicable or outdated guidance, such as concerning waterbars. Guidance on maintenance, assessment, and signage are useful practices.

Birchard W. & Proudman, R. (2000). *Appalachian Trail Design, Construction and Maintenance*, 2nd ed. Harpers Ferry, VA: Appalachian Trail Conference.

A how-to guide for design, construction and maintenance of the Appalachian trail, this publication is widely applicable to most pedestrian trails. It outlines the traditional basics of many tenants of trails: planning, design, corridor clearing, tread construction, structures, stream crossings and bridges, tools, management and maintenance. Guidance on bridges and riparian areas is very helpful.

Carsten, J. (2023). *Mountain Bike Trail Development: Guidelines for successfully managing the process*. Greater Minnesota Regional Parks and Trails Commission & International Mountain Bike Association.

Thus far, this document is the only book in the trails industry to focus solely on trail planning and design. It is also the most recent IMBA partnered publication since *Guidelines for a High Quality Trail Experience*, jointly created by IMBA and BLM in 2018. It integrates and builds upon all prior IMBA publications, updating some of the specifics to a more modern approach to mountain bike trails.

*Cuyahoga Valley National Park Sustainable Trail Guidelines*. (2012). National Park Service.

These guidelines were created to aid in management of the Cuyahoga Valley National Park trail system and contain guidance on trail management and classification specific to this National Park for a variety of trail types, guided by many of the most recent guidelines included in this bibliography.

*DCR Trails Guidelines and Best Practices Manual*. (2019). Department of Conservation and Recreation (MA).

Updated in 2019, these DCR specific guidelines include incorporation of the USFS trail classification system and draw from Minnesota and IMBA publications to create guidelines for trail system development, management and maintenance with an appendix of specifications and documents specific to DCR trail management activities.

*District of Squamish Trails Standards*. (n.d.). District of Squamish.

The trail standards and classifications developed in this document include a system for classifying trails and charts that align the standards for each of these classes of trails. Photos and diagrams of specifications accompany these management objectives. The section on mountain bike trails draws heavily from previous documents from Whistler Trail Standards and IMBA's Trail Solutions that provide guidance on Technical Trail Features and fall zones, which are well documented in this publication, along with guidance on stormwater management and corridor clearing for construction, bridges and riparian areas.

Felton, V. & International Mountain Bicycling Association. (2004). *Trail solutions: IMBA's guide to building sweet singletrack*. IMBA.

This classic publication laid the groundwork for many of the sustainable trail guidelines that have followed in the last 20 years. It is highly referenced in almost all materials that are compiled and published after 2004 and is seen by many as the main guidance for mountain bike trail building, despite its age.

*Guidelines and Best Practices for the Design, Construction and Maintenance of Sustainable Trails for All Ontarians*. (2006). Trails for All Ontarians Collaborative.

A massive 300 page document, these guidelines outline principles and practices related to developing and managing All People's Trails under the core principles of universal and sustainable design, much of which can be helpful resources specifically for trail design and maintenance.

Hesselbarth, Woody ; Vachowski, Brian ; Davies, Mary Ann. (2007). *Trail Construction and Maintenance Notebook*: 2007 Edition. Missoula, MT: U.S. Department of Agriculture, Forest Service, National Technology and Development Program.

A short instruction manual on how to construct and maintain trails, focusing primarily on pedestrian and multi-use trail types. The updated version is currently being reviewed by USFS and PTBA partners.

*Maintenance Manual*, Slate Valley Trails. (2021).

The maintenance manual for Slate Valley Trails is an internal document of a non-profit trail organization and VMBA chapter in southern Vermont that documents their regular maintenance protocols.

*Management Guidance Siting Construction and Maintenance of Singletrack Bike Trails on Forest Preserve Lands in the Adirondack Park*. (2017). Department of Environmental Conservation.

A short (18 page) guidance document for construction and maintenance of “single track” and “double track” mountain bike trails within the Adirondack Preserve, with guidance specific to the preserve, including insloped turn/berm heights and “Parallel Feature Trails.”

*Multi Use Trail Building Standards and Definitions*. (2023). Kingdom Trails.

This internal document used to guide trail design, building and maintenance for the Kingdom Trails network draws directly from many of the resources included in this literature review.

