pec
pennsylvania environmental council

TRAIL MAINTENANCE ASSESSMENT GUIDE

A Visual Reference for Evaluating and Sustaining Multi-Use Trails

Prepared By
environmental planning & design

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BENCHMARK TRAILS OR TRAIL NETWORKS
Allegheny Valley Trail
Armstrong Trail
Bob Rodale Cycling Trail
Capital Area Greenbelt
Cherry Creek Trail
Clarion-Little Toby Trail
Delaware & Lehigh (D&L) Trail
Erie Bayfront Trail
Great Allegheny Passage (GAP)
Kensington and Tacony Trail (K&T Trail)
Knox & Kane Rail Trail
Lackawanna River Heritage Trail
Manayunk Canal Towpath
Montour Trail
Northwest Lancaster County River Trail
Pine Creek Trail
Red Bank Trail
Schuylkill River Trail
Spring Creek Canyon Trail
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Cover photo: Bob Rodale Cycling Trail, Bob Rodale Cycling and Fitness Park, Breiningsville, PA.

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The **Pennsylvania Environmental Council (PEC)** is a 501(c)(3) nonprofit focused on protecting and restoring the natural and built environments through innovation, collaboration, education, and advocacy. PEC believes in the value of partnerships with the private sector, government, communities and individuals to improve the quality of life for all Pennsylvanians. Founded in 1970, PEC now has offices across the Commonwealth of Pennsylvania in Philadelphia, Pittsburgh, State College, and Dallas. To learn more about PEC, please visit our website at pecpa.org. For more information on PEC's work related to trail maintenance, contact Zhenya Nalywayko at znalywayko@pecpa.org.

environmental planning & design (epd) is a landscape architecture and nature-centric planning team. The firm's professionals, through outdoor recreation passion and respected technical expertise, work with regions, communities, and organizations to transform trail ideas to trail realities. In delivering long-standing trail designs, epd is keenly tuned to responsible, quality construction and maintenance techniques. With miles upon miles under their feet and their wheels, they know each renowned project begins with one meaningful step or crank of the pedals at a time. To learn more about epd, visit epd-pgh.com and to learn more about our work, contact Andrew Schwartz, in our Pittsburgh, PA office, at AndrewSchwartz@epd-pgh.com.

Photo: The Great Allegheny Passage in Fayette County, PA, between Connellsville and Ohiopyle.

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PREFACE

For the past half century, a network of national, regional, and local trails has been expanding across the United States. The **1968 National Trails System Act** set the stage for establishing trails in both urban and rural settings for people of all ages, interests, skills, and physical abilities. With President Lyndon Johnson's signature, this Act established **National Scenic Trails** and **National Recreation Trails**.

Ten years later President Jimmy Carter signed an accompanying bill into law to create **National Historic Trails**. Today, in all 50 states, organizations widely ranging in size and formality carry out the Act's intent: promoting trail enjoyment and appreciation while encouraging greater public access.

In the subsequent decades, multi-use trail systems have continued to grow and greatly expand our recreational and transportation infrastructure. At the same time and with each mile the systems have endured wear and tear — along with exposure, every minute of every day, to Mother Nature's ever-changing elements. No matter the community or county, nor the dry or wet day, nor stifling heat or freezing temperatures, many multi-use trails are understandably showing their age.

Tens of thousands of trail miles have evolved from idea to construction. Trail enthusiasts often consider that when a trail finally gets built, the hard work is done. However, that's when the hard work actually begins. For the health of our trails, more resources must be put toward sustainability. Specifically, sustainability focuses on proactive methods of trail maintenance and on increasing the longevity of trails and their many assets, features, and amenities.

Seeing the dearth of advice and resources available for maintaining trails, we created this ***Trail Maintenance Assessment Guide (Guide)*** to provide trail owners and managers with a long-needed guide to best practices for sustainable trail maintenance. Though it employs examples from Pennsylvania, this ***Guide*** is applicable across the country. It is intended to help all those who take care of our trails as they adopt changing practices, embrace useful technologies and tools, become aware of what to look for when inspecting their trails, achieve long-term success through proactive maintenance, and establish best management practices for their organizations.

Sustainability is the strongest link between trail enjoyment, trail safety, and trail longevity. This ***Guide*** shows you and your team how to achieve these connections. We hope you will find it useful!

Photo: Huntington & Broad Top Rail Trail, Hopewell Township, Bedford County, PA.

INTRODUCTION

THE CASE FOR TRAIL SUSTAINABILITY

In 1967, the Elroy-Sparta State Trail, the first **multi-use trail** in the country built on a former railroad right-of-way, opened to the public in southwest Wisconsin, pioneering a new type of recreation. When the Wisconsin Conservation Commission purchased the 32-mile-long corridor from the Chicago and North Western Railway, the members of the commission were not certain who would use its future trail. They soon learned that 40% of trail users were bicyclists. Not long after opening, the commission smoothed over the railbed and surfaced it with crushed gravel — the material that continues to be the product of choice for soft-surface **rail trails** today.

ELROY-SPARTA STATE TRAIL: THE FIRST RAIL TRAIL

"This 32 mile state trail was formerly the mainline of the Chicago and North Western Railway. The conversion from 'rail to trail' represented a new concept in recreational development. Utilizing the abandoned railbed, it was the first trail of its kind in the United States to be designated a National Recreation Trail by the United States Department of Interior. The trail is primarily used for bicycling, hiking and snowmobiling. Passing through scenic areas, it links the communities of Elroy, Kendall, Wilton, Norwalk and Sparta. Added attractions are its three tunnels, the longest being 3,833 feet. Train service began in 1873 as steam locomotives hauled grain, livestock and passengers. Rail service ended in 1964. The trail was established by the Department of Natural Resources in 1965 and opened to the public in 1967."

— Wisconsin Official Marker, erected 1979

Above: One of three tunnels along the Elroy-Sparta State Trail. (Photo credit: Wikipedia user Wikideas1.)

In 1983 Congress passed legislation to facilitate "**railbanking**," which allowed inactive rail corridors to be preserved for future rail use while they served as recreational trails. This law fueled an explosion of multi-use trail development throughout the country. Midwestern and Northeastern states became early leaders in trail construction, thanks to their rich industrial legacy and the many miles of railways that accompanied it. Local jurisdictions and trail organizations were quick to leverage railbanking in light of the abundance of idle rail corridors in these states. Additional factors, both social and economic, converged around this time to spur rapid growth of the country's trail system, as summarized in **Figure 1**.

After six decades of steady development of multi-use trails — some of which cross multiple states and are parts of larger trail systems — the United States is now home to more than 41,000 miles of trails serving bicyclists and foot traffic, among other modes of recreational transportation such as horseback riding, cross-country skiing, snowshoeing, and snowmobiling. According to the Rails-to-Trails Conservancy, 26,000 miles of these multi-use trails are rail trails — constructed on abandoned rail corridors like the pioneering Elroy-Sparta State Trail.

Figure 1:

KEY INFLUENCES ON THE GROWTH OF OUR NATION'S TRAIL SYSTEM

- Deindustrialization of older parts of the United States, particularly the Midwest and Northeast, providing a strong foundation for rail-to-trail conversions
- Consolidation of the freight rail industry, which led to the closure of many branch lines and even mainlines that provided shallow-grade corridors perfect for multi-use trail development
- Renewed interest in nonmotorized and alternative transportation
- Growth of public interest in outdoor recreation, health, and fitness
- Recognized value of reconnecting people, communities, local economies, and the outdoors

60 YEARS OF BUILDING MULTI-USE TRAILS! NOW WHAT?

While multi-use trails are no longer a novel concept, there continues to be a strong appetite for constructing new trails and for closing gaps within or between existing trail systems. Multi-use trails have become widely supported by the public and have generated new opportunities for tourism and economic development. They have brought new life to communities of all sizes, and their impact has consistently proven to be a benefit where they exist.

As existing multi-use trails age, however, addressing the "wear and tear" from decades of use becomes an increasing need. Multi-use trails, like other transportation or recreation assets, demand an appropriate level of maintenance to continue to meet users' expectations. Foregoing maintenance is all but guaranteed to pose serious challenges to their sustainability, threatening the positive contributions and economic impacts they've generated for communities. Ongoing maintenance, at least to some degree, is "built in" to the construction of roads and highways. Why not trails?

MULTI-USE TRAIL

key term

A paved or unpaved path open to use by bicyclists, pedestrians, and other authorized (usually only nonmotorized) users. A multi-use trail allows for two-way travel and is typically located in its own right-of-way separate from roadways. Also known as a **shared-use path** or **shared-use trail**.

Because multi-use trail development in the United States is still in its growth stage, a dearth of literature exists on how to maintain a trail once it's built. Hence, the purpose of this ***Trail Maintenance Assessment Guide***. While many of the examples and experiences from this ***Guide*** originate from Pennsylvania, an early leader in rail trail development and the U.S. state with the second-most number of trail miles, we believe that trail managers in other states or even other countries will find its contents useful. The best practices involved in the maintenance of trails, their features, and their amenities hold true in most climates and settings — dry or wet, urban or rural.

The connection between maintenance practices and the long-term sustainability of our nation's multi-use trail network is clear. Well-maintained trails are an essential element of our civic, recreational, and transportation infrastructure and are of great economic importance to many communities. This ***Assessment Guide*** accentuates the need for more proactive and preventative approaches to maintaining our trail assets and provides a guidebook to assist trail operators in keeping an eye on issues and conditions to look for before some compound into severe or budget-busting problems. More importantly, this ***Guide*** explains why particular maintenance issues may have occurred or are beginning to occur so that trail operators can stop an emergent problem in its tracks and address it along with the repair itself.

MAINTAINING A HIGH-QUALITY USER EXPERIENCE

No matter the reason to be on a trail, the perception of the trail user's experience is influenced by its appearance, cleanliness, convenience, and level of safety. While some early multi-use trails may not have been originally constructed to today's highest standards, the current level of maintenance concerns most trail users, whether they use a trail for their daily commute or just for weekend recreation.

In other words, most people will decide to use a trail if its surface is in good condition, the adjacent vegetation has been trimmed to enable clearance and visibility, and they don't have to constantly tiptoe their hiking boots or white-knuckle their handlebars through standing water, mud, or ice. If trail users become frustrated with its conditions, they may use the trail less or simply avoid it altogether. This is especially true if the trail is anything less than a national draw and relies on its reputation as a high-quality local or regional recreational asset. The wellness, recreational, economic, and social benefits of a trail rely on the trail being used, and all of these suffer when the trail's conditions and reputation decline because of **deferred maintenance**.

Lack of funding for trail maintenance undermines the expectation of a high-quality user experience just as trails are getting more sophisticated and the public is readily embracing them. Moreover, limited money or a tight budget can lead to difficult priority choices for trail operators, who are faced with choosing whether to defer cleaning out drainage swales or resurfacing a worn trail section because operational funds need to go toward the removal of downed trees or the repair of washouts from storms. In other words, trail operators frequently use available funds for emergencies rather than the *causes* of those emergencies — which is deferred maintenance in a nutshell.

DEFERRED MAINTENANCE

key term

Maintenance of trails or trail amenities that was not performed when it should have been or when it was scheduled and which, therefore, was put off or delayed to a future period. Deferred maintenance leads to deterioration of performance, increased costs to repair, and a greater likelihood of needing replacement or reconstruction.

A NEED TO SHIFT OUR FUNDING PRIORITIES

The development of multi-use trails has occurred through a variety of funding sources. These include municipal capital dollars, state recreation grants, state transportation grants (inclusive of federal pass-through programs), and private funds (foundation grants, philanthropic gifts, individual donations, etc.). While many avenues are available for funding trail construction, the story is very different when it comes to funding maintenance.

Trail owners and operators typically cannot use state "liquid" fuel taxes on multi-use trails because, unlike roads and highways, trails (usually) do not permit motor vehicles such as cars, trucks, and buses. Often only municipal funds and private contributions, donations, or grants are available to pay for trail upkeep. This includes all the costs related to labor, materials, and equipment. Trail operators, in turn, often rely heavily on volunteer assistance to complete many maintenance tasks. Such dependence on volunteers can reduce the speed of maintenance — which is often already in a backlog — and may produce inconsistent and sometimes marginal results.

Some jurisdictions have enacted special tourism-related taxes, such as a hotel bed tax, to help pay for trail construction, maintenance, management, and promotion. These special levies, while typically restricted in their use, can capture a portion of tourism dollars and direct the proceeds back to the source of the tourism, which includes trails. While many experts agree this could be a path to sustainable maintenance of trails, not many jurisdictions have used this approach as higher lodging costs in communities that often already struggle to attract visitors may not be politically popular among elected officials and voters.

THE PERILS OF DEFERRED MAINTENANCE

Trail organizations frequently struggle with making priority decisions about how and where to use their limited financial resources. It is common for a trail's core infrastructure to drop to the lowest priority on the maintenance list because repairs to the infrastructure may present a prohibitive short-term cost. Core infrastructure includes, among other items, trail surfaces, drainage swales and pipes, retaining walls, fences, and railings. Additionally, the maintenance issues related to core infrastructure often take years to emerge or to become noticeable both to trail managers and the general public. While this type of deferred maintenance is not intentional, it results in greater long-term costs and a diminished trail experience.

Conversely, the repair or clean-up of an amenity such as a waste receptacle or a bench is generally minor, low-cost, and highly visible at trailheads. Subsequently, these maintenance tasks often rise on the priority list and take attention away from the larger infrastructural problems even if the answer sometimes is just to remove the waste receptacle or bench. The unfortunate result of this circumstance can be that sometimes a trail organization does not devote enough maintenance resources to core issues; then one moment of indecision can jeopardize the long-term sustainability of the trail.

Deferred maintenance of a trail is much like that on one's health. Years of unhealthy habits or a poor diet — a lack of body maintenance — may slowly turn into multiple and interconnected health problems such as heart disease, high blood pressure, and/or diabetes. A parallel phenomenon in the trail world is surface drainage. When drainage swales begin to regularly hold water, that is an indication that a problem with drainage exists. If an investigation and swale repair are deferred, the standing water will eventually begin to create structural problems such as a water-saturated trail subbase, heaving of the trail surface, or a compromised trail shoulder from grass intrusion on the edge of the trail. Any of these outcomes will weaken the integrity of the trail.

A CRITICAL DEFLECTION POINT

Outdoor recreation is a booming U.S. industry, which has only accelerated since March 2020 with the onset of the COVID-19 pandemic. As of 2023 the Outdoor Industry Association (OIA) reports that more than 168 million Americans over age 6 — 55% of the total population — enjoy some form of outdoor recreation in their lives. The OIA estimates that 10 million new outdoor recreation participants have been recorded since March 2020, and the U.S. Department of Commerce projects that outdoor recreation has contributed $14 billion to the nation's economy, created over 150,000 full time jobs, and provided the industry's workers with more than $6.8 billion in compensation. With statistics like these, our nation very clearly benefits from investments in trails.

As legacy trails age, we face a critical deflection point — a point at which balancing the continued expansion of the trail network and the maintenance of existing trails is more important than ever. Budgets to sustain trails will be stretched more thinly as multi-use trail miles continue to increase if all things remain constant. Too often, deferred maintenance and needed repairs go unaddressed. This can lead to costlier long-term consequences for trail organizations that often do not have sufficient financial and human resources to address them. Ultimately, the trail-using public will notice deferred maintenance, which could result in fewer potential tourism dollars and less local spending. Trail organizations need to implement sustainable trail funding and maintenance practices so that multi-use trails can continue to serve as a major contributor to the nation's tourism industry.

For more than six decades, multi-use trails have played an important role in expanding the public's interest in outdoor recreation. While trails have facilitated a crucial tourism industry centered around spending by people with discretionary income (e.g., middle-to-upper-income families with children and seniors enjoying retirement), they have also emerged as a public good for people from less affluent socioeconomic groups — a function that has become increasingly vital over time. By keeping trails well-maintained and by recognizing them as the asset that they are, trail organizations will be able to sustain trails and the helpful benefits they offer for decades to come.

PART 1: THE STATE OF OUR TRAILS

AN ASSESSMENT OF LONG-TERM MAINTENANCE

1.1 TRAILS AS CIVIC INFRASTRUCTURE

Civic infrastructure is the collection of shared public places where people and communities come together. Examples of civic infrastructure include transportation systems, parks, trails, playgrounds, libraries, and schools. At its core in every type of climate, local leaders, residents, and civic infrastructure create much of the fabric in our communities. Pride, stability, and so many other factors determine each community's quality of life and prosperity.

In little more than a half-century, the network of multi-use trails spanning our urban, suburban, and rural landscapes has emerged as an important component of our civic infrastructure. Trails are often multi-dimensional elements, supporting a broad diversity of uses. They function as transportation routes, recreational facilities, gathering spaces, places for birdwatching, important homages to history, and respites in nature. Particularly for those who live near trails or who operate the growing number of businesses that rely on trail users, trails have become indispensable to many people's daily lives and well-being.

1.2 WHAT IS A SUSTAINABLE TRAIL?

The word **sustainable** is often a vague, undefined term when used alone without context. For some, sustainability is related to the protection of the natural environment, low-impact building design, or healthy living that helps to guarantee a world for future generations that is as good as or better than the present day. For others, it's about maintaining a balance between the supply and use of natural resources in which their depletion, disruption, or degradation is avoided. Our cultural focus toward sustainability has led to new industries and market demand for more environmentally-friendly products and practices.

While minimizing impacts, conserving resources, and planning for the future are often thought of from the perspective of the environment, sustainability should also be considered in terms of human and financial resources. In the world of trail maintenance, the three cogs driving the sustainability engine — environmental, human, and financial — are very much intertwined.

So, how does this translate to the trail world? What exactly is a **sustainable trail**? For the purposes of this ***Guide***, we have adopted the following definition, which emphasizes the preservation of limited resources — human, financial, environmental, and material alike:

SUSTAINABLE TRAIL

key term

A sustainable trail is one that limits trail degradation, minimizes unpredictable maintenance needs, creates little environmental impact, ensures user safety, provides a positive experience, and ultimately minimizes costs to the trail owner, independent of the trail type or location.

A sustainable trail is one that takes advantage of the natural features of the environment rather than attempting to transform the landscape to meet the trail's needs. By minimizing disturbance to nature, a trail lasts longer and is safer and more enjoyable for its users. Sustainable trails are built correctly in the first place, rendering the predictability of what maintenance *is* needed a lot more certain as well as the planning and budgeting for that maintenance. Such trails require less frequent tapping of scarce human resources (often consisting of volunteers who do this work for free) and financial resources (including donations and grants). That's environmental, human, and financial sustainability all rolled into one.

Only recently has sustainability come into the trail world's vocabulary. Mountain bike trails were the first to be scrutinized for sustainability as decades of rapid mountain bike trail construction and user growth led many riders, land managers, and trail stewards to question the long-term repair cost and environmental impact of their trails. In 2004 the International Mountain Bicycling Association (IMBA) published *Trail Solutions*, a seminal guide to trail design, construction, and maintenance; in it they identified what they characterized as "the core elements of a sustainable trail." (See **Appendix D** for a list of references, including the IMBA's guide.)

Sustainability concerns eventually migrated to multi-use trails, such as rail-to-trail conversions and dedicated off-road bikeways. The specific questions for these types of trails, addressed in this ***Assessment Guide***, are grounded not only in environmental considerations such as erosion or rainwater runoff but also in the replacement cost of past investments, the negative impacts of poor user experiences or closures because of trails' falling into disrepair, and the degrading appeal of trails' suffering from neglect and vandalism.

The actual design and construction of a trail are crucial to its sustainability. If the trail is built correctly in the first place, minimal ongoing maintenance should be required. Design and engineering considerations influential to a trail's long-term sustainability include its grade (also commonly referred to as "longitudinal slope"), the underlying soils, access of the trail surface to sunlight, and its handling of drainage. However, there is also the dimension to sustainability related to the resources (e.g., equipment, manpower, funding for maintenance, etc.), abilities (e.g., skills, expertise, and physical labor), and priorities set by trail owners and managers.

1.3 KEY OBSERVATIONS AND INSIGHTS

In developing this *Guide*, 15 trail specific maintenance assessments were completed to gather facts about current practices and to identify both successes and opportunities for improvement. The assessments scrutinized the real-world conditions of 250+ miles of multi-use trails in Pennsylvania by evaluating a variety of trail surfaces, amenities, structures, and drainage improvements. Assessing the conditions of the trails and their supporting features was a helpful "state of the union" for a mature trail network.

The following subsections summarize the observations and insights from these 15 assessments by describing the most important lessons learned, the maintenance factors most directly influencing the conditions of multi-use trails in a four-season climate (a problem that may become only more acute with increasing extreme weather events), and the major challenges and obstacles to sustaining trails and their assets well into

Above: The Knox & Kane Rail Trail in Kane, PA, on a crisp fall day.

the future. These observations and insights were instrumental in shaping the topics, organization, and specific content of this ***Guide***, including the best practices found in **Part 3: Trail Sustainability Guide**.

It must be mentioned that the observations here are in no way a critique or indictment of the hard work and sweat equity of the thousands of dedicated trail enthusiasts who have contributed to the development of our nation's trail network. Rather, they are meant to be a "call to arms" with the goals of: 1) raising awareness of existing and emerging maintenance issues as trails age, and 2) changing the way we view and prioritize maintenance, particularly in the context of the continued desire to build more trails and add mileage to existing ones.

OBSERVATION 1: A LIMITED UNDERSTANDING OF TRAIL MAINTENANCE NEEDS

TRAIL MAINTENANCE ENCOMPASSES A VARIETY OF ACTIVITIES

The term **maintenance** is often thought of only as an undesirable, backbreaking menial physical labor. That could not be further from the truth! Trail maintenance involves a wide range of projects and activities, and requires careful planning. As shown in **Figure 2**, there are four different types of maintenance that most trail owners, managers, and stewards (i.e., volunteers who focus on maintenance tasks) should be familiar with — all of which require different needs and costs, and which may be on different timelines:

1. "**Ongoing maintenance**" includes routine activities performed to ensure that trail assets are clean, safe, and operational. Examples include picking up litter and emptying waste receptacles, clearing debris and sediment from swales, pruning overhanging trees, mowing grass, cleaning restrooms, and painting and sealing wood decking. The goal of ongoing maintenance is to ensure that a trail successfully serves the needs of its visitors and fosters a positive experience through preventative and routine measures. Ongoing maintenance is a type of **preventative maintenance**.

2. A "**capital improvement**" refers to a financially significant, long-term project with the express purpose of expanding and/or enhancing an existing trail or its infrastructure. Examples of capital improvements include building a new trail section, constructing a new pavilion, or erecting Adirondack shelters for long-distance trail users. A capital replacement typically requires even more financial investment to maintain the functionality and safety of the trail or its assets.

3. "**Repair**" is the term used to describe the process of fixing or restoring damaged or broken elements along a trail, such as filling a pothole or crack in the trail surface, replacing a splintered fence rail, removing the graffiti from a sign, or completing any other maintenance of trail assets that may deteriorate over time due to usage, vandalism, or weather conditions. A repair is essentially a maintenance activity aimed at restoring the trail asset to a functional state.

4. A "**capital replacement**" refers to the process of replacing major, long-lasting trail assets, such as the asphalt pavement on a trail section, replacing a restroom building when it reaches the end of its useful life, or updating the mileage signs when a once-isolated trail gets subsumed by a longer trail. Capital replacements necessitate substantial investments in order to improve the overall trail experience.

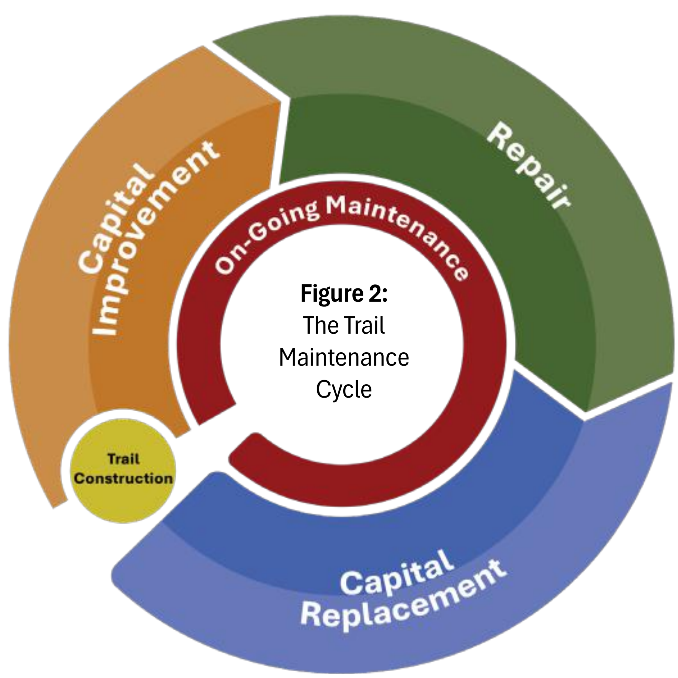


Figure 2: The Trail Maintenance Cycle

Many trail managers and stewards don't readily distinguish between the different types of maintenance, nor do they recognize that there is often a sequence or progression from one type to another. For instance, neglecting ongoing maintenance and repairs may lead to the need for more expensive capital improvements or replacements. Suddenly, that small crack in the trail pavement that wasn't filled last spring grows into a big pothole.

Think of a new trail like a new car. The owner of the car sees only the brand new — the temporary license plate, the new car smell, the low mileage, the shiny black tires. Before long, he or she may neglect to check the tire pressure, which could lead to premature wear of the drive axles. Or, s/he may neglect to get the brake pads changed until metal starts grinding on metal, which could necessitate a much costlier replacement of the rotors. To make matters worse, if the car owner forgets to change the oil, accelerated wear and tear could cause the engine to overheat. Ongoing maintenance is needed for the car, whether it has 2,000 or 200,000 miles on the odometer.

People may think that little to no maintenance is needed — at least any time in the near future — when a trail is brand new and enjoying its honeymoon stage. That, however, is not the case. Good habits start early, and ongoing maintenance should begin when the contractor vacates the site, even before the trail is open to the public and the ribbon is cut. **PLAN AHEAD: Draft a written maintenance plan and share it with all parties who will be maintaining the trail — before the trail even opens to the public.**

OBSERVATION 2: MANY SIMULTANEOUS CHALLENGES FOR TRAIL OPERATORS

SHINY OBJECT SYNDROME

During the 20th century, as the U.S. became more affluent, our culture simultaneously became more focused on building new things and less interested in maintaining what was already built. This mindset, which has been turbocharged in the 21st century, has affected not only buildings and homes but also our transportation infrastructure. Take our highway system, for example. In 2021, state and local jurisdictions in the United States spent $206 billion on roads and highways. Of that figure, 56% was used for new construction while just 44% was earmarked for maintenance and operations. In fast-growing regions like the Sunbelt, this ratio is even more stark.

Ribbon cuttings that announce new projects convey an image of progress and advancement, and they make for great photo-ops. Once the grand opening is over, we move on to the next shiny new object. Keeping things "up to snuff" is more mundane and less memorable. And there is less appetite for the mundane.

However, building a growing inventory of shiny new objects without planning for maintenance is just "kicking the proverbial can down the road." Without preventative maintenance or even a maintenance plan to follow, that shiny new object becomes a white elephant 20 years later. Deferring minor repairs and routine maintenance that would have cost less over time — and that could have been budgeted annually — leads to much more expensive and less predictable major repairs and rehabilitation. And that doesn't even take inflation into account! Worse yet, if "rainy day" money isn't there, a dire situation could force closing a section of a trail or the entity owning a trail may end up taking a big risk in keeping it open, jeopardizing public safety or exposing itself to liability. Additionally, larger repairs often necessitate expensive professional design services, resulting in "soft costs" unseen by the public.

AN OVERWHELMING AMOUNT OF MAINTENANCE NEEDS AS TRAILS AGE

Many "legacy trails" (i.e., older, earlier-developed trails) have not seen significant maintenance or capital improvements since their original construction. Common deferred maintenance items include resurfacing, vegetation management, and drainage swale upkeep. These often pose significant financial and human challenges for trail organizations. In some cases, the deferred maintenance and the capital replacement resulting from it may be as expensive as or even more expensive than the original trail's construction cost, especially with inflation.

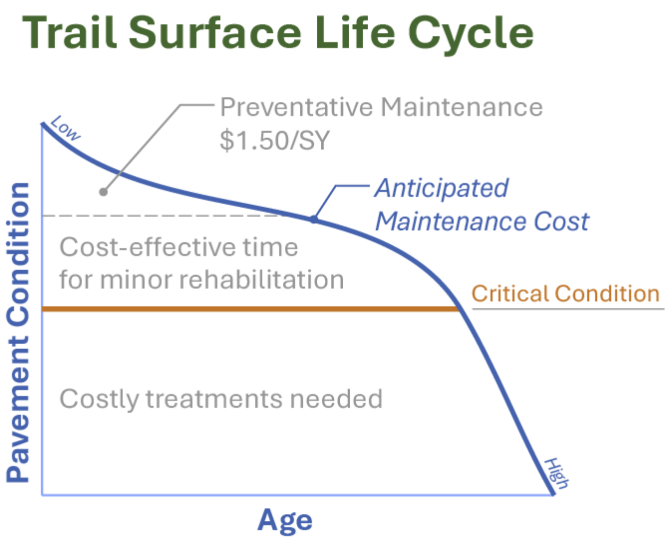


Figure 3: Investing in preventative maintenance early on prolongs the life of a trail and saves money in the long run. (Adapted from the Minnesota Local Road Research Board [LRRB].)

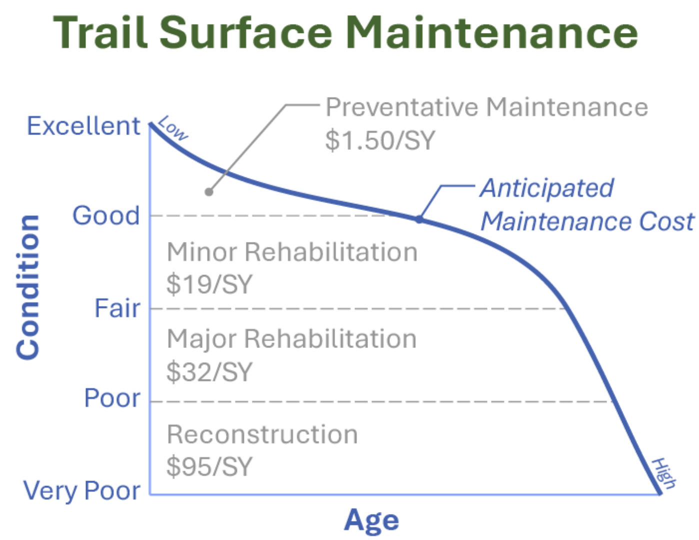


Figure 4: Maintenance costs for trail surfaces skyrocket when maintenance is neglected. (Adapted from the Minnesota Local Road Research Board [LRRB].)

It is important to remember that a trail is constructed as an interconnected set of individual improvements — the trail surface, a swale, culverts, a retaining wall, bridges, etc. — that are intended to serve particular roles. These improvements must work in unison so that the trail can function properly. As trails age, individual improvements age at different rates depending upon their materiality, their exposure to the elements, the original design assumptions, the amount of use they endure, and the level of deferred maintenance that has occurred over time.

When maintenance is deferred for one of a trail's improvements, it may — and usually will — begin to affect the performance of the other improvements, leading to a domino effect. For instance, neglected drainage swales that hold water for extended periods of time may affect the adjoining vegetation, killing the grasses that were absorbing and slowing the flow of the water and reducing the surface of the swale to just mud. Eventually, the water from these neglected swales will send the mud downstream to a culvert, where it becomes impervious sediment that plugs up the culvert, leading to a trail flooded with muddy water. The trail, which never has a chance to sheet off this water, loses its surface material, and the rigidity of its stone subbase becomes compromised. Once the subbase is compromised, the trail surface will begin to wear unevenly, heaving in some places, settling in others, and making for a bumpy, muddy ride. These effects both undermine the trail user's experience and shorten the life of the trail. As shown in **Figure 4**, maintenance costs for trail surfaces skyrocket when maintenance is neglected.

PRESSURE TO CONTINUE DEVELOPING NEW TRAILS RATHER THAN MAINTAINING EXISTING ONES

In many cases, once someone experiences riding or walking a trail, they get hooked. Trails often become a part of the user's daily or weekly routine, or a place they can't wait to get to every weekend. For some, a ride or walk on a trail is a less stressful means of getting to work, a moment to decompress from the rigors of daily life, an opportunity for physical activity outside of an indoor gym, or a place to socialize with friends and neighbors.

Some trails are so widely regarded by long-distance cyclists — no shortage of whom may come from other states or even other countries — that communities along many trails have transformed themselves into "trail towns," with economies reliant on the tourism generated by these trail users. Seeing these successes, nearby towns often want their own trails as well as the tourism and economic development associated with them. This is especially pronounced in parts of the country that suffered from deindustrialization in the second half of the 20th century as the towns left behind seek new economic opportunities. For more information about trail towns, we recommend checking out Amy Camp's work as a pioneer of the trail town model at https://www.cycleforward.org/.

To develop these new routes and to respond to the communities' wishes, recreation planners, trail organizations, and state and local governments focus on "filling the gaps" between existing multi-use trail segments. The pressure to continue developing new trails is certainly a watershed moment for those who remember a lot of the earlier skepticism about trails when their positive effects on struggling communities had not yet been realized by the general public.

THE INFLUENCES OF WATER, SOIL, TREE COVER, GEOGRAPHY, AND SURFACE MATERIALS

As pointed out earlier, many of the country's 41,000 multi-use trail miles have been constructed from rail-to-trail conversions. The railroads they replaced, particularly in hilly regions, were often constructed in valleys, hugging a river or stream, to take advantage of naturally gradual grade changes. By the forces of gravity, these valleys function as natural drainageways for the surrounding hills and mountains.

Such valleys often have dense tree canopies, which create a lot of shade that trail users enjoy on hot summer days. However, this shade also minimizes the ability for sunlight to dry the trail after rain events. Trails can become muddy and retain water longer without the warmth of sunlight, which is especially the case in the spring in parts of the country with significant snowfall. Perpetual moisture additionally promotes the growth of mold, mildew, and moss, which often affect organic surfaces such as wood rails, bridge decking, and signposts. Because of their steep side slopes, the valleys are subject to landslides, soil slippage, and flooding as well.

Without thoughtful maintenance practices and functional drainage, the effects of lingering moisture and water can wreak havoc on the trail. Crushed stone trails can remain soft and become easily rutted as the season transitions from spring to summer, and asphalt trail surfaces can be susceptible to frost heave and surface fractures when their stone bases do not quickly drain.

Consequently, the maintenance needs of a trail require trail organizations, their staff, and their volunteers to deploy different equipment and skills, different amounts of attention, and different levels of financial resources in various trail sections. This lack of uniformity and predictability is made further challenging when maintenance is completed by volunteers who *may* have some experience but maybe not the full breadth of maintenance expertise that a trail throws at them.

SHORTAGES IN SKILL, MANPOWER, AND FUNDING

From our experiences in Pennsylvania — and certainly the case in other parts of the country, particularly those where government is devolved to a hyperlocal level — trail maintenance is commonly performed by volunteers and members of small nonprofit trail organizations. These are unpaid roles, which dedicated trail enthusiasts fit within their other daily commitments. In many cases, the individuals taking on these roles have no formal training or experience in trail construction, landscaping, facilities operations, and other trail maintenance responsibilities.

While volunteers may provide a cost-effective means of trail maintenance, their participation can vary significantly by trail location, season, and needed work tasks. When there are not enough volunteers or the volunteers available do not have the training or expertise to effectively complete a specific maintenance activity, such tasks can often go unaddressed for a long time. This circumstance leads to deferred maintenance.

Finally, most trail organizations and local governments do not have extensive maintenance budgets. Because philanthropic foundations and state government agencies do not typically fund maintenance, trail operators are highly dependent on small grants, donations, and sweat equity. Thus, their financial resources for maintenance can fluctuate wildly throughout the year and from year to year. Sadly, this dilemma is not unique to just certain regions in the United States; it's a story throughout the country.

Top left: Bollard light fixtures showing the effects of flooding and vandalism.

Top right: A painted wooden bench that has experienced many seasons of the elements.

Center left: A bridge railing that has partially dislodged.

Center right: Encroachment of grass both on the edges and in the center of a crushed gravel trail.

Bottom left: A trail that has lost most of its crushed gravel surface, leaving the rougher subgrade as the main trail tread.

Bottom right: The effects of erosion around the concrete footing of a fence post.

OBSERVATION 3: THREE PRIMARY ISSUES AFFECTING TRAIL SUSTAINABILITY

WATER: THE CULPRIT FOR MOST TRAIL MAINTENANCE PROBLEMS

As discussed in **Part 1.2**, sustainable trails reduce long-term costs by minimizing failures of trail surfaces, structures, and amenities through a proactive, preventative approach to maintenance. When it comes to trail sustainability problems and the effects of deferred maintenance, water is very often the common denominator. First, environmental factors related to surface water runoff are extremely common and can have both direct and indirect negative impacts on trail conditions. The sources of surface water runoff include everyday rainfall, snowmelt, natural springs, natural seeps (colloquially referred to as "bleeds"), and from time to time and in certain parts of the country, metal or coal mine openings, which release toxic, ochre-colored **acid mine drainage** in the vicinity of trails after earth disturbances.

The severity and prevalence of surface water problems are largely dependent on how effectively runoff can be directed away from a trail. Allowing concentrated and fast-flowing water to run on, across, and alongside trail surfaces can lead to degradative effects such as **standing water**, **mud and sediment buildup**, **involuntary widening of the tread**, **tree root exposure**, **erosion of the trail edge**, **overwhelmed drainage features**, and any number of various types of **cracks**, **depressions**, **potholes**, and other distresses to the trail's structural integrity.

Another water-related environmental factor affecting trails is the **freeze/thaw cycle**. Water absorbed by the soils adjacent to the trail, by the gravel subbase, and by the trail surface itself negatively impacts the trail as it freezes, thaws, refreezes, and rethaws during the winter and transitional seasons. The frozen water expands in volume and often results in differential displacement ("heaving") of parts of the trail just a few inches away from one another. With asphalt, this results in cracks and potholes. With concrete, this results in uplifted slabs and cracks. And with crushed gravel, this results in ruts, depressions, and unwanted vegetation in the middle or edges of the trail.

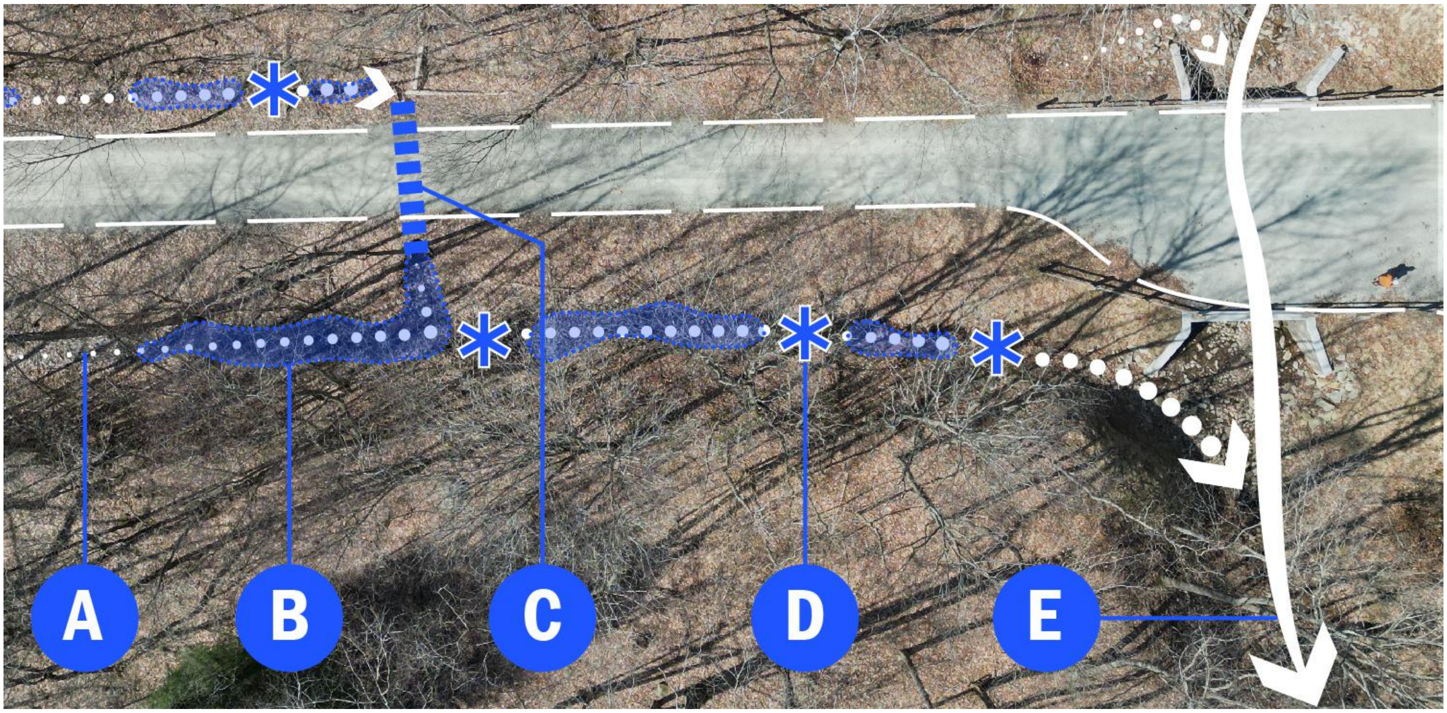


Figure 5: The Many Ways That Water Can Affect Trails. The white dots denote the location of a swale and the arrowheads indicate the direction of flow. The blue stars denote where drainage obstructions have occurred in the existing swale system and is now compromising the integrity of the trail surface. "A" depicts a swale that is free flowing, with no obstructions. "B" provides an example of where sections of the swale system are blocked by obstructions created by debris and a landslide ("D"), which has caused standing water. "C" indicates an underground drainage pipe that is no longer free-flowing because of the downstream debris and soil obstruction. "E" is the natural drainage course to which the swale system is to connect but currently does not.

Once a trail surface becomes too degraded, rehabilitation can be prohibitively expensive with impacts on financial and human resources — not to mention the user experience. Trail surface degradation often leads to altered user behavior, as bicyclists and walkers negotiate degraded areas, leading to unwanted trail widening or unsanctioned "social trails" that take drier, less muddy routes. This behavior can act as a catalyst for environmental damage such as trampling of vegetation, land erosion, water pollution, and even wildlife displacement.

Besides causing erosion on trails, water can also diminish trail assets, particularly those made of wood (damaged by rot, mold, mildew, and warping) or metal (damaged by rust). These assets include benches, signposts, fences and railings, gates, retaining walls (including, in rare cases, headwalls for culverts), waste receptacles, water fountains, and more. Finally, swales, pipes, and other drainage features can become clogged with soil, sediment, vegetation, and debris carried by water, which can cause the proliferation of mosquito colonies.

USER VOLUMES: INCREASING POPULARITY FOR BOTH RECREATION AND TRANSPORTATION

An increase in the number of people using a trail is a double-edged sword for trail organizations. Most trail owners want as many users as their trails can attract, and most trail towns whose economies depend on them want the same. However, being "loved to death" can also mean a need for more frequent or costly maintenance. A high volume of users can lead to unforeseen or unmanageable wear and tear not originally anticipated or planned. Such circumstances frequently trigger a widening of the tread, the development of multiple treads, the creation of unofficial detours (often referred to as "social trails"), and erosion of the trail edge.

Moreover, an overabundance of users can lead to quick deterioration of trail amenities such as benches, signage, and waste receptacles. Wear and tear, including vandalism and graffiti on these items, can decrease or diminish a trail user's positive impression or experience by suggesting, at least visually, a lack of maintenance.

THE LIFE CYCLE OF MATERIALS: WHEN TRAIL SURFACES AND FEATURES APPROACH END-OF-LIFE

Just like any other piece of transportation infrastructure (such as roads and sidewalks), multi-use trails have a serviceable life. Their longevity will vary based on the type of materials used, the quality of construction, the ability of the trail to effectively handle water, and the frequency and scope of maintenance performed.

A significant number of our nation's legacy multi-use trails are now between 30 and 60 years old. Many of these trails have not been repaved or resurfaced at all over that time. Some legacy trails have small reconstructed or patched-over trail sections because of an emergency situation (such as a landslide) or a one-off circumstance (such as a sewer line reconstruction project). Some have never been fully repaved. In the case of asphalt, 25 to 30 years is considered by pavement experts to be an expected serviceable life, assuming typical conditions and maintenance practices. Many asphalt trails, however, have experienced pavement problems much sooner than that and are on track for a serviceable life of only 12 to 20 years.

Wood is often used as a decking material for trail surfaces on bridges and boardwalks. The railings and guardrails for these structures are also frequently made of wood. Treated lumber is usually warranted for about 25 years. However, in real-world applications that we have observed, it commonly has a serviceable life of only 10 to 15 years. Even long before it is replaced, the wood may have already experienced the negative effects of excess moisture, prolonged sun exposure, and general wear and tear: twisting, uplifting, splitting, and splintering.

Few trail owners and managers have planned for the inevitable point in time when a lot of things will need to be replaced all at once. Given price increases over the past few decades and accelerated deterioration resulting from deferred maintenance, some surface replacement projects for legacy trails are estimated to be nearly double their original construction cost. And these amounts are on top of the everyday maintenance expenses that must be borne until the funds for the capital replacement are secured.

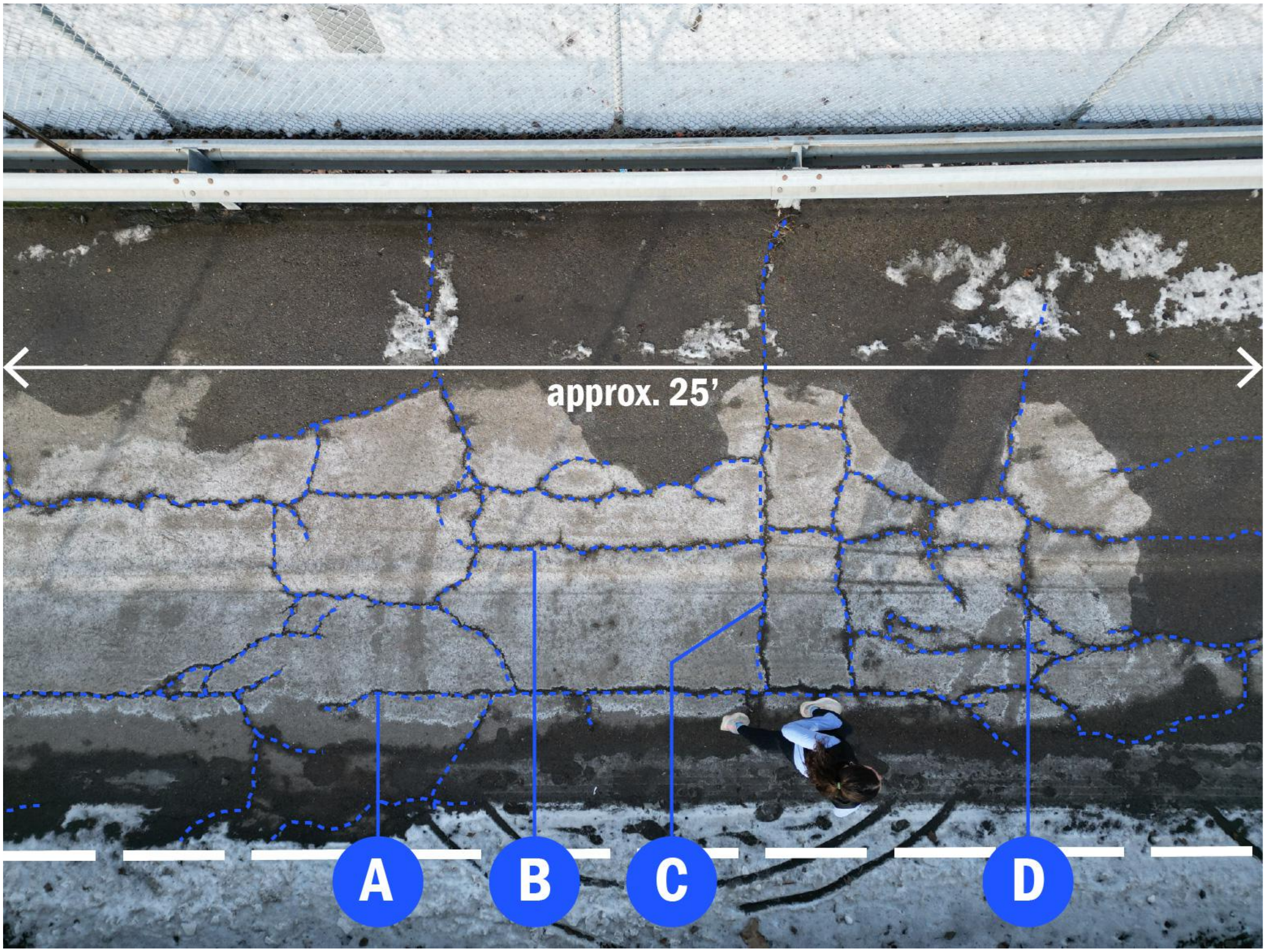


Figure 6: Aerial View of Asphalt Cracks. An example of a seriously degraded asphalt trail surface. Within a 25’ long section of asphalt trail, the effects of poor soils, defective construction, deficient drainage, and a lack of ongoing maintenance have produced over 45 cracks! “A” shows an edge crack. “B” represents a longitudinal crack. “C”is a transverse crack. “D” is a block crack. See **Part 3.3.2** of this ***Guide*** for more information on these types of cracks.

1.4 OTHER IMPORTANT INFLUENCES ON TRAIL MAINTENANCE

Beyond the observations and insights gleaned from the 15 trail maintenance assessments, we also conducted a number of conversations with trail operators and advocates, who pointed to additional factors that influence their ability to address trail maintenance and to plan proactively for future capital projects. These influences center not on the weather and environmental factors affecting trails but, rather, on trail organizations, their dedicated volunteers and advocates, and the availability of financial resources to support maintenance activities. Through no fault of their own, trail organizations and volunteers have had to shoulder the burden of managing the growing mileage of multi-use trails with little supportive funding. Having been stretched as thinly as they have already been just further compounds the problems and future challenges associated with trail sustainability.

AGING TRAIL ADVOCATES, LEADERS, AND VOLUNTEER MAINTAINERS

Many trail organizations, particularly those in wealthier areas, have been able to sustain substantial membership numbers over the years. Other groups, however, have struggled to get people involved or to keep volunteers’ and donors' attention. Historically, the primary support of trail organizations has been from an aging volunteer pool, incluring retirees with available time and discretionary income.

This trend does appear to be shifting — though slowly and unevenly. Over the past decade some trail organizations have seen an increase in younger members' getting involved and in building a new generation of advocates. However, in the grand scheme of things, the proportion of members in their working age remains relatively small — and even more so in rural areas. In addition to the aging of the volunteer and membership base, many trail organizations have reported over the years that involvement of members waxes and wanes. Some members regularly participate in trail planning, promotion, fundraising, and maintenance activities. Others occasionally volunteer but will normally phase in and out, depending on their personal lives.

As with many volunteer-led efforts, organizations rely upon "go-to" leaders who do not hesitate to step up to take care of things and who have the time and money to do so. Thus, while many trail organizations host seasonal or annual membership drives, few organizations have begun to actively recruit the next generation of trail leaders, who will be tasked with maintaining a growing mileage of trails in the decades to come.

VOLUNTEER LABOR (GRASS IS NOT GOING TO MOW ITSELF!)

One of the foremost challenges in trail maintenance is the historically heavy reliance upon volunteer labor. This relationship stems from limited maintenance funding that is familiar to most trail organizations and local governments. Any trail organization can save money if it can recruit volunteers to mow grass, paint woodwork,

Above: Volunteers building a gate for Pennsylvania's Knox & Kane Rail Trail. (Photo credit: Trail Association of the McKean/Elk Divide.)

empty waste receptacles, or even clean the restrooms, but are the volunteers equipped with the consistent time, energy, and tools needed to do the work?

It is also considerably more difficult to find volunteers for work that requires some level of advanced skill or specialized knowledge such as engineering or construction. People with these abilities typically earn compensation for their time and expertise. Volunteers usually do not have backgrounds in construction, engineering, power equipment use, or facilities operations, which are sometimes needed to complete commonly encountered trail maintenance tasks. Thus, trail organizations tend to defer maintenance in those areas where more specialized skills are needed. Operators rely upon volunteers to do less-labor-intensive tasks and frequently delay addressing other needs until they can raise the funds specifically for the work.

LACK OF CONSISTENT FUNDING FOR MAINTENANCE

As discussed earlier, most trail organizations don't have extensive annual maintenance budgets and are dependent upon private financial contributions, donations, volunteer sweat equity, and in-kind contributions of public works staff from the local municipality. State government agencies and philanthropic foundations don't typically fund maintenance.

Trails owned outright by local municipalities or counties *do* often have the ability, at least in theory, to receive direct state government funding for maintenance tasks (sometimes passed through from the federal government). However, trails are very often competing with other infrastructure projects such as roads, highways, and street

Above: Volunteers clear brush alongside the Three Rivers Heritage Trail in Pittsburgh, PA. (Photo credit: Friends of the Riverfront.)

lighting. Consequently, the budgeted amounts of funding available for trails tend to be marginal. Further, local municipalities and trail organizations alike often do not have the capacity or expertise to prepare competitive grant applications to access these state funds.

No legacy trail of which we know assesses user fees as a toll road or passenger rail line would. This concept would almost certainly be unpopular because trails are supposed to be the most basic and democratic form of transportation, available to anyone, regardless of their financial means. Would such fees, perhaps on certain days of the year, help trails address emergencies such as landslides, floods, and fallen trees? It's unclear, but it is an idea that has been occasionally proposed.

As for now, under the current funding schemes, trail organizations must rely on cash-strapped local municipalities and private donors to provide much of the financial bandwidth for maintenance operations. Those funds are typically derived from fundraising drives and the generosity of individuals, both of which are unpredictable.

LIMITED ADOPTION OF ASSET MANAGEMENT AND MAINTENANCE TECHNOLOGY

By and large, trail organizations have done a good job at mapping their trail corridors for trail users, especially in recent years. Such maps, which are found in paper brochures and online as portable document format (PDF) files, are excellent at pinpointing trailheads and amenities such as restrooms, campsites, parking, and locations of scenic overlooks. They are also helpful, in many cases, for determining approximate mileage traveled.

However, static "overview" maps are not as suitable for managing trail operations or addressing maintenance tasks. They are too broad in scale to identify individual pieces of trail infrastructure such as retaining walls, culverts, fences, and signs. Trail operators and their staff need precise coordinates for these items.

Many trail organizations, given their limited human and financial resources and their reliance on volunteer leaders, have not been able to utilize more robust, comprehensive, detailed, and accurate methods to map their trails and trail assets or to manage work orders. These methods often necessitate special skills or software that volunteers don't have, or the technology can seem cost-prohibitive for a trail organization.

Using **cloud**-based **geographic information systems (GIS)** technology and databases, however, would allow trails to be managed in a more proactive manner. Locations of trail assets could be geocoded to an actual trail alignment with great accuracy. Additionally, records for each asset could be created to track when they were installed or constructed, what materials or products were used, when they were last serviced, their current condition, and when additional maintenance should be anticipated. The limited data and field-gathered information with which many trail operators now work is a roadblock to long-term planning. This information gap manifests in the reactive nature of the typical trail maintenance approach. Fortunately, with a little more organization and foresight and with the adoption of mapping and tracking procedures, this is something that can be more easily fixed than increasing available budgets for trail maintenance. Just piggybacking onto existing county or municipal GIS systems, for instance, could offer a cost-effective way to employ this invaluable technology for trail maintenance planning.

SILOED RESPONSIBILITIES, MANAGEMENT, AND ADMINISTRATION

Like other assets commonly managed by multiple parties, multi-use trails are subject to the challenges and pitfalls of a "bureaucratic" environment: one in which different departments and/or organizations manage different aspects of the same trail — but where those responsibilities are not always clearly delineated, agreed-upon, or understood by the individual departments or organizations.

The phrase "working in **silos**" refers to an organizational condition in which the teams or parties managing the same project isolate themselves from the other responsible teams or parties — often unintentionally. The symptoms of this condition are a lack of communication, collaboration, and information sharing. This includes important information related to decisions, expectations, and deadlines. Ultimately, the result is missed opportunities, misalignment of goals and objectives, a duplication of efforts, an inefficient use of resources, and a lack of trust between responsible parties. In some cases, rather than a duplication of efforts these parties also may avoid efforts altogether — not out of ill intent, however, but because of unclear or missing delineation of each party's roles and responsibilities.

In the trail world, this siloed condition usually results in a trail that is either not well-maintained or maintenance tasks are completed with a different expectation or standard because various organizations or departments managing it don't know who is responsible for what. The term "bureaucracy" is synonymous with a slow-moving process, but the effects of a neglected trail surface, exposure to the elements, vandalism of amenities, and fast-growing invasive vegetation unfortunately happen more quickly.

WORKING IN SILOS

key term

"Working in silos" is a phrase commonly used to refer to an organizational condition in which the teams or parties managing the same project isolate themselves from the other responsible teams or parties, often unintentionally. The symptoms of this condition are a lack of communication, collaboration, and information sharing, resulting in reduced efficiency and trust.

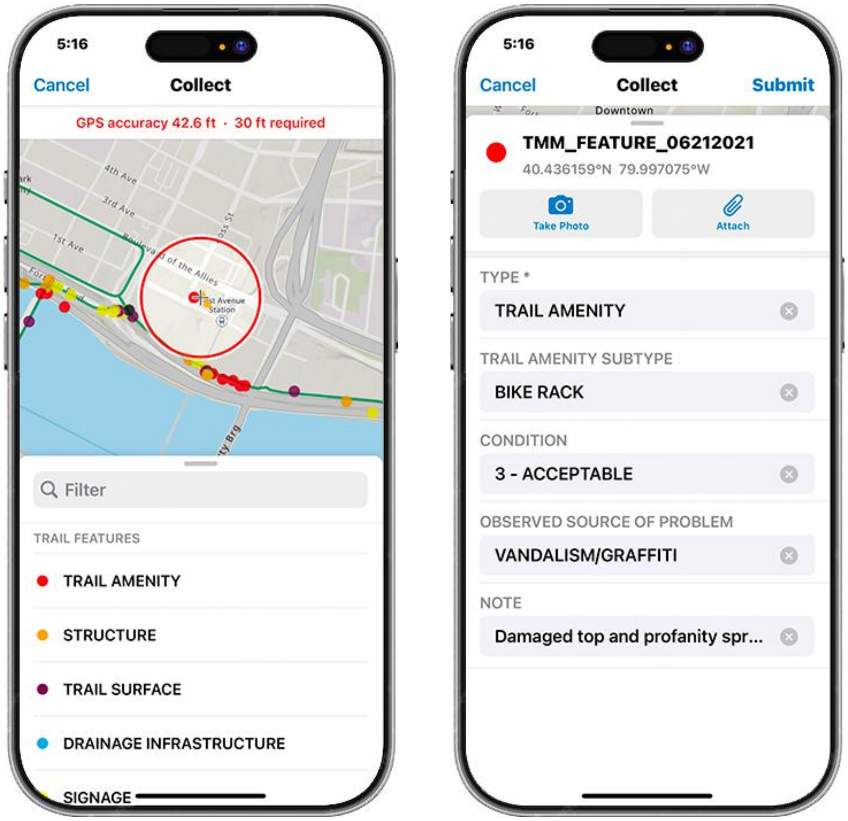


Figure 7: Trail Maintenance Toolkit. While challenges such as limited funding and human resources may not be easily solved, what trail operators *can* control is *how* they work. Asset management technology can be extremely helpful for trail maintenance, allowing real-time data to be easily gathered and shared, reducing silos between different parties involved in maintaining a trail, and giving operators a better view of trail assets and their conditions. These graphics depict PEC's **Trail Maintenance Toolkit** mobile app. For more information, see **Appendix B**.

THE CLOUD

key term

A network of remote computer servers, accessed over the internet (wired connections, Wi-Fi, or mobile networks/broadband), that store data, applications, and files, allowing users to access them from anywhere with an internet connection.

GEOGRAPHIC INFORMATION SYSTEM (GIS)

key term

A computer system that captures, stores, analyzes, edits, outputs, and visualizes geographic data. This data is tied to specific geographic (spatial) positions, often expressed as coordinates of the earth (longitude and latitude), and is stored in a database hosted on a cloud server.

PART 2: MAKING OUR TRAILS MORE SUSTAINABLE

FROM A REACTIVE TO A PROACTIVE APPROACH

2.1 A PREVENTATIVE APPROACH TO TRAIL MAINTENANCE

INTRODUCTION

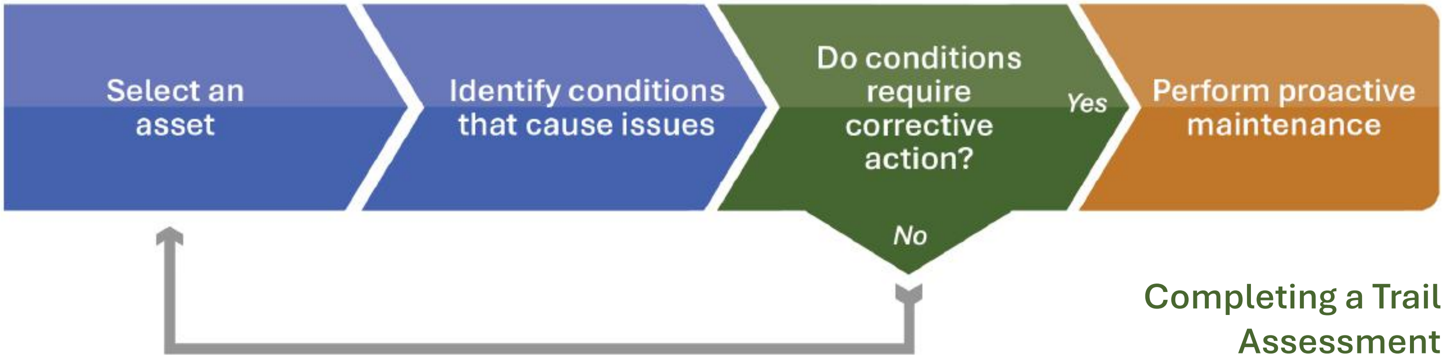
While wear and tear is inevitable over the lifetime of a trail, investing available time and resources in a proactive, routine approach to maintenance can significantly extend its lifespan. In an age when technology allows us to immediately access information from the bounce of a communications tower, cloud-based digital mapping and database platforms allow for more effective, efficient, and proactive maintenance than ever. Repairs, reporting of local conditions, and even cost estimates for capital replacements of specific assets can be planned for, coordinated, and shared with the tap of a finger or the click of a mouse. This provides for more detailed analysis of and planning for anticipated costs, timing and prioritization of repairs, and targeted approaches to fundraising.

FOUR COMPONENTS TO A PREVENTATIVE MAINTENANCE APPROACH

Preventative maintenance (also known as **preventive** or **proactive maintenance**) is a maintenance approach by which routine inspection and minor repairs are done to avoid potential failures and to extend an asset's life — well in advance of any significant structural failures or damage. It can be contrasted with **reactive maintenance**.

Back to our example of the new car from **Part 1.3**, we can relate trail maintenance to the completion of routine oil changes. When a car is running on dirty, sludgy, or low levels of oil, engine deterioration accelerates more quickly than expected. At a certain point deferred maintenance may result in a nightmare of a car repair if a repair is even possible. Minimal investment of time and money every 5,000 miles could have saved thousands of dollars over time and given the owner many more years of life from his or her vehicle.

Trails work in a similar way. There are four components to a preventative trail maintenance approach — **trail assessments, maintenance training, proactive scheduling, and capital planning** — which work hand in hand, forming a step-by-step plan over the years, all with the goal of sustaining the usability of your trail and its assets.



Completing a Trail Assessment

TRAIL ASSESSMENTS

Trail assessments are in-the-field evaluations of actual (and honest) conditions of your trail and the features and amenities supporting it. Think of these as akin to getting bloodwork done. Maybe you feel as though you're in great health, but the lipid battery reveals that your HDL ("good") cholesterol is too low (some fish oil might be what your doctor prescribes you) or that your LDL ("bad") cholesterol is too high. By seeing the results of your blood test, your doctor is able to note what conditions are important to address but are not immediately pressing if proper intervention can prevent a bigger problem from happening. A trail assessment is similar in that it enables you to determine how well your trail's supporting features — drainage, signage, fencing, and retaining walls, to name a few examples — are meeting their intended purpose.

MAINTENANCE TRAINING

Next we have **maintenance training**, the maintenance-specific education of the personnel doing work out in the field. Great maintenance starts with these individuals, who interact with the trail more than perhaps anyone else. Maintenance training, which includes but is certainly nowhere near limited to this ***Guide***, is intended to help build familiarity with common conditions encountered, indicators and clues of potential emerging problems, and methods for mitigating these problems. It is an essential component to a comprehensive maintenance approach.

PROACTIVE SCHEDULING

A **maintenance schedule** should be part of every **trail maintenance plan**. It should identify upcoming priorities, timelines for carrying out inspections of trails and their supporting features, and any remedial actions needed. Schedules should reflect results from the trail assessment (and any data gathered later during routine inspections) as well as the trail organization's established priorities.

CAPITAL PLANNING

This refers to long-term, strategic, and systematic processes used by trail organizations (or local governments if they are the caretakers) to plan, to prioritize, and to manage the financial investment in their trail and its assets, including the equipment needed to support the physical work. **Capital planning** enables those who manage trails to project or forecast repair, replacement, and capital improvement needs over a length of time (e.g., 5 years).

Figure 8 (previous page)**: Completing a Trail Assessment**. Trail assessments allow a trail asset to be methodically evaluated and follow-up actions to be proactively defined and executed.

Figure 9 (right)**: The Five Areas of Responsibility in Trail Development and Maintenance**. Trail development and maintenance can be grouped into five overarching areas of responsibility, which are all crucial over the life of the trail. (Adapted from the Minnesota Local Road Research Board [LRRB].)

2.2 COMMON OPERATIONAL AND MAINTENANCE ISSUES

As with the upkeep of a home, building, or car, trail operators encounter common (and oftentimes recurring) maintenance issues. This analogy makes sense when one considers that all multi-use trails consist of the same basic building blocks: a trail surface, supporting structures, drainage features, and signs. While some trails in unique landscapes or featuring special materials may have unique maintenance needs, trail maintenance issues are usually predictable, interrelated, and almost "programmable." That is, compromised maintenance in one area will often result in maintenance needs in another area. Trail operators need to consider these interconnections.

The most common non-routine maintenance issues involve trail surface smoothness, drainage failures and washouts, vegetation management, effects of exposure to the elements, issues with the terrain, compromises of soil and geology, as well as vandalism and graffiti, all of which are summarized below.

TRAIL SURFACE SMOOTHNESS

Crushed gravel, asphalt, and concrete are the most common materials used for multi-use trail surfaces. Each material resists, reacts to and rebounds to use and exposure to the natural elements differently. Consequently, each has different issues that can impact or compromise the smoothness of the trail itself. Foot and tire traffic, stormwater surface drainage, vegetation growth, heavy shade, and frost all affect surface quality.

DRAINAGE ISSUES

Properly flowing drainage swales, pipes, and outfalls are essential to keeping a trail operational. Vegetation (particularly non-native/invasive), downed leaves and branches, trash, erosion debris, and sediment build-up are the bane to proper flows. When the upkeep and function of drainage infrastructure is in order, the negative impacts of flood events and washouts can be minimized and the trail surface will rebound more quickly.

VEGETATION MANAGEMENT

A dense tree canopy (i.e., heavy shade), overgrown vegetation along the trail edge or within a **swale**, or even the lack of absorbent vegetation within a swale can wreak havoc on the operational quality of a trail surface. Additionally, such conditions can reduce the longevity of steel and wood components by increasing levels of exposure to moisture and accelerating decay.

FREEZE/THAW CYCLES

Repeated **frost heaves** contribute to the stress of core trail elements, especially the trail surface itself, and are common in climates where temperatures consistently fall below freezing during winter. They are characterized by a swelling of the soil, in which the soil and the trail surface above it are lifted because water expands as it freezes, and are accentuated in areas with poor soil or a high water table. If you've ever left a can of soda in your car overnight in freezing weather, you've probably noticed that the can has swollen. That's what happens to the soil!

TERRAIN AND SOLAR ORIENTATION

Trails are often constructed on challenging terrain such as along steep hillsides. A **landslide** above a trail can result in blocking of the path when soil and rocks tumble down onto the trail surface, while a landslide below a trail can result in failure of the trail's structural integrity. Lack of sunlight, such as when a trail is located in a steep valley or on the side of a north-facing slope, can cause stormwater retention on the trail surface or in the soil.

SOIL AND GEOLOGY

Multi-use trails are constructed on countless types of soils, which all have different properties — how much moisture they contain, how densely compacted they are, how well they drain water, and how well they control erosion. Clay soils, in particular, restrict water and air movement, which leads to pooling of water and damage to a trail's foundation. In some settings soil subsidence is a common issue, which can happen unpredictably where groundwater has been removed, underground mining has taken place, or oil and natural gas have been extracted.

VANDALISM AND GRAFFITI

Vandalism and graffiti are the only issues that are totally and directly produced by human behavior rather than natural causes. While some trail operators view these challenges as routine maintenance tasks, both issues are often the first to be deferred and the most noticeable to trail users. In the trail world these are some of the most highly visible issues and carry negative connotations.

SWALE

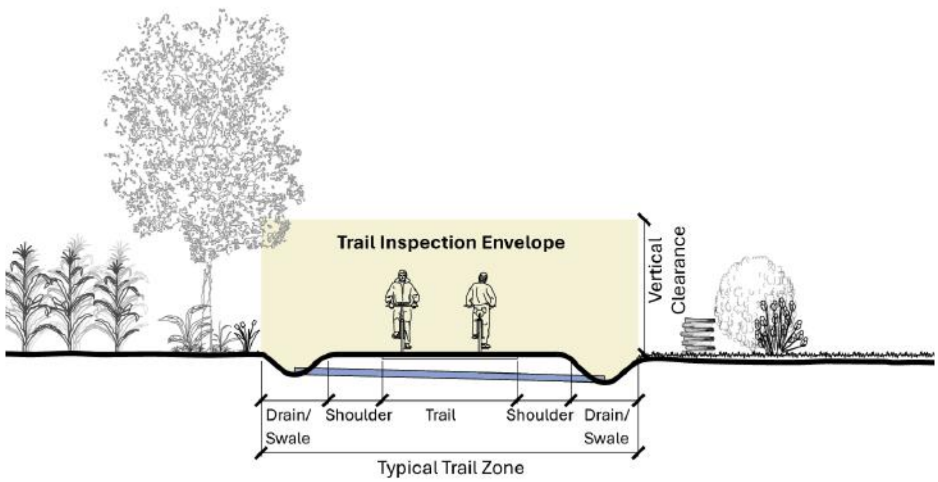
key term

A shallow ditch with gently sloping sides designed to handle stormwater runoff for conveyance and absorption. Manmade swales typically run parallel to roadways, trails, and other travel ways.

FROST HEAVE

key term

The upwards swelling of soil during freezing conditions caused by the growth of ice upward from the groundwater table toward the surface.



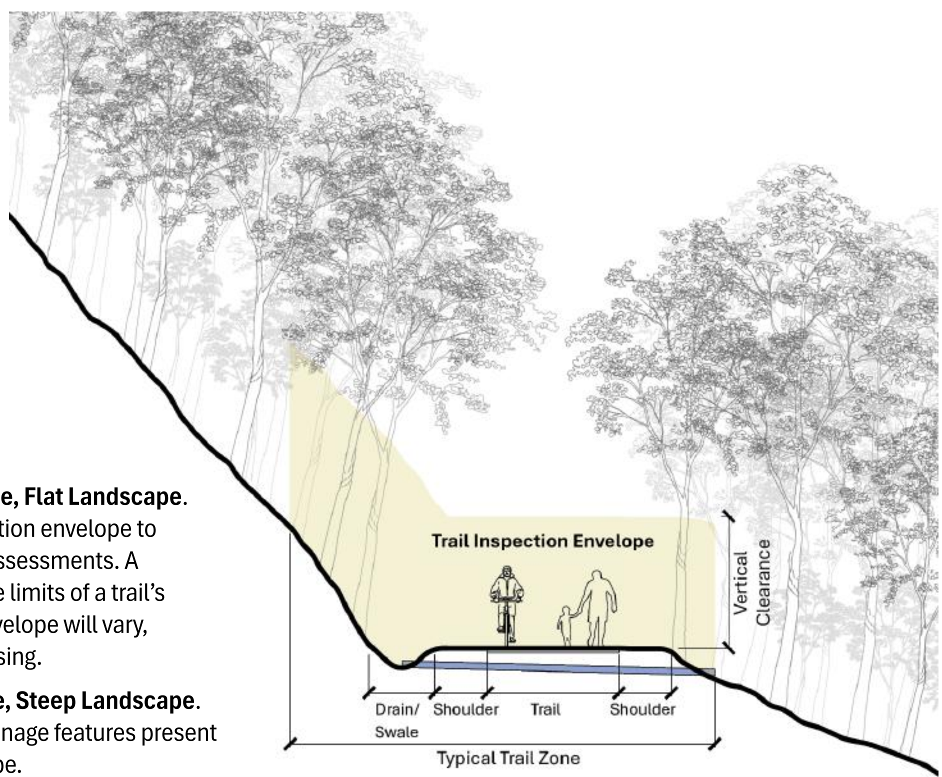
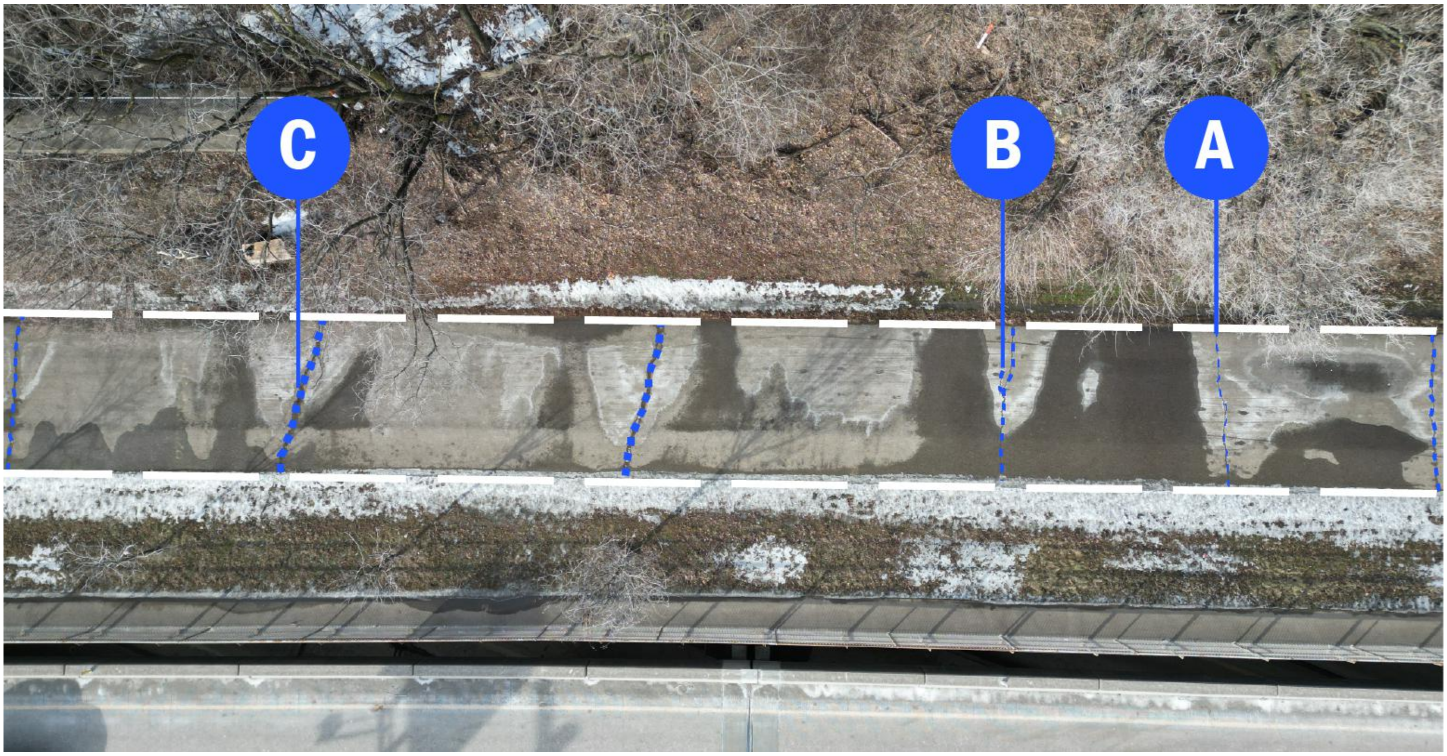


Figure 10 (top right)**: The Trail Inspection Envelope, Flat Landscape**. Trail organizations should adopt a standard inspection envelope to use when completing routine trail inspections or assessments. A trail inspection envelope should extend beyond the limits of a trail's shoulders and its swales, if any. The inspection envelope will vary, depending upon the landscape that a trail is traversing.

Figure 11 (bottom right)**: The Inspection Envelope, Steep Landscape**. Terrain, vegetation, adjacent land use, and any drainage features present will inform the scope of the trail inspection envelope.



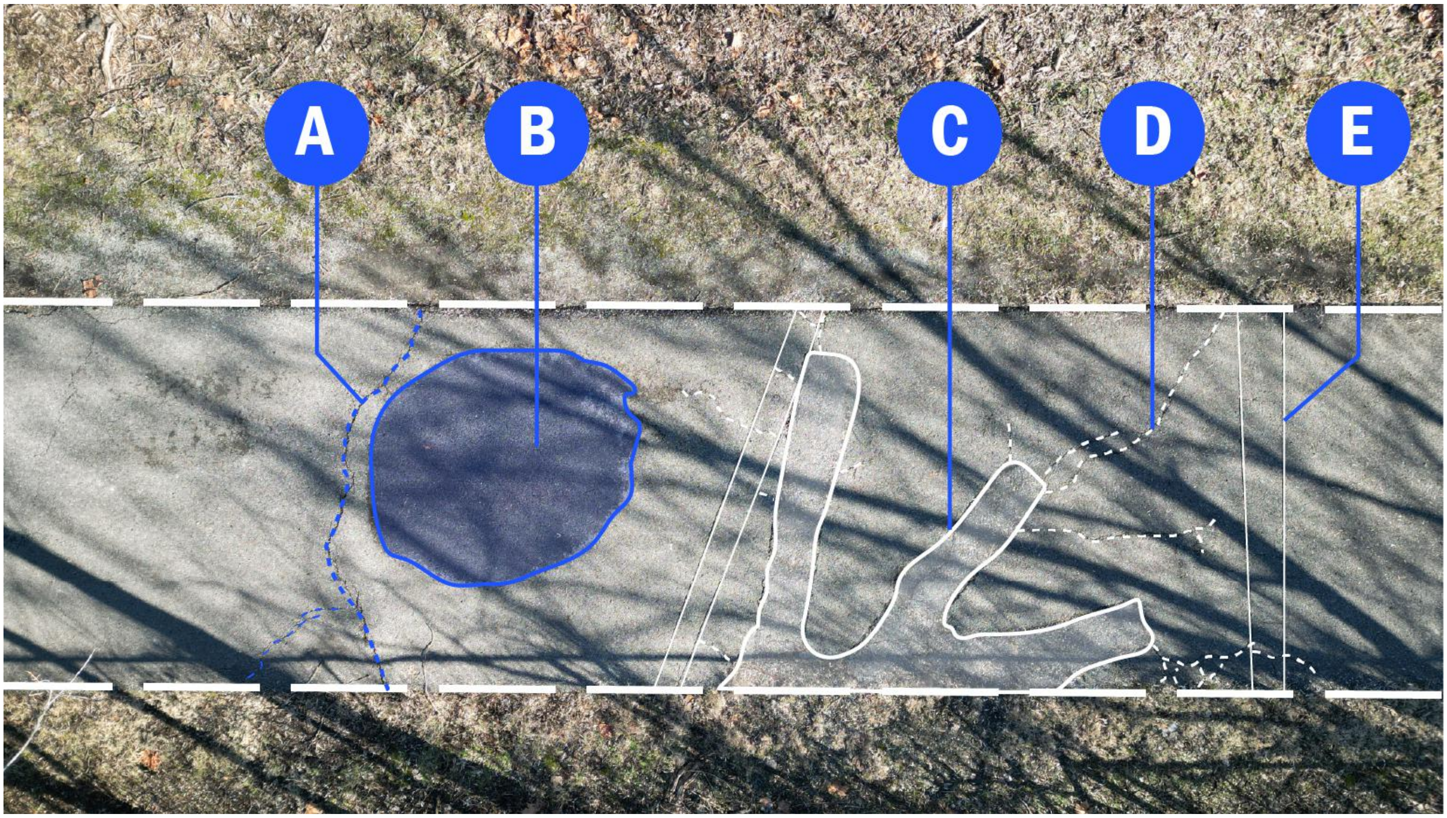


Figure 12 (top)**: Aerial View of Asphalt Cracks**. A trail surface with multiple transverse cracks (items **A**, **B**, and **C**), which are typically caused by shrinkage and expansion from temperature changes, premature hardening of the asphalt, expansion of frozen rainwater that has seeped into existing smaller cracks, or reflection of cracks in underlying layers or pavement slabs. Refer to **Part 3** of this ***Assessment Guide*** for more information about trail surface cracks.

Figure 13 (bottom)**: The Many Types of Pavement Distresses Found on Trails**. A variety of pavement distresses in a section of asphalt trail. The depression (item **B**) is a result of water that has failed to drain off the trail surface. The humps marked by item **C** are a result of tree root intrusion. Items **A**, **D**, and **E** indicate transverse, diagonal, and reflection cracks, respectively.

2.3 THE BENEFITS OF COMPLETING A TRAIL ASSESSMENT

The ultimate benefit of completing a trail assessment is that it puts your trail organization in a position to make the best possible decisions. A trail assessment is a diagnostic tool enabling a clearer understanding of the conditions of your trail and its assets. This allows your organization to spend limited funds more effectively and to achieve the goal of a high-quality trail. It is the first step in shifting from a mindset of "fighting fires" to one of "preventing fires."

Completing a trail assessment should be viewed as taking that first step toward a sustainable trail. Here are just a few benefits of trail assessments:

- ✓ Reducing wear and tear on your trail and its amenities.
- ✓ Preventing damage (e.g., trail widening) caused by users' physical avoidance of issues on your trail.
- ✓ Minimizing or eliminating unexpected trail detours or closures caused by a weakened trail or by the supporting land giving way.
- ✓ Avoiding economic impacts on trail-related businesses affected by a closed trail.
- ✓ Tempering potential negative perceptions or publicity of your trail because of visible deferred maintenance.
- ✓ Discovering any construction flaws or quality issues that can be avoided in the future, remedied by better construction warranty requirements, or fixed before they become bigger problems.
- ✓ Determining the most appropriate design and engineering strategies when planning future trails as well as what amenities to provide (or not provide) based on available human and financial resources.

In addition to these benefits, the completion of periodic trail assessments enables trail managers to be better in tune with their trail, its features, and its traffic patterns. The sequence of comprehensive, standardized reviews shared among all relevant parties sets a baseline from which to evaluate conditions, performance, and change. Comparisons between what has happened within your trail corridor from season to season and from year to year allow you to more accurately predict expected upcoming maintenance needs and to minimize surprises. An understanding of usage patterns and volumes provides additional insight into your trail's potential longevity and its ability to withstand wear and tear. **Regular trail assessments are like a report card for your trail: They tell you what's working and what's not.**

Trail assessments are a learning experience in themselves and an integral part of the training component within a proactive trail maintenance approach. They allow trail operators to evaluate a trail corridor as a holistic system — not just an assortment of individual and unrelated parts. The context these assessments can provide about physical influences beyond a trail's shoulders is valuable — even essential. Refer to Appendix B for a summary of the Pennsylvania Environmental Council's **Trail Maintenance Toolkit**. The toolkit houses a full suite of trail assessment tools to guide or support trail owners and maintainers deliver sustainable trail facilities and to transition from reactive maintenance practices to preventative approaches.

Changes in a trail's surrounding landscape often give insights into why certain maintenance issues are emerging or already exist. Off-site conditions — land use changes, new nearby development, changes to the quality of adjoining woodlands, erosion, sedimentation, and soil and water creep — often stealthily create impacts on trails. Three major determinants can inform you about the potential long-term performance of your trail:

- **Design/Engineering:** The general design criteria, assumptions, and parameters used to engineer the layout of your trail can determine whether your trail sheds water (good!) or pools it (not good). The construction plans for your trail should be drawn to provide the necessary depth, width, and slope to effectively drain stormwater and to keep your trail surface dry. It is critical that the construction drawings are "as-builts," reflecting what was actually constructed based on in-the-field constraints.

- **Construction:** The in-the-field methods and specifications that your contractor used to construct your trail can significantly affect your trail's performance over its lifetime. Unfortunately, construction failures or cut corners don't always become noticeable for several years. But they are almost certain to reveal themselves over time. For instance, too many aggregate fines in your asphalt mix or improper proof-rolling may diminish the longevity of your hard-surface trail. Similarly, not enough angular stones — and too many rounded ones — in your crushed gravel mix or a failure to moisten the crushed stone so that it cures and hardens properly may similarly cause premature wear of your soft-surface trail.

- **Maintenance Practices:** The methods and frequency of your maintenance efforts are crucial to the sustainability of your trail. While minor maintenance tasks may not seem important, if you too often defer from your maintenance routine, the effects will soon become visibly apparent to trail users. For instance, unchecked grass intrusion in the middle of your crushed gravel trail will begin to negatively affect the appearance of your trail and its ride quality. Similarly, not keeping your waste receptacles routinely emptied will suggest to trail users that maintenance isn't a priority, inviting vandalism and littering. (This is often referred to as the "broken windows theory.")

Given the growth in the number of miles of completed trails, the constant issue of limited funding for maintenance, and the frequent reliance on volunteer labor, trail operators should prioritize the core elements of their trails — the things that will make or break their trails' usability. Those are:

- **Trail surface materials**, which provide your trail's riding surface.

- **Trail structures** such as bridges, boardwalks, and guardrails, which provide safety and crucial access for your trail.

- **Drainage structures** such as culverts and swales, which are designed to keep water off your trail.

- **Signs**, which help users navigate the trail, particularly in the absence of (or more often than not in the case of rural trails) reliable GPS and cell service.

These core elements are what makes your trail function properly, **directly affecting safety and usability**. The core elements are also what trail users interact with the most. When these elements are neglected and fall into disrepair, a trail user's experience is immediately impacted.

Negative reviews and photos of trails that have suffered from deferred maintenance will inevitably be shared online. Images of trail washouts, missing signage, bumpy trail surfaces, overgrown vegetation, and faded pavement markings will make the rounds. Once trail users and potential trail users see these photos, it can be difficult for your trail to regain a positive reputation.

While trail amenities such as benches, picnic tables, waste receptacles, bike repair stations, and restrooms are important to public perception and enrich the overall trail experience, they do not affect the usability or function of the trail. Thus, they should be addressed after the core elements. Additionally, maintenance of these amenities may require specialized skills, equipment, tools, and parts; these amenities are often also operationally more complex than the core elements of your trail. Sometimes, for the best results, you may just have to pick up the phone and call the company from whom you purchased the bike repair station or waste receptacle.

However, don't do this right away! If you are forced to make decisions because of limited resources, make sure that the "nice-to-have" amenities do not divert time and resources away from the upkeep of your core trail elements. Preferably, before you install an amenity at all, consider whether you'll have the human and financial resources to maintain it. If the answer is "no," leave it out. **REMEMBER: Don't go "off-trail" in fulfilling the purpose of your trail!**

2.4 ASSET MANAGEMENT

Asset Management for Local Officials, a fact sheet issued by the U.S. EPA, defines **asset management** as the maintenance of "a desired level of service for what you want your assets to provide at the lowest life cycle cost. Lowest life cycle cost refers to the best appropriate cost for rehabilitating, repairing, or replacing an asset." The goal of asset management is to "keep assets productive, and not allow them to become disruptive liabilities." Sometimes asset management may mean "a commitment of time and money to make cost-effective asset decisions (spending some money in the short-term to save more money over the long-term)."

Asset management is a standard practice in the facility management industry and is useful to organizations that need to maintain multiple buildings, pieces of equipment, and pools of personnel. The principles of asset management have since been adapted and are now being applied to trails; the concepts provide a number of benefits to trail organizations. These include:

- Improving trail safety and extending the overall life of the trail surface, drainage systems, and trail structures.
- Providing useful real-time information for projecting current and future maintenance costs for budgeting purposes.
- Integrating seamlessly into a public works or recreation department's existing processes if the trail owner is a government entity that has experience in maintaining roads, parks, buildings, or other such facilities.
- Facilitating a systematic, consistent approach to evaluating the present condition of trail assets.
- Identifying and prioritizing maintenance and rehabilitation needs.
- Generating educational opportunities and data for the public, elected officials, and funders.
- Mitigating unsubstantiated biases and politically charged decisions.

Preventative maintenance, as discussed in **Part 2.1**, refers to maintenance actions done proactively to avoid potential failures of a trail and its assets and to extend their lifespans. Asset management is a preventative maintenance strategy that aims to find the best "bang for the buck" when it comes to actions toward preventative maintenance.

Four steps are important in a preventative maintenance regimen (as shown in **Figure 14**). The first step is the development of an annual maintenance schedule prescribing actions for non-routine maintenance activities. The second step is the execution of tasks prescribed in the maintenance regimen. The third step is the periodic assessment or inspection of the trail improvements themselves and identification of emerging problems. The fourth step is the modification of the annual schedule to incorporate maintenance actions in response to any emerging problems.