*National Water Trail System- Best Management Practices*. (n.d.). National Water Trail System.

This simple and approachable checklist highlights aspects of management practices important to the NWTs, including examples in the various management areas of projects where these practices could be observed.

*NH Trail Construction and Maintenance Manual: Best Management Practices For Erosion Control During Trail Maintenance and Construction*. (2017). State of New Hampshire Department of Resources & Economic Development, Division of Parks & Recreation; Bureau of Trails.

This 84-page (half page format) publication addresses various practices for the range of trail types. It is more narrative and “how to” than practices, though bulleted lists scattered throughout can be helpful. It was adapted from the Maine Department of Conservation, Bureau of Parks & Lands, Off Road Vehicle Division’s publication, “Best Maintenance Practices. Maine Motorized Trail Construction and Maintenance Manual”. Though much of the content is not as applicable to many types of mountain bike trail in Vermont, notable subjects included are stormwater management, corridor cleaning and vegetation management.

Parker, T. S. (2004). *Natural Surface Trails by Design: Physical and human design essentials of sustainable, enjoyable trails*. Natureshapes.

Troy Scott Parker’s scientific approach to natural surface trails creates a platform of the fundamentals for creating sustainable trails according to the main tenets of their physical and social properties: human perception, human feelings, physical forces, tread materials and tread watershed. It includes many helpful images and graphics to illustrate these topics and supporting details, as well as case studies and evaluation process. It is a wealth of applicable information for all natural surface trails.

*Parks Canada National Best Management Practices for Trail Maintenance and Modification*. (2016). Parks Canada.

A comprehensive list of 166 Best Management practices for trail maintenance, reconstruction and reroutes to mitigate impacts on soil, air, water, vegetation, wildlife, visitor safety and cultural resources. It is accompanied by a tool created for Parks Canada staff to filter applicable BMP's based off of maintenance activities for a project to guide staff and contractors.

*Pennsylvania Trail Design & Development Principles Guidelines for Sustainable, Non-motorized Trails.* (n.d.). Pennsylvania Department of Conservation and Natural Resources.

The Pennsylvania Guidelines is a 254 page document comprehensively covering planning, design requirements for trail use, design requirements for sustainable trails, construction and management of non-motorized trails. It is accompanied by an expansive 20 page glossary of trail terms.

*Shuswap Trail—Trail Design Standards.* (n.d.). Shuswap Trail Alliance.

These standards for trail design come out of the Shuswap Trail Alliance in BC, and draw from the foundations of the preceding IMBA publications, Natural Surface Trails by Design, as well as a few others (and through consultation with user groups and construction experts). Sustainable design practices are well-documented in this publication.

*Trail Competency Framework: Construction, Maintenance, Design & Planning- Draft (2024).* Trails Skills Committee of Professional Trail Builders Association and American Trails.

This framework outlines the trail skills utilized at varying levels of expertise for most tasks related to trail construction and maintenance. It is still in draft form, with review underway through a team composed of Agency partners, American Trails and Professional Trail Builders Association and is a project of Trailskills.org.

*Trail Construction and Maintenance Notebook- Draft.* (2024). United States Department of Agriculture and Forest Service.

The newest version of the notebook has been drafted and is currently being reviewed and edited by USFS staff and PTBA partners. It is more inclusive of multi-uses than the previous version and incorporates more modern thinking on trails and trail structures, such as the avoidance of waterbars.

*Trail Design Guidelines for Portland's Park System.* (2009). Portland Parks and Recreation.

These guidelines consist of a variety of trail classifications and related specifications for trail types and designed and managed uses. A variety of specifications for trail structures are also included with accompanying images.

*Trail Management Manual: Standards and Guidelines for Planning, Design, Construction, and Maintenance of the Trails and Track Systems for Maricopa County Parks and Recreation Department.* (2018). Maricopa County Parks and Recreation Department.



This comprehensive manual outlines the core components for management of the trails in this specific management area, as well as the standards to utilize in order to support them. There are helpful glossaries of terms. While the climate is very different in this desert region than Vermont, there are useful design and vegetation management practices in this manual that can be applied in any natural surface trail project.

*Trail Planning Design and Development Guidelines.* (2007). Minnesota Department of Natural Resources, Parks and Trails Division.