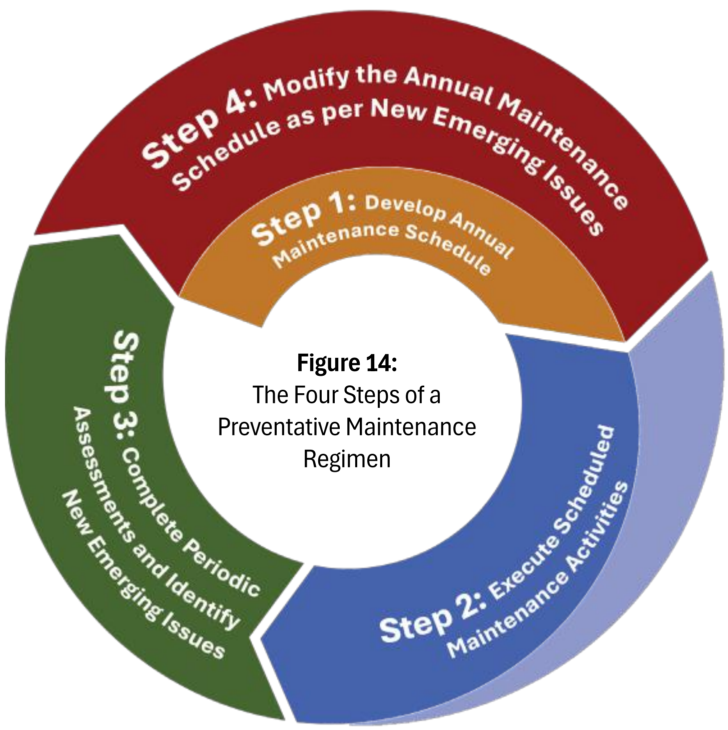


Figure 14: The Four Steps of a Preventative Maintenance Regimen

2.5 CREATING AN ANNUAL TRAIL MAINTENANCE SCHEDULE

In a 2014 survey published by the Rails to Trails Conservancy, only 40% of owners of rail trail facilities reported having up-to-date maintenance plans. This is a clear indicator that maintenance is not commonly a high management priority and that many trail organizations may have some liability exposure of which they may not be aware. All trail operators should have documentation that the entity owning a trail exercises a reasonable amount of due diligence to ensure its trails are safe. Keeping a maintenance schedule and records of maintenance activities is at the heart of this documentation.

An annual maintenance schedule is the management plan for executing preventative maintenance tasks. It involves organizing all available resources to ensure that tasks are performed according to a specific timeline or level of usage. Effective schedules help trail operators efficiently allocate resources and appropriately plan for the year ahead. Creating an annual maintenance schedule involves more than just setting dates on a calendar. It requires a detailed operational understanding of your individual trail assets (e.g., a wood deck bridge vs. a metal bike rack vs. a concrete block retaining wall), your available resources, and your trail as a whole. A maintenance schedule also designates who will perform recommended maintenance tasks and when. Consequently, it needs to accurately anticipate equipment, tools, materials, workers, and realistic timeframes for completing each task.

When making an annual maintenance schedule, two approaches can be taken to defining and scheduling maintenance tasks: fixed versus floating. The **fixed maintenance schedule** is based on tasks that either use specific equipment or materials or occur at specific time intervals. A fixed schedule is based on a calendar; it focuses on future planned tasks, regardless of whether previous scheduled tasks were completed. For example, a fixed maintenance schedule calls for swales to be brush hogged every two months. When the two-month calendar date arrives, a work order is issued and the maintenance work is executed. It doesn't matter how much the vegetation has grown in that period; the brush hogging occurs as planned.

A **floating maintenance schedule** is based on a specified performance metric or standard. Floating schedules are typically informed by a trail asset's past use or maintenance history. For example, they may call for drainage swales to be brush hogged once the vegetation has reached a specified height. When the vegetation reaches that height, a work order is drafted and the maintenance work is completed. It doesn't matter how long it takes for the vegetation to grow to the specified height; the work is executed when needed to meet the performance standard.

An effective annual maintenance schedule will often contain both a section of fixed tasks and a section of floating tasks. As noted above, the development of an annual maintenance schedule should be a reflection of the trail manager's understanding and familiarity with the individual trail's improvements and features, the availability of resources, and the skills of the trail organization's maintenance workers. A sample trail maintenance schedule from the Minnesota Local Road Research Board (Minnesota LRRB) is provided in **Figure 16** for reference.

Figure 15:

COMMON TRAIL MAINTENANCE TASKS

- ✓ Clearing of Swales and Culverts
- ✓ Litter Cleanup
- ✓ Maintenance of Fencing
- ✓ Maintenance of Gates and Bollards
- ✓ Maintenance of Pavement Markings
- ✓ Maintenance of Restrooms
- ✓ Mowing
- ✓ Signage Repair and Maintenance
- ✓ Trail Surface Clearing
- ✓ Trail Surface Regrading
- ✓ Tree Removal
- ✓ Vegetation Management

Figure 15: A list of common and routine maintenance tasks encountered by trail groups. (Content source: Rails to Trails Conservancy.)

TRAIL MAINTENANCE SCHEDULE (EXAMPLE ONLY)

Maintenance Activity	Optimal Frequency							Notes
	Weekly	Monthly	Quarterly	Annually	Spring/Fall	After Storm	Other	
General								
1 Safety inspection	X					X		
2 General debris and trash pickup	X					X		
3 Vandalism inspection	X							
4 Encroachments							Ongoing	
Pavement								
1 Pavement survey					X			Conduct Spring and Fall surveys
2 Crack sealing							Reactionary	
3 Patching							As needed	
4 Fog seal							As needed	Lifespan approximately 4-6 years
5 Sealcoat							As needed	Lifespan approximately 6-10 years
6 Slurry seal							As needed	Lifespan approximately 8-10 years
7 Overlay							As needed	Lifespan approximately 15 years
8 Reconstruct							As needed	
9 Inspect pavement markings				X				
10 Repaint pavement markings							As needed	
Vegetation								
1 Mowing - clear zones, trailhead areas	X	X						
2 Brush trimming/overhead trimming				X				Spring activity
3 Clear zone weed control							As needed	Noxious weed spraying/ removal
4 Sight line trimming at intersections		X						Roads, other trails, driveways, etc.
5 Tree removal						X	As needed	Storm cleanup
6 Rain garden maintenance		X				X		
7 Trail sweeping/blowing					X	X	As needed	Up to weekly frequency in Fall
8 Seeding				X	X			Spring activity
9 Root cutting							As needed	Monitor root activity along trail
Drainage								
1 Erosion repair			X		X	X		After spring snowmelt, storm cleanup
2 Culvert/catch basin clearing			X			X		Storm cleanup
3 Ditch maintenance (clear of debris, trash, branches)				X		X		Spring activity
4 Standing water repair				X				

Figure 16: An example of a trail maintenance schedule. Example only, not intended for immediate use. Trail managers may use this maintenance schedule as a baseline and modify it for their specific trail or purposes. A blank copy can be found in **Appendix E** of this ***Guide***. (Content source: Minnesota Local Road Research Board [LRRB].)

Top: The Honda Pioneer 1000-5 utility terrain vehicle (UTV), as seen on the Great Allegheny Passage between West Newton and Connellsville, PA.

Bottom left: The Kubota RTV 1140 CPX UTV, as seen at the Foxburg trailhead of the Allegheny River Trail in Foxburg, PA.

Bottom right: A GMC Sierra 2500 HD pulling a trailer of crushed gravel. (Photo credit: Trail Association of the McKean/Elk Divide [TAMED].)

2.6 TRAIL MAINTENANCE EQUIPMENT

The equipment available to a trail organization varies widely based upon who owns the trail, who maintains it, and who funds the maintenance. A combination of mechanized (power) equipment and non-mechanized (hand) equipment is usually necessary for the most efficient and cost-effective maintenance regimen.

Not all trails require or demand the same equipment, and trails will differ in their characteristics with respect to their trail maintenance envelopes (see **Figures 10 and 11**). The surface material of a trail, what vegetation grows around it, the hydrological characteristics of the trail corridor (including the presence or absence of drainage features), and the roster of amenities available to trail users will all dictate the amount of maintenance involved and the types of equipment required. For instance, a crushed gravel trail with grass-lined swales and few surrounding trees along its shoulders will necessitate a different set of tools and equipment than an asphalt trail with an underground drainage system that adjoins an urban highway corridor.

Figure 17 (next page) provides a non-exhaustive list of commonly used equipment and tools for trail maintenance. The list is meant to aid trail organizations in planning for, acquiring, or accessing general types of equipment or as part of ongoing maintenance operations. **However, trail organizations certainly do not need all or even most of this equipment for routine maintenance, particularly the riding/tractor-type equipment.** In some cases — as well as for practical reasons — very specialized or costly equipment could be shared by multiple trail organizations or rented only when needed. If sharing is a possibility, trail operators will need to consider availability of equipment when developing their annual maintenance schedules.

Figure 17:
TRAIL MAINTENANCE EQUIPMENT AND TOOLS

Common Riding/Tractor-Type Equipment

- Riding Lawnmower
- Compact Utility Tractor
- Mini Excavator
- Front Loader/Backhoe
- Skid Steer
- Bulldozer
- Paving Machine
- Drum Vibratory Roller/Compactor/Grader
- Street Sweeper

Common Tractor Attachments

- Boom Mower
- Rotary Mower (Brush Hog)
- Sickle Mower
- Drag Harrow/Landscape Rake
- Pickup Broom
- Rotary/Angle Broom
- Auger/Bit
- Snowblower/Snowplow

Other Mechanized Equipment

- All-Terrain Utility Vehicle (ATV/UTV)
- Dump Truck
- Leaf Blower
- String Trimmer
- Brushcutter (Weed Whacker)
- Walk-Behind Mower
- Cultivator (Rototiller)
- Chainsaw
- Woodchipper

Non-Mechanized and Hand Tools

- Trailer
- Shovel
- Rake
- Broom
- Pruners/Loppers
- Hand Saw
- Hoe
- Digging Bar
- Manual Post-Hole Digger
- Wheelbarrow
- Hammer and Nails
- Screwdriver and Screws

Top: In a 2014 Rails to Trails Conservancy survey, trail organizations selected blowers as the most common tool used to keep trails free of trash and debris. (Photo credit: Friends of the Smokies.)

Center: A volunteer uses hand loppers to trim trees along Pennsylvania's Knox & Kane Rail Trail. (Photo credit: TAMED.)

Bottom: Volunteers performing vegetation management along Pennsylvania's Knox & Kane Rail Trail. (Photo credit: TAMED.)

Top left: A single drum vibratory roller compacting crushed gravel on Pennsylvania's Knox & Kane Rail Trail. (Photo credit: TAMED.)

Top right: A tow-behind drag harrow used for maintenance of the crushed gravel surface of Pennsylvania's Great Allegheny Passage.

Center left: A compact tractor with a boom mower attachment used for mowing. (Photo credit: West Virginia Rails-to-Trails Council.)

Center right: A front loader with a boom mower attachment used for tree pruning. (Photo credit: York County Rail Trail Authority.)

Bottom left: A UTV rake attachment, known as the Gravel Rascal Pro. (Photo credit: ABI Attachments, Inc.)

Bottom right: A mini excavator used on Pennsylvania's Knox & Kane Rail Trail to dig a drainage ditch. (Photo credit: TAMED.)

Top left: A front loader attachment adding crushed gravel fines to a trail surface. (Photo credit: Westmoreland Yough Trail Chapter.)

Top right: A compact asphalt paving machine, York County Heritage Rail Trail, PA. (Photo credit: York County Rail Trail Authority.)

Center left: A trail volunteer uses a manual post-hole digger on Pennsylvania's Knox & Kane Rail Trail. (Photo credit: TAMED.)

Center right: A miter saw, a generator, and plenty of screws and hand tools used for work on a trail bridge. (Photo credit: TAMED.)

Bottom left: Volunteers spread crushed gravel fines on Pennsylvania's Montour Trail. (Photo credit: Rails to Trails Conservancy.)

Bottom right: A volunteer installs a subsurface cross-trail pipe on Pennsylvania's Knox & Kane Rail Trail. (Photo credit: TAMED.)

2.7 DEVELOPING A CAPITAL IMPROVEMENT PLAN

A **capital improvement plan (CIP)** is a multi-year budgeting and planning tool designed to lay out a "roadmap" for funding and implementing major capital improvements over a multi-year period. A capital improvement or **capital project** is a non-recurring physical expenditure such as a new building, resurfacing of an aged section of a trail, or a new trail bridge. CIPs are commonly prepared by government entities and some non-profit organizations that manage and construct physical assets.

The use of capital improvement planning helps to ensure the timely repair and replacement of aging infrastructure. It also identifies the most economical means of financing the proposed capital improvements. Despite the benefits most trail organizations, unfortunately, haven't used a CIP when planning for their long-term investments. As our nation's trails age and trail organizations face increases in capital repairs and replacements, CIPs will become more and more essential for those who own and operate trails.

HOW CAPITAL IMPROVEMENT PLANS DIFFER FROM OTHER BUDGETING PROCESSES

The common characteristics of a CIP that distinguish it from other budgeting processes include:

- **A Focus on Major Projects Only:** CIPs deal with significant investments in core infrastructure like roads, bridges, buildings, water systems, parks, and public transportation. These investments could be for building new facilities, completing capital repairs to a damaged asset, or executing a capital replacement of a worn-out asset. CIPs are *not* used to plan routine, regular maintenance activities such as mowing, cleaning swales, or emptying waste receptacles. A CIP is also not limited to just one major project.
- **Long-Term Planning and Budgeting:** A CIP usually spans several years (typically three to seven), which allows proper budgeting and phasing of projects. Given the longer planning horizon, CIPs are not used for emergency repairs.
- **Prioritization and Ranking:** Projects within a CIP are very often ranked based on their importance and urgency. The prioritization aspect is often the most useful to a trail organization when multiple major projects need to be completed.
- **Financial Considerations:** A CIP includes details about funding sources for each project such as bonds, grants, donations, or other dedicated revenue streams.

TYPICAL COMPONENTS OF A CAPITAL IMPROVEMENT PLAN

A CIP typically includes four components:

- **Project Prioritization:** Proposed projects are evaluated and scrutinized based upon criteria such as:
  - Desired service level standard.
  - Project demand, as determined by an inventory of existing land, equipment, and facility conditions.
  - Number of people or scope of geographic area served.
  - Return on investment, cost savings, or revenue generation.
  - Sustainability.
  - Economic, environmental, aesthetic, or social impacts.
  - Public health, safety, or other legal concerns.
  - Consistency with community plans and policies.
  - Public or political support.

- **Cost Estimates:** These are the projected construction costs for the proposed capital improvements, prepared by an architect, engineer, and/or landscape architect. Estimates should include a contingency as well as dollar figures for land or right-of-way acquisition and associated legal costs, final design and engineering, and project management, inspection, and construction administration costs. Additionally, the cost projections should anticipate the longest-duration estimated timeframe for implementation. In other words, the estimates should include a cost escalation factor based on the typical three-to-seven-year timeframe of a CIP.
- **Funding Sources:** Complementing the cost estimate is a funding sources analysis. Frequently referred to as a "Sources and Uses Table," this analysis is an array of the project financing amounts by each funding source. At a minimum, the total funding available for a specific project must meet its cost estimates. Funding sources can include public grants, private donations and contributions, loans, bond revenues, and other funds set aside.
- **Project Timelines:** The final component of a CIP is the anticipated timeline for implementing the project. Project timelines become crucial when the CIP is planning for multiple long-term projects and the availability of capital is a concern. To aid in this situation, a project timeline can also indicate the availability of its anticipated funding sources so that a trail organization can assess capital outlays in the context of other capital projects.

2.8 USING DIGITAL TOOLS TO IMPROVE TRAIL MAINTENANCE

To approach maintenance in a proactive way and from a preventative mindset, it is essential to collect and to use data to inform your maintenance capabilities. No longer are pen, paper, and film needed to document the conditions of your trail and its amenities. Most smartphones are now capable of capturing, saving, and processing massive amounts of data from GPS coordinates, photos, and videos to inputted condition ratings, submitted work orders, and estimated costs. All of this information can be stored and accessed at just the tap of a finger or the click of a mouse — and it is available both on your phone and on your computer. Using digital tools, trail assessors can easily, accurately, and quickly collect data related to their trails and trail assets, which can be inventoried, photographically documented, and "rated" in real time. This resulting information is invaluable to trail organizations because it pinpoints problem areas and helps prioritize issues based on actual observed conditions.

Such digital tools range in price, and your trail organization should consider a solution that you can both afford and from which you can derive meaningful information for your maintenance regimen. Digital trail maintenance can be as free or low-cost as a simple spreadsheet, Google Maps, and a smartphone with a camera. If your organization can afford it, you could subscribe to an online GIS mapping platform and connect it to a custom database. Trail managers who work in local government may also find that their public works department is already using a similar type of maintenance platform.

At the bare minimum your trail organization should have **an online map**, **a way to record issues and conditions out in the field** (with both photography and written descriptions), and **a means of doing analysis** with the data that you've mapped and collected. Regardless of the digital medium that you ultimately choose, your trail organization should consider these "virtual" maintenance tools to be just as important as your physical maintenance tools — your mowers, skid steers, brush cutters, and chainsaws — as they are what will inform how and when you use your physical tools and which tools you may even need (or not need).

If you don't want to run your own database or to pay for GIS services but want something more robust than just a spreadsheet and a camera, PEC hosts a "happy medium" digital trail maintenance platform called the **Trail Maintenance Toolkit**. Refer to **Appendix B** to learn more and to see if it may be a good fit for your organization.

PART 3: TRAIL SUSTAINABILITY GUIDE

ASSESSING YOUR TRAIL AND ITS FEATURES

3.1 OVERVIEW

The purpose of the **Trail Sustainability Guide** is to provide concise, easily accessible information and best practices on the management, operations, and maintenance — the **sustainability** — of multi-use trails. Not only are trail surfaces accounted for but also many of the other features that support or otherwise affect trails and their users: bridges, fences, signs, drainage features, and vegetation, just to name a few examples.

HOW TO NAVIGATE THE TRAIL SUSTAINABILITY GUIDE

The **Trail Sustainability Guide** is separated into multiple **Topics**, as shown in **Figure 18**. Each Topic — with the exception of 3.9 (Signage), 3.10 (Vegetation Management), and 3.11 (Other Environmental Concerns) — is further divided into **Subtopics**. For instance, under the Trail Surfaces Topic (3.3), Crushed Gravel (3.3.1) and Asphalt (Blacktop) (3.3.2) are individual Subtopics. Another example is the Drainage Features Topic (3.5), with Culverts and Pipes (3.5.1) and Swales (3.5.4) being among the listed Subtopics.

<u>Note:</u> Your trail will most likely not have all of the trail surfaces, features, and amenities listed.

A variety of trail surfaces, features, and amenities are discussed in the **Trail Sustainability Guide**. How many can you spot in these photos?
Above left: Bench, bike racks, bike repair station, concrete foundations, fence, portable restroom, waste receptacle.
Above right: Bollards, bulletin board, crushed gravel trail surface, picnic table, trail underpass, visitor's center.

Figure 18:
ORGANIZATION OF THE TRAIL SUSTAINABILITY GUIDE

Topics	Subtopics
3.3 TRAIL SURFACES	**3.3.1 Crushed Gravel** **3.3.2 Asphalt (Blacktop)** **3.3.3 Concrete** **3.3.4 Decking Materials**
3.4 TRAIL STRUCTURES	**3.4.1 Bridges and Boardwalks** **3.4.2 Underpasses and Tunnels** **3.4.3 Retaining Walls** **3.4.4 Fences, Railings, and Gates**
3.5 DRAINAGE FEATURES	**3.5.1 Culverts and Pipes** **3.5.2 Headwalls and Endwalls** **3.5.3 Inlets and Manholes** **3.5.4 Swales**
3.6 AMENITIES	*Examples: Benches, Bike Racks, Bike Repair Stations, Bollards, Lighting, Pavilions, Permanent Restrooms, Picnic Tables, Portable Restrooms, Public Art, Storage Buildings, Visitors' Centers, and Waste Receptacles.*
3.7 PARKING LOTS	
3.8 TRAIL CROSSINGS	
3.9 SIGNAGE	*Examples: Donor/Dedication/Memorial Signs, Gateway Signs (Trailhead Entrance Signs), Interpretive Signs, Kiosks, Mile Markers, Point-of-Interest Markers, Posted Rules/Trail Etiquette Signs, and Regulatory Signs.*
3.10 VEGETATION MANAGEMENT	*Examples: Trailhead Landscaping, Mowing, Tree and Brush Maintenance, Weeds and Invasive Species, and Cleanup/Tree Removal after Storm Events.*
3.11 OTHER ENVIRONMENTAL CONCERNS	*Examples: Landslides, Fallen Rocks, Fallen Trees, Acid Mine Drainage, and Pool Soils.*

Each Subtopic in the **Trail Sustainability Guide** — or Topic, in the case of Trail Amenities (3.6), Trail Parking Areas (3.7), Trail Crossings (3.8), Signage (3.9), Vegetation Management (3.10), and Other Environmental Concerns (3.11) — includes five recurring sections, summarized below and identified by the following unique icons:

🔍 "WHAT IS/WHAT ARE..."

These sections briefly describe what a particular trail surface, feature, or amenity is made of and/or used for, and in some cases where it is located. For instance, most people would have a general idea of what asphalt, concrete, and crushed gravel look like, but they may not necessarily know what they're made of, how they're held together, or the different types or mixtures of these materials. In the case of trail surfaces, the "What Is/What Are" sections also list some Pros (**+**) and Cons (**—**) of different types of surface materials to help trail operators in maintenance planning or even to decide on the optimal material to be used for new or replacement trail sections.

⚠️ "COMMON SUSTAINABILITY PROBLEMS"

As discussed in **Part 1.3** of this ***Assessment Guide***, water — whether in its liquid form or as ice — is most often the culprit of sustainability problems involving trails and their supporting structures. Other sustainability problems include vegetation, overuse, and vandalism. For trail surfaces, common symptoms of distress and what causes them are briefly summarized and depicted in accompanying example thumbnail photos.

💡 "MAINTENANCE TIPS"

This ***Assessment Guide*** emphasizes preventative maintenance as the best practice to significantly lower costs for trail managers in the long term, even if it might require a bit more upfront cost and consistent oversight. Checklists for the maintenance of trail surfaces, features, and amenities are provided in the "Maintenance Tips" sections. They identify what trail managers should look for, causes and effects to address, potential physical improvements to reduce long-term maintenance needs, and other best practices related to the performance and timing of maintenance activities.

📊 "EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT"

When completing trail assessments, it can be very helpful to provide numbered ratings for your trail's surface, its features, and its amenities. Giving a simple '1' through '5' rating allows you to prioritize maintenance needs, anticipate timelines, and plan your maintenance budget. Is the appearance of a trail surface or trail feature a consequence of expected natural aging, or does it point to a potentially important structural or safety concern? In the "Existing Conditions Rating Scale" sections, we use the following scale, with example photos and descriptions of what each numbered rating may look like:

- **1: Like New**
- **2: Good**
- **3: Acceptable**
- **4: Poor**
- **5: Issue Needs Further Evaluation**

🎨 "ILLUSTRATED EXAMPLES OF COMMON PROBLEMS"

These sections build on the "Existing Conditions Rating Scale," pointing out specific issues using notated diagrammatic photos of real-life trail scenarios rated '2' through '5' on the rating scale. For each example, explanations of the illustrated issue are provided — and in the examples that identify emerging problems, what a problem may lead to if it is not addressed. Some photos feature more than one identifiable issue. For instance, a photo of an asphalt trail may show multiple types of cracks resulting from different conditions (e.g., a crack resulting from improper construction, another resulting from the effects of the freeze/thaw cycle, and yet another resulting from intrusion of aggressive tree roots).

Above left: An aggressive invasive plant species that is held back by a well-performing fence and routine trimming.

Above right: The same invasive species that is growing largely uncontrolled on both sides of a fence in disrepair.

WHO, WHAT, WHERE, WHY, AND HOW?

Who owns a trail and who manages it are important factors in how maintenance is handled, as these factors determine who performs the maintenance, who pays for it, where it is performed, how often it occurs, and what components of a trail and its features and amenities are addressed.

In 2005 and 2014 surveys conducted by the Rails to Trails Conservancy, volunteers were the single biggest cohort of trail maintenance labor, followed by municipal governments. Trail and community group volunteers, municipal governments, and county governments all significantly increased their maintenance workload between the two surveys. Volunteers, in particular, who already shouldered a large burden for trail maintenance, only further increased their share of the burden during this time.

The predominant parties who owned trails and funded their maintenance differed between the surveys, but state governments, county governments, municipal governments, and nonprofit entities all made up large percentages in both categories. Municipal governments increased their funding share for trail maintenance significantly between 2005 and 2014, from 26% to 42%. Many nonprofit entities — including anything from (sometimes) well-funded conservancies and land trusts to smaller unpaid trail groups — also pay the costs of maintenance themselves, obtaining funds from charitable contributions, membership dues, fundraising events, and grants from governments, businesses, and foundations. Some donations are also of materials and in-kind labor rather than direct costs, such as when a business supplies lumber to be used for fences, a local donor provides a bench memorializing a cherished family member, or scout troops build a new picnic pavilion.

As discussed in **Parts 1 and 2** of this ***Assessment Guide***, whether maintenance is performed on a consistent basis or only on an "as-needed" basis depends on an individual trail's ownership, labor, and payment arrangements. **The ideal scenario is for maintenance to be undertaken routinely and guided by a documented trail maintenance plan that establishes the level of expected care and the frequency of maintenance activities.** With mowing, this may mean once a week during the growing season. For keeping paper trail maps in stock at trailheads, it could be placing 50 additional copies in the brochure holder at each monthly inspection of the general conditions of the trail. For bridges, there may be requirements — particularly for bridges maintained by your state's department of transportation — that inspections take place at least once every two years. And, for an asphalt trail, it may be applying a fog seal every six years over the life of the pavement to keep small cracks from becoming bigger ones.

Above left and **above right**: A "before" and "after" view from approximately the same location. The trail shown had been frequently affected by offsite stormwater, which was greatly exacerbated by a reshaping of the adjacent landowner's property. The original swales could not handle the added volumes, causing large pools of water at best and a complete inundation at worst. Because of the constant presence of undrained water, the trail could not remain open in the winter, as it would completely ice over. Unfortunately, no other convenient routes existed for bicycle commuters. Emergency funding was sought to reengineer and reconstruct the trail at this location, which involved elevating the surface, redesigning the swale, and adding a pipe that crossed underneath the trail and daylighted toward an outfall into a nearby river.

ANOTHER WORD ABOUT MAINTENANCE PLANNING

Multi-use trails have rapidly grown in popularity over the past 30 years, thanks to their inherent flexibility of allowing for multiple modes of travel. Once primarily used by recreational bicyclists, they now also function as routes for people to walk or run who may not desire the difficulty of a hiking trail but still seek a quieter environment and a more natural, forgiving trail surface than a city sidewalk. Trails have also increasingly gained importance as components of the larger transportation network, particularly in urban areas, where they are used for commuting to work, connecting to public transit as a "last-mile" transportation link, and providing convenient travel to destinations such as parks and stadiums without the need to pay for parking. Like with any other recreational or transportation facility, ongoing maintenance and upkeep is critical to trail sustainability.

Given their multifunctional role and increasing popularity, maintaining trails to the level of quality that users expect has become more complex and resource-consuming. A well-thought-out trail maintenance plan can go a long way toward making this a less daunting task, keeping both those who pay for and maintain trails more organized and future-oriented.

There are a number of specific maintenance issues that commonly occur on trails. These fall into two categories: **A) issues directly related to the trail infrastructure itself**, such as surface deficiencies, and **B) issues related to not performing routine maintenance**. An effective trail maintenance plan needs to address both.

Infrastructure issues associated with trails can further be subdivided into **surface problems** and **structural problems**. Most structural deficits will ultimately affect surface conditions, but there are certain surface conditions that are not caused by structural conditions.

Minor defects may only affect appearance at first but can deteriorate over time and become moderate to major structural defects. Moderate to major defects may ultimately become a safety concern if not addressed and may significantly affect the usable life of the trail, increasing costs in the long run as well as potential liability.

PRINCIPLES OF TRAIL SUSTAINABILITY

The main goal of trail sustainability is to find and fix all problems while they are still small — and also to prevent problems in the first place. This approach calls for frequent inspections and routine maintenance to extend the useful life of a trail and its facilities — a proactive rather than a reactive approach. It also helps keep your trail accessible to as many users as possible, reduces the exposure of trail groups and local governments to liability, increases community pride in the trail, and makes for better relationships with adjacent landowners. **Since problems are usually still minor when corrected early, most regular maintenance should be possible with just 1 or 2 people and a minimal amount of expensive heavy equipment.**

There are many safety issues directly attributable to poorly maintained trails. Improved safety through preventative maintenance reduces the risk of crashes, trips, slips, and falls. Maintaining a clean, smooth trail free of defects makes it more likely that bicyclists and walkers will be able to use the trail safely, steadily, and comfortably without fear of accidents. Small inconsistencies in trail surfaces, such as potholes, ruts, cracks, and upheaving, can sometimes be enough to cause a bicyclist to lose control.

As underscored in **Part 1** of this ***Assessment Guide***, **the ideal trail is one that requires minimal maintenance**. A trail requiring minimal maintenance is one that takes advantage of its natural environment instead of transforming the landscape to meet the trail's needs. After all, Mother Nature always wins! (And so do the laws of gravity.)

In a 2014 survey conducted by the Rails to Trails Conservancy, trail organizations located in four-seasons climates were asked to identify the major sustainability problems involving their crushed gravel and asphalt trails (percentages shown in **Figure 19** below are approximate):

Figure 19:

MAIN SOURCES OF TRAIL SURFACE DAMAGE

2014 Rails to Trails Conservancy Survey of Trail Organizations in Four-Seasons Climates

Asphalt Trails

- Tree roots: 63%
- Frost/freeze cycle: 44%
- Water erosion: 43%
- Sub-surface failure: 35%
- Vegetation (grass, weeds): 20%

Crushed Gravel Trails

- Water erosion: 77%
- Vegetation (grass, weeds): 33%
- Other: 27%
- Frost/freeze cycle: 17%
- Sub-surface failure: 3%
- Tree roots: 2%

From these results, it's clear that the **effects of water** ("water erosion," the "frost/freeze cycle," and "sub-surface failure") and **vegetation intrusion** (aggressive tree roots, grass growing through trail surfaces, vegetation encroaching on trail edges, and proliferation of invasive species) are the primary causes of trail damage in four-season climates. Mitigating the problems associated with these causes — fixing them while they're small, or preventing them in the first place — is thus the primary means to a sustainable trail.

For trail features — the supporting structures, signage, and amenities that provide services, information, safety, and convenience for trail users — general **wear and tear** and **vandalism** are of primary concern. While these problems do not necessarily affect the usability or structural integrity of a trail, they are important because they are what trail users see and what helps them make their decision as to whether to use a trail in the first place. They also reflect (whether fair or not) upon the organizations and governments who own and manage the trail. **That said, the problems that affect usability and structural integrity should be addressed first as a primary concern.**

3.2 GENERAL MAINTENANCE GUIDELINES

The following general guidelines should be kept in mind when thinking about the maintenance of your trail and its supporting features and amenities holistically:

- ☐ **Use your trail!**
  To know what problems exist on your trail, especially those that are frequent or recurring, using your trail frequently is the best way to become familiar with it, warts and all. Maybe you notice a culvert that always seems to get plugged by sediment, even after you just cleaned it out a week ago. Or, you see that there's a large puddle that never seems to go away. Is there a plank on a bridge that keeps making a loud thump when people ride over it? It might be missing a bolt.

- ☐ **Try to minimize the need for maintenance in the first place.**
  If you don't have the manpower to consistently service permanent restrooms, renting portable toilets may be a better option, both in terms of human and financial resources. Is your asphalt trail that is constantly being pierced by tree roots at the end of its life? Consider replacing it with a crushed gravel trail surface that requires less expensive (even if more frequent) maintenance. Is the public art piece at your trailhead constantly getting vandalized? It might benefit from being installed somewhere else than next to your trail.

- ☐ **Perform general cleanup and repairs.**
  The high-quality public image of your trail should be maintained to encourage trail use and your trail's reputation as a premier recreational asset in your community. All litter, no matter how small, should be picked up and disposed of. Any graffiti should be removed before it becomes a "canvas" inviting further graffiti. Show that vandalism is not tolerated by quickly repairing or replacing vandalized trail features.

- ☐ **Clean up the things that get dirty quickly.**
  The presence of fallen leaves on an asphalt trail can make for a slippery surface. Focus on taking care of that, especially in autumn. The waste receptacle that seems to always be overflowing? Make sure it's cleaned out regularly, whether it's by one of your volunteers or by the public works crew of your municipality. Are your culverts and drains rapidly accumulating debris? Clean those out — and then consult an engineer to develop a solution so that it doesn't happen nearly so often. This may involve shortening their running length, building a headwall or endwall to better support the hillside above the culvert, or reseeding a swale devoid of the vegetation necessary to slow and filter stormwater.

- ☐ **Keep access in mind.**
  If you need to involve heavy motorized equipment in the maintenance of your trail, especially if it's a remote section far away from road access, you will need a way to get the equipment in there. Make sure your trail or what's beside it can facilitate that access. Better yet, keep to a preventative maintenance routine that will not require you to use that heavy equipment in the first place.

- ☐ **Post rules and regulations.**
  Clearly think out the rules you would like to enforce to enhance the safety and sustainability of your trail. This includes, for example, listing what types of users are allowed (bicycles, walkers and runners, leashed pets, in-line skaters, etc.) and not allowed (e.g., ATVs, e-bikes, dirt bikes, scooters, etc.), your trail's hours of operation, who has the right-of-way, and what trail users are expected to do with litter and pet waste.

- ☐ **Consider getting counts of trail users.**
  Automated counts can be done either by installing sensor-based portable counters (the simplest and cheapest method) or infrared counters with inductive loops or other sensors (a method that is costlier and which, in some cases, may require the transfer of cellular data, but provides more detailed and sometimes real-time data). Getting traffic counts for your trail is important, as it lets you know who is using your trail, when they are using your trail, and how much wear and tear your trail may potentially be experiencing.

Top left: A TRAFx automated trail counter mounted to a safety bollard at a trail crossing. (Photo credit: U.S. Fish and Wildlife Service.)

Top right: An Eco-Counter Multi automated trail counter housed inside a wooden post. (Photo credit: Eco-Counter.)

Bottom left: A TRAFx automated trail counter housed inside a closed box just beneath the surface of a trail and backfilled with soil. (Photo credit: U.S. Fish and Wildlife Service.)

Bottom right: A close-up of the trail counter in the bottom left photo, with the soil and lid removed. (Photo credit: U.S. Fish and Wildlife Service.)

☐ **Consider performing surveys of trail users.**
Conducting trail user surveys will help you understand how your trail is perceived. Most trail users will be more than happy to let you know of any problems they've faced while riding or walking your trail, a fallen tree or landslide that you may not be aware of, the condition of your trail and its features and amenities, and what they find most important about the trail user experience. This can help you prioritize maintenance tasks and inform of what amenities to add or remove in the future.

☐ **Create a written trail maintenance plan.**
If you don't already have one, as discussed in **Part 3.1**, a written maintenance plan will identify responsibilities and responsible parties, outline both emergency and routine maintenance tasks, help you budget for maintenance, and ultimately save time and money.

☐ **Safety comes first.**
When prioritizing maintenance tasks, remember that the safety of your trail and its users is of utmost importance. Any problem that presents potential safety concerns should be addressed first. After that, address less-urgent infrastructural issues and structural problems, and then finally, your trail's amenities.

3.3 TRAIL SURFACES

The rapid growth of the nation's multi-use trail network has been instrumental in learning about the performance, user experience, and maintenance requirements of different types of trail surfaces in different climatic and hydrological conditions. For multi-use trails in the United States, **crushed gravel**, **asphalt (blacktop)**, and **concrete** are most commonly used, varying by geographical location and setting (urban, suburban, or rural).

National guidelines for the design of multi-use trails are provided in the latest edition of AASHTO's *Guide for the Development of Bicycle Facilities*. As of the time of this writing, the latest version is the *5th Edition*, published in 2024, which can be purchased at https://store.transportation.org. When possible and where relevant, the AASHTO guide should be referenced in addition to the guidelines provided in this **Trail Sustainability Guide**.

Due to physical or funding constraints, recommended trail dimensional and maintenance standards may not always be achievable. In those cases, it is a good opportunity to note any needs for improvement as potential targets for funding, either in a capital improvements budget or in the pursuit of grants. **The most important things to keep in mind are that 1) the overall goal of trail surface maintenance is a smooth surface, free of bumps, potholes, and debris, and 2) effective drainage and erosion control are the keys to preventative maintenance.**

GENERAL TRAIL SURFACE MAINTENANCE GUIDELINES

📝 WATER ON TRAILS

Standing water and flowing water are both enemies of trails. Even for hard-surface trails like asphalt and concrete, water can weaken the subgrade and compromise the trail's structural integrity, resulting in the formation of ruts, cracks, and potholes. The fundamental maintenance principle of a sustainable trail surface is to do what it takes to **keep water off the trail**.

📝 TRAIL PROFILE

The profile of a trail, no matter the surface material, should always be maintained in a way that sheds water off of the trail surface. The surface of the trail should be shaped to **shed water** and to **keep it from accumulating**. Additionally, the trail profile should be "predictable," with uniform trail edges free of abrupt drop-offs.

📝 TRAIL SURFACE DEBRIS

Whether it's fallen leaves and branches, glass, litter, mud, or gravel from adjacent roadways, debris can impact trail users' experience and safety, especially for those on road bikes or in shoes with little tread. Debris should be routinely swept, vacuumed, cleared, or picked up and should not be allowed to accumulate.

📝 CROSS SLOPES

A trail's **cross slopes** — the slope across the trail's travel path from edge to edge, or from the centerline of the trail to its edges — are the most important factor in how a trail drains water and counteracts its erosive nature.

- **Hard-Surface Trails:** Cross slopes for hard trail surfaces such as asphalt (blacktop), concrete, and wood/composite decking should be maintained at between 1% and 2%, to provide a good balance between drainage performance and trail user accessibility.
- **Soft-Surface Trails:** Cross slopes for soft trail surfaces such as crushed gravel should be maintained at between 2% and 5%, providing a good balance between drainage performance and trail user accessibility.

- Cross slopes of properly designed trails are either:
  - **Insloped**: Shaped so that water drains toward the backslope (the uphill side) into a swale;
  - **Outsloped:** Shaped so that water drains to the downslope (the downhill side); or
  - **Crowned:** Shaped so that the trail has an elevated centerline that drains water toward the shoulders, dividing the direction of the runoff toward both the uphill and downhill sides.

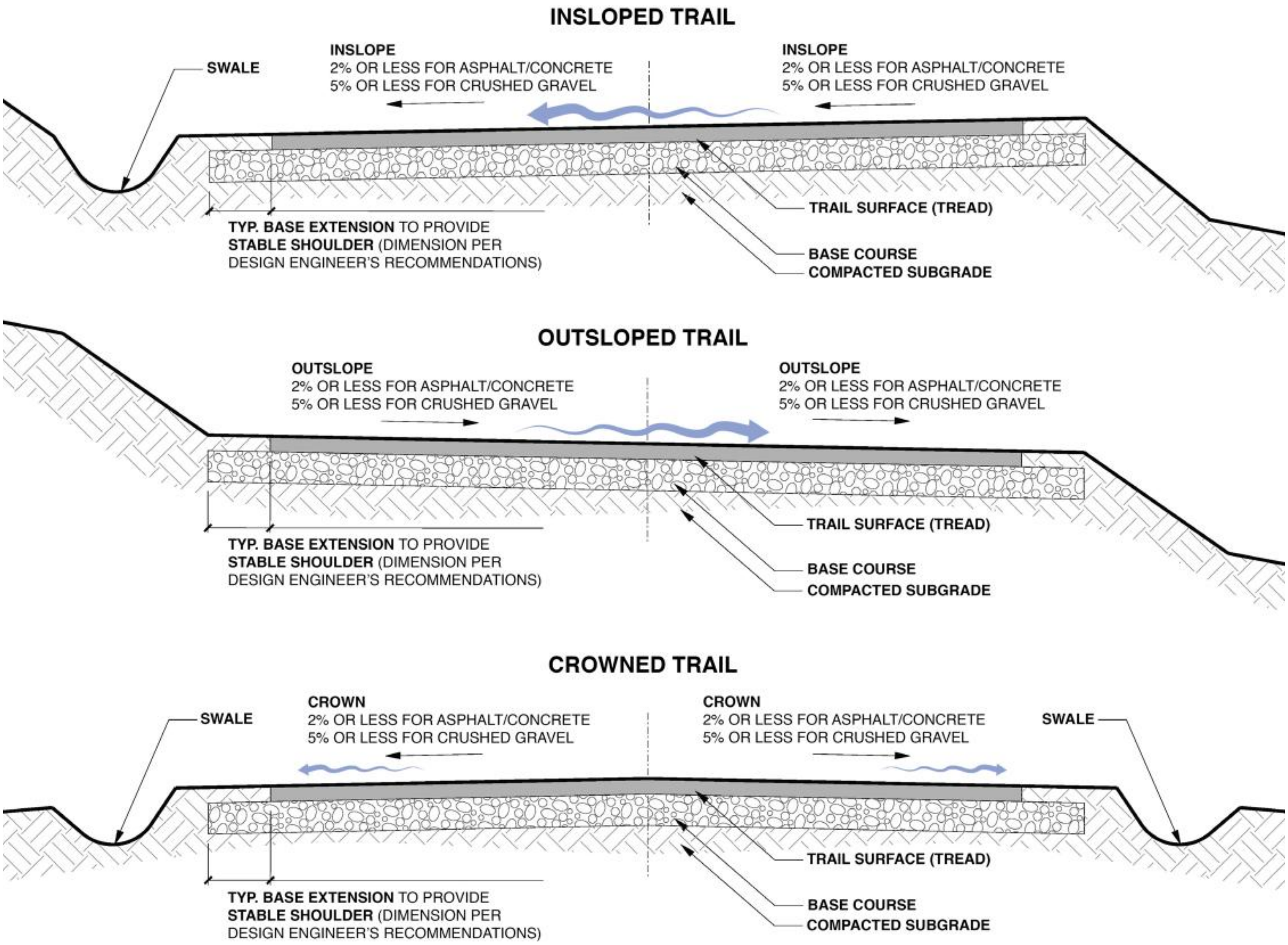


Figure 20 : Cross Slopes: Insloped, Outsloped, and Crowned. Cross slopes are the primary means that trail surfaces drain water.

RUNNING SLOPES

A trail's running slopes — the linear **grade** (lengthwise or longitudinal slope) of the trail, parallel to the path of travel — are also an important consideration for both drainage and accessibility.

- Running slopes for all trail surfaces should be maintained at no steeper than a 5% grade, except where absolutely necessary.
- In no case should any section of a multi-use trail have a grade of over 12%, no matter the surface material. For crushed gravel trails specifically, the maximum grade for a trail that is both accessible and sloped so the gravel particles do not prematurely wash away is 8%.

VERTICAL CLEARANCE

Maintain a vertical clearance of 8 to 10 feet from the surface of the trail to any overhead obstruction, such as tree limbs and power lines. Trim or prune overhead trees as needed to maintain this clearance. More vertical clearance may be needed if the trail is open for equestrian (horse) travel or snowmobiles.

HORIZONTAL CLEARANCE

Maintain a horizontal clearance of at least 2 feet (ideally 3 feet) from the edge of the trail surface to any potential off-trail obstruction, such as a tree, a pole, or the edge of a sign.

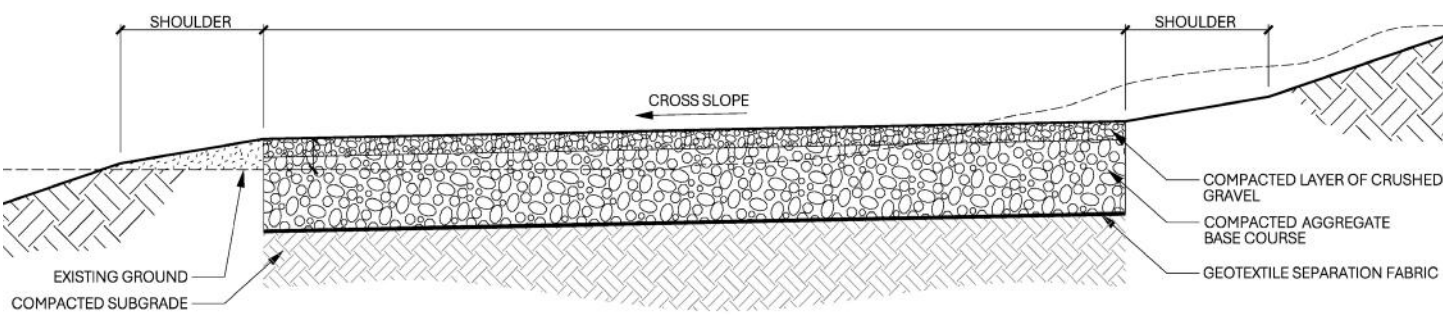
TRAIL PAVEMENT MARKINGS

In lieu of or in addition to signage, some asphalt and concrete trails have pavement markings applied to their surfaces, warning of upcoming trail crossings, directing which lanes walkers and bicyclists are to use, or delineating the centerline of the trail as it approaches an intersection. These markings should be maintained for continued readability, particularly if they are important for the safety of trail users.

TRAIL ACCESSIBILITY

Multi-use trails, particularly those in urban and suburban environments, should ideally be maintained with **accessibility** in mind. Some trail surface materials, especially soft surfaces such as crushed gravel, will need to be regraded periodically to continue to meet **Americans with Disabilities Act (ADA)** requirements. A width of 10 feet should be maintained for trails seeking to accommodate wheelchair travel in both directions. Alternatively, if a trail is under 10 feet wide, passing spaces can be provided every 1,000 feet.

CRUSHED GRAVEL TRAIL



ASPHALT (BLACKTOP) TRAIL

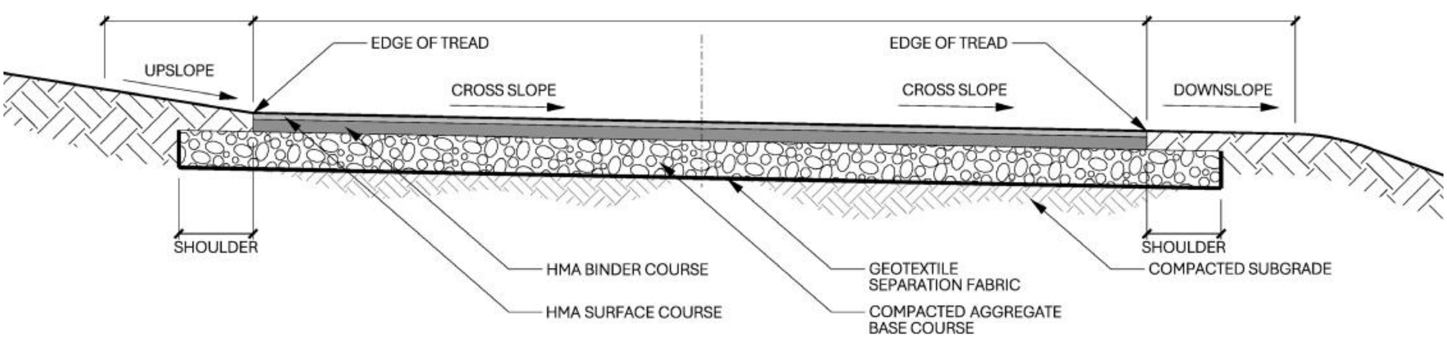


Figure 21: Typical Cross Sections for Multi-use Trails. Typical cross sections for crushed gravel and asphalt multi-use trails.

Top: The trail pavement paint reading “STOP” is not accompanied by a physical stop sign. Since it is severely faded, it should either be repainted, or a physical stop sign should be installed, as the message is needed for trail user safety. Additionally, snow coverage in the winter may obscure pavement markings altogether, making physical signs that much more crucial in northern climates.

Bottom: These trail pavement markings are bright and readable, easily delineating the path of the trail and dividing opposing traffic.

3.3 TRAIL SURFACES

3.3.1 CRUSHED GRAVEL

Top left: Detail of crushed limestone. (Photo credit: Sutherland Landscape Center, Chico, CA.)

Top right: Detail of crushed limestone. (Photo credit: Sullivan Hardware & Garden, Indianapolis, IN.)

Bottom: The Tredway Riverfront Trail in Allegheny Township, Westmoreland County, PA.

🔍 WHAT IS CRUSHED GRAVEL?

Known by a seemingly endless number of names — crushed stone, crusher fines, crushed limestone, crusher run, crusher dust, chips and dust, stone dust, limestone dust, quarry dust, quarry process, limestone screenings, screened limestone, packed limestone, decomposed granite, dense graded aggregate, or any variation of those names joined with measurements (e.g., 1B, #8, 970, 5 mm, 3/8", etc.) — **crushed gravel** consists of small particles of rock ("fines") derived as a byproduct of rock-crushing and gravel operations. The size of the particles varies from a fine dust up to 3/8".

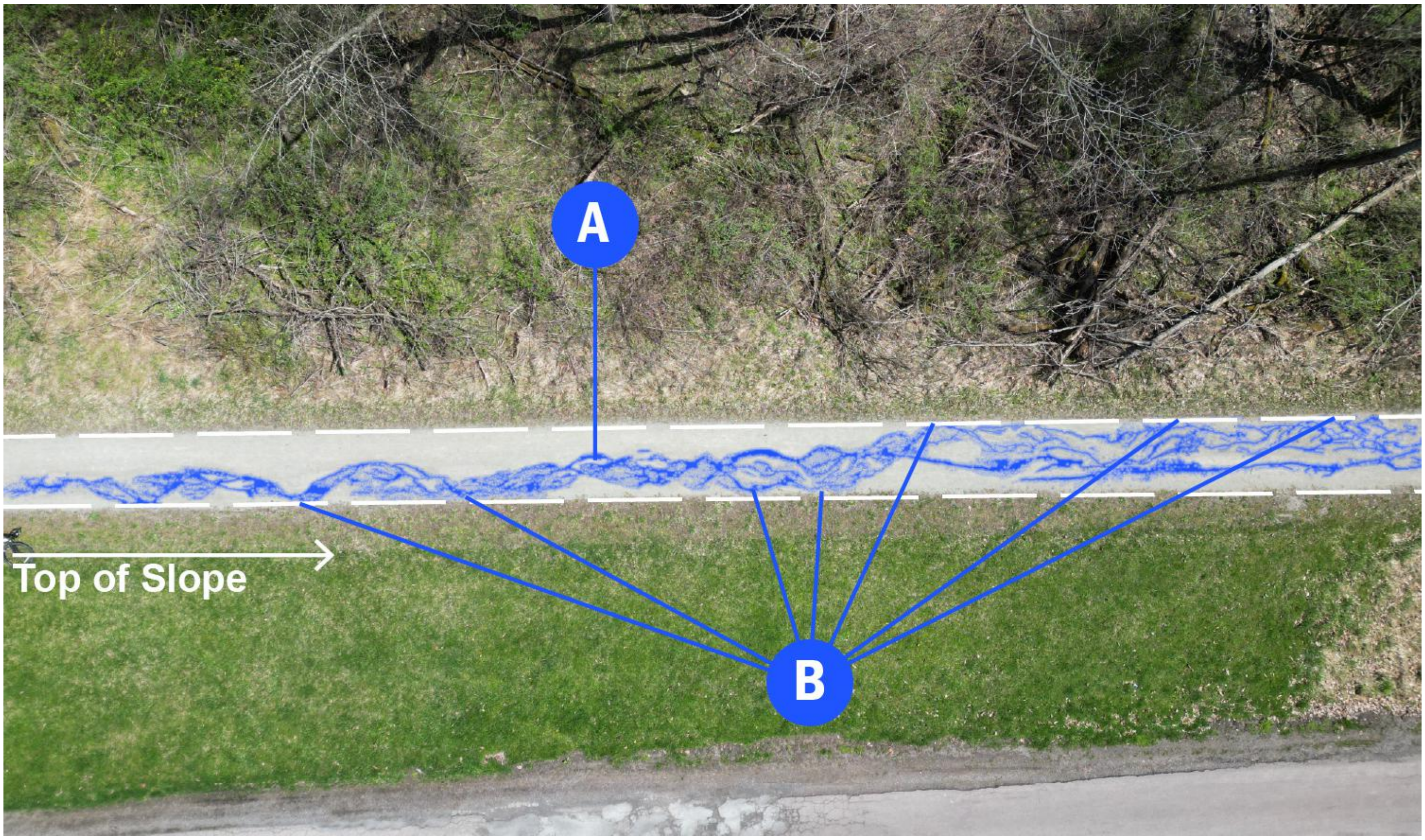
+ PROS

- Crushed gravel trails hold up well under heavy use compared to natural surfaces such as dirt.
- Crushed gravel trails complement the aesthetic of a natural landscape better than hard-surface asphalt or concrete trails.
- Crushed gravel trails are firm enough to be accessible. Virtually every type of trail user can use a properly compacted crushed gravel trail other than inline skaters. Wheelchairs and strollers can use well-graded crushed gravel trails, whereas trails made up of larger gravel or natural surfaces such as dirt are not accessible.
- Crushed gravel trails are more easily shaped and reshaped when needed, such as when implementing shallow dips or grade breaks for improved handling of stormwater runoff.
- If the trail is properly constructed, little annual upkeep is typically required, and what maintenance is needed is typically far less expensive and requires less expertise than with hard-surface trails; however, any needed maintenance must be timely.

– CONS

- In general, seasonal maintenance will be needed more often than with hard-surface trails but will be much less expensive each time it is performed (though not necessarily over the life of the trail).
- Washouts are a concern, because crushed gravel trails erode more easily than hard-surface trails.
- Crushed gravel trails can experience frequent problems when located in low-lying areas or areas of wet soil and are discouraged in favor of hard-surface trails in these types of locations.
- Crushed gravel is porous, which allows some water to be absorbed rather than just sheeting across the trail surface. This means that it is more prone to pooling water in depressions than hard trail surfaces.
- Crushed gravel trails can be rough and fatiguing to ride if surface issues have created dips, ruts, or erosion of surface fines.
- In the late winter and early spring in colder parts of the country, crushed gravel trails are often saturated with snowmelt, making them difficult and slow to ride, with a sensation almost like riding through sand.
- Crushed gravel trails in colder climates cannot be maintained in the winter, unlike asphalt trails, which can be plowed.

Above: This crushed gravel surface shows evidence of pooled water, indicative of a low point that has not been properly draining.



Above: This section of crushed gravel trail has continually been subject to the formation of rills (channels) in its surface (item **A**). With an over 5% grade from the top of the slope to the low point at the right, crushed gravel was not the optimal choice of surface material for this section. The grassy berms on both sides of the trail also prevent water from moving off-trail, resulting in an increasing number of rills downslope (item **B**).

Above: The rills in the trail surface (item **A**) start as a trickle from the top of the slope and expand into a delta formation with increased velocity and strength downslope, covering almost the entire trail width. The grassy areas on the side of the trail are higher than the trail itself so water does not flow off the trail surface like it should, channelizing instead.

3.3.1 Trail Surfaces: Crushed Gravel

⚠️ COMMON SUSTAINABILITY PROBLEMS

The major sustainability problem associated with crushed gravel trails is **erosion and drainage issues** due to poor **compaction**, improper slopes (both vertically and laterally), the impacts of stormwater and snowmelt, or simply the popularity of the trail and the volume of users.

Erosion and a lack of trail grooming can cause crushed gravel trail surfaces to become loose and uncompacted over time, exposing larger pieces of gravel from the **subbase**. Or, they can lead to washouts. In addition, when slopes are too steep for crushed gravel trails, surface fines easily erode away. There are multiple types of pavement distresses common in crushed gravel trails:

Vegetation Encroachment

Vegetation growth in the middle or along the edges of the trail can occur when there is no geotextile barrier under the trail surface or just from all the seeds dropped from trees.

Washouts and Flooding

When a crushed gravel trail is not elevated enough above the ground, has no cross slope, or does not include needed drainage, water concentrates on the trail rather than sheeting off.

Rutting (Washboarding)

Rutting occurs due to inadequate compaction or when the trail is saturated with water or snowmelt in late winter or early spring. The result is sunken tracks in the surface.

Depressions

An uneven subgrade or an uneven depth of the trail surface can result in the emergence of depressions that pool water. If drainage or cross slope are inadequate, the depression may grow.

Edge Erosion

A trail built into an unstable slope or a trail that is too outsloped can undergo erosion of its edges, exacerbated by fast-moving runoff and a higher volume of trail use on the outslope side.

Surface Erosion

If the fines material on a crushed gravel trail is not properly compacted, it can become loose and easily washed away by water. Excessive trail slope (>6%) can also be a cause of surface erosion.

💡 MAINTENANCE TIPS

- Maintenance consists largely of **continual inspection** of the surface for washouts, **immediate repair** of washouts and the source of those washouts, **regrading** of parts of the trail surface as needed, and **occasional replenishment of crushed gravel material** to the surface when and where needed.
- Drainage is critical to crushed gravel trails. The trail surface must be protected from even small concentrated flows of water, and efforts must be taken to prevent the fines from being saturated. With drainage problems, the trail can wash out or form semipermanent ruts from usage. Ensure the following:

- – Keep crushed gravel trails from becoming saturated with water.
- – **Prevent concentrated flows of runoff** from reaching crushed gravel surfaces.
- – **Quickly and efficiently drain crushed gravel surfaces** before water can form a concentrated flow across the fines and compromise its integrity.
- – Every part of the crushed gravel trail surface should **pitch water at a 2% cross slope**, whether the trail is insloped, outsloped, or crowned.

- Not only is too much water a danger to the integrity of crushed gravel trails, but too little water is as well. Moisture is needed to keep the fines from blowing away. The smallest particles — what makes up the natural binders in the trail surface — must appropriately compact to form a solid surface.
- **Do not use snowplows** on crushed gravel trails.
- The effectiveness of crushed gravel trails depends on the size and shape of the particles. **Angular particles** with relatively flat sides are what allow the trail surface to hold itself together in an **interlocking matrix**. If particles are too round, too big, or are simply missing, the interlocking function of the particles is lost, and the trail should be resurfaced with appropriate crushed gravel fines.
- If replacing crushed gravel fines with new or additional material, choose a proper mix. A **mix consisting of a varied size of particles of 3/8" in diameter and less** is ideal. This will allow the smaller particles to fill voids left by the larger ones, acting as a natural "cement" binder for the interlocking matrix and improving overall trail strength. Once fines have been laid down, they need to be **moistened and compacted**.
- In areas of frequent or unpreventable washouts due to consistently erosive water flows or low-lying, flood-prone land, **consider adding a small concrete trail section** to reduce frequency of maintenance needed.
- If the crushed gravel trail is crossing a flat area with no cross slope, the trail surface may need to be raised. In other words, the trail needs to be raised above the surrounding ground and **crowned** (slightly sloped downhill on both sides, with a peak in the center of the trail) to ensure proper drainage off the trail surface.
- **Swales** on both sides of the trail may be needed when the trail is crowned, which may be the case when it runs through a flat or wet area. (For more about swales, flip to Part 3.5.4 of this ***Guide***.)
- **Keep vegetation from growing in the middle of the trail** by pulling any vegetation that emerges from the trail surface. Consider using landscape fabric underneath gravel for trail sections to be repaired or replaced in the future.
- **Crushed gravel trails should be inspected as part of a regular maintenance routine**, noting the presence of the following on and alongside the trail:

  ☐ **Potholes, depressions, ponding of water, or subsurface water making its way up to the trail**

  Signs and symptoms:
  - Presence of or change in wetland vegetation
  - Frequent ruts and potholes
  - Springs, seeps, or obvious wet areas on the trail that do not dry up
  - Frequent flooding
  - Water pooled on the trail edge
  - Unstable cutslope or fillslope
  - Accelerated erosion of swales or ditches

  Potential causes:
  - Trail is intercepting a subsurface flow
  - Trail is crossing a wetland or other low-lying area

- Water table is naturally high at that site
- Soils are poorly drained (e.g., dense clay soils)

Potential solutions:

- Install an underdrain or a **French drain**.
- Install a cross-trail culvert or pipe.
- Dig a drainage swale alongside the trail if not already present.
- Raise the trail profile (surface elevation).

☐ **Rutting, washboarding, streams of water flowing the length of the trail, or berms**

Potential causes:

- Increase in trail traffic, especially when the trail is saturated with water or snowmelt
- Loss of the crushed gravel surface material or the presence of sediment/mud on the trail
- Inadequate drainage features (not enough frequency of drainage features, or drainage feature design inconsistent with topography)
- Infrequent maintenance or grading

Potential solutions:

- Modify the trail surface shape with a crown, outslope, or inslope as necessary.
- Regrade the trail.
- Implement drainage features, if water is not sheeting off the trail.

☐ **Erosion along the edges or on the surface of the trail, including the loss of limestone fines** (and the presence of increased sediment on the surface of the trail in place of fines)

Potential causes:

- Improper compaction of the crushed gravel trail surface material
- Drought conditions causing the fines to lose all of their moisture
- Improper specification of the crushed gravel trail surface material (not enough angular stones to “lock” the fines together)
- High water velocities on or alongside the trail

Potential solutions:

- Stabilize disturbed areas adjacent to the trail (such as hillsides and swales) by revegetating, seeding, mulching, addition of **rip-rap** or gravel to swales, construction of gravel trail shoulders, or installation of erosion control blankets.
- Install additional cross-trail culverts or pipes to shorten drainage runs.
- Freshen up the surface of the trail with a new or additional layer of crushed gravel fines.
- Moisten the trail surface slightly during drought conditions.

☐ **Encroaching vegetation from the side of the trail or on the trail surface**

Potential causes:

- Uncontrolled invasive/exotic plant species
- Water table is naturally high at that site
- Lack of maintenance of the trail or its side clearance (e.g., pruning trees/brush and weeding)

Potential solutions:

- Install a **geotextile** fabric layer or root barriers between the trail’s surface and subbase.
- Remove invasive plant species adjacent to the trail and replace with native plant specimens to reduce the dominance of the invasive species and promote biodiversity.
- Introduce plant species along the trail that reduce soil erosion.
- Freshen up the surface of the trail with a new or additional layer of crushed gravel fines.

Above: Example of regular trail surface grooming: the crushed gravel surface is free of ruts and grass growth.

Above: Example of a crushed gravel trail in which grass has invaded the trail surface, both along the edges and in the center of the trail.

Above: Accumulated leaf litter and fallen branches can reduce a swale's depth and ultimately its efficacy.

Above: This crushed gravel trail is deceptively bumpy, and debris like what's in the center of the trail gets trapped easily in bicycle spokes.

Above: Crushed gravel trails, particularly in shady locations, are prone to rain and snowmelt saturation that causes a muddy surface.

Above: The lack of a swale next to this crushed gravel trail means that the flow from this waterfall simply sheets across the trail surface.

3.3.1 Trail Surfaces: Crushed Gravel

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

Freshly groomed trail, with neatly defined edges, a consistent width, and an evenly compacted, level surface, all while still effectively directing runoff to the sides of the trail.

2 GOOD

Groomed trail surface with consistent width and little to no grassy incursions. Some debris collecting along the lesser-used middle and edge areas of the trail.

3 ACCEPTABLE

Trail surface in ridable but not optimal condition in early spring, with much of the fines surface eroded or washed away and pitted areas beginning to form.

4 POOR

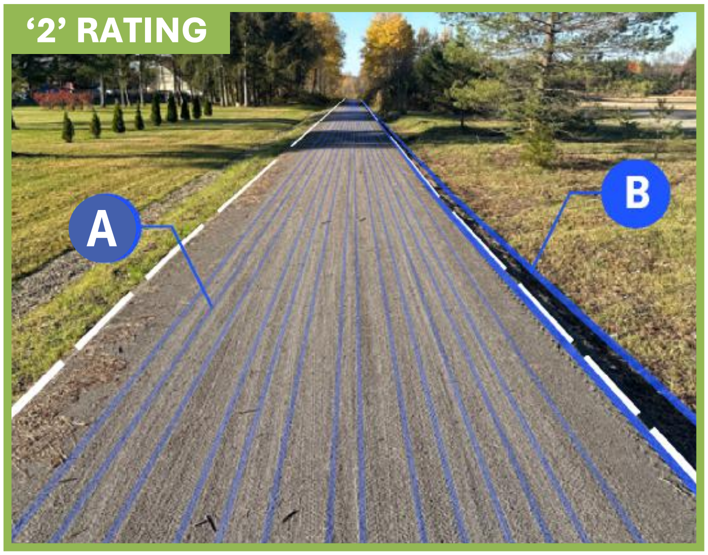
Ponding on trail surface beginning to result in rutting and depressions, though the trail surface has yet to deteriorate to the point of large puddles and potholes. Nearly all crushed stone has been washed away.

5 ISSUE NEEDS FURTHER EVALUATION

Downspout from the neighboring building has been allowed to discharge directly on the trail, resulting in ponding on the trail surface where it meets the boardwalk. The problem will continue to worsen until addressed.

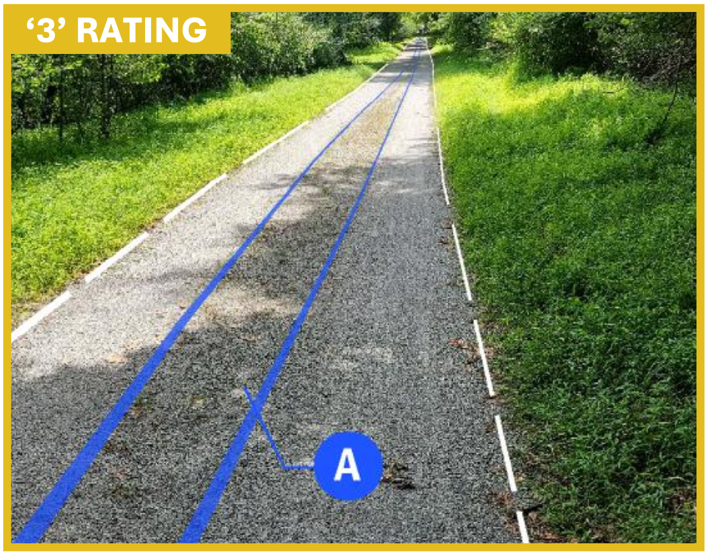
3.3.1 Trail Surfaces: Crushed Gravel

ILLUSTRATED ISSUES OF COMMON PROBLEMS

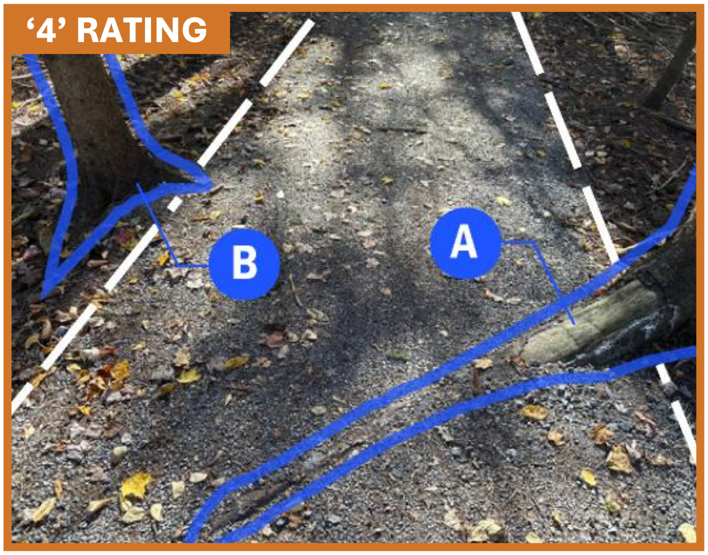


A Rutting or "washboarding" of the trail results from inadequate compaction. This could be exasperated by heavy use during wet conditions, leaving impact scars which subsequently dry. This surface can be uncomfortable or even tricky for some cyclists.

B Erosion of trail shoulder has created a pronounced drop-off between the gravel and adjacent grassy bank.

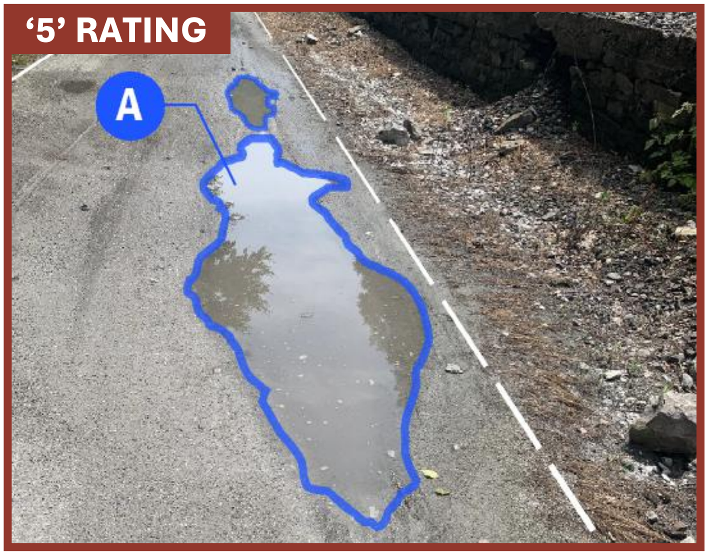


A If grass or other vegetation is allowed to grow in the median, the riding surface will be reduced and will lead to increased impact along the edges causing additional problems like drainage issues and rutting.



A Tree roots create tripping hazards and cause trail surface damage. Roots can also be exposed by erosion of the crushed gravel over time.

B Small trees close to the trail will encroach further and cause problems if not addressed. New vegetation should be cleared on a regular basis to prevent overcrowding of the trail corridor.



A An example of poor drainage with standing water pooling on the trail surface resulting in muddy conditions. A natural clay subgrade may be hindering water filtration, and insufficient cross-slope is allowing water to collect in dips and voids. This section will require regrading to restore proper drainage off the trail corridor and into the adjacent swale.

3.3 TRAIL SURFACES

3.3.2 ASPHALT (BLACKTOP)

Top left: Detail of asphalt (blacktop) pavement. (Photo credit: Wm. Mueller & Sons, Inc., Hamburg, MN.)

Top right: Detail of chipseal pavement. (Photo credit: Wikipedia user Xf8.)

Bottom: The Northwest Lancaster County River Trail near Columbia, PA.

WHAT ARE ASPHALT AND BLACKTOP?

Asphalt is a mixture of bitumen, a sticky black petroleum-based material, and crushed aggregate. **Blacktop**, also known as "asphalt concrete," is a type of asphalt with a significantly higher ratio of aggregate to bitumen and is heated at a slightly higher temperature. For multi-use trails, blacktop is usually the asphalt type used, as it is more flexible and easier to repair than high-bitumen grades of asphalt, which are used more for heavy-load situations such as highways and airport runways. In this guide, we use the universal term "asphalt" to refer to blacktop.

+ PROS

- Asphalt provides a continuous, smooth, joint-free trail surface. The flexible pavement material is quiet and forgiving, creating an enjoyable experience for bicyclists, rollerbladers, joggers, and walkers alike.
- Asphalt paving projects can be completed relatively quickly compared to other options. Fresh blacktop can often be used within a couple of days of when it is poured.
- Asphalt is flexible, allowing for some expansion and contraction to minor ground movements without cracking. It performs better than concrete in colder climates that experience frost heaves.
- Asphalt is less expensive than concrete, often at about half the initial price, and repairs are cheaper and easier.
- Bicycles do not exert the type of pressure on asphalt that cars do, so asphalt trails may last longer than expected.

– CONS

- Due to its flexible nature, asphalt is less durable and has a shorter expected lifespan than concrete (20 years vs. 40 years), though it tends to perform better than concrete in cold, wet climates.
- Asphalt requires regular maintenance for optimal performance, with resealing and/or resurfacing recommended every 5 years at most. Cracks form relatively often and need to be addressed as soon as possible.
- As a petroleum-based product, asphalt is generally less environmentally friendly than concrete and generates more heat due to its dark color, though it can be produced from recycled materials such as recycled asphalt millings.

WHAT ABOUT CHIPSEAL?

Chipseal, also known as "tar and chip," is a surface treatment used on top of existing asphalt pavement to prolong its life. On older trails and low-volume roads that have not undergone a full repaving, chipseal is often applied. Chipseal consists of one or more layers of sprayed-on asphalt emulsion on top of the old pavement, with one or more layers of crushed aggregate placed on top of the asphalt emulsion and rolled into place. It is rougher and noisier than blacktop.

+ PROS

- Chipseal is a low-cost yet effective way to repair and prolong the life of asphalt trails, adding 5 to 7 additional years of pavement life.
- Chipseal provides a less bumpy surface than applying asphalt overlay patches over an existing pavement.
- Chipseal can often be applied directly over existing gravel trails, using that material as a subbase. This costs about 1/4 of the price of a brand-new asphalt pavement.

– CONS

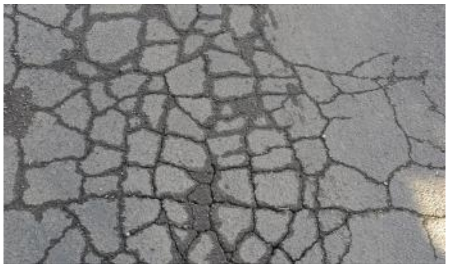
- Loose rocks are often left on the surface of chipsealed trails and roads, creating potential hazards for bicyclists and depositing foreign material into waterways. (On newly chipsealed roads, you may see signs that say "Fresh Oil and Chips.")

- Bicyclists tend to hate chipseal, as the rough surface induces friction and vibration that slows riding speeds, causing fatigue, requiring more pedaling effort, and increasing tire wear.
- Chipseal lasts only half as long as brand-new asphalt pavement, for approximately 7 years. During that time, it also requires more maintenance.
- Chipseal is less durable and more pervious than asphalt, being more prone to everyday wear and tear, cracking, raveling, potholes, snowplow damage, and water intrusion.

3.3.2 Trail Surfaces: Asphalt (Blacktop)

⚠️ COMMON SUSTAINABILITY PROBLEMS

The major sustainability problem associated with asphalt trails is **pavement distress** due to temperature changes, **subgrade** movement, water infiltration, poor drainage, and quality issues with the original mix or its application There are multiple types of pavement distresses common in asphalt trails:



Alligator/Fatigue Cracking [1]

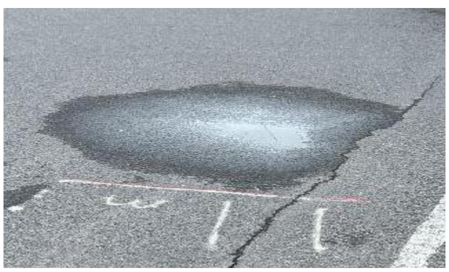
This distinct pattern of interconnected (<6" wide) "pieces" is caused by repeated loads over time that exceed the asphalt's structural capacity. Patching or replacement is needed.

Potholes

Potholes often result from alligator or block cracks left untreated, causing pieces of asphalt to become dislodged. The holes grow in size as additional wear erodes their edges.

Thermal/Transverse Cracking

Thermal cracks are often perpendicular to traffic, a result of contraction and expansion due to temperature swings, hardening of the asphalt binder, or reflection cracking (see below).



Depressions

Unlike potholes, depressions and dips do not involve pavement loss. Instead, they typically occur due to improper compacting of the trail foundation, leading to settling of the pavement.

Upheavals/Tree Root Intrusion

The encroachment of tree roots on a trail tread is a potential hazard and threatens the integrity of its subgrade, base course, and surface. Certain tree species are especially aggressive.

Longitudinal Cracking

Longitudinal cracks form parallel to traffic, typically near a trail's centerline, and result from temperature swings, new or existing reflection cracks, or weak longitudinal pavement joints.

Reflection Cracking [2]

Rail trails are often built on top of old pavement that was used by former railroad lines. When these underlying pavement layers expand and contract, it affects the newer asphalt surface.

Raveling

Raveling is the slow disintegration of the asphalt surface and its aggregate particles, caused by any number of factors (though traffic loads and water are the two most common causes).

Block Cracking

Block cracks are widely spaced (6" to 3'), interconnected cracks. They are typically caused by the inability of cold-hardened asphalt binder to expand and contract with temperature cycles.

Failing Patches

Asphalt patches are temporary solutions to prolong the life of a trail. Since they introduce new points of weakness, they tend to develop issues faster than the original trail surface.

Edge Cracking

Poor drainage can cause edge cracking, when water is able to seep under the pavement, aided by organic material touching the trail surface, resulting in a loss of shoulder support.

Bleeding [3]

Bleeding occurs when excess asphalt binder (bitumen) makes its way to the surface of the pavement, forming a layer over the aggregate and resulting in a slick and slippery trail surface.

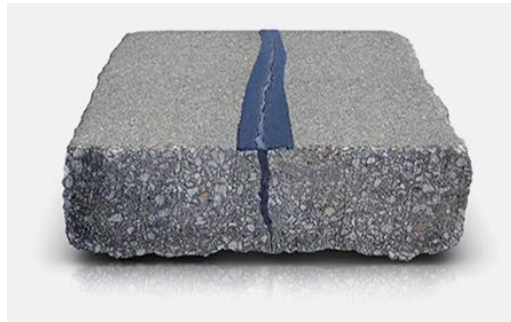
Photo credits: 1. Wikipedia user Bidgee. 2. City of Port St. Lucie, FL. 3. Pavement Management Services, The Rocks, NSW, Australia.

Above: Longtime drainage issues in this section of an asphalt trail that merges with a roadway have left consistent deposits of mud and pooled water as a continuous obstacle to bicyclists. This results in bicyclists venturing into the dirt parking area on the right, which is private property.

3.3.2 Trail Surfaces: Asphalt (Blacktop)

MAINTENANCE TIPS

- **Asphalt trails should be inspected as part of a regular maintenance routine**, noting the presence of:
  - ☐ Cracks
  - ☐ Loose rocks
  - ☐ Tripping hazards
  - ☐ Rutting and raveling
  - ☐ Pooling water
  - ☐ Potholes
  - ☐ Encroaching vegetation
  - ☐ Weeds coming through cracks
  - ☐ Faded pavement markings
  - ☐ Graffiti or vandalism



Above: Cross section of crack sealed asphalt. (Photo credit: Midstates Equipment & Supply, Mountain Lake, MN.)

Below: An asphalt fog seal at a trail crossing for the Great Allegheny Passage in Dunbar Township, Fayette County, PA.

- **Routine sweeping or blowing** of asphalt trails, particularly during the fall season or after storms, helps to improve overall appearance, reduce slipping hazards, and extend the asphalt's lifespan. Sweeping can be performed during inspections or concurrently with other trail maintenance tasks.
- **Cracks 1/4" to 1" wide (not including alligator cracking):** Fill with crack seal to prevent water intrusion.
- **Cracks over 1" wide or with raveling:** Remove the cracked pavement layer; replace with an overlay patch.
- **Preventative maintenance** can add 10 years to the life of the asphalt. Performing one or more of the following sealing methods is recommended every 5 years (or earlier, as needed):
  - ✓ **Crack sealing** is used to fill individual pavement cracks to prevent entry of water or other non-compressible substances such as sand, dirt, rocks or weeds. Crack sealant is typically used on early-stage longitudinal cracks, transverse cracks, and block cracks.
  - ✓ **Fog sealing** is a pavement preservation technique that involves spraying a thin asphalt emulsion onto an existing asphalt pavement to seal cracks, restore flexibility, and extend the life of the pavement.
  - ✓ A **slurry seal** is similar to a fog seal except it has aggregates as part of the mixture of emulsified asphalt, water, and mineral filler. Slurry seals are used to fill existing pavement surface defects as either a preparatory treatment for other maintenance treatments or as a wearing course.
  - ✓ **Micro surfacing** is similar to a slurry seal except that hardening takes place as a result of chemical additives rather than from evaporation of water in the asphalt emulsion in the heat and sunlight.
  - ✓ **Chip sealing** is a thin film of heated asphalt liquid sprayed on the pavement surface, followed by the placement of small aggregate ("chips"). A chip seal is one-quarter to one-fifth the cost of a conventional asphalt overlay and extends the life of pavement by 5 to 7 years.

Top: This asphalt trail section, which was constructed on top of old railroad ties, shows evidence of the pavement having settled into the spaces between the ties. This is an early indication of potential reflection cracks forming.

Bottom: The cracks visible here were largely formed by the upward movement of tree roots. The asphalt has degraded to the point that trail user comfort is a significant concern. Handling a bicycle is more challenging, and the upheaved areas are potential trip hazards for pedestrians.

3.3.2 Trail Surfaces: Asphalt (Blacktop)

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

Asphalt is in new or lightly worn but smooth condition, with no cracking.

2 GOOD

Asphalt has minor areas of distress, with cracks less than 1/4 inch wide. Investigate the root cause of distress and eliminate the source if possible. Crack seal to prevent moisture intrusion and widening of existing cracks.

(Photo credit: Los Angeles County Public Works, Los Angeles, CA.)

3 ACCEPTABLE

Asphalt has a moderate number of areas of distress, or cracks are 1/4 to 1/2 inch wide. Crack seal to prevent further raveling of cracks. Consider overlaying with a slurry seal. If severe, remove and replace affected area with a small overlay.

(Photo credit: Los Angeles County Public Works, Los Angeles, CA.)

4 POOR

Asphalt has cracks over 1/2 inch wide, or areas of distress are extensive. If asphalt is not yet at the end of its lifespan (approximately 20-30 years), place a hot mix asphalt overlay patch over the affected surface.

(Photo credit: Los Angeles County Public Works, Los Angeles, CA.)

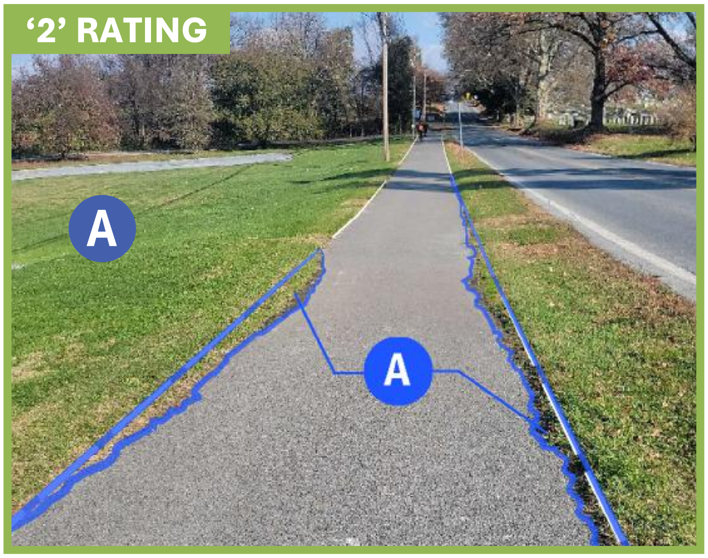
5 ISSUE NEEDS FURTHER EVALUATION

Asphalt is at the end of its useful life or is in a condition requiring complete replacement. Complete a full replacement and reconstruction of the affected asphalt trail section.

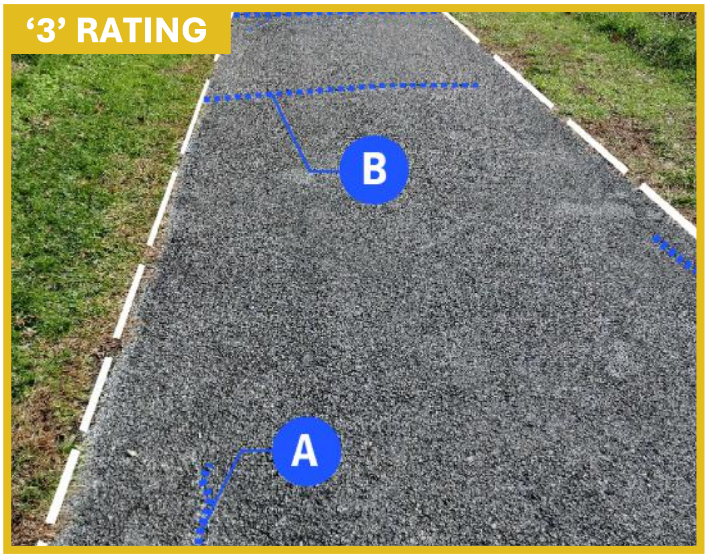
(Photo credit: Los Angeles County Public Works, Los Angeles, CA.)

3.3.2 Trail Surfaces: Asphalt (Blacktop)

ILLUSTRATED ISSUES OF COMMON PROBLEMS

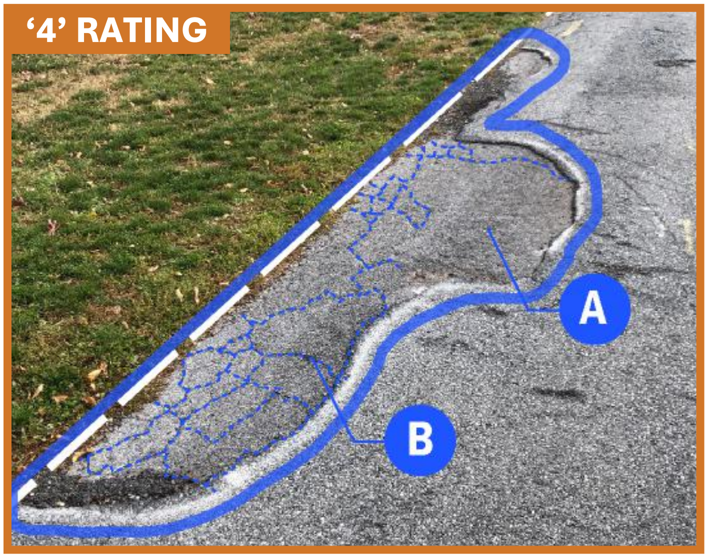


A Vegetation encroaching onto the trail at the edges suggests the asphalt is becoming mixed with adjacent soils. Eventually, along with increasing maintenance requirements, water can no longer drain off the edges properly and will puddle on the trail until it evaporates.



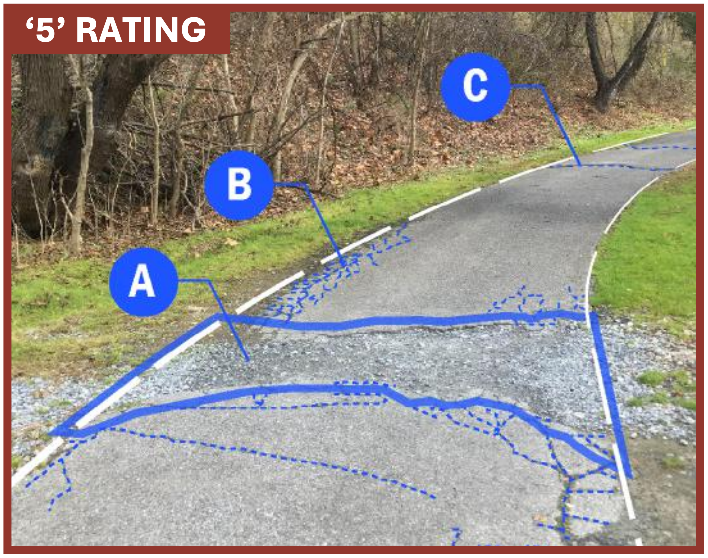
A This aging asphalt trail shows signs of raveling caused by surface weathering. Aggregate particles have dislodged, and a significant amount of the asphalt binder has shrunk away.

B A thin transverse crack is present here. Transverse cracks are exceedingly common on asphalt trails in northern climates due to the freeze-thaw cycle.



A The "alligator" paving is an indicator of a subbase failure.

B The "weaving course" of asphalt has deteriorated, exposing the base course. The failure in the trail's subbase has caused this problem, which will continue until the subbase is addressed.



A Recent underground utility work impacted this trail, and the damage to the asphalt has not been addressed, creating a dip with a rough surface.

B The alligator cracks here are noticeably wider than in the previous photo and should be addressed with resurfacing.

C Transverse cracks are present in the distance.

3.3 TRAIL SURFACES

3.3.3 CONCRETE

Top left: Detail of exposed aggregate and brushed concrete finishes on the Three Rivers Heritage Trail in Pittsburgh, PA.

Top right: Brushed concrete slabs at the Buffalo Bike Park in Buffalo, NY.

Bottom: The Eastbank Esplanade, which runs along the Willamette River in Portland, OR.

🔍 WHAT IS CONCRETE?

Concrete is a composite material consisting of a mixture of aggregate (typically sand and gravel), cement (typically Portland cement), and water. The type of concrete used for most multi-use trails, sidewalks, and low-volume roadways is **jointed plain concrete pavement (JPCP)**, which is constructed in sections and saw-cut with contraction joints intended to control the location of expected natural cracks. The resulting concrete trail pavement appears as individual slabs that abut each other at the joints, which are typically no more than 20 feet apart and transversely cut — that is, oriented perpendicularly to the direction of travel. The contraction joints in JPCP do not use reinforcing steel. Sometimes, the joints are sealed with a silicone sealant to prevent infiltration of water or contaminants.

Though **concrete is the pavement material used for the vast majority of sidewalks**, it is less often used than asphalt and crushed gravel for multi-use trails in some parts of the country. Sometimes, this is a because of specifications from the state department of transportation; other times, it is because of local climatic considerations or the availability or price of the paving material in a specific market.

Two other concrete types are used sparingly for trails, primarily in an urban context and for decorative purposes:

- **Exposed aggregate** is a decorative concrete finish that features a visible surface of aggregate materials, such as pebbles and stones. It is made by placing a concrete pavement and then removing the top layer of cement to reveal the rough aggregate underneath.
- **Permeable pavers** are concrete bricks separated by gaps filled with small stones (rather than mortar), which are laid over a bed of aggregate stones. The gaps between the pavers are wide enough that water is able to infiltrate through the aggregate, where it is stored and slowly filtered back into the soil.