These guidelines are comprehensive, focusing on the variety of trail types and uses and cover the range of trail design, construction, maintenance and management. Ecological Design Principles are clearly articulated and many sections are accompanied by images to further illustrate principles.

*Vermont Town Forest Trail Design Guide.* (n.d.). Vermont Urban and Community Forestry Program.

This guide accompanies a tool kit to assist town forest committee in Vermont with planning for multi-use trails in town forests with information drawn directly from IMBA guidelines, Minnesota guidelines and USDA Trail Handbook.

*Vermont Trails and Greenways Manual.* (2005). Vermont Trails and Greenways Council.

Despite being almost 20 years old with broken internet links and outdated references, this manual still holds useful information and practices for navigating trail projects in Vermont and advice on practices and processes for managing trail projects.

Webber, P. & International Mountain Bicycling Association. (2007). *Managing mountain biking: IMBA's guide to providing great riding.* International Mountain Bicycling Association.

Published in 2007, this guide picked up where Trail Solutions left off, addressing more of the topics land manager and clubs that manage land with mountain biking are most involved with. Specifically helpful components it delivers related to best practices include: mechanized construction, corridor clearing and sustainable trail design.

*Western Australia Mountain Bike Management Guidelines.* (2019). Parks and Wildlife Service (Department of Biodiversity, Conservation and Attractions), Department of Local Government, Sport and Cultural Industries; WestCycle; West Australian Mountain Bike Association.

One of the newer documents that is part of this review, it had much to offer in terms of planning and design practices that are applicable to mountain bike trails from Western Australia to Vermont. It is a wealth of information related to every aspect of trail project development and management. The main document is 90 pages, with an extensive glossary and appendix that contains a variety of useful tools and resources.

*Whistler Trail Standards: Environmental and Technical Trail Features.* (2003). Whistler Cycling Committee.

This publication was informed by previous guidelines provided in IMBA publications and includes specific standards related to Technical Trail Features (TTF's), Fall Zones and environmental guidelines for sustainable trail siting, and standards and rating for trail difficulty and type.

### **Vermont Specific Regulatory and Natural Resource Guidance Documents**

These guidelines and resources were also reviewed as part of the process of BMP documentation and creation. They can be used for reference for trail activities that may trigger local, state or federal jurisdiction and oversight over proposed trail stewardship and construction activities, as well as guidance for ANR lands projects.

Guidance for Designing Recreational Projects to Maintain Ecological Function on ANR Lands, Draft v. 2.0 (2024)

Created to help guide trail development on ANR lands, this most recent guidance document focuses on the intersection of activities related to the development and maintenance of trail-based recreation in the various categories of the ecological landscape of Vermont.

Riparian Management Guidelines for Agency of Natural Resources Lands, Agency of Natural Resources (2015)

These guidelines focus on ANR lands and the protection of riparian areas within them.

Low Risk Site Handbook for Erosion Prevention and Sediment Control, Vermont Environmental Conservation (2020)

Many trail projects fit into the category of “low risk” for erosion prevention and sedimentation control. This handbook outlines standard mitigation practices applicable to this category of project.

Naughton, M. *Wildlife and Recreation: Understanding and Managing the Effects of Trail Use on Wildlife*. Vermont Department of Forests, Parks & Recreation (2021)

This literature review commissioned by FPR is the first comprehensive guidance on the intersection of trails and wildlife. The document reviews the existing data and literature available and makes a small variety of recommendations for trail based activities based on the findings of the literature review.

*Landowners Guide to Wetlands*, Vermont Wetlands Program of Vermont Department of Environmental Conservation (2018)

Preceding guidance specific to trails and wetlands, this simple and straightforward brochure is designed to help landowners navigate the very initial questions of whether their land contains a wetland, and what to do if they think it does in terms of when a permit may or may not be needed for various activities on their land.

*Recreational Trail Building in Wetlands*, Vermont Wetlands Program of Vermont Department of Environmental Conservation (2020)

This guidance is tailored specifically to trail building and maintenance activities in jurisdictional wetlands in Vermont on what are permissible activities within the wetland or wetland buffer, beyond which a permit will be needed.

Appendix: [Matrix of Resources](#)