+ PROS

- When properly designed and constructed using quality materials, concrete is durable and long-lasting. Compared to asphalt, which typically lasts 20-30 years, concrete can last 30-50 years or even longer.
- Concrete can be used decoratively, in a variety of finishes, styles, and patterns. It can be used not only as a travel surface but also as a form of public art itself.
- Concrete pavement can be constructed and implemented in a variety of ways, from fixed forms to a continuous pour reinforced with steel rebar to small brick-like pavers.
- Though concrete is about twice as expensive as asphalt initially, it is relatively low-maintenance over its lifetime.
- If looking to build an ADA-accessible trail for wheelchair use, concrete provides the best surface.
- Unlike asphalt trails, concrete trails do not require a gravel base.
- Concrete pavement works better than other trail surface types for areas susceptible to flooding. It also stands up better to heat than asphalt and does not generate as much heat itself.

– CONS

- Concrete is a more rigid material than asphalt or crushed gravel, and this makes it taxing for runners' legs and feet. There are also joints every 20 feet or so, unlike the continual smoothness of an asphalt pavement in good condition.
- Concrete involves a higher upfront material cost than asphalt and requires a longer curing time.
- Concrete requires less frequent maintenance than asphalt, but when repairs are needed, they are usually more expensive and require more intensive labor.
- When concrete slabs experience distress, the slabs frequently need to be replaced entirely (full-depth repair) rather than just sealed. Resurfacing of concrete using diamond grinding is typically not an appropriate solution for cracking and spalling caused by freeze-thaw cycles. It is primarily designed to smooth out surface irregularities.

3.3.3 Trail Surfaces: Concrete

⚠ COMMON SUSTAINABILITY PROBLEMS

The major sustainability problem associated with concrete trails is **pavement distress** due to temperature changes, **subgrade** movement, structural causes due to loads, and quality issues with the original concrete mix, design, or construction. There are multiple types of pavement distresses common in concrete trails:

Map/Hairline Cracking (Crazing) [1]

These cracks are caused by shrinkage due to temperature drops and ensuing moisture loss, either during curing or over time. Crazing is a surface defect and does not necessarily progress.

Spalling

Spalling is defined as the flaking, chipping, or fraying of concrete. When the area of distress extends 3 inches or more in either direction from a joint or slab edge, it is considered severe.

Alkali-Aggregate Reaction [2]

These reactions occur when alkali in cement chemically react with the aggregate, resulting in expansion cracks that look similar to map cracks but that structurally compromise the concrete.

Corner Breaking

Corner breaks result from cracking or raveling of a concrete slab near one of its corners, eventually leading to spalling. Common causes are weak concrete and repeated traffic loads.

"LTD" Cracking

Longitudinal, transverse, and diagonal ("LTD") cracks extend across a slab, dividing it into pieces. Causes include repeated load, subgrade settlement, and shrinkage from cooling and drying.

Durability Cracking (D-Cracking)

Though similar in appearance to alligator/fatigue cracking in asphalt, durability cracking in concrete usually occurs near joints and is caused by the freeze-thaw cycle.

Transverse Joint Fault/Settlement [3]

Two adjacent concrete slabs may end up at different vertical elevations over time due to uneven movement of the subgrade. Freeze-thaw cycles lead to "pumping" up of water under the slab.

Upheavals [4]

Concrete upheavals are similar to transverse joint faults but happen when tree roots, not pressurized water, push upward on the trail surface, raising the elevation of the affected concrete slab.

Blowups [5]

Concrete pavement is susceptible to buckling upward in abnormally hot weather. Adjacent slabs expand and push against one another, sometimes shattering at the joint and "blowing up."

Failing Patches

Patches of concrete or asphalt are often used to repair concrete distress or fill holes cut by utility companies. Concrete patches may weaken over time, showing spalling or cracking.

Delamination

Delamination occurs when pieces of the surface layer of the concrete (usually 0.5 to 2 inches thick) separate from the substrate. It often results from untreated and weakened cracks.

Efflorescence

Efflorescence is an aesthetic defect that occurs when soluble salts in the cement are left behind on a concrete surface after evaporation of moisture, leading to areas of white discoloration.

Photo credits: 1. Pro Painting & Renovations, Cape Town, South Africa. 2. RJ Lee Group, Inc., Monroeville, PA. 3. Snyder & Associates, Ankeny, IA. 4. Pierman Foundation Repair Services, Ada, OK. 5. Pavement Interactive, Seattle, WA.

MAINTENANCE TIPS

- **Concrete trails should be inspected as part of a regular maintenance routine**, noting the presence of:
  - ☐ Cracks
  - ☐ Areas of spalling
  - ☐ Deterioration around joints
  - ☐ Slabs at uneven elevation
  - ☐ Pooling water
  - ☐ Potholes
  - ☐ Encroaching vegetation from the trail edge
  - ☐ Vegetation coming through pavement cracks
  - ☐ Faded pavement markings
  - ☐ Graffiti or vandalism
- Cracks are relatively common in concrete and can be indicative of poor subgrade support, the act of the freeze/thaw cycle on the subgrade, or the differential movement of various parts of the subgrade. Recommended maintenance and/or repair methods differ depending on whether the concrete on both sides of a crack have moved (either vertically or horizontally):
  - If the concrete on both sides of a crack has shifted vertically and/or horizontally (called a "working" crack): Remove and replace the affected slab.
  - If the crack has not resulted in vertical movement or horizontal separation (such as with map/hairline cracks or large isolated but dormant cracks): Route and seal the crack. Routing and sealing involve slightly enlarging the crack at the surface with a saw or grinder and then filling the resultant groove with a flexible sealant (such as an epoxy, silicone, asphalt, or polymer mortar).
- If two adjacent concrete slabs have shifted apart vertically (known as transverse joint faulting), repair methods depend on how far apart the slabs have shifted:
  - If the elevation of the slabs has shifted less than 1/4 of an inch: Do nothing.
  - If the elevation of the slabs has shifted 1/4 to 1/2 of an inch: Grind with a self-propelled concrete grinder.
  - If the elevation of the slabs has shifted over 1/2 of an inch: Perform a slab jacking and pressure grout, which involves jacking up the settled slab and then injecting grout under it to lift it back into position.
- If "LTD" (longitudinal, transverse, and/or diagonal) cracks or durability cracks (d-cracks) have formed:
  - If the concrete slab is divided into multiple pieces: Remove and replace the slab.

  - If there is only a longitudinal crack, and it is less than 1/4 of an inch wide: Do nothing.
  - If there is only a longitudinal crack, and it is between 1/4 and 1/2 inches wide: Fill it with sealant.
  - If cracks are greater than 1/2 of an inch wide: Remove and replace the slab.

- When laying down new concrete pavement or patches, it is essential to properly cure the fresh concrete to minimize dehydration. If curing does not occur or is not properly done, water will evaporate from the freshly placed concrete mix, causing increased risk of shrinkage and cracking. How concrete is cured:
  - One option is to spray the fresh concrete surface with a curing agent immediately after finishing (finishing is the process of adding texture to the concrete surface, such as with a broom).
  - Curing may also be accomplished by placing plastic or wet burlap on the pavement surface and keeping it in place for 3 to 7 days. If wet burlap is used, it is important that the burlap is kept saturated during the entire curing period.

- Be careful with pressure washers. It is advised to pressure wash concrete no more than once a year, at the same time it is to be resealed. If you use pressure that is too strong or too close to the trail surface, you could risk damage to the concrete, including a breakdown of sealants, chipping, or unwanted etching.

Above: Concrete can be more easily customized into pronounced forms and meandering paths than asphalt, making it a good choice for decorative trail applications, such as this s-curving section of the Rotary Trail in Birmingham, AL.

Top: One disadvantage of concrete is that it can be slippery in wet weather. Roadway treatments of concrete often use a tine rake finish to add traction, though this is uncommon on sidewalks and trails. (Photo location: the Eastbank Esplanade in Portland, OR.)

Bottom: Concrete is typically preferable to asphalt in areas with hot weather, as its brighter surface better reflects (rather than absorbs) heat. Painted treatments can add context to concrete, such as differentiating bikeways from pedestrian sidewalks, as shown here in Miami Beach, FL.

3.3.3 Trail Surfaces: Concrete

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

Relatively new concrete slab pavement with thin joints.

2 GOOD

Concrete ramp trail surface is in decent condition. Some vegetation growth within joints and along edges by railing. Graffiti in the center of the trail has been covered.

3 ACCEPTABLE

A single transverse crack along a concrete trail surface otherwise in good condition. This crack is probably indicative of the subgrade on one side settling.

4 POOR

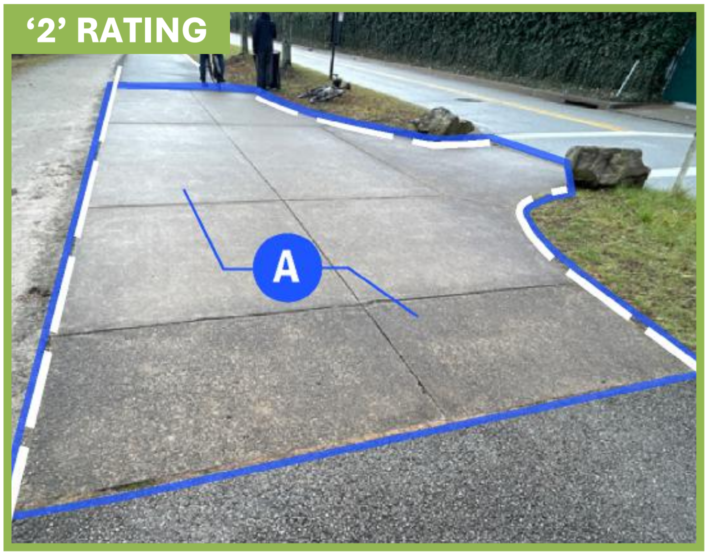
Concrete road/trail crossing with wide transverse cracks forming. This concrete roadway is under constant stress from vehicular use at a busy urban intersection.

5 ISSUE NEEDS FURTHER EVALUATION

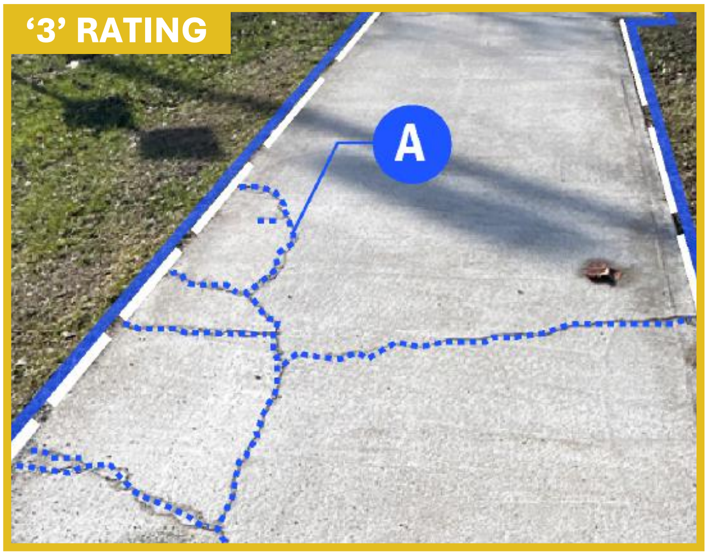
Significantly deteriorated concrete trail surface with extensive graffiti present.

3.3.3 Trail Surfaces: Concrete

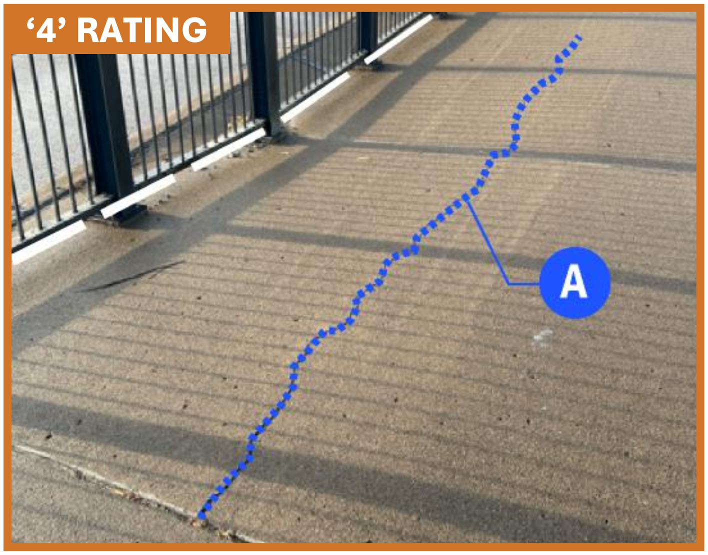
ILLUSTRATED ISSUES OF COMMON PROBLEMS



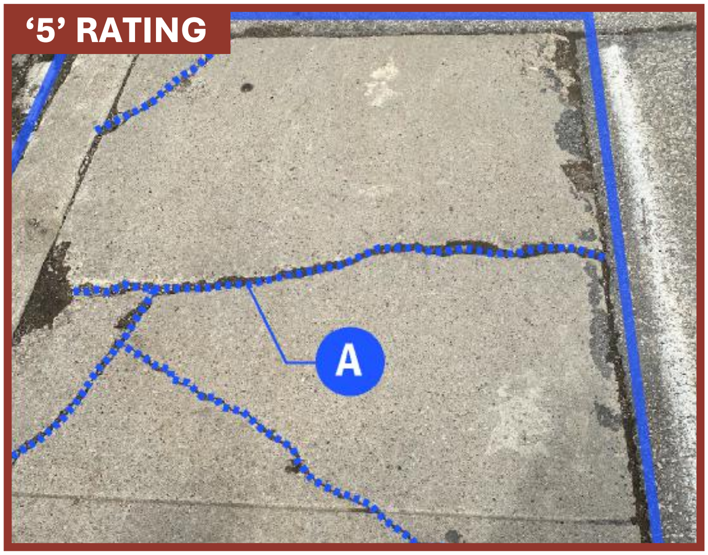
A This concrete section of trail is in good condition and was likely inserted between asphalt surfaces to better handle extra loads from maintenance vehicles that access this section of trail occasionally from the adjacent roadway.



A Large block/alligator cracks are forming on this concrete trail surface. However, the cracks are not yet deep or wide and the concrete surface continues to hold together well.



A Long longitudinal crack starting to get significant separation towards the joint.



A This section of concrete trail surface is deteriorating significantly with large LTD cracks extending into adjacent slabs and large missing chunks.

3.3 TRAIL SURFACES

3.3.4 DECKING MATERIALS

Top left: Detail of PROForms® fiberglass (FRP) decking product. (Photo credit: Bedford Reinforced Plastics, Bedford, PA.)

Top right: Detail of wood decking on a bridge.

Bottom: A boardwalk along the Mountains to Sound Greenway Trail in Bellevue, WA.

🔍 WHAT ARE DECKING MATERIALS, AND WHAT ARE THEY USED FOR?

Decking consisting of a series of narrow planks or panels are frequently employed on multi-use trails as a trail surface for bridges and boardwalks. Two of the most popular **decking materials** are wood and fiber-reinforced plastic (FRB), better known as fiberglass. Concrete is also frequently used. (Note that many new bridges, particularly if their spans are relatively short, are made of precast concrete and placed directly on the site by crane; these types of bridges often do not use planks or panels at all on their travel surface.)

On rail trails, **wood decking** typically consists of planks of lumber — often treated or stained — that are placed either perpendicularly or at an oblique angle to trail traffic. The planks are nailed or screwed to structural stringer beams (crossbeams) that run the length of the bridge or boardwalk below the deck.

Like wood decking, **composite decking** is often arranged in planks or panels oriented perpendicularly to trail traffic. Common materials include fiberglass, plastic (often recycled, with integrated wood fibers or sawdust), concrete, and aluminum. Unlike wood decking, composite products are often patented, branded products with usage instructions, specific maintenance guidelines, and warranties.

⚠️ COMMON SUSTAINABILITY PROBLEMS

The major sustainability problem associated with wood decking is **weathering** due to the elements (particularly moisture absorption and subsequent drying — a cycle of expansion and contraction). **Fading** and **warping** are the primary sustainability issues with composite decking, which occur due to ultraviolet (UV) exposure and temperature fluctuation, respectively. Both types of decking materials can grow **mold** if not properly maintained. For wood decking, mold occurs when the wood absorbs moisture without ample opportunity to dry; untreated or unsealed lumber makes mold more likely. For composite decking, mold may form in humid environments if the decking is never cleaned.

💡 MAINTENANCE TIPS

- Decking materials should be inspected as part of a regular maintenance routine, noting the presence of the following:
  - ☐ Warped, splintered, cracked, or damaged planks
  - ☐ Loose or rusty nails or screws
  - ☐ Mold, mildew, rot, or insect activity
  - ☐ Loose connections between planks, posts, decking support structures, etc.
- During routine inspections — and more often during the fall season — sweep away accumulated debris, leaves, and dirt from the surface.
- Consider sealing wood planks, if they are not already, to prevent cracking and splintering, mold growth, and water damage. Staining and oiling are sealing methods to help resist water and UV damage that lead to cracking and shrinking. Reseal every 2 to 3 years.
- If planks are warped or distorted but otherwise undamaged, unscrew them, flip them over, and screw them back in (preferably in newly drilled holes). If unrepairable, replace damaged planks as soon as possible.
- Avoid using chemicals or bleach to clean wood decking in a natural environment. If mold and mildew are severe, try pressure washing to see if the problem can be solved before replacing individual planks. Pressure washing is generally acceptable for composite decking materials; however, refer to the manufacturer's specifications for recommended cleaning methods.

3.3.4 Trail Surfaces: Decking Materials

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

Composite decking that is almost 15 years old but still in like-new condition.

2 GOOD

Wood decking in good condition, but with some evidence of ponding water on certain boards. These boards will likely deteriorate faster than adjacent boards with no ponding water.

3 ACCEPTABLE

Aged wood decking partially covered by adjacent limestone surfacing material and leaf debris. Clear wood decking of debris and address erosion of the adjacent limestone trail surface.

4 POOR

Wooden boards that have expanded, contracted, and cracked, causing a bumpy ride for bicyclists and tripping hazards for walkers.

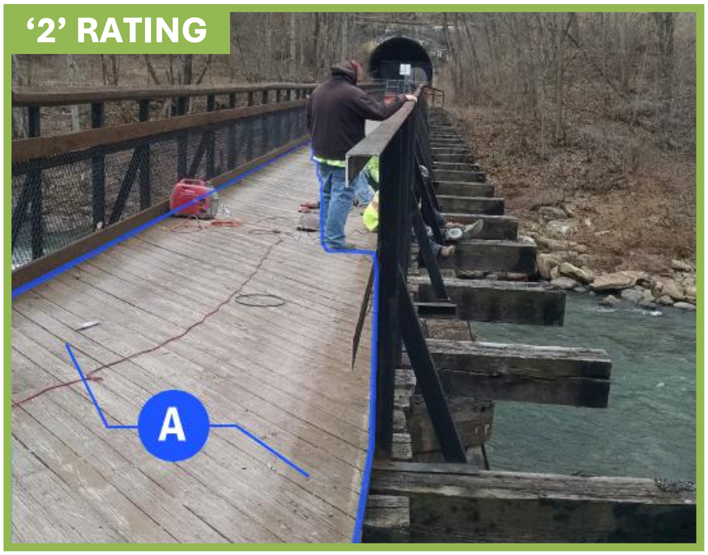
5 ISSUE NEEDS FURTHER EVALUATION

Old and rotten wood decking that was recently closed to trail users. Individual rotten wooden boards can no longer be adequately replaced as the entire structure has deteriorated.

3.3.4 Trail Surfaces: Decking Materials

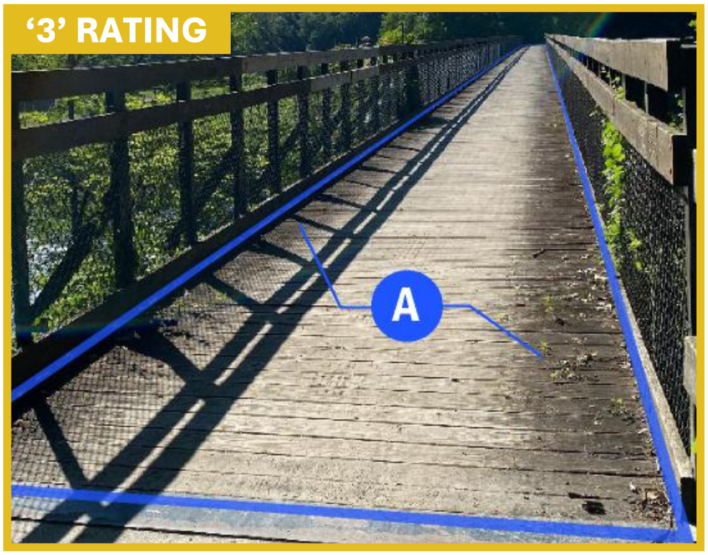
ILLUSTRATED ISSUES OF COMMON PROBLEMS

'2' RATING



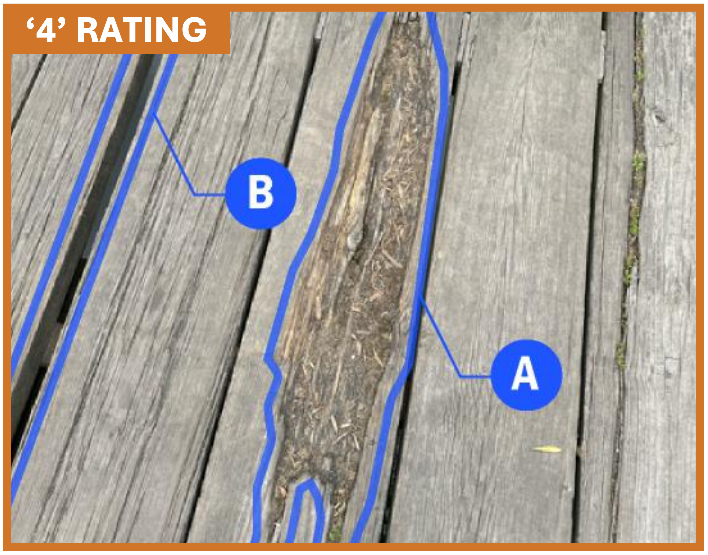
A Older decking that has been recently swept and cleaned of debris with other active restoration efforts ongoing.

'3' RATING



A Aging wood decking on flyover bridge showing evidence of debris building up along the edges that is contributing to the deterioration of the wood.

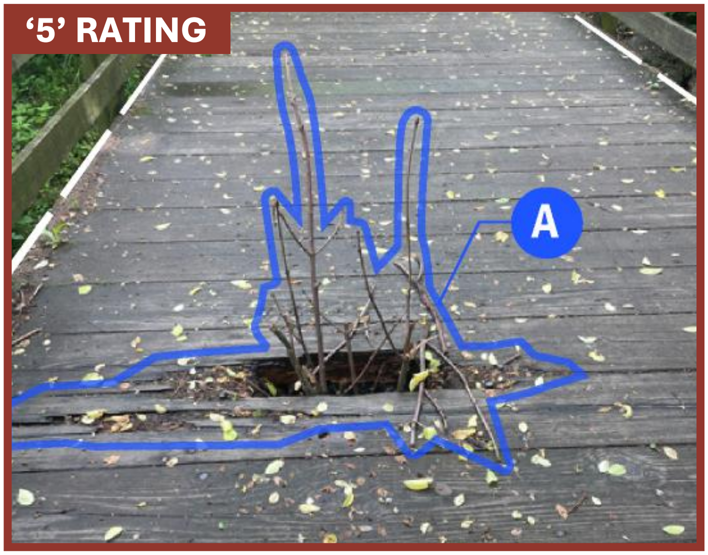
'4' RATING



A Some boards of this wood decking have become rotten and are beginning to develop holes.

B Spaces are forming between the wooden boards which creates a potential tripping hazard.

'5' RATING



A A large hole has developed in the middle of this bridge with wooden decking. These boards were very rotten and eventually collapsed, creating a significant safety hazard. Someone had placed tree branches within the hole for increased visibility, but that is not a fix and this issue must be addressed ASAP.

3.4 TRAIL STRUCTURES

Many types of structural elements provide support for multi-use trails. From bridges and tunnels to fences and retaining walls, the integrity of a trail depends more than one may expect on structures not directly on the trail surface itself. As these structures are often crucial for trail user safety, it is important that their maintenance is prioritized. Supportive **trail structures** are not simply “nice-to-have” amenities!

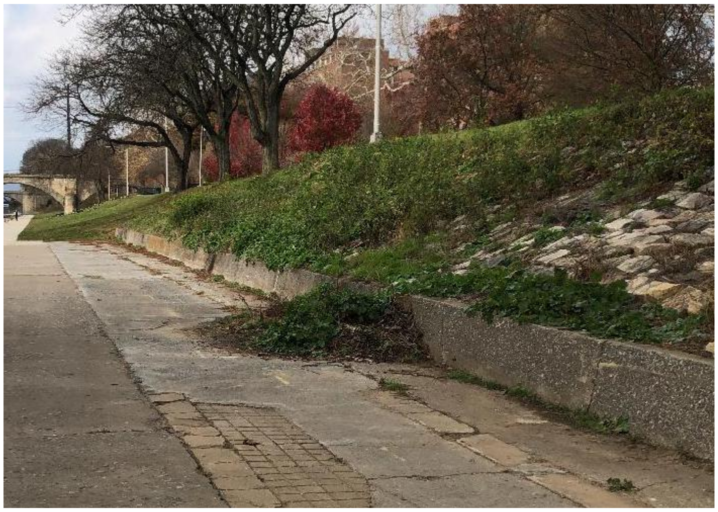
GENERAL TRAIL STRUCTURE MAINTENANCE GUIDELINES

- **Conduct regular inspections** of trail structures to evaluate their continued structural integrity.
- **Trim vegetation** that interferes with the function of trail structures or that reduces their visibility to trail users.
- **Tighten and secure** any loose hardware, such as screws, bolts, and footings.
- **Note any signs of moisture intrusion** and monitor accordingly.
- **Maintain the visual condition** of trail structures by cleaning, staining, sealing, and patching when needed.

Above: A trail bridge on the Great Allegheny Passage crosses Ramcat Run, a tributary of the Youghiogheny River.

Above: A former railroad truss bridge repurposed for the Pine Creek Rail Trail in Watson Township, Lycoming County, PA.

Above: This rail became dislodged from a fence post and warped from the effects of weather after not being immediately addressed.



Above: While this retaining wall remains mostly functioning, some earth from the hill it is holding up has managed to slide past it.

Above: The 849-foot-long Pinkerton Tunnel on the Great Allegheny Passage in Upper Turkeyfoot Township, Somerset County, PA.

Above: This railroad underpass on the Three Rivers Heritage Trail in Pittsburgh, PA is served by a lighting fixture for better nighttime safety.

Above: The repurposed Safe Harbor Bridge on Pennsylvania's Enola Low Grade Trail. (Photo credit: Susquehanna Greenway Partnership.)

Above: A concrete boardwalk constructed for the Three Rivers Heritage Trail in Pittsburgh, PA.

Above: This damaged safety railing on an urban trail should be repaired to prevent inadvertent injury to trail users.

Above: This structure was constructed under an active railroad bridge to catch any potential debris falling onto trail users from rail cars.

Top: Large trail structures such as bridges, boardwalks, and overlooks are memorable parts of many trail users' visits. This view from the Great Allegheny Passage's Whitaker Bridge in Whitaker, PA looks out across the Monongahela River toward the town of Braddock.

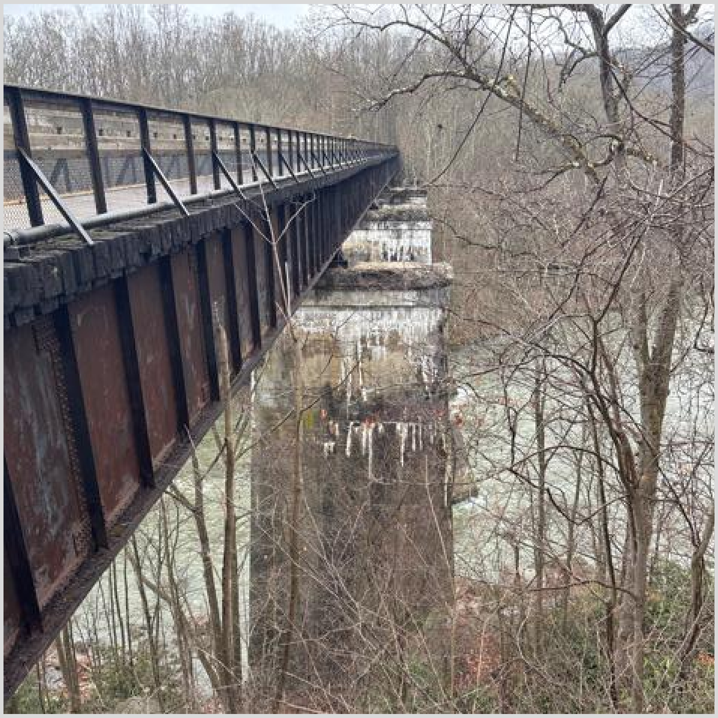
Bottom: The Enola Low Grade Trail's Safe Harbor Bridge, in Conestoga Township, Lancaster County, PA, hugs the edge of a bluff high above the scenic Susquehanna River. (Photo credit: Susquehanna Greenway Partnership).

Top: This portion of the Tampa Riverwalk in Tampa, FL provides unique views of city landmarks and the river.

Bottom: The Salisbury Viaduct in Summit Township, Somerset County, PA provides a 1,908-foot-long uninterrupted view of the Pennsylvania countryside as the Great Allegheny Passage approaches the town of Meyersdale. (Photo credit: Great Allegheny Passage Conservancy.)

3.4 TRAIL STRUCTURES

3.4.1 BRIDGES AND BOARDWALKS



Top left: Detail of a boardwalk structure on the Summit MetroParks Bike & Hike Trail in Sagamore Hills Township, Summit County, OH.

Top right: The repurposed Ohiopyle High Bridge on the Great Allegheny Passage in Ohiopyle, PA, crossing the Youghiogheny River.

Bottom: The repurposed Hot Metal Bridge elevates Great Allegheny Passage trail users across this busy intersection in Pittsburgh, PA.

🔍 WHAT ARE BRIDGES AND BOARDWALKS USED FOR?

Bridges and boardwalks provide trail access over lower-lying natural and manmade features, such as waterways, wetlands, roads, and railroads.

Bridges used for multi-use trails include prefabricated span bridges, simple deck girder bridges, side girder bridges, and truss bridges, among other types, some of which are repurposed abandoned rail bridges in the case of rail trails. Common materials include wood, steel (e.g, painted, galvanized, or weathering/Corten), concrete, and synthetic materials such as fiberglass (fiber-reinforced polymer) and wood-plastic composite. Bridges are typically held up by abutments (most often made of concrete), which are the substructures at a bridge's two ends that support the deck structure.

Boardwalks are often constructed or placed in urban settings where space for a trail is otherwise constrained. Wood, concrete, or composite materials are typically used for most of a boardwalk structure, including its decking. Steel footings are sometimes used as a secondary material for stronger base support.

⚠️ COMMON SUSTAINABILITY PROBLEMS

Wood bridges and boardwalks are prone to **natural agents of deterioration** such as insects, fungi, and rot. They can also undergo freeze/thaw cycles that result in expanding and shrinking. As with wood decking, intense sunlight exposure and wear and tear through long-term use are also sustainability concerns. Steel structures are prone to **rust and corrosion**, even if classified as galvanized or stainless.

💡 MAINTENANCE TIPS

- Bridges and boardwalks should be inspected at the regular frequency required by the laws of your jurisdiction for bridges carrying vehicular traffic and railroads (typically every 2 years). Inspections should be completed by certified bridge inspectors or professional engineers.
- Between these formal inspections by engineers, trail managers are encouraged to do visual inspections to note any potential problems.
- New or replacement bridges and boardwalks are often prefabricated products manufactured by companies specializing in trail bridges, boardwalks, and decking materials (often composite). These structures should be maintained per the manufacturer's specifications.
- If choosing a prefabricated bridge or boardwalk, ensure that the site is accessible by tractor-trailers and cranes. While prefabricated products involve minimal on-site construction, they do require placement, even though such placement can be done in as quickly as one day.
- Existing and reused trail bridges, such as repurposed abandoned rail bridges and trestles, should be inspected yearly by an engineer to assess and monitor their structural integrity. This includes checking posts, piers, screw anchors, footings, and foundations, as applicable.
- Trail surfaces just off each end of a bridge or boardwalk should match the height of the bridge surface. Avoid drop-offs and ensure a continuously smooth riding experience.
- Ensure that guiderails meet AASHTO standards. If there is a 30-inch or greater difference in the bridge or boardwalk elevation and the ground elevation below, the guiderail must be at least 42 inches high.
- If emergency and maintenance vehicle access is expected, bridges and boardwalks will need to be able to structurally support the weight of such vehicles as well as accommodate their width. The replacement of wood decking material with asphalt or concrete may be warranted in such cases.

3.4.1 Trail Structures: Bridges and Boardwalks

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

New precast concrete bridge that carries a trail over an intermittent stream, with decorative abutments.

2 GOOD

Elevated boardwalk constructed on a challenging embankment, in good used condition.

3 ACCEPTABLE

Old railroad bridge with a slightly sagging edge of the trail tread and concrete abutments with isolated areas of spalling.

4 POOR

This concrete bridge pier shows evidence of the alkali-aggregate reaction (swelling of the Portland cement paste), which can lead to spalling, a loss of strength, and ultimately reduce the service life of the concrete.

5 ISSUE NEEDS FURTHER EVALUATION

Major spalling and scouring are present on the side of this small concrete bridge. The presence of these significant distresses on the supportive elements of the structure is the cause for this rating.

3.4.1 Trail Structures: Bridges and Boardwalks

ILLUSTRATED ISSUES OF COMMON PROBLEMS

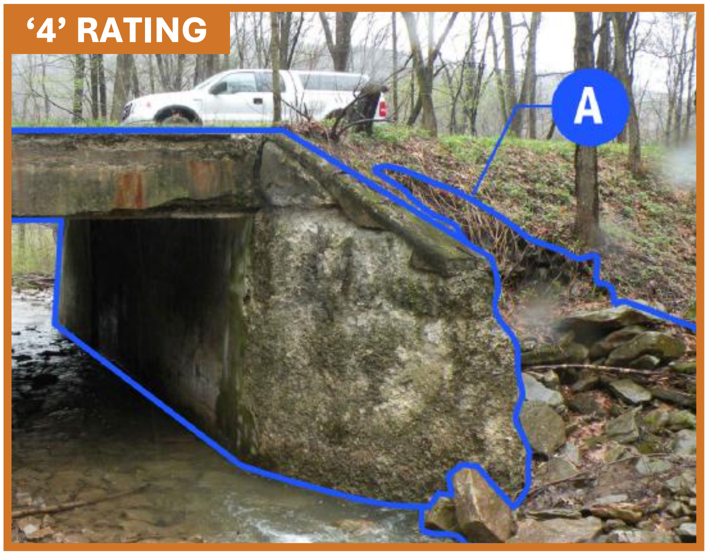
'2' RATING

A Narrow wood plank boardwalk (planks are not completely flush with one another) with wood railings. The view around this sharp corner on the narrow path is obscured by the support columns of the highway overpass. Caution signage is needed to alert trail users of the blind spot and potential trail user traffic conflicts.

'3' RATING

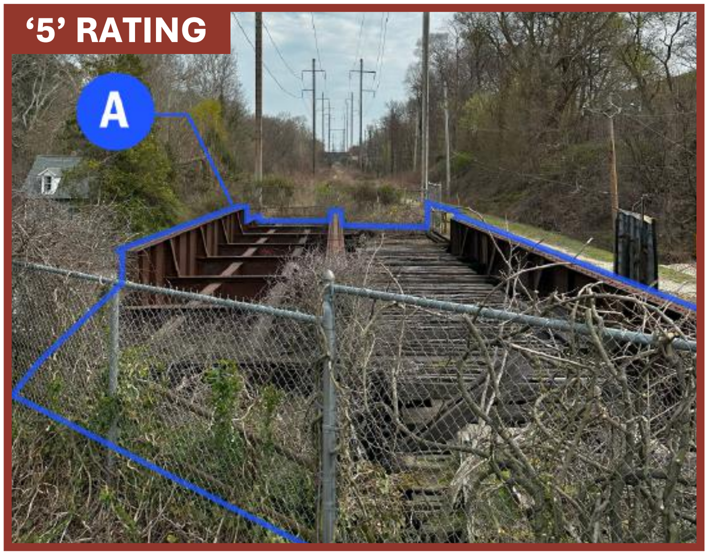
A Bridge structure is old but still in good condition, with no signs of major weaknesses. However, due to its age, regular and frequent inspections should be conducted.

'4' RATING



A Bridge over creek showing signs of subsidence and structural deterioration. There is significant erosion of the bank behind the abutment.

'5' RATING



A This old railroad bridge needs a structural assessment by a qualified professional as well as new decking and railings before it can function as a trail bridge. Depending on the height of the bridge and the use of the land below it, further safety improvements may be necessary.

3.4 TRAIL STRUCTURES

3.4.2 UNDERPASSES AND TUNNELS

Top left: The Canoe Creek State Park to Lower Trail connector underpass. Blair County, PA. (Photo credit: Rails to Trails of Central PA.)

Top right: The Northwest Lancaster County River Trail's Point Rock Tunnel, in West Hempfield Township, Lancaster County, PA.

Bottom: A railroad underpass along the Lower Scioto Greenway in Columbus, OH.

🔍 WHAT ARE UNDERPASSES AND TUNNELS USED FOR?

Underpasses serving multi-use trails typically take the form of either trails crossing under existing bridges (carrying roads, railroads, or intersecting trails) or through specially constructed box culverts that resemble short tunnels. **Tunnels** serving multi-use trails are most often former railroad tunnels repurposed for rail trails.

⚠️ COMMON SUSTAINABILITY PROBLEMS

Underpasses and tunnels are subject to **graffiti** (especially in urban areas) and other **vandalism**. The top maintenance priority should be to prevent these from occurring and to quickly address them if they do. Damage to underpass and tunnel walls due to **constant moisture** and water is also a concern. While moisture is an inevitable issue, keeping **debris** out of underpasses and tunnels will help preserve the integrity of these structures and maintain a satisfactory experience for those who use them.

💡 MAINTENANCE TIPS

- Underpasses and tunnels should be inspected at the regular frequency required by the laws of your jurisdiction for those accommodating vehicular traffic and railroads (typically every 2 years). Inspections should be completed by certified bridge/tunnel inspectors or professional engineers.
- Between these formal inspections by engineers, trail operators are encouraged to do visual inspections to note any potential problems.
- Underpasses and tunnels should be regularly assessed for the presence of graffiti and vandalism. Any damage should be repaired and repainted as soon as possible.
- The walls and ceiling of tunnels and box culvert underpasses should be painted white to maximize light and visibility. Keep extra white paint on hand to repaint any graffiti in underpasses and tunnels.
- In urban areas especially, underpasses that consist of box culverts, as well as all tunnels, should be lit for trail users' safety and peace of mind. If the road above the trail is wider than two lanes and light wells do not provide sufficient natural light, lights are strongly encouraged. Fixtures should be no more than 30 feet from each entrance. If more than one light is needed, they should be spaced no more than 25 feet apart.
- Lighting should also be provided if there is a low vertical clearance into or within the tunnel or underpass.
- Install vandal-resistant lighting fixtures or protective barriers that are out-of-the-reach of trail users.
- Consider using LED lighting fixtures to reduce the need and frequency of replacing bulbs.
- Consider using lighting fixtures that are triggered by sensor or that are programmed to turn on and off at the same time each day.
- Adequate sightlines to the entrance of an underpass are important for trail users' safety — particularly in the case of box culverts, which can often be dark inside — as well as for all tunnels.
- Trail surfaces within underpasses and tunnels should be kept free of debris. Sweeping may be needed, especially during the winter (if open) and early spring, when road debris may be thrown onto the path.
- If a box culvert is used as an underpass or tunnel, it will need to be cleaned out if a storm event fills it with debris. This debris could be slippery and hard to see if the underpass or tunnel is dark inside.

3.4.2 Trail Structures: Underpasses and Tunnels

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

New debris-catching metal structure under a railroad bridge ensures the safety of trail users passing underneath by intercepting any loose material that may fall off a passing train.

2 GOOD

Wide concrete trail underpass along the Susquehanna River in Harrisburg, PA. Trail users need to exercise caution as visibility is limited by the sharp turn in the trail around the highway abutment.

3 ACCEPTABLE

Concrete trail pavement with slightly raised joints and weathered concrete retaining walls, leading to an underground road crossing. The trail is well-maintained, but the tunnel may appear dark and uninviting.

4 POOR

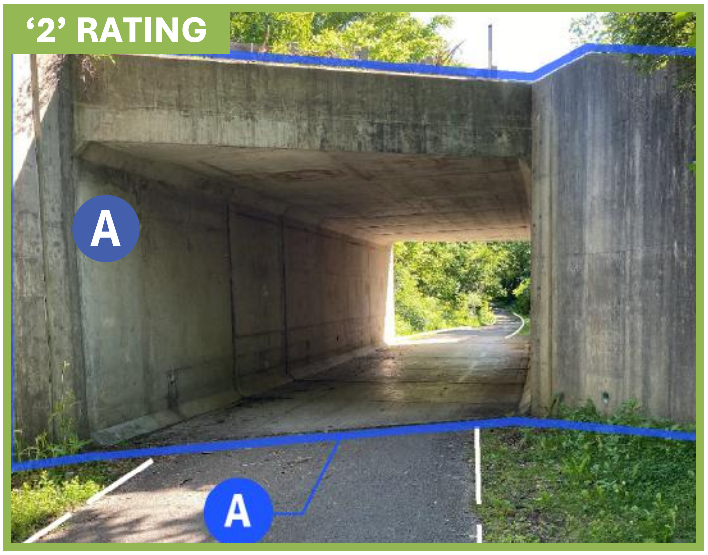
The underside of this bridge structure has significant rust and chunks of rusty metal are beginning to fall onto the trail surface.

5 ISSUE NEEDS FURTHER EVALUATION

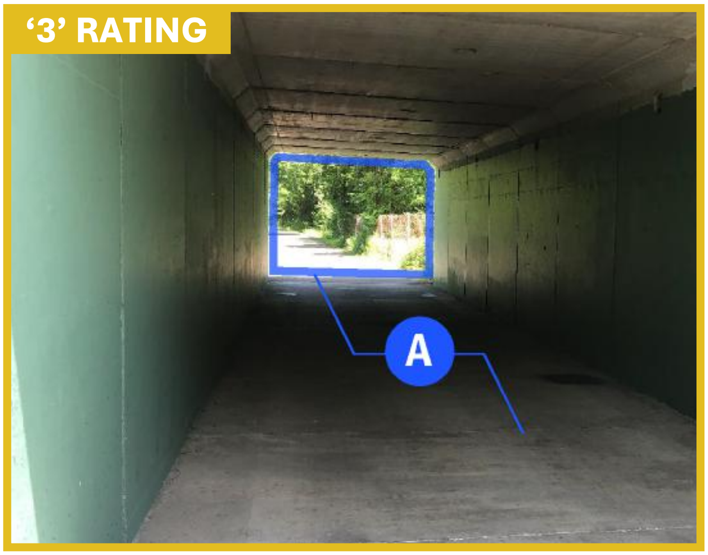
This active railroad bridge has many large gaps in its structure which would easily allow large pieces of loose material from trains to fall through onto the trail below.

3.4.2 Trail Structures: Underpasses and Tunnels

ILLUSTRATED ISSUES OF COMMON PROBLEMS

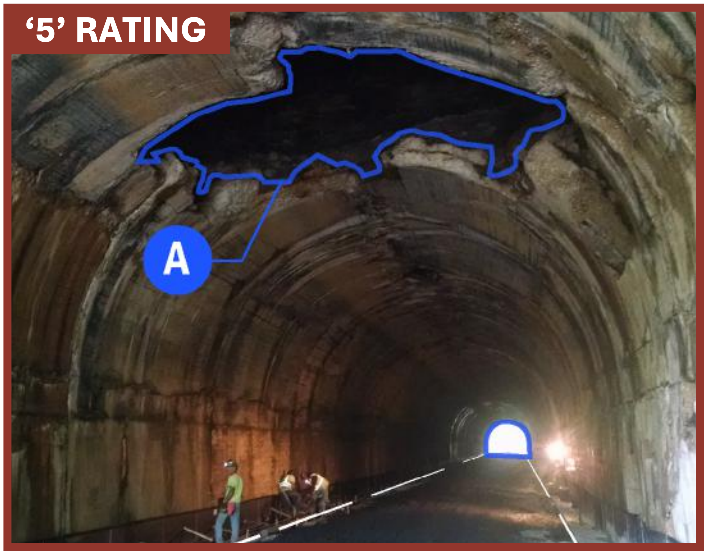


A This concrete tunnel-style underpass with concrete floor is a good example of a short, simple trail underpass.



A This concrete tunnel-style underpass with concrete floor gets fairly dark in the center and should have some lighting to improve safety and visibility, especially at night.

A This tunnel is beginning to show signs of significant deterioration. The tunnel is also too long for trail users to traverse without lighting. Lighting improves safety and visibility. If lighting cannot be added, consider signage to prepare and alert trail users for reduced visibility.



A Trail users should not be allowed to enter until safety issues are addressed. The hole in the ceiling is likely to continue breaking apart until addressed and is the most obvious example of the structural issues throughout the tunnel.

3.4 TRAIL STRUCTURES

3.4.3 RETAINING WALLS

Top left: A cut stone block retaining wall along the Lackawanna River Heritage Trail in Scranton, PA.

Top right: A stacked stone gravity retaining wall along the Lackawanna River Heritage Trail in Taylor, PA.

Bottom: A concrete retaining wall separates the Northwest Lancaster County River Trail from an adjacent roadway in Columbia, PA.

🔍 WHAT ARE RETAINING WALLS USED FOR?

A **retaining wall** is a structure used to provide stability and strength to the uphill edge of a trail, typically comprised of stone or concrete. (Some retaining walls are also constructed of timber, though this is generally not recommended.) Retaining walls are recommended in situations involving steeper slopes:

- If the original slope that was cut to allow for the placement of a level trail surface is over 30%, a retaining wall (preferably a stone gravity retaining wall) should be constructed for uphill slope retention and integrity. A swale should also be provided at the bottom of the retaining wall.
- If the original slope that was cut to allow for the placement of a level trail surface is over 60%, retaining walls (preferably a stone gravity retaining wall) should be constructed both on the uphill and downhill sides of the trail for slope retention and integrity. A swale should also be provided at the bottom of the uphill retaining wall. If the downhill drop-off is greater than 30 feet, a safety railing should be provided at the downhill edge of the trail.

⚠️ COMMON SUSTAINABILITY PROBLEMS

Retaining walls can suffer from problems such as **poor drainage**, **foundation issues**, **erosion** of uphill soils behind and above the wall, **sagging and leaning**, **cracks**, and poor original construction methods. Too much pressure and stress on retaining walls can contribute to their failure. Pressure is often the result of too much "holding" of water behind the wall through saturated soils. Water, which is subject to gravitational forces like everything else, is always seeking lower ground (i.e., the back of the retaining wall).

💡 MAINTENANCE TIPS

- Retaining walls should be inspected at regular intervals by inspectors or professional engineers. Conduct visual inspections at least twice a year, preferably in spring and fall, to identify any signs of damage or potential issues.
- Check for cracks, bulging, missing mortar, erosion, and signs of water damage. Repair any cracks promptly with mortar, concrete patching compound, or additional stones to prevent cracks and holes from widening and causing further damage.
- Maintain the backfill behind the retaining wall to prevent water from pooling and causing erosion or damage. Use clean, coarse gravel as backfill to promote slowing and infiltration of water flow and mud, or plant/seed ground covers to help hold uphill soils in place. When properly placed, backfill helps to ensure drainage happens as it should, keeping any water pressure against the wall to a manageable amount.
- Ensure proper grading around the retaining wall to direct water away.
- "Weep holes" should be created at specific intervals along retaining walls to relieve water pressure. Consult an engineer to determine proper spacing.
- Regularly remove weeds and other vegetation that can grow on or near retaining walls, as their roots can destabilize the structures.
- Clear away any debris, such as leaves, branches, or soil, that can accumulate around the base of the wall. Consider cleaning the wall annually.
- Particularly for wood retaining walls, address any pest or fungal infestations that could damage the wall or its surrounding area.

3.4.3 Trail Structures: Retaining Walls

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

Brand new tiered gabion basket retaining wall built as part of a trail restoration project following a landslide event.

2 GOOD

Older retaining wall that is well maintained despite being covered in and adjacent to fast-growing invasive plants. The vegetation appears to be regularly cut back.

3 ACCEPTABLE

This retaining wall is made up of railroad ties. The railroad ties are deteriorating and are not keeping the gravel along the railroad tracks from migrating towards the trail. However, at this time the trail surface has not been impacted.

4 POOR

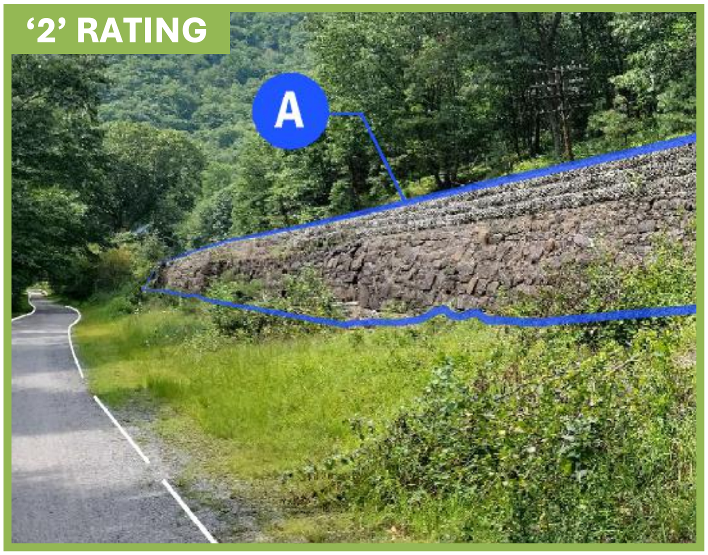
This wooden retaining wall is beginning to deteriorate. Vegetation has been allowed to start growing through the cracks.

5 ISSUE NEEDS FURTHER EVALUATION

The structural integrity of this retaining wall has been compromised by water that has been allowed to seep beneath the wall. The retaining wall is beginning to collapse.

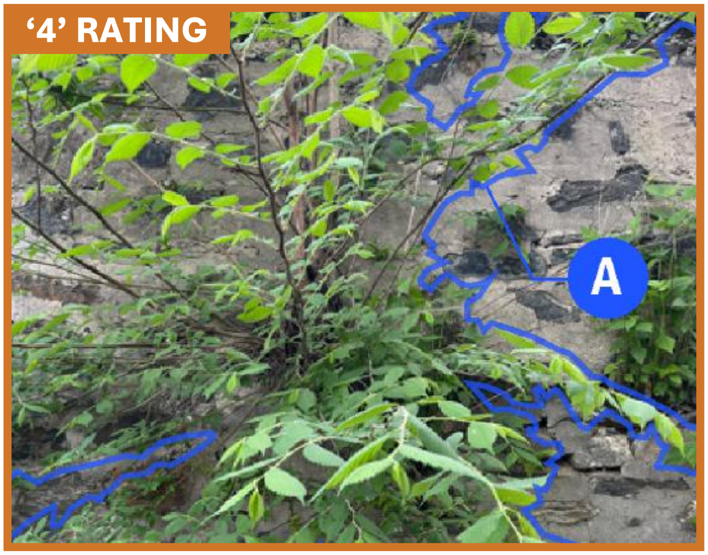
3.4.3 Trail Structures: Retaining Walls

ILLUSTRATED ISSUES OF COMMON PROBLEMS



A This retaining wall is in decent condition. Keep vegetation low in between the trail and the wall in order to easily view the wall's condition over time.

A While still mostly in good condition, this retaining wall has begun to slightly erode, dropping rocks onto or near the trail edge. Some of these rocks are large enough to cause a crash or damage to a bicycle if hit.



A A tree is growing out of this retaining wall. As the tree grows, it will compromise and eventually destroy the structure.

A This retaining wall is no longer functioning properly as it is not preventing the upslope railroad ballast from migrating downslope and onto the trail surface. Loose gravel and stone like this can pose a serious safety hazard.

3.4 TRAIL STRUCTURES

3.4.4 FENCES, RAILINGS, AND GATES

Top left: Wood railings along the Great Allegheny Passage in Dunbar Township, Fayette County, PA.

Top right: Different types of railings, including a bridge rail with integrated chain-link fencing. Great Allegheny Passage, Ohiopyle, PA.

Bottom: A swinging gate and wood fences at a trail crossing of the Palmer Bikeway in Palmer Township, Northampton County, PA.

🔍 WHAT ARE FENCES, RAILINGS, AND GATES USED FOR?

Fences, **rails**, and **gates** are used for safety and access control. They are intended to prevent trail users from accidentally falling into an unsafe location (such as a steep hillside or beyond the edge of a bridge) or accessing an unauthorized area (such as private property or a trail that has closed for the evening).

⚠️ COMMON SUSTAINABILITY PROBLEMS

Fences, railings, and gates are typically made from wood, metal, or a combination of both. Sometimes, concrete is also used for posts. Sustainability issues include those related to the materials they are made from themselves, such as **rust and corrosion**; **rot and insects**; **loose screws, bolts, and fasteners**; and **warping**. In addition, the posts and footings of fences and gates are also affected by **erosion**: Stormwater can wash away the earth around the footing, leaving a fence post that is not securely attached to the ground.

💡 MAINTENANCE TIPS

- Fences, rails, and gates should be regularly inspected while assessing the condition of your trail overall.
- Know who is responsible for maintenance fences and gates so that no parties are left guessing if they need to be repaired or replaced.
- For wood structures and rails, check for signs of damage like rust, rot, cracking, or warping. These conditions can result in soft or crumbling wood, visible cracks or splits, or posts that are loose or leaning.
- Split-rail fencing is a popular wood fence type along trails, as the rails are relatively easy to replace if needed. However, the rails can also easily become dislodged. Ensure that any damage (or missing rails) is promptly addressed, particularly if the fence is needed for trail user safety.
- Apply a protective sealant or stain to wood fences to prevent moisture damage and rot. Clean wood with a brush and mild detergent, preferably once a year. If powerwashing, maintain at least a foot of distance to avoid damage to the wood.
- Keep vegetation trimmed away from wood fences to prevent moisture buildup and potential damage. Remove any fallen leaves, branches, or other debris that could trap moisture against the fence.
- Inspect fasteners (screws, bolts, nails, and hinges) for looseness or rust. Lubricate any moving parts that are experiencing a lot of friction or otherwise not performing adequately.
- Look for issues with drainage around fence and gate posts. Control drainage around the posts to prevent erosion as well as the effects of pooling water. In the fall, remove fallen leaves and debris to prevent moisture buildup.
- Paint or repaint metal fences to protect against rust and corrosion. Choose products specifically designed for outdoor use. Clean metal with mild soap and water.
- Inspect and repair any issues with gates and latches, including loose screws, broken hinges, or malfunctioning latches.
- Chain-link fences are prone to the growth of vines, which can be extremely hard to remove once mature. Monitor any plant growth near their bases and control any viny vegetation early in their growth cycle.

3.4.4 Trail Structures: Fences, Rails, and Gates

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

Relatively new split-rail wood fencing clearly delineates the trail and keeps users from accessing the steep slopes along the trail edges.

2 GOOD

Composite split-rail fencing with concrete posts clearly delineates trail edges and keeps users from accessing the wooded area beyond the trail corridor.

3 ACCEPTABLE

Aging fence with exposed footings. This fence is being used to define the boundary of a parking area and is not being used for restricting access for saftey reasons.

4 POOR

Unchecked vegetation growth can become entwined with chain link fences and will make maintenance more difficult. Over time, vegetation such as woody vines can even damage or warp the fence, requiring eventual replacement.

5 ISSUE NEEDS FURTHER EVALUATION

The broken top rail on this wooden barrier fencing has created multiple instances of jagged wooden pieces while also providing a space in the fencing the could be percieved as an easy route over the fence.

3.4.4 Trail Structures: Fences, Rails, and Gates

ILLUSTRATED ISSUES OF COMMON PROBLEMS

'2' RATING

A This fixed metal gate is in excellent shape, but access for maintenance vehicles is restricted as the gate cannot slide or be swung open. Maintenance vehicles would have to drive around the gate, which could damage the grass or trail edges.

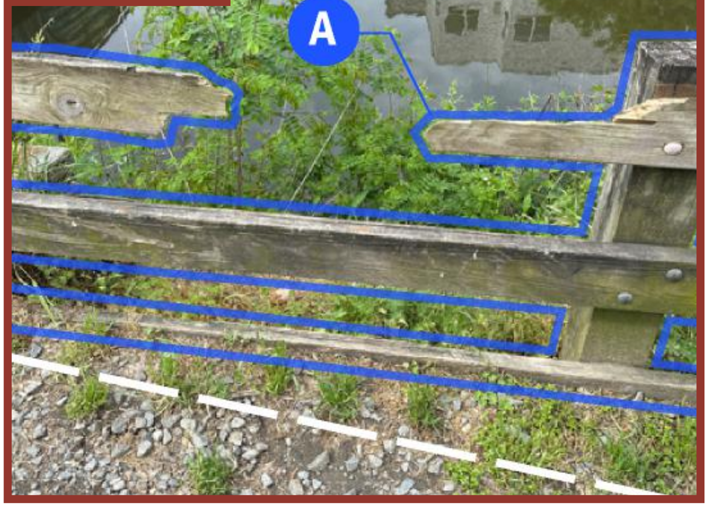
'3' RATING

A This older fence has a newer replaced section that has been connected to the rest of the fence by being nailed to a third board. This is a sign that the overall fence may need further evaluation or replacement in the near future.

'4' RATING

A The separated and warped top portion of this wood railing is bending out into the trail corridor and has the potential to snag or impale a trail user. A nail is also now sticking out of the post that the rail was previously attached to.

'5' RATING



A This section of wooden fence is broken along a particularly steep bank above a urban canal. It should be fixed to ensure trail user safety.

3.5 DRAINAGE FEATURES

Proper drainage is one of the most important requirements of a sustainable trail. Drainage affects the performance and longevity of a trail's surface, its structural integrity, and ultimately, its usability. Well-drained trails require well-maintained drainage infrastructure, including swales, pipes, and culverts. Keeping **drainage features** free of debris — whether leaves, mud, sediment, or invasive vegetation — is crucial to their continued functionality.

GENERAL DRAINAGE FEATURE MAINTENANCE GUIDELINES

- **Ensure that drainage infrastructure is properly sized**, sloped, and engineered to handle the maximum potential amount of stormwater runoff.
- **Conduct regular inspections** of drainage features to check for erosion and debris buildup.
- **Keep drainage features from accumulating debris** by implementing a routine cleaning schedule.
- **Control erosion within drainage features as well as above them**. Revegetate and regrade slopes if necessary.

Above: A swale filled with water along the Great Allegheny Passage in Dunbar Township, Fayette County, PA.

Above: Ensuring that the outlets of pipes and culverts are not blocked by debris is an ongoing maintenance challenge.

Above: The continued use of historic railroad drainage infrastructure is commonplace for rail trails.

Above: Asphalt and concrete trails, which are usually impervious, often feature stormwater inlets covered by drainage grates.

Above: A major landslide has rendered this small pipe, which was already under-capacity, inoperable.

Above: Many concrete pipes along rail trails were originally constructed for the former railroads their rights-of-way once served.

Above: The land around this old iron pipe has long shifted, and it is no longer functioning as intended. It also has a large hole in the side.

Above: A look inside a concrete pipe.

Above: The headwall and wingwalls of this culvert are made up of natural rocks and boulders.

Above: The headwall of this culvert is also made up of natural rock. (Photo credit: Trail Association of the McKean/Elk Divide [TAMED].)

3.5 DRAINAGE FEATURES

3.5.1 CULVERTS AND PIPES

Top left: A well-placed cross-trail corrugated plastic pipe used as a culvert, with a riprap spillway below it for erosion control.

Top right: An old concrete pipe and a newer corrugated plastic pipe, emptying into the same drainage swale.

Bottom: A corrugated plastic pipe with attached plastic wingwalls and spillway.

🔍 WHAT ARE CULVERTS AND PIPES USED FOR?

A **culvert** is a structure placed under a trail or road to convey stormwater or an existing stream from one side of the trail or road to the other. Culverts can be as small as a 12-inch-diameter corrugated pipe or as large as a bridge-sized precast concrete box culvert, the latter of which is just as likely to be used for conveyance of water as it is for an underpass or short tunnel for a trail, a road, or livestock.

Culverts can be thought of as a subset of the larger world of **pipes**: Culverts usually use pipes as their conveyance mechanism, but pipes are not necessarily used as culverts. Modern pipes come in three types: concrete, metal (usually steel or aluminum now), and corrugated plastic (usually high-density polyethylene, or HDPE). Historically, pipes were also made of lead or clay/terracotta.

⚠️ COMMON SUSTAINABILITY PROBLEMS

Culverts and pipes are prone to becoming **clogged** with debris (e.g., mud and fallen leaves), sediment, and vegetation growth. Metal pipes can **rust and corrode** over time, leading to cracks and holes. Concrete pipes and culverts, like other concrete structures, experience **cracks and spalling** due to excessive water pressure and the freeze/thaw cycle. **Extreme storm events** can be especially harsh on these crucial elements of drainage infrastructure and reveal that they are either undersized or underequipped to handle such events.

💡 MAINTENANCE TIPS

- Maintain a minimum of 3 feet between the edge of the trail and the openings of pipes and culverts running beneath the trail.
- Water should not lose momentum at the outlet of a pipe or culvert, if the pipe or culvert is functioning properly and well-maintained.
- Pipes and culverts that serve manmade drainage streams rather than natural waterways should be located directly beneath the trail it is crossing. The depth of the bottom of the pipe or culvert should not exceed 30 inches below the surface of the trail.
- Inspect culverts and pipes for the effects of too much water, too much sediment, or poor drainage. Culverts and pipes can easily become clogged with debris, such as mud and leaf litter. Sometimes all it takes is one storm event or a couple weeks of the fall season. Plan to regularly clear culverts and pipes, with special attention after storms or during wet seasons. If a culvert or pipe is beginning to fill with leaves or sediment, clean it out long before it fills up.
- If sediment is the cause of a clogged pipe or culvert, find the source of the sediment and, if possible, reduce the amount of sediment flowing in.
- If crushed gravel is a major component of the sediment filling a pipe or culvert, the part of the trail contributing to the washout problem should be corrected.
- If the outlet below a pipe or culvert is eroding, add riprap beneath the outlet.
- An alternative to using a culvert or pipe is to build a "French mattress," an innovation from the Pennsylvania State Conservation Commission and Penn State University's Center for Dirt and Gravel Road Studies. This type of structure is similar to a French drain or rock swale, except that it is placed underneath a trail (similar to a culvert or pipe), rather than alongside it, and is full enclosed (while still maintaining porosity).
  - Just like a French drain, a French mattress is comprised of geotextile fabric and large coarse rocks.

However, the fabric is completely wrapped around the rocks rather than simply being placed under them. Whereas a French drain is an open-faced sandwich or tostada, a French mattress is a burrito.

- Water moves into the French mattress from any direction through the geotextile fabric, which functions to prevent migration of sand, silt, and other fine sediment. The water collects in the voids provided by the rocks and moves by gravity either into the soil or into subsurface drainpipes (if provided), or exits as a gentle seep on the downhill end of the structure.
- French mattresses may be preferable to culverts and pipes in some circumstances. Penn State's Center for Dirt and Gravel Road Studies lists the following benefits:
  - Corrects trail support problems in areas where the trail base has been weakened by water saturation caused when the trail acts as a dam to natural water flow.
  - Allows for natural equalization of subsurface water on both sides of a trail.
  - Requires little, if any, maintenance compared to cross-drainage culverts.
  - Eliminates the need for additional cross pipes in some instances.
  - Allows a gentle, non-erosive water discharge rather than concentrated flows.
  - Provides an indefinite service life if not compromised by heavy flows of sediment.
  - Is useful in low-lying areas near streams or wetlands where installing cross drains would be difficult.
  - Can be used in areas where concentrated outlet flow through a pipe may be undesirable, impractical, or regulated.
  - Can be used in areas where a trail is acting as an impoundment or dam to the natural water flow by isolating subsurface water on one side of the trail from the other.
  - Can be used in areas where placement of a pipe at the depth necessary to provide structural cover would lower the natural water table of the area and require long-term maintenance.

Above left: It may be surprising to see a concrete culvert from 1914 used on a modern trail, but this structure on Pennsylvania's Northwest Lancaster County River Trail has stood the test of time.

Above right: French mattresses allow water to pass through geotextile fabric while still supporting the trail's foundation. (Photo credit: Cambria County Conservation District, Cambria County, PA.)

Top left: This headwall or endwall is completely covered by moss, obscuring the pipe opening.

Top right: Though it may not be noticeable at first glance, this headwall is leaning forward, crushing the pipe it is serving.

Bottom: A natural stone headwall protects a culvert beneath the Great Allegheny Passage in Stewart Township, Fayette County, PA.

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

Concrete box culvert properly sized to handle large storm events. The accompanying spillway ensures that water and debris will not build up around the mouth of the culvert.

2 GOOD

Corrugated plastic pipe culvert in good condition discharging water away from the bank immediately surrounding the pipe. However, there is no backfill or endwall structure noticeable to prevent erosion of bank over time. Additionally, there is no stone rip-rap at the end of the pipe discharge to slow the stormwater and minimize erosion of the slope.

3 ACCEPTABLE

Concrete culvert with no standing water, beginning to become choked by vegetation and debris.

4 POOR

This corrugated plastic pipe culvert mostly blocked by soil, sediment, and leafy debris. The culvert needs to be cleared of debris to allow for proper drainage.

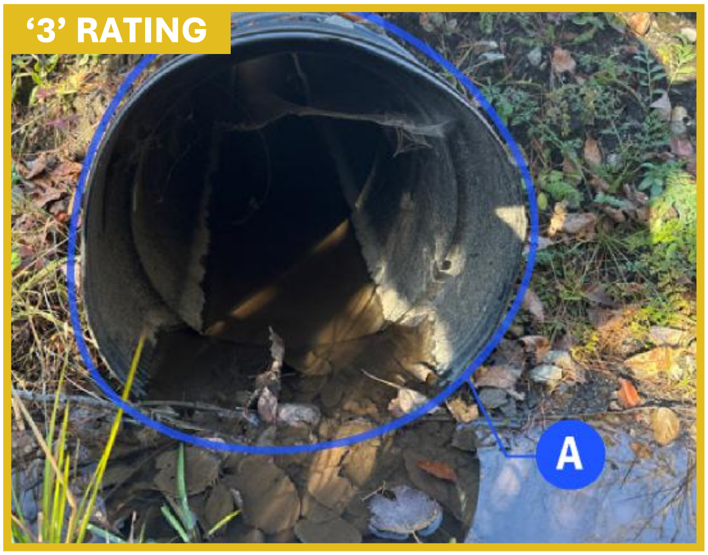
5 ISSUE NEEDS FURTHER EVALUATION

This old clay pipe has become clogged with debris and is broken to the point that it is no longer functioning properly.

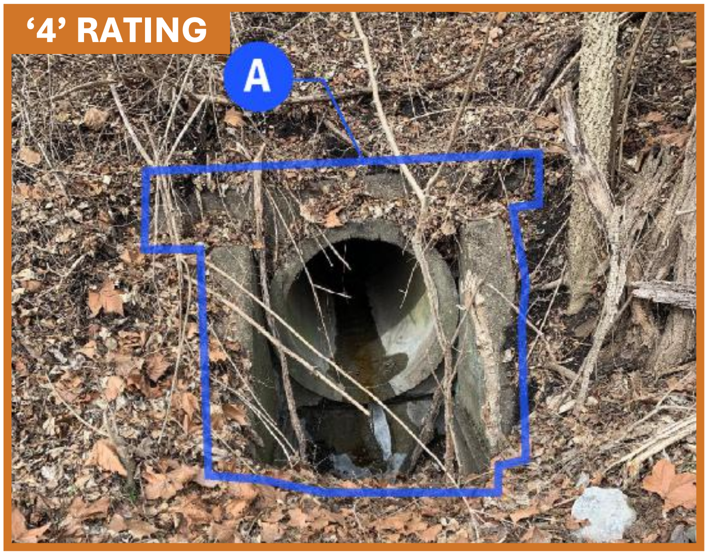
3.5.1 Drainage Features: Culverts and Pipes

ILLUSTRATED ISSUES OF COMMON PROBLEMS

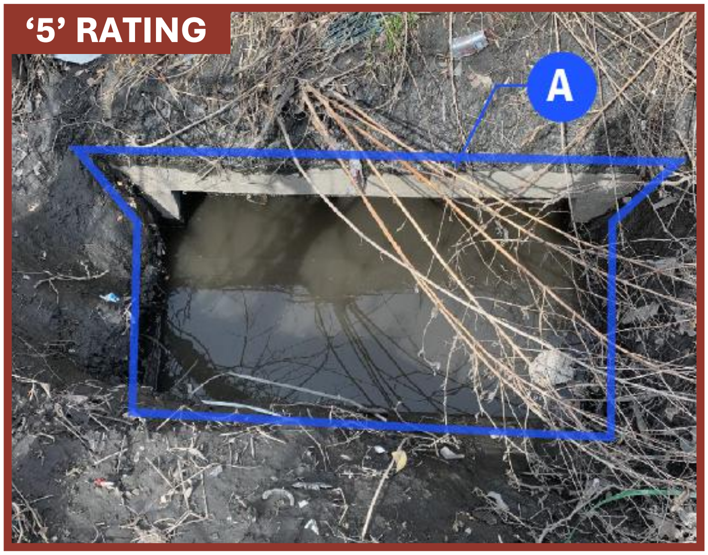
A This corrugated plastic pipe culvert has no apparent backfill or cover which increases the likelihood of the pipe getting crushed, such as if a maintenance vehicle drives over it on the trail above.



A This corrugated steel pipe culvert is not draining properly as water is ponding around the mouth of the pipe. Removing debris from the area around the mouth of the pipe may improve drainage, otherwise the adjacent drainage swale may need to be re-graded to allow for proper drainage.



A Drainage through this concrete pipe culvert is blocked by soil, sediment and debris accumulation in front of the outlet. Small trees and other debris adjacent to the culvert are also beginning to block the culvert's outlet. Work needs to be done to remove all obstructions and restore proper drainage.



A This concrete box culvert has a large volume of water ponding around the inlet. This indicates that a blockage somewhere is hindering drainage. Maintenance needs to be performed to restore proper drainage and prevent water ponding.

3.5 DRAINAGE FEATURES

3.5.2 HEADWALLS AND ENDWALLS

Top left: A trail organization volunteer inspects a concrete headwall and culvert serving Pennsylvania's Great Allegheny Passage.

Top right: A three-sided concrete headwall along the Great Allegheny Passage in Baldwin, PA.

Bottom: A culvert with a natural stone headwall beneath Pennsylvania's Great Allegheny Passage.

🔍 WHAT ARE HEADWALLS AND ENDWALLS?

A **headwall** is a small retaining wall built at the inlet of a pipe or culvert to control water flow, support the pipe or culvert, improve drainage, and protect the integrity of the area above. Headwalls are differentiated from **endwalls** by their location at the inlet, rather than the outlet, of water flow. Headwalls and endwalls should ideally consist of concrete (precast or poured) or carefully fitted native stone walls.

⚠️ COMMON SUSTAINABILITY PROBLEMS

Headwalls and endwalls are important components for protecting pipes and culvert openings. They provide physical support for the trail and land above the openings and help guard against crushed pipes.

If not adequately designed, headwalls/endwalls can become displaced, with shifting foundations, leaning, and weakening of their structural integrity. Water flow can also erode the soil beneath headwalls and endwalls, causing them to become unstable and potentially displaced. Headwalls and endwalls need to be situated at an elevation low enough to protect the trail from flooding.

Concrete headwalls and endwalls are subject to the same sustainability problems as other concrete structures. They can crack, spall, or suffer from other defects (like "honeycombing" or "bugholes") due to weathering, freeze/thaw cycles, or material degradation.

Stone/masonry headwalls and endwalls, which are typically not held together by mortar or other adhesive compounds, can fall apart from the effects of weather events and earth disturbances.

💡 MAINTENANCE TIPS

- Inspect headwalls and endwalls for settling and water damage, particularly after large storm events and during the spring snowmelt.
- Check for cracks, bulging, missing mortar, erosion, and signs of water damage. Repair any cracks promptly with mortar, concrete patching compound, or additional stones to prevent cracks and holes from widening and causing further damage.
- To prevent scour (erosion of the soil surrounding the foundation of the headwall or endwall), either install a concrete apron at the mouth of the culvert or a large stone that shields water from the dirt beneath the headwall/endwall structure.
- For higher water flows, extend the length of stone riprap from the endwall at least three times the width of the culvert. This is especially the case if there is no concrete apron.
- Regularly clear debris, sediment, and plant growth near the opening of the pipe or culvert served by the headwall or endwall. Trees, weeds, and other vegetation that can grow on or near headwalls and endwalls can also weaken them, as their roots can destabilize the structures.
- Use wingwalls on both sides of your headwall or endwall to protect the stormwater outfall from eroding the earth and soil around the mouth of the pipe or culvert. Wingwalls also improve drainage effienciency by controlling the location of water flows, steering flow to the pipe inlet in the case of headwalls.
- Headwalls and endwalls are a type of retaining wall. Follow the maintenance tips in Part 3.4.3 for retaining walls, as they are also applicable.

3.5.2 Drainage Features: Headwalls and Endwalls

📊 EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

Newer endwall with drain pipes flowing.

2 GOOD

Endwall is still functioning well but is showing signs of age and subsidence.

3 ACCEPTABLE

Headwall showing signs of age and deterioration, but still functioning well. Large chunks of concrete are beginning to fall into the stream.

4 POOR

Concrete pipe culvert with wood wingwalls. Due to the proximity of water running through the drainage channel, these areas are inherently damp. Wingwalls made of wood rot and deteriorate quickly in these conditions.

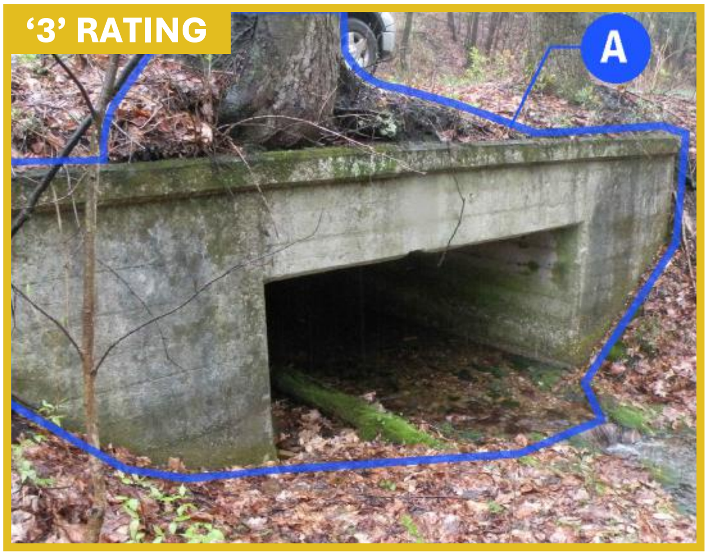
5 ISSUE NEEDS FURTHER EVALUATION

A headwall made of concrete blocks that have fallen off and are now a barrier to water flow.

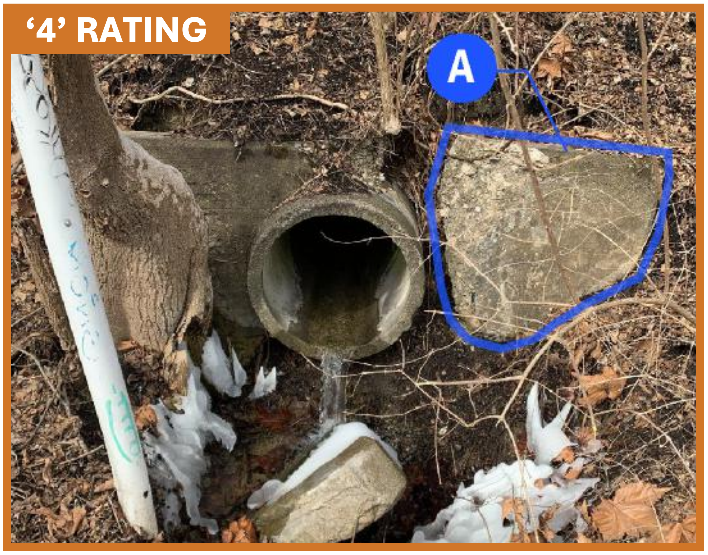
3.5.2 Drainage Features: Headwalls and Endwalls

ILLUSTRATED ISSUES OF COMMON PROBLEMS

A This old stone endwall is still functioning well and has been well maintained throughout the years. The channel is clear and water is flowing unimpeded by vegetation and debris.



A This concrete endwall is functioning properly, however, the tree growing on top of it along the trail edge may eventually compromise the structure.



A Part of the end wall of this concrete pipe culvert has broken off. The hillside is not being properly retained and may erode downslope. The broken piece may also eventually fall in-front of the outlet, blocking water from properly draining.

A There is no endwall present to protect the drainage pipe or the trail edge from erosion and heavy loads. The hillside or bank around the drainage pipe is showing signs of significant erosion.

3.5.3 INLETS AND MANHOLES

Top left: A circular iron grate with fallen leaves swept away to encourage water to properly flow into the inlet.

Top right: A rectangular iron grate with small openings designed to prevent larger debris from entering the inlet.

Bottom: A manhole for electric utilities in the exposed aggregate concrete pavement of the Great Allegheny Passage in Pittsburgh, PA.

🔍 WHAT ARE INLETS AND MANHOLES USED FOR?

An **inlet**, also known as a storm drain, catch basin, or curb inlet, is a structure that collects water from paved surfaces and directs it into underground pipes. A **manhole** is a covered opening in the ground that provides access to these underground water and sewer pipes, allowing workers to inspect, maintain, and repair them. Both types of drainage features are commonly found on urban hard-surface trails and other locations where public utilities exist.

⚠️ COMMON SUSTAINABILITY PROBLEMS

Like other parts of the trail surface, manhole covers and stormwater grates may suffer from the effects of **thermal expansion**, **freeze-thaw cycles**, and **traffic loads**.

Misalignment and cracks in manhole covers can result in unwanted infiltration, placing a burden on sewer and water systems and contributing to water pollution.

Similarly, broken grates can let in more debris than anticipated, resulting in blockages of catch basins. Leaves, twigs, stones, and mud that enter inlets compromise the ability of the drainage infrastructure to work properly. Additionally, some grates pose risks to bicyclists, whose tires may get caught in the openings, especially if the openings are parallel to trail traffic.

💡 MAINTENANCE TIPS

- Remove any debris, dirt, leaves, or other detritus that may have accumulated on or around stormwater grates and manhole covers. Sweep away loose debris with a brush or broom. If your trail is owned or maintained by a local government, a street sweeper may be available to service the trail as part of a normal street cleaning regimen.
- Use a high-pressure hose to wash away stubborn dirt and debris as needed from stormwater grates and manhole covers.
- Check for cracks, fractures, and other signs of deterioration in manhole covers and stormwater grates. Address any identified issues promptly, including misalignment, to prevent further damage and to reduce repair costs.
- Inspect metal components and surfaces for rust and corrosion, especially in areas prone to harsh or wet weather conditions.
- Apply appropriate sealants or coatings to metal grates and manhole covers to protect them from corrosion and rust. Lubricate moving parts as needed.
- Ensure manhole covers are properly seated and not misaligned, which can pose safety hazards for walkers and bicyclists.
- Strongly consider replacing any old, non-bike-friendly grates that have the potential to trip up trail users (or their tires).
- If possible, locate or relocate grates and manhole covers away from travel paths.
- When performing maintenance at inlets or manholes, set up clear warning signs at the site of work to alert pedestrians and bicyclists. Mark any potentially hazardous locations with bright spray paint.

3.5.3 Drainage Features: Inlets and Manholes

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

Brand new steel grate inlet adjacent to new trail segment showing proper installation, still under construction.

2 GOOD

Galvanized steel grate cover over catch basin, beginning to gather fallen leaves and other debris. Debris can quickly build up at catch basins during certain times of the year, increasing the risk for flooding in adjacent areas.

3 ACCEPTABLE

Old inlet within an on-road bike lane. The inlet is relatively flush with the pavement and there is not too much debris collecting here. Drainage inlets within bike lanes and on-road trails need to be maintained regularly to ensure obstacles and debris do not build up.

4 POOR

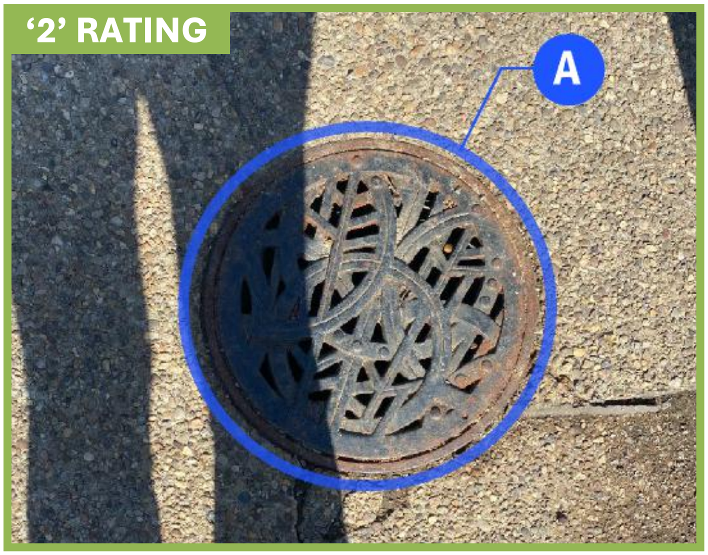
Curved steel inlet with drainage slots that are parallel to the trail direction. These kinds of inlets can be safety hazards to bicyclists because thin tires could slip into the drainage slots and the curved form of the inlet essentially acts as a pothole in the trail for an unsuspecting cyclist.

5 ISSUE NEEDS FURTHER EVALUATION

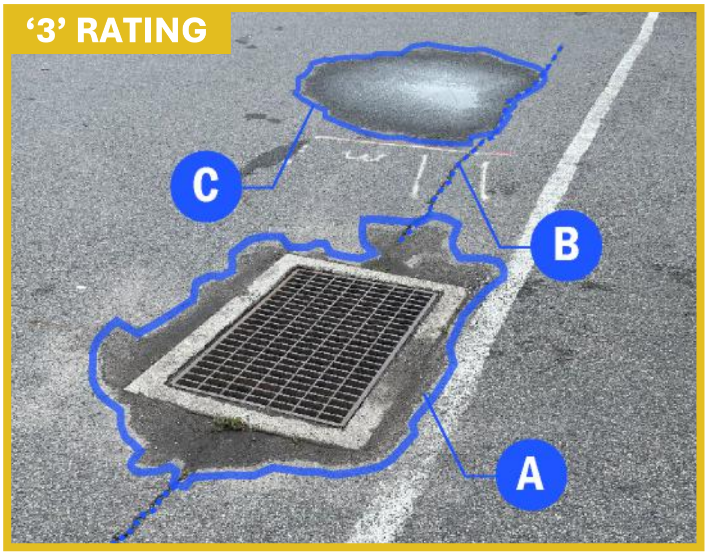
Manhole within a significantly buckled concrete trail surface. The concrete has broken apart creating gaps that could catch a bike tire and uneven surfaces that could easily trip a pedestrian.

3.5.3 Drainage Features: Inlets and Manholes

ILLUSTRATED ISSUES OF COMMON PROBLEMS



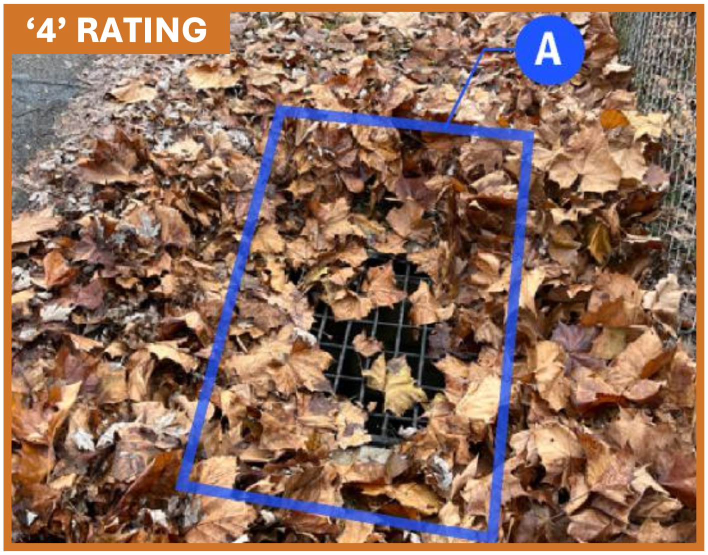
A Slightly rusted decorative inlet drain that is flush with the surrounding trail surface and free of debris.



A Inlet showing signs of chronically ponded water, evidenced by surrounding wet asphalt. The inlet elevation is higher than the surrounding asphalt.

B Longitudinal pavement cracking will continue expanding due to infiltration from water ponding around the inlet.

C Ponding water in another area in this parking lot indicates a lack of slope towards the inlet.



A This inlet is completely covered and clogged with recently fallen leaves and other debris. Needs prompt and regular maintenance to remove debris to prevent flooding or water backing up across the trail during future rain events.

A A sinkhole or significant depression formed on the edge of this inlet by a busy section of urban trail. The plywood board used to cover the hole has also deteriorated. While this is definitely a safety issue that needs to be addressed, this sinkhole is also likely to begin to affect the structural integrity of the inlet itself. It is also possible that this problem is related to the original installation of the inlet or its base material.

3.5 DRAINAGE FEATURES

3.5.4 SWALES

Top left: A swale hugging a cliffslide along the Great Allegheny Passage in Perry Township, Fayette County, PA.

Top right: A rock-lined swale just off the Knox & Kane Rail Trail in Kane, PA.

Bottom: A shallow swale alongside the Tredway Riverfront Trail in Allegheny Township, Westmoreland County, PA.

🔍 WHAT ARE SWALES?

A **swale** is a ditch or depression situated along the side of a trail whose bottom elevation is lower or below the elevation of the trail surface itself. A swale facilitates drainage of rainwater runoff and snow melt. Swales both infiltrate and divert water as opposed to letting it pool on the surface of the trail or to flow uncontrolled downhill. They are needed to intercept stormwater if a moderate to large amount of that stormwater is likely to wash down to the trail from uphill. They should also be used where runoff from above is likely to deposit silt and debris on the trail surface.

Swales should never deposit water across the surface of the trail. The slope into the swale should be maintained at between 2-5%. All edges of a swale should be rounded, with no sharp angles. Swales are strongly recommended in the following scenarios:

- A swale should be present along the uphill side of a trail if the trail is banked toward that side to properly engineer a curve (known as superelevation).
- A swale should also be present along the uphill side of a trail if the trail is at the bottom of a steep slope, in order to catch runoff from that slope.
- Swales should be present along both sides of the trail if the trail runs at the base of two uphill slopes, such as between two cliffs.

⚠️ COMMON SUSTAINABILITY PROBLEMS

Common sustainability problems with swales include **erosion**, **sediment buildup**, **clogging**, **poor grading** leading to **water pooling**, and inadequate drainage infrastructure serving the swale (such as pipes and culverts). Pooled water that remains in a swale for a long time suggests poor drainage performance.

💡 MAINTENANCE TIPS

- Inspect swales for the effects of too much water, too much sediment, or poor drainage. If a swale is beginning to fill with leaves or sediment, clean it out long before it fills up.
- Remove sediment and debris from in and around swales.
- Perform routine vegetation maintenance in and around swales. Remove weeds and plants that do not belong. Mow grass no shorter than 3 to 6 inches.
- Check for obstructions or blockage of flow, including trash, debris, or sediment, near pipes and culverts.
- If the bottom of a swale shows erosion occurring, an intermediate culvert or other means of draining the swale at more intervals should be installed.
- If sediment is the cause of a swale that is no longer properly channeling water, find the source of the sediment and, if possible, reduce the amount of sediment flowing in.
- If crushed gravel is a major component of the sediment filling a swale, the part of the trail contributing to the washout problem should be corrected.
- If the sides and bottom of the swale are losing vegetation due to erosion, reseed the swale with native grasses or erosion-resistant plantings. Consider lining the swale with rip-rap (river rocks) and geotextile fabric if erosion is a consistent problem.
- The slopes of the sides of swales is important to their functionality. Slopes should be gradual, not steep. Incorrect grading can accelerate erosion.

3.5.4 Drainage Features: Swales

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

Newly maintained swale along the side of a trail. Vegetation has been cut back, and the channel has been cleared of debris and regraded.

2 GOOD

Well maintained, shallow grassy swale next to asphalt trail. This swale is likely a little too shallow to be effective in heavy rainfall events.

3 ACCEPTABLE

Shallow swale covered in leafy debris. Water is unlikely to drain off the trail and into the swale until leaves are removed from the trail surface and the swale is cleared of debris.

4 POOR

Standing water within the swale indicates a lack of slope for proper drainage. The edges of the swale are also showing signs of erosion.

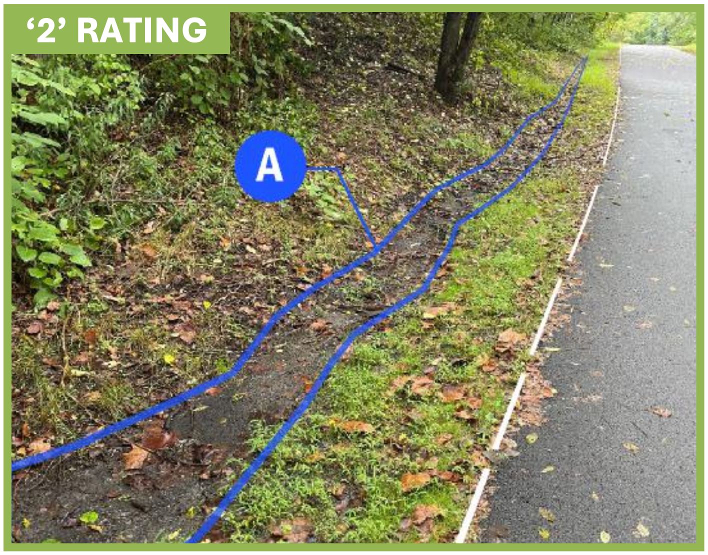
5 ISSUE NEEDS FURTHER EVALUATION

This swale is overgrown with woody vegetation and the edges are no longer clearly defined. Vegetation growth within the swale will inhibit the flow of water and reduce the effectiveness of the swale. Eventually, standing water will begin to collect and the swale will no longer properly function.

3.5.4 Drainage Features: Swales

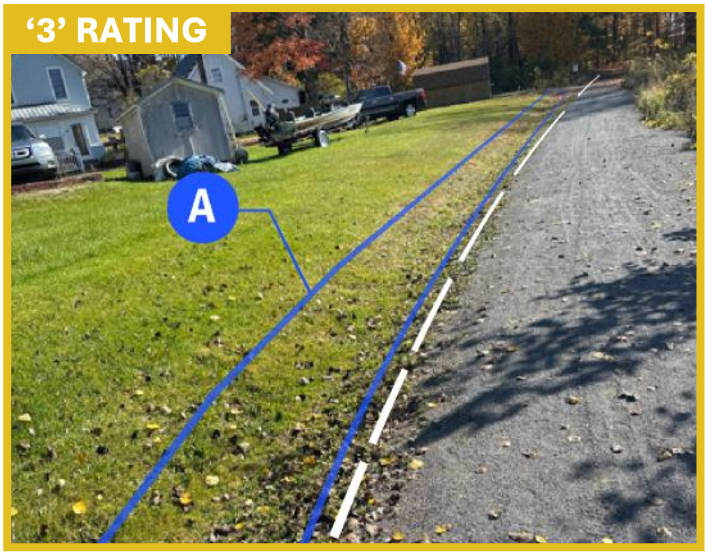
ILLUSTRATED ISSUES OF COMMON PROBLEMS

'2' RATING



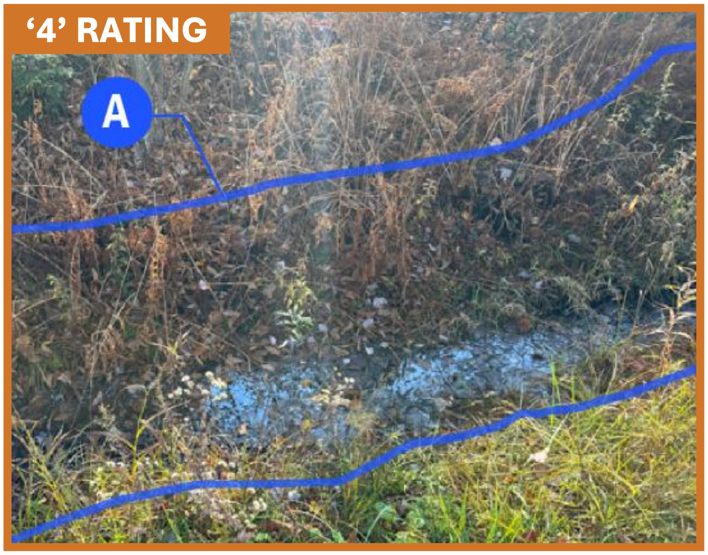
A This swale is clear of debris with evidence of recent maintenance. It has a proper slope for drainage evidenced by flowing water. However, the swale itself is very shallow and runoff has the potential to spill back into the trail corridor during heavy rainfall events.

'3' RATING



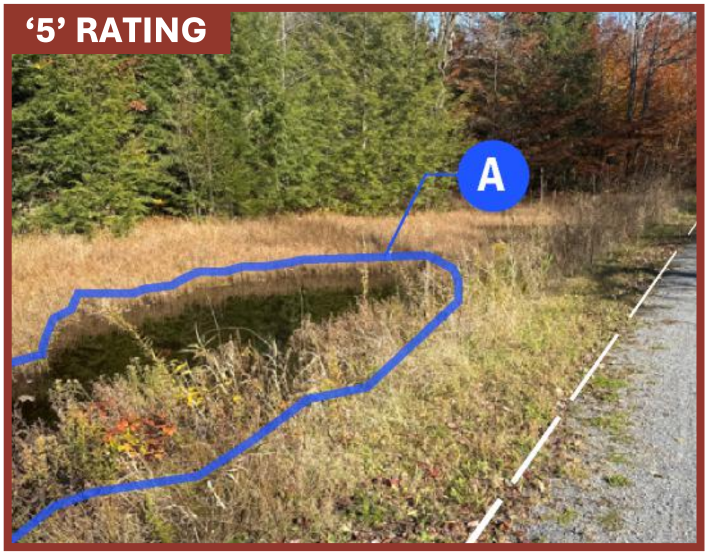
A This shallow grassy swale is right at the edge of the crushed gravel trail. Runoff has the potential to spill back into the trail corridor during heavy rainfall events which can erode and damage the trail.

'4' RATING



A This swale is becoming overgrown with vegetation and water appears to no longer be draining properly. The steep slope adjacent to the swale could be contributing to this by eroding into the swale and blocking proper drainage.

'5' RATING



A This swale was not maintained and has become a trail-adjacent wetland, indicating that a lack of sufficient slope within the swale at some point prevented water from properly draining towards drainage infrastructure further along the swale.

3.6 TRAIL AMENITIES

Top left: An amenity station for the Hoodlebug Trail in Indiana, PA, with sheltered bike racks, bench, bike repair hub, and trash can.

Top right: Multiple trailside amenities are present in this photo including a trash can, a portable restroom, a bench, and a bike rack.

Bottom: These bike racks, lighting fixtures, and waste/recycling receptacles are located along the Scioto Greenway in Columbus, OH.

🔍 WHAT ARE TRAIL AMENITIES?

Trail amenities are objects or structures that provide convenience and enjoyment to trail users but are not necessary for the physical safety and integrity of a trail. Examples include bike racks, bike repair stations, benches, pavilions, picnic tables, drinking fountains, restrooms, trash cans, pet waste stations, visitors' centers, and pieces of public art, just to name a few.

⚠️ COMMON SUSTAINABILITY PROBLEMS

Trail amenities are comprised of many different types of materials, including metal, wood, plastic, concrete, and composites. The maintenance of amenities is often specialized, as amenities are commonly purchased from third-party vendors. **Lack of maintenance funding** and **not enough staff or volunteer capacity** are significant factors to deferred maintenace of trail amenities, as they are not necessarily toward the top of an already long backlog of maintenance tasks.

Vandalism and graffiti are seemingly ubiquitous problems for trail amenities, especially in settings with a higher concentration of people using the trail. General **overuse**, **wear and tear, rust and corrosion**, **rot and insects**, **fading**, and **surface damage** are also common sustainability problems.

💡 MAINTENANCE TIPS

- Inspect and make note of the conditions of trail amenities and the foundation pads that often support them. Do this every time you're on the trail for some other reason such as to clear debris or open gates.
- **Concentrate amenities** such as waste receptacles and restrooms at trailheads. This reduces maintenance and inspection times as well as the need to drive service vehicles on your trail surface to reach remote locations on your trail.
- The visual condition and performance of trail amenities is more important than having the amenities themselves. It is better not to provide portable restrooms, waste receptacles, pet waste stations, bike repair stations, drinking fountains, and other similar amenities at all, if they are not able to be properly maintained, emptied, or cleaned routinely, or fixed when needed.
- If bulbs for lighting fixtures are broken or burn out, replace them promptly. Trail users may be dependent on the lighting for safety or visibility, particularly in urban areas where many commuters use trails.
- Bollards are often one of the first objects that trail users see as they begin their journey on your trail. They are also important to preventing unauthorized access of your trail by motor vehicles. Make sure that they are in good condition, free of rust, and standing upright.
- Ensure that waste receptacles are frequently emptied, preferably every couple of days to every week, especially during the busy season.
- Complete repairs or replacements of vandalized amenities as soon as possible. Addressing the vandalism quickly will show would-be vandals that their actions are not tolerated.
- Volunteers are often held up as a way to solve the maintenance backlog for trail amenities, but they need to be appropriately trained and/or qualified to complete repairs and reconditioning of amenities, which often require special tools and knowledge.
- Ensure that trail amenities are located sufficiently off the trail travel path to avoid user conflicts and to maintain standards for accessibility.

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

Pavilion at a trailhead in good condition. The pavilion has a built-in bench, a new roof, and provides shelter for a picnic table.

2 GOOD

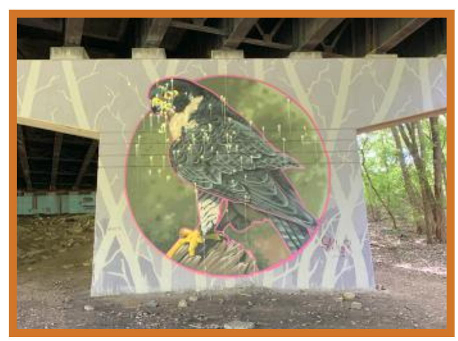
Metal bike racks in good condition, but showing some surface weathering and staining.

3 ACCEPTABLE

Aging, small lean-to structure with deteriorating roof covered in moss. At this time, the roof does not appear to be leaking but the moss will continue to retain water from rainfall and further contribute to future deterioration.

4 POOR

This beautiful mural has unfortunately been vandalized by someone with a paintball gun. Its location beneath a highway overpass away from the public eye makes vandalism more likely.



5 ISSUE NEEDS FURTHER EVALUATION

Waste receptacle not easily identifiable because it is small, has a unique shape, and is painted to blend into the background. Trash regularly overflows onto the adjacent trail.

3.6 Trail Amenities

ILLUSTRATED ISSUES OF COMMON PROBLEMS

A Though it isn't brand new, this is a good example of a clean and aesthetically pleasing permanent restroom with a clear ADA accessible entrance and adjacent landscaping.

A These older trash and recycling receptacles are functioning well. However, staining on the base and lids is unsightly, and is beginning to obscure the labeling. A good power washing should remove the staining.

A This picnic table is weathered and rotting due to its location in a shady, forested area. The table and bench boards will need to be replaced in the near future.

A This drinking fountain does not work and is a magnet for graffiti. In addition, it is rusting and may soon present a safety hazard as it deteriorates further. This fountain should be replaced with a modern bottle filling station, if it is to be replaced at all.

Top: Along with natural and historic points of interest, public art is one of many types of amenities that can be found alongside trails.This statue of a lumberjack on the Susquehanna River Walk & Timber Trail in Williamsport, PA speaks to the importance of forestry in north central Pennsylvania's vast Lumber Heritage Region. (Photo credit: Susquehanna Greenway Partnership. Artist: Pamela Madai Barner.)

Bottom: This sculpture at a trailhead of the Knox & Kane Rail Trail in Kane, PA was made from recycled bicycles. (Artist: Jody Aiello.)

Top: The Connellsville Gateway Arch in Connellsville, PA greets Great Allegheny Passage trail users when they enter the city. The arch features stained glass made in the town's own Youghiogheny Opalescent Glass Factory. (Artists: Steven Fiscus and Jeff Dardozzi.)

Bottom: These metal sculptures of a runner and bicyclist in Spring Garden Township, York County, PA add a touch of whimsy to the York County Heritage Rail Trail, which is lined with many pieces of public art.

3.7 TRAIL PARKING AREAS

Top left: A typical rural parking area for a minor trail access point. Bicyclists ride through the parking lot to cross the street.

Top right: An asphalt paved parking lot paralleling a trail, with improvements such as curb stops, a fence, and bike racks.

Bottom: A trailhead parking lot that also serves boaters and visitors to the Columbia Crossing River Trails Center in Columbia, PA.

🔍 WHERE AREA PARKING AREAS LOCATED FOR TRAILS?

Parking areas for trails are typically located at designated trailheads, providing trail users a place to park their vehicles off the street to access a trail.

Minor trailheads often consist of just a small gravel parking area with no pavement markings or curb stops. Permanent amenities such as restroom buildings, bike racks bolted to the ground, trash cans, and lighting are rarely present at these secondary access points.

Major trailheads, on the other hand, are usually prominently visible from abutting roads and include improvements such as paved and marked parking spaces, permanent bike racks, picnic pavilions, and aesthically pleasing amenities (e.g., benches, waste receptacles, and bike repair stations) sourced from third-party street furniture manufacturers. These trailheads often feature branded identification signage, interpretive displays, and kiosks.

⚠️ COMMON SUSTAINABILITY PROBLEMS

Trail parking areas typically consist of the same few types of surfaces used on trails themselves. The problems you may encounter are thus parallel to those of your trail — except with the added component of vehicular loads that potentially accelerate the timeline of problems. This means that cracks, potholes, rough and uneven surfaces, and other **pavement distresses** and **drainage issues** are the major sustainability problems for parking areas — just as they are with asphalt, concrete, and crushed gravel trails alike.

💡 MAINTENANCE TIPS

- The parking area at a trailhead is often a trail user's first impression of your trail. Keep it neat, tidy, and visually attractive. It should look like it is safe and well-maintained.
- A well-maintained paved parking area has clearly visible striping and smooth asphalt or concrete. Just as with hard-surface trails, fill cracks, sealcoat, apply overlays, and repave as necessary.
- Just as pavement markings should be clearly visible, the signs at your parking area should be as well. Replace any signs that are faded or have been compromised by vandalism and graffiti to the point that the message is no longer readble.
- Ensure that waste receptacles at trail parking areas are regularly emptied.
- Address areas of standing water with drainage improvements, just as you would with your trail.
- Treat the maintenance of your parking areas as an extension of the maintenance of your trail. Include relevant tasks to the upkeep of your parking area in your trail's maintenance schedule.

Above: A trail parking area for Harrisburg's Capital Area Greenbelt. (Photo credit: Susquehanna Greenway Partnership).

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

New parking lot with covered bike racks, benches, and interpretive signage. The parking spots are clearly defined and are separated from the sidewalk by a planting strip.

2 GOOD

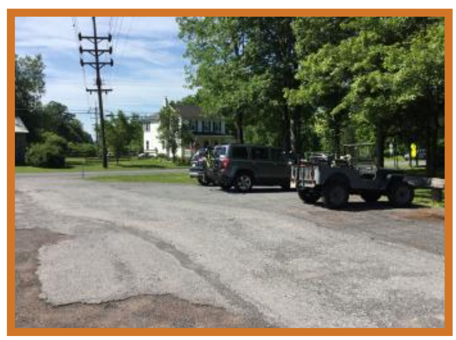
Trail-adjacent parking lot with clearly defined spaces and a kiosk with informational signage. Car bumpers may encroach into the trail corridor if cars park too close to the curb.

3 ACCEPTABLE

Well-graded gravel parking lot with little to no depressions and potholes. However, the edges of the parking lot are undefined with an irregular grassy perimeter. This encourages parking outside of the gravel area meant for that purpose and allows for vegetation to encroach into the parking area.

4 POOR

The parking spaces for this trailhead are in acceptable shape, but the peeling asphalt in the drive aisle is in dire need of replacement.



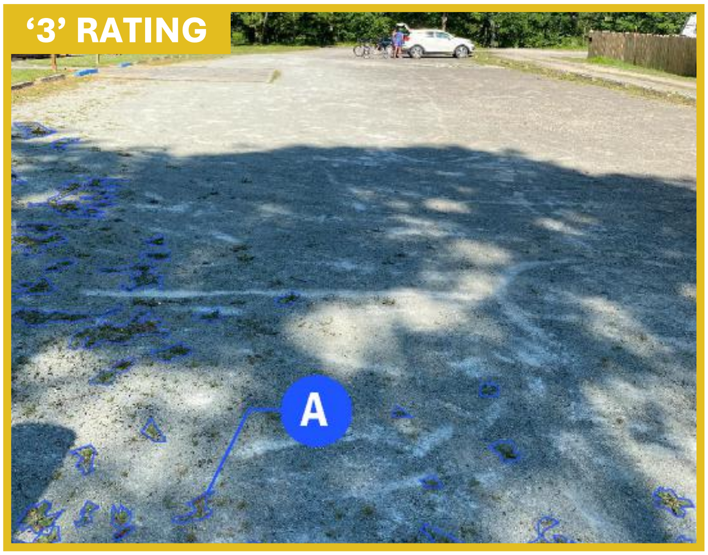
5 ISSUE NEEDS FURTHER EVALUATION

Old urban trailhead parking lot with both brick and asphalt surfacing. The parking lines have not been repainted on the asphalt overlay and traffic circulation at this trailhead is unclear.

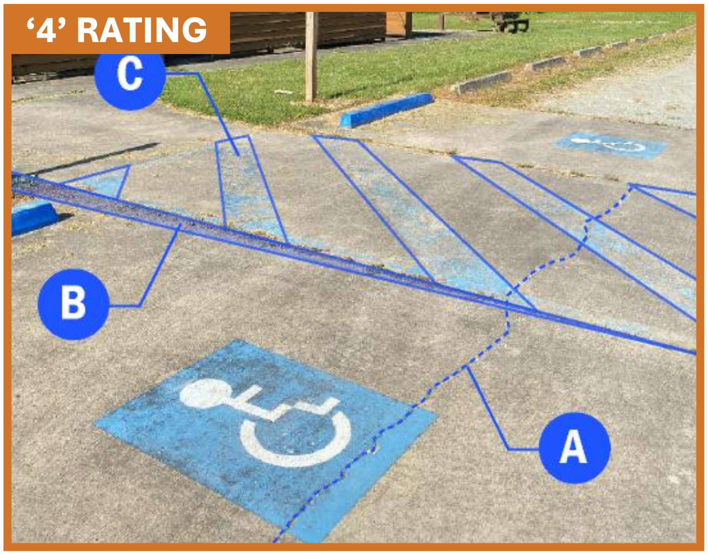
3.7 Trail Parking Areas

ILLUSTRATED ISSUES OF COMMON PROBLEMS

A With limited space for parking at this trailhead, faded or non-existing parking space lines may encourage more haphazard parking and lead to reduced parking capacity at busy times. Marked parking spaces effectively utilize space and clearly define where cars are supposed to be placed.



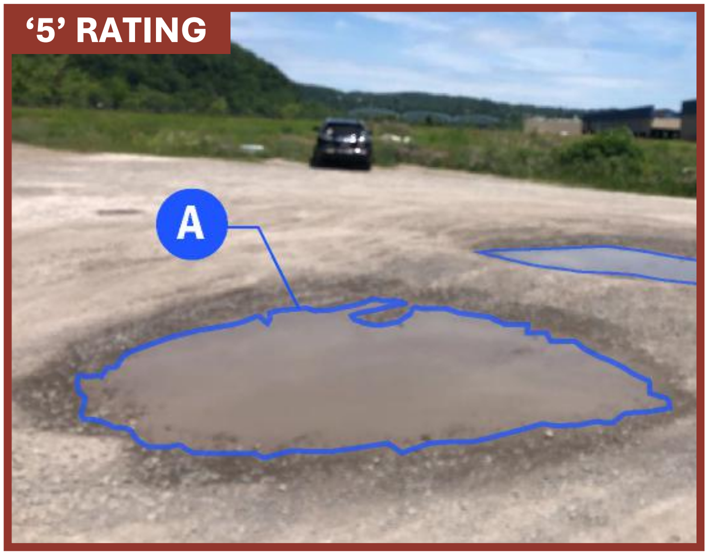
A This parking lot surface has significant vegetation growth. Vegetation growth will reduce run-off capacity and lead to pooling water and surface deterioration.



A This concrete pavement has a large transverse crack across multiple slabs.

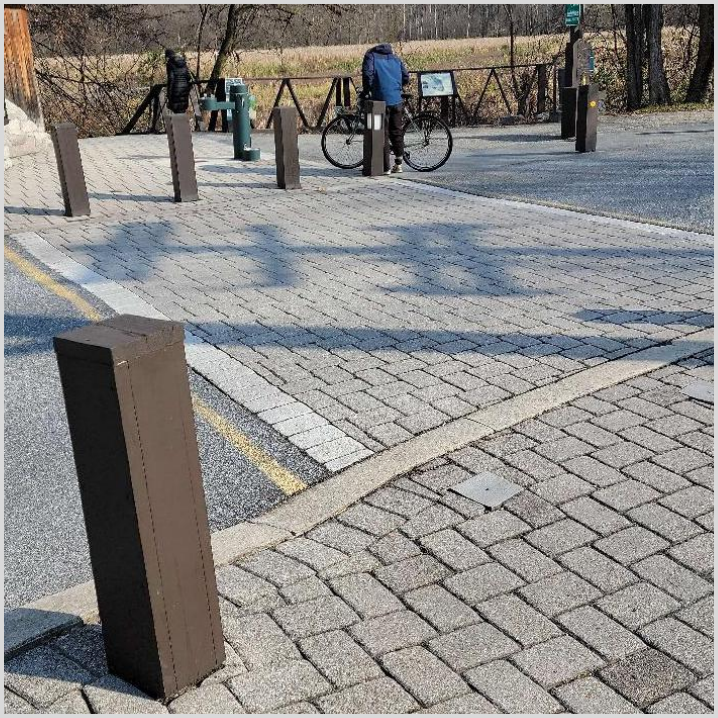
B The center slab between the two ADA parking spaces has uplifted, creating a tripping hazard and possibly limiting mobility.

C The ADA loading zone paint markings have faded significantly.



A Gravel and dirt parking area with large depressions/potholes filled with stormwater. Gravel parking lots should be graded to allow for stormwater to run off to one side and retained in a basin or dispersed along a swale.

3.8 TRAIL CROSSINGS



Top left: This trail crossing for the Capital Area Greenbelt in Harrisburg, PA includes permeable pavers.

Top right: A trail crossing on the suburban Palmer Greenway in Palmer Township, Northampton County, PA.

Bottom: A signalized crossing for the York County Heritage Rail Trail in Spring Garden Township, York County, PA.

🔍 WHAT ARE TRAIL CROSSINGS?

A **trail crossing** is the point at which a trail intersects with a roadway used by motor vehicles. Trail crossings are often located at trailheads adjacent to trail parking areas but can also be present at locations without access points for trail users arriving in vehicles.

⚠️ COMMON SUSTAINABILITY PROBLEMS

Trail crossings often stand out as locations where the conditions of asphalt and concrete pavement are especially distressed. **Pavement distresses** such as block cracks, alligator cracks, potholes, depressions, raveling, and failing patches are very common at asphalt trail crossings. At concrete trail crossings, LTD cracks, durability cracks, corner breaking, and failing patches are commonly observed.

💡 MAINTENANCE TIPS

- Build a working relationship with the government agency that owns and maintains the intersecting roadway (usually the municipal government, county government, or state department of transportation's local district).
- **Ensure that trail crossings are as highly visible as possible.** Cut back vegetation that may impede visibility of trail users to oncoming vehicular traffic or the visiblity of oncoming vehicles to trail users. A minimum **clear sight triangle** of 25 feet (from trail centerline to intersection) by 15 feet (in each direction of the intersecting road) should be maintained at trail crossings.
- Add bright safety bollards to mark your trail crossing that are highly visible to drivers and that also prevent vehicles from driving onto your trail.
- Make sure that appropriate signage is placed at your trail crossing. For instance, it is generally required for bicyclists to stop at trail crossings, so stop signs should be placed.
- Sweep or powerwash trail segments adjacent to the roadway to clear debris, mud, and loose rocks from the roadway.
- **Ensure that the trail adjacent to the crossing is well-drained.** If pooled water is an ongoing problem, consider installing swales or other drainage infrastructure to mitigate the problem.
- **Check for the same types of pavement distresses that you may have experienced on your trail.** Follow the maintenance tips from **Parts 3.3.1** (crushed gravel), **3.3.2** (asphalt), and **3.3.3** (concrete) for the applicable pavement type.

Above: A sign advising trail users of an upcoming trail crossing on the Capital Area Greenbelt in South Harrisburg, PA.

CLEAR SIGHT TRIANGLE 📖 key term	A clear sight triangle is a triangular space at trail crossings designed to ensure unobstructed visibility for drivers and trail users. Nothing should be erected, placed, or allowed to grow there in a way that limits or obstructs the sight distance of motorists and trail users alike entering the intersection.

3.8 Trail Crossings

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

Trail crossing at a wide road with pedestrian signage, visible zebra crosswalk, lighting, ADA curb ramps, and other crossing infrastructure. A protective median offers an additional safe waiting space for pedestrians.

2 GOOD

A crushed gravel access road crossing a crushed gravel trail. The larger material of the access road is beginning to mix with the trail surface. It appears as though ATVs may be driving on this trail illegally.

3 ACCEPTABLE

Crushed gravel trail crossing an asphalt backroad. There is signage present for trail users approaching the intersection, but there is no crosswalk or signage to alert passing drivers on the roadway.

4 POOR

Trail crossing of a busy two-lane road, with advisory signage but no marked crosswalk and poor visibility for both drivers and trail users (no sight triangle and abutting shaded woodland areas).

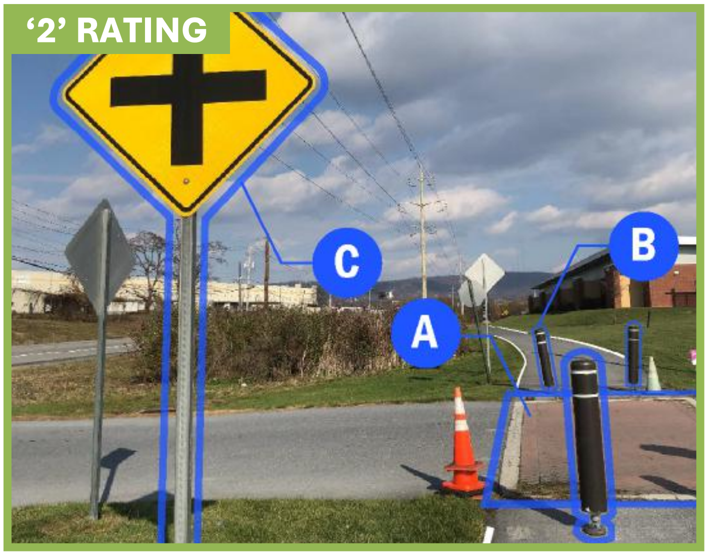
5 ISSUE NEEDS FURTHER EVALUATION

Trail crossing of an asphalt roadway in poor condition. This crossing has significant potholes and patchwork which are beginning to pose a tripping or falling hazard.

3.8 Trail Crossings

ILLUSTRATED ISSUES OF COMMON PROBLEMS

'2' RATING

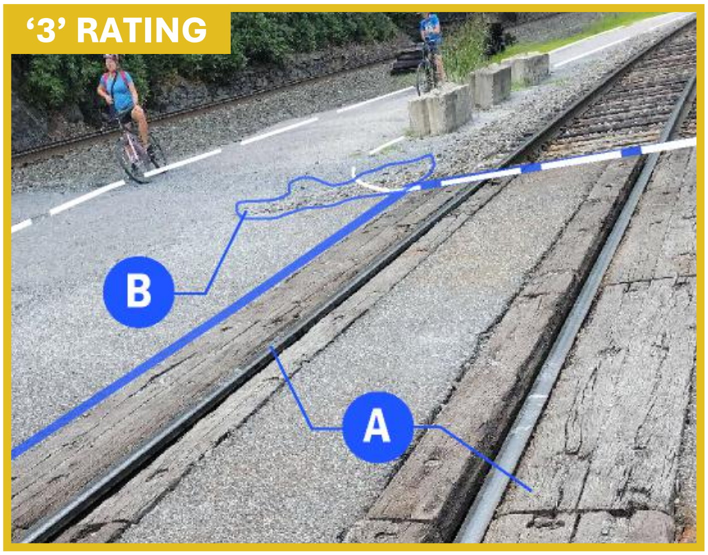


A This decorative stamped concrete trail crossing is easily visible and has aesthetic value.

B Metal bollards (one is not completely vertical) help to keep unwanted vehicular use off the trail.

C MUTCD- compliant four-way intersection advisory signage alerts trail users to the road crossing.

'3' RATING



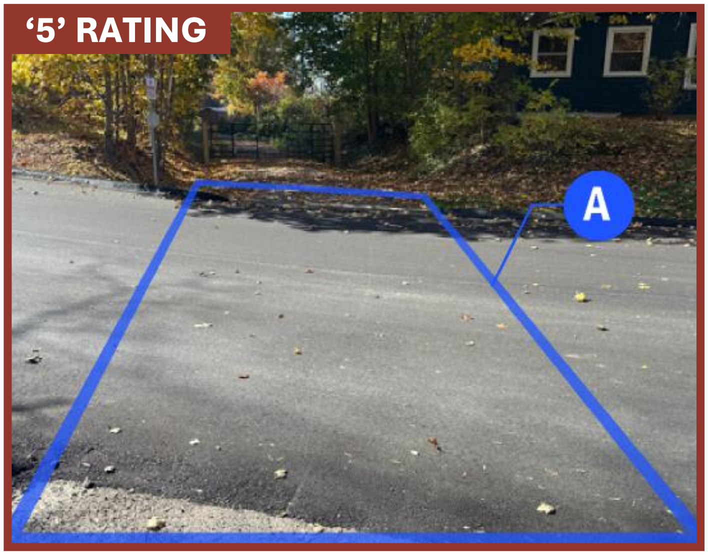
A This trail crossing of an active railroad provides no signage to alert trail users of potential conflicts.

B The railroad ballast is migrating onto the trail surface at the point where the trail curves to cross the railroad tracks and could pose a sliding or falling risk for cyclists.

'4' RATING

A This trail crossing has no crosswalk or pedestrian crossing infrastructure at a dangerous, wide intersection of two arterial roadways. This crossing is also located significantly behind where a car would stop at the intersection.

'5' RATING



A A trail crossing with no crosswalk or advisory signage for either trail users or motorized vehicles on the intersecting roadway. Drivers along this roadway may not be aware of the trail, and thus may not be prepared to stop if a trail user crossed out in front of them.

3.9 SIGNAGE

Top left: Pedestrians have the right-of-way over bicyclists on some urban trails, such as this section of the Three Rivers Heritage Trail.

Top right: Pylon signs along the Great Allegheny Passage identify the trail, provide mileage to upcoming trailheads, and list amenities.

Bottom: Interpretive signage along the Delaware & Lehigh (D&L) Trail for the eponymous D&L National & State Heritage Corridor.

🔍 WHAT IS SIGNAGE USED FOR ON TRAILS?

Signs are used for a variety of different purposes alongside trails and at trailheads. Trail signs fall into two categories: safety and information. Trail users should be informed where they are, where they are going, and how to use trails safely. Signs related to safety are most important and should be considered first. Mile markers, if not present on your trail, are especially helpful if precise locations are needed for emergencies.

⚠️ COMMON SUSTAINABILITY PROBLEMS

Signs are frequently subject to **vandalism and graffiti**. Vandalism and graffiti will often occur when the sign cannot be repaired or replaced in a timely manner due to lack of available funds, as they suggest to would-be vandals that maintenance is not a priority.

💡 MAINTENANCE TIPS

- Regularly check for signs of damage, such as cracks, peeling, rust, or loose fixtures. Address any damage to signs such as scratches, fading, or vandalism as soon as possible.
- Know who is responsible for sign maintenance (including graffiti removal) so that no parties are left guessing if signs need to be repaired or replaced.
- Prioritize the repair or replacement of signs on which the vandalism and graffiti obstruct crucial information about your trail. Signs whose information may have a large impact on trail users' navigation or safety should be the top priority. The key to graffiti control is prompt observation and removal. During scheduled trail inspections any graffiti should be noted and those whose task is to address graffiti and vandalism promptly notified.
- Regularly inspect and replace rotting sign posts, especially those made of untreated wood.
- Metal signs and fixtures are prone to rust and corrosion. If rust appears, clean it off and apply a rust-resistant primer or paint to prevent further corrosion.
- Ensure signs are securely mounted and address any loose or fallen signs.
- Ensure that signs are located in areas where they do not obstruct the movement of trail users.
- Control the vegetation near your sign to prevent the message being obscured by overgrowth.
- Strike the right balance between having the number of signs needed to provide the optimal experience for trail users and having the human and financial resources to maintain them. Having surplus signs that are not needed adds to the costs and requirements of maintenance and confuses trail users.
- Information (text, maps, etc.) provided at kiosks should be written and presented to be as "future-proof" as possible, to reduce the need to replace the signage before it physically wears out. Otherwise, ensure that there is a budget to keep the signage up to date. Out-of-date information, such as obsolete maps and amenity listings, will easily frustrate trail users.
- Clean interpretive signs at least once a season with a soft brush and mild, non-abrasive soap.
- Know where all of your signs are. Keep an inventory and note when signs were installed as well as their current condition.

3.9 Signage

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

A brand new wayfinding sign in top condition. There are no instances of graffiti or vandalism.

2 GOOD

Relatively new wayfinding signage. It has some dirt and grime on it and needs to be cleaned but is otherwise clear and legible.

3 ACCEPTABLE

Mile marker on wooden signpost showing signs of longitudinal cracking at its base. The wooden post will continue deteriorating until replaced.

4 POOR

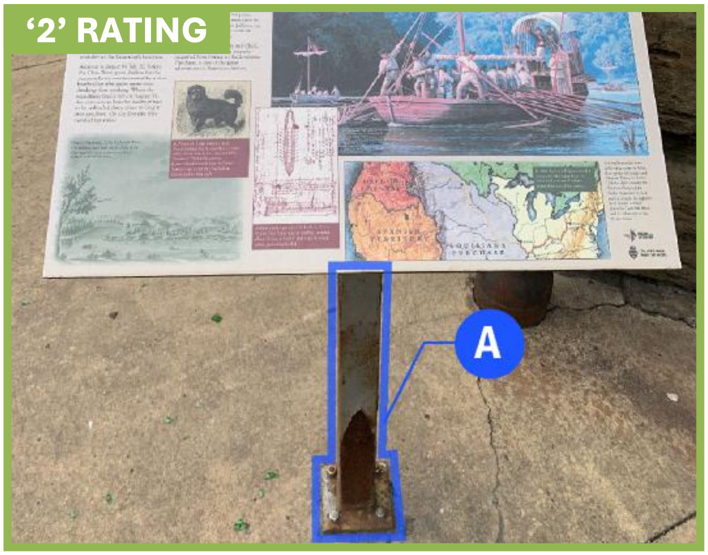
This trailhead has a disorienting number of signs including some that are redundant (and a few additional signs that were cropped out of this photo!). This information would better serve the public by being consolidated within a single display area such as a kiosk.

5 ISSUE NEEDS FURTHER EVALUATION

Barely legible sign for an old exercise station that has been removed or moved elsewhere. The sign is no longer serving any purpose and may now just be confusing to trail users.

3.9 Signage

ILLUSTRATED ISSUES OF COMMON PROBLEMS



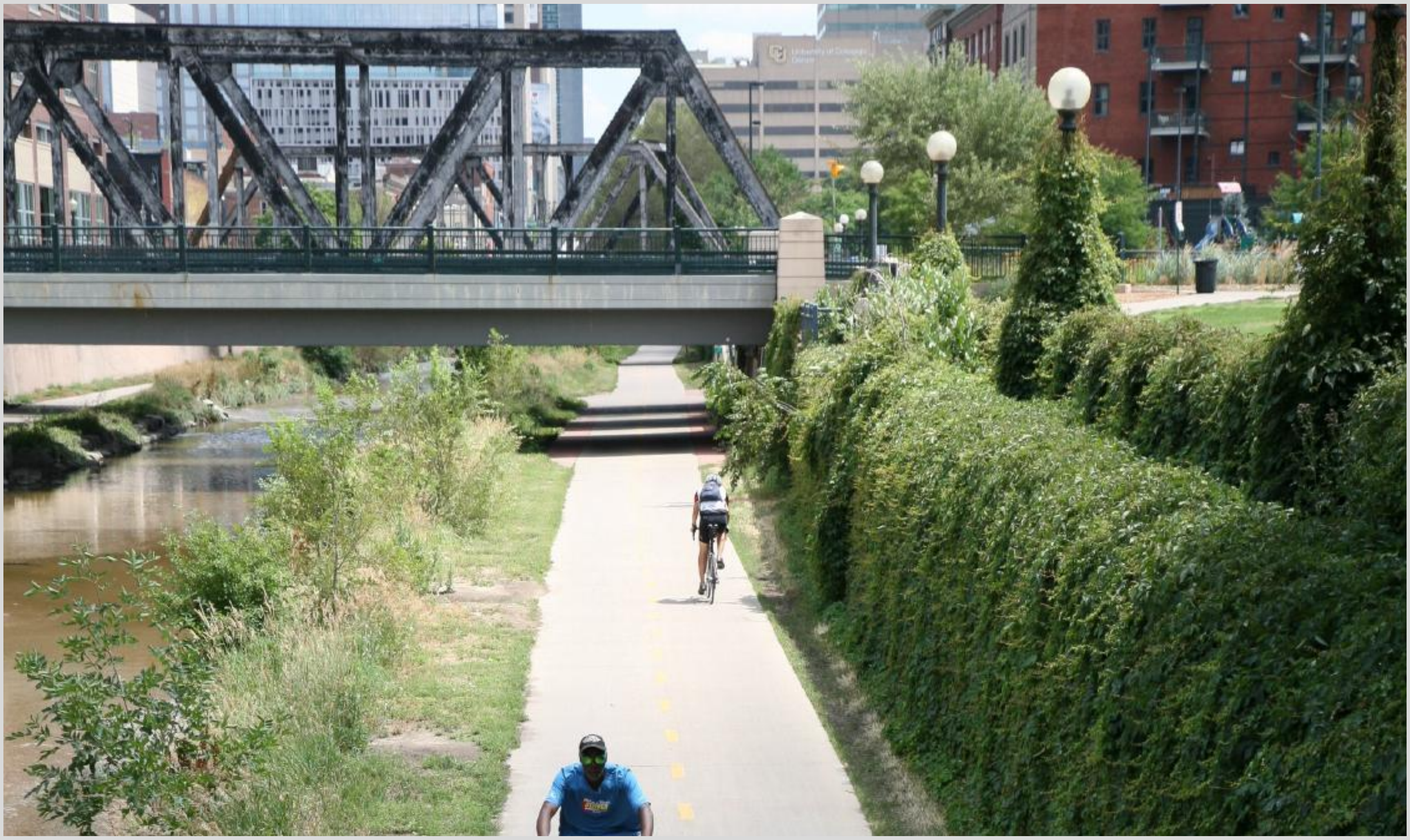
A This aging but perfectly legible interpretive sign has a bolted signpost with moderate rusting. The sign functions perfectly well as designed but could be improved aesthetically by addressing the rust.

A This wooden mile marker is in good condition, but the mileage depicted on the marker is difficult to read. Painting the engraving a different color than the wooden post should address the problem.

A This wooden bulletin board is beginning to deteriorate. There is no roof to protect the posted information from the natural elements, which is weathered and difficult to read.

A The multiple instances of graffiti on this sign completely obscures the sign's text. The sign is no longer serving its function of properly displaying information and needs to be replaced.

3.10 VEGETATION MANAGEMENT



Top left: Trees and branches commonly fall on trails after storms, forcing trail users to bike or walk off-trail until the debris is removed.

Top right: Invasive species can be aggressive along trails, which are similar to their preferred habitat of disturbed edges of woodlands.

Bottom: Some trails require formal pruning of vegetation and others use native landscaping where maintenance needs are minimized. This example, from the Cherry Creek Trail in Denver, CO, shows both native landscaping on the left and formal hedges on the right.

🔍 WHAT IS VEGETATION MANAGEMENT?

Vegetation management tasks include mowing, trimming, tree pruning, fallen tree removal, tree removal as a safety issue, and removal of invasive plant species (often through the application of herbicides). A 2014 survey of trail management organizations by the Rails to Trails Conservancy (RTC) found that vegetation management was the second most labor-intensive and costly maintenance item for trail managers.

⚠️ COMMON SUSTAINABILITY PROBLEMS

The growth and proliferation of **weedy vegetation**, especially **invasive species** without much natural competition or foraging interest from wildlife, can seem to be a never-ending problem during the growing season. **Keeping grass mowed** alongside the trail can also seem like a never-ending responsibility — as well as an outsized part of a trail's maintenance budget. Additionally, nearby **tree branches and tree roots are constantly poking their way through or above trails**, which is particularly a problem with asphalt trails. Lastly, branches, twigs, leaves, and seeds are constantly falling onto the trail surface, and their presence is especially noticeable after storm events.

💡 MAINTENANCE TIPS

- When trail sections are being constructed or reconstructed, remove organic matter such as grass, leaves, seeds, and topsoil to a sufficient depth to prevent any seeds or roots present from reestablishing themselves. Also consider placing a geofabric textile or applying herbicides below the trail surface to deter unwanted plant growth.
- Use a quality aggregate free of organic matter (clay, soil, seeds, etc.) and apply it to a sufficient depth.
- Mow the trailside at sufficient intervals to deter the spread of vegetation onto the trail.
- If frequent mowing is too expensive or time-consuming, consider adding gravel shoulders alongside the trail to either reduce or eliminate mowing needs altogether. If vegetation starts peeking out from the gravel shoulder, herbicides can be applied to keep them off the trail corridor.
- If possible, reduce the number of obstructions present in mowed areas to reduce maintenance time and effort. This includes sign posts, fence posts, and trees, just to name a few common examples.
- If your trail is in a less urban setting, organic debris such as cleared brush, fallen limbs and trees, and mowed grass can be left in the trailside area, where it will provide habitat and eventually decompose. This will reduce the time and expense of removing this material. If you normally chip this material, handle the chippings in the same manner. Or, reuse them for the surface of a side nature trail for pedestrians or to mulch flower beds at the trailhead, rather than haul them away.
- When revegetating areas surrounding a trail after construction, reconstruction, or implementation of erosion control or drainage measures, keep in mind the following:
  - Carefully inspect all revegetation efforts. All plantings should be at the appropriate stage of growth depending on the season and when they were planted. Any areas that are stunted or behind schedule should be monitored.
  - Any erosion in revegetated areas should be stopped through the use of erosion control blankets, bales of hay or straw, diverting site drainage, or other appropriate means. The eroded areas should be reseeded or replanted (if the time of year is appropriate), then protected by mulch or erosion control blankets as necessary.
  - In maintenance during the spring, replace plantings that did not survive the winter unless site or growing conditions indicate otherwise.
  - For future reference, keep records of which plants do best and worst under their site conditions.

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

Neatly landscaped planting areas adjacent to trail. These planting areas are intentionally planted and maintained.

2 GOOD

Landscaped planting mound with branded trail identification/ directional monument sign. This planting mound is well maintained and serves as a node for the local and regional trail system.

3 ACCEPTABLE

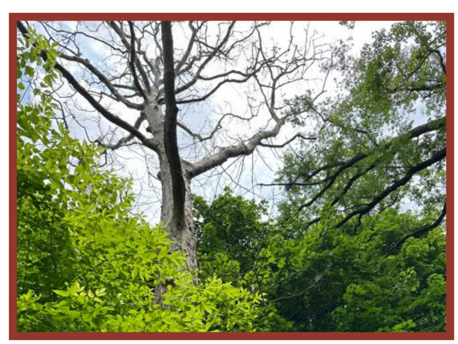
The area around this historical marker shows some signs of maintenance, but vegetation is still threatening to overgrow it and obscure this point of interest from view.

4 POOR

Knotweed (*Fallopia japonica*) and Tree of Heaven (*Ailanthus altissima*) dominate the forest edge along this trail. They are two of the most common invasive species in eastern North America.

5 ISSUE NEEDS FURTHER EVALUATION

This large dead tree near a busy urban trail poses significant risk to passersby if it, or a part of it, should fall. This situation probably calls for the prompt removal of the tree, but consideration should be taken for how to thoughtfully incorporate the wood and woody debris into the landscape once the tree has been felled.

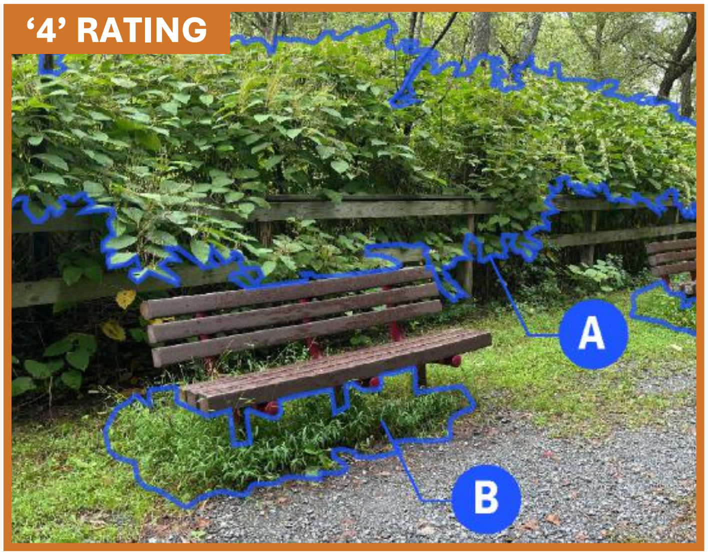


3.10 Vegetation Management

ILLUSTRATED ISSUES OF COMMON PROBLEMS

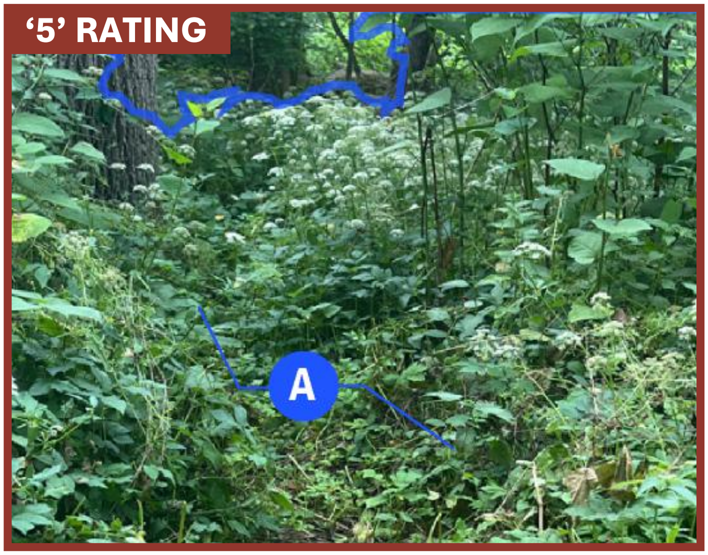
A Encourage native plants like yellow jewelweed (*Impatiens pallida*) to grow along trails. Healthy, undisturbed ecosytems are much more resilient to colonization by non-natives and invasive species.

A This is a good example of vegetation along a fence line that has been allowed to grow with little maintenance. So far, the vegetation here is tall grass and should not affect trail users too much.



A Knotweed (*Fallopia japonica*) thrive along trail edges throughout the eastern U.S. It is important to identify and eliminate occurrences of this plant quickly when there are only a few specimens present. Otherwise, they can quickly spread throughout an area, choking out native plant species and becoming incredibly hard to manage.

B Vegetation has been allowed to grow under and through this bench.



A This trail has been nearly completely taken over by invasive species. Serious effort needs to be put in to addressing the issue if the trail is to be navigable again by the general public.

3.11 OTHER ENVIRONMENTAL CONCERNS

Top left: Rock falls can deposit rocks of all shapes and sizes onto a trail, including some as large as this boulder.

Top right: Orange-stained, toxic acid mine drainage is often seen where previous underground and surface coal mining have occurred.

Bottom: Steep slopes have thinner, shallower soil, making it more likely for trees to uproot from ice load, strong winds, or landslides.

WHAT ARE "OTHER ENVIRONMENTAL CONCERNS"?

The environmental problems discussed in this Topic are maintenance concerns related to the disturbance of earth (i.e., rock and/or soil) and the stability, strength, and integrity of the land and water adjacent to a trail. Such issues include **landslides**, rock falls, unstable or uneven slopes, groundwater seepage (e.g., natural springs), and **acid mine drainage (AMD)**. These concerns are known as "environmental hazards."

COMMON SUSTAINABILITY PROBLEMS

Environmental hazards can greatly affect the sustainability of your trail, including your trail's very continued existence. Controlling upslope activity that can result in landslides and rock falls is of utmost importance. Just like with one's personal health and with the concept of trail sustainability as a whole, the focus should be on prevention versus treatment.

MAINTENANCE TIPS

- Maintenance of potential environmental hazards such as landslides and rockfalls should be focused on future prevention or mitigation. Slope stabilization, drainage improvements, and removal of debris are the major efforts needed for this.
- When inspecting your trail's "envelope" (see **Part 2.2**), look beyond the limits of your trail's shoulders and its swales. Make sure to look up at the slope of hillsides adjacent to your trail, taking note of the soil, rocks, and trees. Consult an engineer, if you notice anything worrying about the slope.
- Reinforce steep slopes vegetatively by planting or seeding ground covers to promote slowing and infiltration of water and soil and to better hold uphill soils in place.
- Reinforce steep slopes mechanically by using soil nails, rock bolts, anchors, geosynthetics, or retaining walls to increase the slope's resistance to sliding.
- Do not let too much time pass after addressing the effects of environmental hazard events. The perception of your trail and the economies of the towns that depend on it will be negatively affected.
- Consider using asphalt or gravel sections in locations on your trail that are prone to landslides, rock falls, and waterfalls. This will help to make cleanup easier after any environmental hazard events and reduce the likelihood of damaging your trail.

LANDSLIDE
key term

A **landslide** is a movement of a mass of rock, debris, and/or earth down a slope (along with the objects on that slope). Landslides occur when gravitational forces acting down the slope exceed the strength of the earth that comprises it.

ACID MINE DRAINAGE
key term

Acid mine drainage (AMD) is the outflow of acidic water from metal and coal mines, primarily caused by the oxidation of sulfide minerals exposed to air and water during mining activities. AMD results in acidic water with high concentrations of dissolved metals. It appears as a dark orange tint in affected water and soil. AMD occurs naturally and can begin at any time, but nearby disturbances of the earth, such as by adjacent property owners or from mine subsidence, can precipitate it.

EXISTING CONDITIONS RATING SCALE: EXAMPLES FOR CONTEXT

1 LIKE NEW

A new retaining wall holding up an embankment that serves as a buffer zone for any rock falls that may occur from the steep hillside. All potential geotechnical concerns are kept distant from the trail.

Photo: Hanover Trolley Trail, Jackson Township, York County, PA. (Photo credit: York County Rail Trail Authority.)

2 GOOD

Previous landslide and landslide-prone area that has been reinforced with riprap.

3 ACCEPTABLE

Small landslide area indicating an unstable hillside. The area should be monitored regularly to promptly identify worsening conditions.

4 POOR

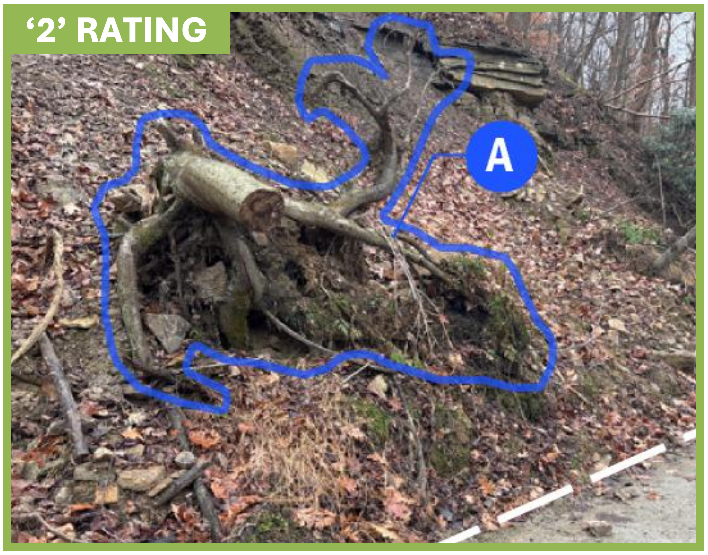
Boulders are falling down this steep hillside onto the adjacent trail. Monitor the hillside regularly. Signage to alert trail users and even a barrier along the trail edge may be required if the hillside is deemed unstable and additional boulders continue to roll downslope.

5 ISSUE NEEDS FURTHER EVALUATION

Large boulders and entire sections of hillside are collapsing onto or near the trail. This situation has the potential to cause a long-lasting closure of the trail that would require a significant capital investment to resolve.

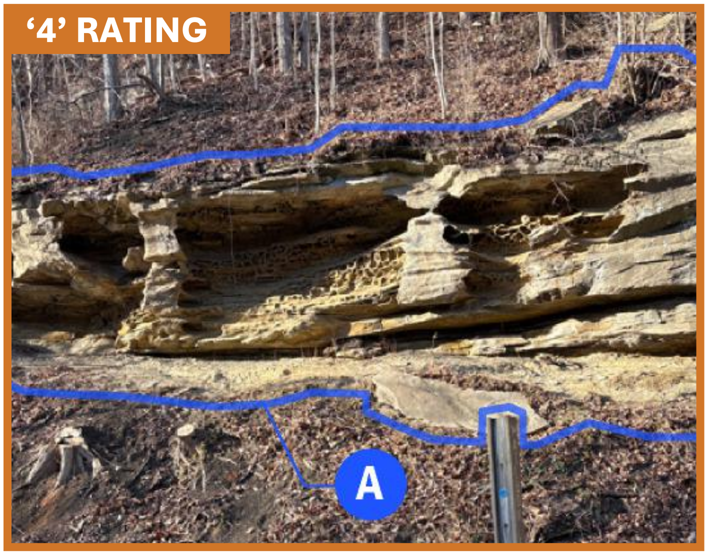
3.11 Other Environmental Concerns

ILLUSTRATED ISSUES OF COMMON PROBLEMS

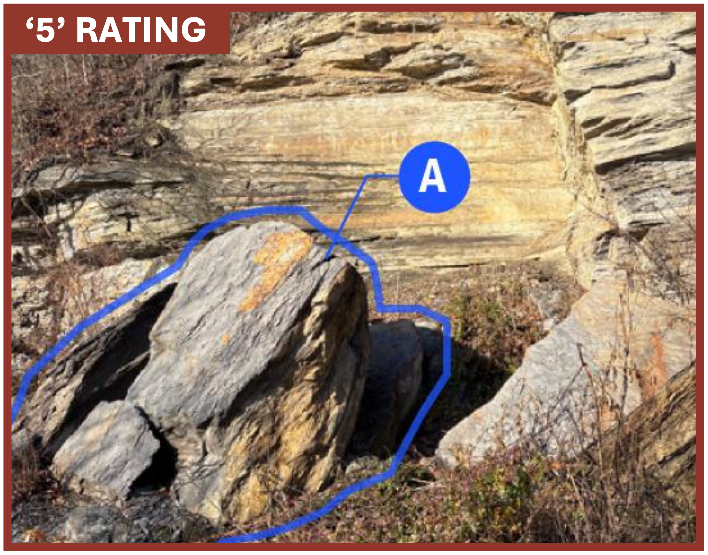


A This fallen tree, though mostly removed, is potentially indicative of poor soils and an unstable hillside, which should be inspected regularly to monitor for worsening conditions.

A Acid mine drainage (AMD), which occurs when groundwater is exposed to heavy metals from abandoned mines, is a common geotechnical concern in coal-mining regions. Rock weathering and large-scale earth disturbances can trigger AMD. It is important to be aware of occurrences, as the toxic water is potentially hazardous to trail users (not to mention, animals and plants). However, trail organizations may be limited in their ability to address this issue.



A The rocky outcrop above this trail has been collapsing over time. Vegetation in front of the outcrop has been cut back in order to properly monitor the hillside.



A Large boulders from this rock cliff are collapsing onto or near the trail. These boulders have the potential to injure trail users or cause serious (and expensive) damage to the trail.

CLOSING THOUGHTS

KEY CONCEPTS AND TAKEAWAYS

Armed with the information in this ***Trail Maintenance and Assessment Guide*** — and with inspection checklists and trail assessment tools — we hope you are in a good position to embark on your own preventative trail maintenance journey!

As existing multi-use trails age, addressing the "wear and tear" from decades of use has become an increasing need. Multi-use trails, like other transportation or recreation assets, demand an appropriate level of maintenance to continue to meet users' expectations. The growth in trail mileage over the past six decades has been astounding. Evolving from a rare, regional form of recreation to a nationally distributed recreational, transportation, and public health necessity, there are now enough multi-use trail miles in the United States to encircle the earth almost two times around the equator! It is clear from this rapid growth that multi-use trails are an essential element of our infrastructure and are of great importance to many communities. Maintaining them so that they continue to provide benefits to community economies and health is thus of utmost importance.

Preventative maintenance is crucial not only for your trail's longevity but also for the people and places that rely on your trail. Small town economies have come to depend on trails that celebrate the beauty of nature, the great outdoors, and the cultural and industrial history of our natural and human landscapes. In our nation's cities, access to recreational amenities have become increasingly important to residents and commercial interests alike as they choose where to live and do business. Additionally, alternative modes of transportation such as biking and walking have gained importance as residents seek to commute without the need for an automobile. As cities and towns have reclaimed their waterfronts from private industrial uses and seemingly impenetrable highways and railroad lines, multi-use trails have provided that much-demanded transportation and recreational link.

Above: An underpass along the Two Rivers Trailway in Easton, PA, just across the Delaware River from New Jersey.

While the diminishing availability of financial and human resources for trail maintenance is a longstanding challenge without easy answers, the availability of a different kind of resource — knowledge and data — is easier than ever for trail operators to access. With just the tap of a finger or the click of a mouse, trail operators can complete a trail assessment, complete with maps, photos, videos, condition notes, GPS locational coordinates, and enough information to issue a work order on the go. Using digital tools like Pennsylvania Environmental Council's (PEC) **Trail Maintenance Toolkit**, trail operators can easily, accurately, and quickly collect data related to their trails and trail assets, which can be inventoried, photographically documented, and "rated." This resulting information is invaluable to trail organizations because it pinpoints problem areas, helps prioritize issues based on actual observed conditions, and can be easily analyzed for patterns, not to mention shared instantly in real time.

Before you flip over to the **Appendices** of this ***Assessment Guide***, we wanted to leave you with a brief list of key concepts to keep in mind that we hope will be your takeaways from this document:

- **Drainage:** Water is the culprit for most trail maintenance problems. How your trail and the land around it handle drainage is the most important factor in how long your trail will last. The severity and prevalence of trail longevity problems are largely dependent on how effectively runoff can be directed off your trail. The faster and more forcefully that water flows onto your trail and the longer it remains, the more potential it has to create problems. Address drainage properly, and you're well on your way to a more sustainable trail.
- **Your Trail's Surface:** The surface of your trail is what trail users interact with the most and what they judge first. When your trail has a smooth, predictable surface, comparatively little else will matter to those who bike and walk your trail. Visitors do not use your trail because it has bike repair stations or picnic tables; they're there because your trail makes for a pleasant ride. Therefore, keeping your trail's surface in tip-top shape should be your utmost priority after effectively managing its drainage (noting that the two go hand in hand).
- **Prevention:** Preventative maintenance has been a recurring theme in this ***Assessment Guide*** and for good reason: Doing the work upfront for a sustainable trail and spending small sums of money routinely will make for a longer-lasting trail facility that is overall less expensive to maintain. Just as eating small meals throughout the day is less taxing for the body than eating few but large meals, a maintenance routine is healthier for your trail than having to shepherd all your resources toward large trail emergencies.

Above: The Carruth Bridge connects the north and south legs of the Buffalo Bayou Trail in Houston, TX.

- **Safety:** The safety of trail users is paramount and can make or break your trail organization. Focus on the "need-to-have" aspects of your trail versus the "nice-to-have" amenities. If you are forced to make decisions because of limited resources, make sure that amenities do not divert time and resources away from the upkeep of your core trail elements — those that impact trail safety and usability. Before you install an amenity at all, consider whether you'll have the human and financial resources to maintain it.

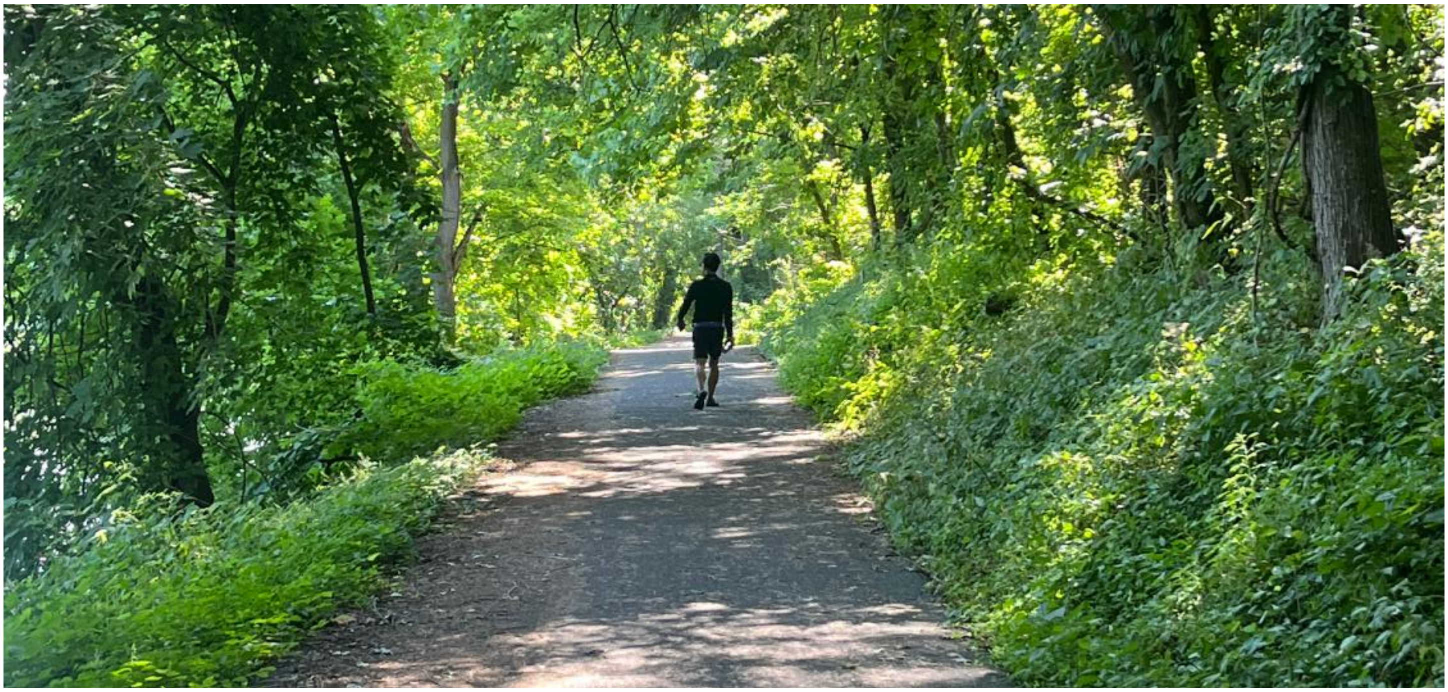
- **Your Trail Inspection Envelope:** Your trail's travel path is not your only maintenance and inspection concern. The areas adjacent to your trail are also important factors in your trail's longevity. Make sure that you pay attention to the drainage patterns next to your trail as well as to the hillsides above and below, the fences, the signage, the retaining walls, and more. Often, problems that eventually may impact your trail start off-trail, within this envelope. Think about landslides, fallen trees, and clogged drainage features, for example.

- **Trail Assessments:** A trail assessment is a diagnostic tool enabling a clearer understanding of the conditions of your trail and its assets — including what assets you are even responsible for in the first place. The ultimate benefit of completing a trail assessment is that it puts your trail organization in a position to have the most information and data possible and thus to make the best possible decisions. To know what exists on your trail, good or bad, assessing your trail frequently is the best way to become familiar with it.

- **Written Trail Maintenance Plans:** All trail operators should have written documentation that the entity owning a trail exercises a reasonable amount of due diligence to ensure its trails are safe. Keeping a maintenance schedule and a log of maintenance activities is at the heart of this documentation, which should be recorded and institutionalized. An annual maintenance schedule is the management plan for executing preventative maintenance tasks, efficiently allocating resources, and appropriately planning for the year ahead.

- **Contingency Planning:** Financial advisors often emphasize the importance of having an emergency fund as a prerequisite to managing one's personal finances. The same concept should be applied to trail maintenance. You do not want to have to "rob Peter to pay Paul." In other words, you should not have to tap into funding intended for ongoing trail maintenance to respond to trail-related emergencies. Once this happens, a domino effect starts in which you're always falling behind and reacting to problems.

Above: A restored caboose located at the Pine Creek Rail Trail's Jersey Shore, PA trailhead. (Photo credit: Susquehanna Greenway Partnership.)



Above: The Lehigh Canal Towpath section of the Delaware & Lehigh (D&L) Trail in Easton, PA.

- **Knowing Your Resources:** How much money you spend on trail maintenance should be reflective of what you have within your trail corridor. You cannot expect to maintain a trail for the long-term using "duct-tape" solutions. Take everything your organization has into consideration — your trail inspection envelope, the availability of volunteers and workers, and your financial resources — and be realistic about your "capacity of care": not just for your trail tread but also for the amenities you've installed.

- **Trees:** Downed trees are one of the most common "big messy problems" that trail operators encounter. Trees within the trail inspection envelope (as described on the previous page) fall as a result of large storms, landslides, and erosion. To mitigate this problem, a closer inspection of your trail inspection envelope may be necessary. Selective thinning of weak, damaged, and unhealthy trees in the envelope could help to lessen the number of (expensive and time-consuming) instances of fallen tree emergencies that your team faces.

- **Vegetation Management:** Beyond fallen trees, vegetation can also affect your trail in many ways. Left uncontrolled, it can result in an unsightly trail, narrow the width of your trail tread, become tangled in your fences, shoot tree roots upward that crack your trail's asphalt surface and make for an unpleasant ride, and clog your trail's drainage features. Mowing grass is also one of the most time- and money-intensive trail maintenance tasks. Look to minimize vegetation management needs to give yourself a break.

This ***Assessment Guide*** is just one source of knowledge that we hope trail operators will take advantage of to better prepare their trails for the long term. A trail that undergoes more *preventative* (*proactive*) maintenance and less *emergency* (*reactive*) maintenance, as this ***Guide*** underscores, is one that will cost less to maintain in the long run as financial and human resources grow ever more unpredictable. It is also a trail that users will feel safe riding or walking, that provides a positive experience, that is a good neighbor, and that lasts longer. As we discussed throughout this ***Guide***, a trail that effectively handles **water** is one that will better stand the test of time. And as we emphasized, completing a trail assessment is the best first step toward understanding your trail, its assets, and its maintenance challenges — which are, more likely than not, related to water.

Now is a better time than ever to complete a trail assessment. We hope you will get out there and get to know your trail better than ever before!

APPENDIX A: GLOSSARY OF TRAIL MAINTENANCE TERMS

AASHTO — The American Association of State Highway and Transportation Officials, a nongovernmental body that publishes guidelines, standards, specifications, and protocols for the design and construction of transportation facilities. Despite the nongovernmental status of the organization itself, AASHTO members are made up of the transportation departments of each state in the United States plus Puerto Rico and the District of Columbia. AASHTO publishes the *Guide for the Development of Bicycle Facilities* and the *Guide for the Planning, Design, and Operation of Pedestrian Facilities*.

ABUTMENT — The two structures, one on each end of a bridge, used to support the bridge span. Abutments are typically built into the side of embankments.

ACCESSIBILITY — The practice of making information, activities, and/or environments sensible, meaningful, and usable for as many people as possible, regardless of one's ability.

ACID MINE DRAINAGE (AMD) — The outflow of acidic water from metal and coal mines, primarily caused by the oxidation of sulfide minerals exposed to air and water during mining activities. AMD results in acidic water with high concentrations of dissolved metals. It appears as a dark orange tint in affected water and soil. AMD occurs naturally and can begin at any time, but nearby disturbances of the earth, such as by adjacent property owners or from mine subsidence, can precipitate it.

ADA — The Americans with Disabilities Act, a federal civil rights law passed in 1990 that prohibits discrimination against people with disabilities in everyday activities, including transportation.

ADIRONDACK SHELTER — An open-front structure typically constructed from stone or wood that includes a sleeping platform and a roof. Adirondack shelters are popular as overnight facilities on long-distance trails. Also known as a LEAN-TO.

ADVISORY SIGN — See SIGN, ADVISORY/CAUTIONARY.

AGGREGATE — Material made up of sand, gravel, and/or crushed rock of various grains and sizes used as a base course for trails and in asphalt and concrete mixes.

ALKALI-AGGREGATE REACTION — A chemical reaction in concrete between the alkali (sodium and potassium) in cement and certain types of aggregates (like silica), leading to expansion and cracking of the concrete, ultimately damaging the concrete structure.

ALLIGATOR/FATIGUE CRACK — See CRACK, ALLIGATOR/FATIGUE.

ALL-TERRAIN VEHICLE (ATV) / UTILITY TERRAIN VEHICLE (UTV) — A compact motorized vehicle, larger than a motorcyle but smaller than an automobile, designed with the ability to maneuver through a variety of terrain conditions. Whereas ATVs are primarily recreational in nature, UTVs are built and used more for work than recreation and typically have more seating capacity and storage space. They are commonly used to haul equipment and supplies in locations that make using a truck impractical or impossible.

AMENITY, TRAIL — See TRAIL AMENITY.

ANGULAR ROCK — Aggregate material characterized by sharp, relatively flat edges as opposed to smooth or rounded surfaces.

ASPHALT — A flexible paving material consisting of a petroleum-based binding material known as bitumen mixed with aggregates. Asphalt provides a smooth surface suitable for areas with high bicycle and pedestrian traffic. The type of asphalt used for multipurpose trails is typically blacktop, which contains a high ratio of aggregates (90-95%) to bitumen. Also see: BITUMEN and BLACKTOP.

ASPHALT BINDER — See BITUMEN.

ASPHALT CEMENT — See BITUMEN.

ASPHALT, COLD-MIX — A type of asphalt that does not require heating for application, making it suitable for patching and temporary repairs, especially in cold weather or when a quick solution is needed.

ASPHALT CONCRETE — See BLACKTOP.

ASPHALT EMULSION — A thin mixture of asphalt binder, chemical compounds, and water, commonly used in asphalt pavement preservation treatments.

ASPHALT, HOT-MIX (HMA) — The type of asphalt (blacktop) most commonly used for paving, made by heating a mixture of aggregate and asphalt binder to high temperatures.

ASPHALT MILLINGS, RECYCLED (RAM) — Recycled bits of old asphalt that have been reclaimed, re-crushed, and repurposed. Asphalt millings are especially useful on steep hills to provide traction and prevent erosion. Also known as RECYCLED ASPHALT PAVEMENT (RAP).

ASPHALT OVERLAY — See ASPHALT PATCH.

ASPHALT PATCH — A repair to distressed asphalt or concrete pavement that involves the use of heated or unheated asphalt material to fill and level the distressed area, creating a smooth and uniform overlay when it hardens.

ASSET MANAGEMENT — A desired level of service for an asset to achieve the lowest cost over the life of the asset (including costs for repair or rehabilitation). The goal of asset management is to keep assets productive and to not allow them to become liabilities.

AUGER — Any of various tools or devices with a helical shaft that is used for boring holes. As a hand tool, an auger can be used alone, as a post-hole digger. Larger augers, which are not used by hand, are attached to heavy machinery for mechanized hole-boring.

BACKFILL — The process of filling in an excavated area around a foundation or structure. Backfill material can be anything from soil to gravel (including soil dug out as part of the excavation process) and is usually compacted to provide support and stability.

BACKHOE — A large machine for digging and moving earth that consists of a large bucket on the end of an arm attached to a vehicle.

BACKSLOPE — The land on the immediately upslope side of a trail's edge. Often refers specifically to an excavated, steeply sloped hillside directly next to the trail on the uphill side or to a parallel swale.

BALLAST — Stone, cinders, gravel, or crushed rock fill material used to elevate a railroad bed above the surrounding ground. Ballast is intended to drain water away from railroad ties, spread the load of railroad traffic over a softer subgrade, provide an even bearing for the ties, hold the ties in place, and restrict the growth of grass and weeds on the railroad bed.

BANK RUN — Unprocessed fill material made up of sand, gravel, and dirt that has not been screened for size, often coming straight from a gravel pit or a bank or bed of a waterway. Also known as UNSCREENED GRAVEL.

BARRIER — See FENCE.

BASE — See BASE COURSE.

BASE COURSE — A layer of aggregate material of an asphalt (and sometimes concrete and crushed gravel) trail, placed on top of the subbase (or directly on the subgrade, if no subbase is present) and immediately beneath the trail surface, providing support for it. Also known as the BASE or AGGREGATE BASE.

BENCHING — A general method of excavating the side of a hillside to form a horizontal level for a trail surface.

BERM — A raised outside edge of a trail, comprised of an earthen ledge, which is used to divert the direction of flowing water. Sometimes a berm may need to be removed to allow runoff to drain, especially with crushed gravel trails.

BEST MANAGEMENT PRACTICES (BMPs) — Practical guidelines that are believed to be the most effective means of preventing or reducing problems. In the world of trail maintenance, BMPs include measures related to erosion control, drainage/stormwater management, and trail surface preservation, among many other standard practices. BMPs involve careful planning, location, design, construction, management, and maintenance.

BIKE RACK — A structure, sometimes affixed to the ground, that is designed to secure bicycles for parking.

BIKE REPAIR STATION — An unattended structure that features tools for performing basic repairs and adjustments to bicycles as well as for the inflating of bicycle tires.

BINDER — A medium (e.g., water, cement, bitumen, or small rock or soil particles) that is used to bind and form compound materials such as asphalt (blacktop) and concrete.

BINDER COURSE — When present, the second layer of an asphalt pavement structure, placed directly below the surface course and comprised of structural hot-mix asphalt intended to distribute traffic loads so that stresses transmitted to the trail foundation will not result in its permanent deformation. The binder course is not always used in asphalt pavement applications; often, the hot-mix asphalt surface course is placed directly on the base course, which may be made up of aggregate or another layer of hot-mix asphalt. Also known as the INTERMEDIATE COURSE.

BITUMEN — A viscous, dark liquid derived from petroleum that serves as the usual binder for aggregates in asphalt and blacktop. Also known as ASPHALT BINDER or ASPHALT CEMENT.

BLACKTOP — The colloquial term for the type of pavement most people call "asphalt," which is made by combining aggregates and hot asphalt, and then laying it down on a base course and compacting it. Blacktop, which consists of a high ratio of aggregates (90-96%) to bitumen and sometimes contains fillers such as fly ash, slag, or limestone dust, is used not only for multipurpose trails but also for low-volume roads. Also known as ASPHALT CONCRETE or BITUMINOUS CONCRETE.

BLEEDING — A condition in asphalt that occurs when excess asphalt binder fills the voids of the aggregate during hot weather and makes its way up to the surface of the pavement, where it spreads out and forms a slick surface.

BLOCK CRACKING — See CRACKING, BLOCK.

BLOWOUT — See WASHOUT.

BOARDWALK — An elevated, fixed-plank structure, usually built on pilings in areas of wet soil or water to provide dry crossings.

BOLLARD — A short post, often in a group of three, placed in the middle and/or edge of a trail, typically near a trail crossing, to keep unauthorized (motor) vehicles off the trail. When a trail directly abuts or shares its pavement with a roadway, bollards are sometimes placed between trail traffic and the roadway to protect trail users from motor vehicles. Occasionally, a large rock in the middle of the trail is used as a bollard in lieu of a manmade post. Bollards are typically anchored to a concrete piling similar to a sign post, and some are removable to allow for maintenance or emergency vehicles to access the trail.

BOOM MOWER — A type of mowing machine, typically attached to a tractor or skid steer loader, that uses a long, articulated arm (the "boom") to reach and cut vegetation in hard-to-access areas.

BOX CULVERT — See CULVERT, BOX.

BRIDGE, TRAIL — A bridge that carries a trail and its users over a roadway, a railroad, another trail, a valley, or a body of water.

BROKEN WINDOWS THEORY — Proposed by James Q. Wilson and George L. Kelling, the "brokenn windows theory" posits that visible signs of disorder and crime, like broken windows, can lead to a decline in community order and an increase in more serious crime if left unaddressed.

BRUSH HOG — See ROTARY MOWER (BRUSH HOG).

BUGHOLES — Small pits and craters on a concrete surface, created by entrapped air bubbles during the concrete placement and consolidation process. Bugholes are primaily a cosmetic issue.

BULLETIN BOARD — A display surface, typically made of plywood or corkboard and sometimes covered with a transparent material such as Plexiglas®, that is intended for the posting of messages and that is usually updated at least somewhat frequently. Bulletin boards are sometimes integrated into kiosk structures.

CAPITAL IMPROVEMENT — A financially significant, long-term project with the express purpose of expanding and/or enhancing an existing asset, such as a trail or its permanent infrastructure. Capital improvements substantially add to the value to the asset and/or appreciably prolong the useful life of the asset.

CAPITAL IMPROVEMENT PLAN (CIP) — A multi-year budgeting and planning tool designed to lay out a "roadmap" for funding and implementing major capital projects over a multi-year period.

CAPITAL PLANNING — The process of budgeting and managing long-term investments, like buildings, infrastructure, and equipment, to ensure they align with an organization's goals.

CAPITAL PROJECT — A project to construct either a new facility or to make significant, long-term improvements to existing facilities. A capital project typically requires the involvement of an architect and/or engineer.

CAPITAL REPLACEMENT — The process of replacing major, long-lasting assets, such as the asphalt pavement of a trail section or a restroom building that has reached the end of its useful life. Unlike a capital improvement, a capital replacement is not simply an addition or alteration to the asset but involves a wholesale replacement of it; however, capital re-placements are included in capital improvement planning.

CATCH BASIN — A drainage structure used to collect, slow, filter (to separate sediment from water), or otherwise temporarily store runoff, typically from paved surfaces, which is ultimately discharged into the stormwater and/or sanitary sewer system. Runoff enters catch basins through inlets.

CEMENT — See PORTLAND CEMENT.

CHIPSEAL — A surface treatment applied to an asphalt pavement to extend its life by 5 to 7 years, comprised of a thin film of heated asphalt liquid sprayed onto the existing pavement, followed by the placement of small aggregate ("chips"). The chips are then compacted with a pneumatic roller for maximum adherence to the asphalt layer. Also known as TAR AND CHIP.

CIVIC INFRASTRUCTURE — The shared public spaces, policies, programs, and practices that support strong communities and foster civic engagement.

CLAY — A stiff, sticky fine-grained earth, typically yellow, red, or bluish-gray in color and often forming an impermeable layer in the soil.

CLEAR SIGHT TRIANGLE — A triangular space at road/trail crossings designed to ensure unobstructed visibility for drivers and trail users. Nothing should be erected, placed, or allowed to grow there in a way that limits or obstructs the sight distance of motorists and trail users alike entering the intersection.

CLEARANCE, HORIZONTAL — The horizontal distance next to the edge of a trail that is cleared of trees, limbs, signs and other obstructions that would otherwise hinder movement along a trail.

CLEARANCE, VERTICAL — The vertical height that must be cleared of all tree branches and other overhead obstructions that would otherwise hinder movement along a trail.

COMPACT UTILITY TRACTOR — See TRACTOR, COMPACT UTILITY.

COMPACTION — The compressing of a volume of material, such as soil or aggregate, into a lesser, denser, and more stable volume. A compacted base course and subgrade are fundamental to a long-lasting trail. However, compaction of off-trail soils, which reduces their performance in handling stormwater, can negatively affect a trail itself. Compaction restricts these soils' natural absorption of water, making flooding, the pooling of water, and other effects of poor drainage more likely.

COMPACTOR — A machine or mechanism used to reduce the size or volume of a material.

COMPOSITE DECKING — See DECKING, COMPOSITE.

CONCRETE — A mix of coarse and fine aggregates (typically sand and gravel), Portland cement, and water, blended and then dried to give a hard, unyielding, light-colored pavement, which can be finished to any degree of smoothness.

CONTRACTION JOINT — See JOINT, CONTROL or CONTRACTION.

CONTROL JOINT — See JOINT, CONTROL or CONTRACTION.

CORNER BREAK — A crack across the corner of a concrete slab, near the intersection of the joints.

CORROSION — The gradual deterioration or breakdown of a material, typically a metal, due to a chemical or electrochemical reaction with its environment. Also see: RUST.

CORRUGATED PIPE — A pipe with a series of ridges and grooves running parallel to each other on its surface. The ridges and grooves follow a pattern that is perpendicular to the length of the pipe.

COUNTER, TRAIL — See TRAIL COUNTER.

CRACK — A separation of a previously-intact hard-surface pavement layer due to pavement distress, such as excessive loads, extreme temperatures, water intrusion, or age.

CRACK, ALLIGATOR/FATIGUE — A cracking pattern in asphalt resembling the skin of an alligator that is caused by repeated traffic loads over time that exceed the pavement's structural capacity.

CRACK, BLOCK — A cracking pattern in asphalt that occurs as widely spaced, interconnected cracks, often caused by shrinkage of the pavement due to the inability of the asphalt binder, which hardens with cold weather and age, to expand and contract with temperature changes.

CRACK, DURABILITY — Closely-spaced fine cracking of concrete near joints. Colloquially called a "D" CRACK.

CRACK, EDGE — A cracking pattern in asphalt that occurs as long cracks along the edge of the pavement. Edge cracking is typically caused by drainage issues, such as a lack of side swales for the discharge of stormwater, resulting in water seeping under and weakening the pavement.

CRACK, LONGITUDINAL — A cracking pattern in asphalt or concrete that occurs as long cracks parallel to traffic, particularly near the centerline of the road or trail. Longitudinal cracking often occurs due to weak longitudinal joints in the pavement or for the same reasons as thermal/transverse and reflection cracking (aging, brittle pavement and thermal expansion/contraction).

CRACK, LTD — Longitudinal, transverse, and diagonal (LTD) cracks in concrete, which divide a slab into two or three pieces and are usually caused by a combination of load repetition, curing stresses, and shrinkage stresses. Also see: CRACK, LONGITUDINAL and CRACK, TRANSVERSE/THERMAL.

CRACK, MAP/HAIRLINE (CRAZING) — A web of fine, shallow cracks across the surface of concrete. Map cracks also occur during curing due to the surface of concrete drying faster than the interior concrete.

CRACKING, REFLECTION or REFLECTIVE — A cracking pattern that occurs on asphalt or concrete that was laid on top of an existing underlying concrete pavement. When the underlying pavement expands and contracts due to temperature changes, it is "reflected" through cracking of the asphalt or concrete overlay above.

CRACK SEAL — See SEAL, CRACK.

CRACK, TRANSVERSE/THERMAL — A cracking pattern in asphalt or concrete, often forming perpendicular to the direction of trail traffic, that occurs when the asphalt or concrete binder contracts and shrinks faster than the aggregate during drops in temperature and/or moisture.

CRAZING — See CRACK, MAP/HAIRLINE (CRAZING).

CROSS DRAIN — See CROSS-TRAIL PIPE.

CROSS SECTION — The vertical layers of a trail from its surface to the subgrade, or a draw-ing depicting these layers as if the trail was sliced across its width like a cake.

CROSS SLOPE — The slope or grade of the trail surface (or the ground beneath it prior to trail construction), expressed as a percentage. When not otherwise specified, cross slope refers only to the slope perpendicular to the direction of travel.

CROSS-TRAIL PIPE — A pipe or culvert installed or constructed beneath a trail surface and used to move water from one side of the trail to the other.

CROWNING — The combination of insloping and outsloping, with a high point in the center of the trail surface designed to shed water in both directions.

CRUSHED GRAVEL — A mix of small particles of rock, typically varying from a fine dust up to about 3/8”, that has been screened to ensure a maximum or uniform particle size. Known by a number of other names (such as crushed limestone, packed limestone, screened gravel, crushed stone, and crusher fines), crushed gravel is derived as a byprod-uct of rock-crushing and gravel operations and is frequently used as a trail surface material for soft-surface trails.

CRUSHED STONE — See CRUSHED GRAVEL.

CULVERT — A metal, plastic, concrete, or wooden pipe passing under a trail, road, or railroad, which is used to convey water from upstream to downstream. Culverts can be as small as a 12-inch-diameter corrugated plastic pipe or as large as a bridge-sized precast concrete box culvert, the latter of which is just as likely to be used for conveyance of water as it is for an underpass or short tunnel for a trail, a road, or livestock.

CULVERT, BOX — A tunnel-like rectangular culvert installed under a road, railroad, or trail to provide cross drainage from one side to the other, typically made of precast or cast-in-place concrete (and less often, from wood). A box culvert can sometimes serve as both as a bridge underpass and a culvert, allowing traffic from a road, railroad, or trail to cross over a waterway or an indirectly intersecting travel way while also providing for the conveyance of water.

CULVERT, PIPE — A culvert comprised of a pipe that is generally at least 1 foot in diameter. Rounded or arched in shape, pipe culverts are designed primarily for the rapid conveyance of water rather than the passage of traffic. Pipe culverts come in three types: reinforced concrete, corrugated metal (usually steel or aluminum, in modern applications), and corrugated plastic (usually high-density polyethylene, or HDPE).

CURING — The process of ensuring proper hydration of cement by preventing moisture loss and maintaining the appropriate temperature after concrete is placed. This is done by keeping the concrete surface wet or damp with water and other curing compounds.

CUTSLOPE — A slope created by excavating or cutting away earth or rock to make way for a trail whose path runs along a hillside.

DAYLIGHTING — Clearing a swale, drainage ditch, or natural stream so that water can run freely, or all the way to “daylight.”

DEBRIS — Any undesirable material that encroaches on a trail surface or a drainage feature, hindering its intended use.

DECKING, COMPOSITE — Planks of manmade material — such as fiberglass (fiber-reinforced plastic, or FRB), metal, concrete, or plastic with integrated sawdust or wood fibers — that are used as a trail surface typically found on a bridge or boardwalk.

DECKING MATERIALS — Materials placed on the deck of a bridge or boardwalk for use as a travel surface.

DECKING, WOOD — Planks of wood (i.e., lumber or plywood) that are used for a trail surface typically found on a bridge or boardwalk.

DEFERRED MAINTENANCE — See MAINTENANCE, DEFERRED.

DELAMINATION — A mode of failure where a material such as concrete fractures into layers.

DEPRESSION — A dip or low area in a trail surface that does not involve pavement loss, and in the case of an asphalt trail, does not penetrate the asphalt itself. Depressions typically occur due to improper compacting of the trail foundation during construction, leading to eventual settling of the trail surface.

DISTRESSED PAVEMENT — The condition of pavement when it experiences a decline or failure in its surface condition.

DOWNSLOPE — The natural slope of the hillside below the edge of a trail.

DRAG HARROW — A farm implement, often pulled by a tractor, that uses flexible teeth or spikes to loosen and smooth soil. Drag harrows are sometimes used on crushed gravel trails to groom the trail surface.

DRAINAGE — The removal of excess surface water (runoff) or groundwater by means of pipes, culverts, drains, ditches, sheet flow, or absorption through the surface.

DRAINAGE DIP — A depression built into a trail to convey water off the trail.

DRAINAGE DITCH — See SWALE.

DRAINAGE FEATURE — A structure whose purpose is to control and divert surface water from entering or remaining on a trail. Examples include swales, pipes, culverts, and drain inlets. Also known as a DRAINAGE STRUCTURE.

DRAINAGE SWALE — See SWALE.

DRUM VIBRATORY ROLLER — A compactor machine equipped with a large, rotating drum that vibrates as it moves, pressing down soil, gravel, and asphalt.

DURABILITY CRACK (D-CRACK) — A series of closely spaced, crescent-shaped cracks in concrete near a joint, corner, or crack, caused by freeze-thaw expansion.

EDGE CRACK — See CRACK, EDGE.

EDGE EROSION — See EROSION, EDGE.

EFFLORESCENCE — A condition in concrete that occurs when moisture in the concrete evaporates, leaving behind soluble salts on the surface that appear as whitish blots visually similar to dried sweat on clothing.

EMBANKMENT — A raised structure, typically constructed of earth, that is used to support and carry a trail, road, or railroad on higher ground, such as on a bridge.

ENDWALL — A small retaining wall built at the outlet of a pipe or culvert to control water flow, support the pipe or culvert, improve drainage, and protect the integrity of the area above. Endwalls are differentiated from headwalls by their location at the outlet, rather than the inlet, or water flow.

ENVELOPE — See TRAIL CORRIDOR and TRAIL INSPECTION ENVELOPE.

EROSION — Natural processes (e.g., water, wind, ice, land disturbances, or other physical processes) by which soil detaches from the ground surface and is transported downslope by gravity. Erosion can occur on soft-surface trails (which are made up of soil and rock particles) as well as on the land, soils, and drainageways around trails. Slope, climate, vegetation (the presence or lack thereof), and particle size are important considerations affecting the potential erodibility of soil.

EROSION CONTROL — Techniques used to reduce and/or mitigate soil movement from processes such as water, wind, and human activities.

EROSION, EDGE — Erosion of the edge of a trail, resulting in the trail surface in that part of the trail disintegrating.

EROSION, SURFACE — Erosion of the surface of a soft-surface trail, which eventually results in an exposure of the subbase and then the subgrade, if not mitigated. The combination of precipitation, stormwater runoff, freezing and thawing, and wear and tear from user traffic can create significant erosion problems on trails.

EXCAVATOR, MINI — See MINI EXCAVATOR.

EXPANSION JOINT — See JOINT, EXPANSION.

EXPOSED AGGREGATE — A type of decorative concrete finish in which the top layer of cement is removed to expose the aggregates.

FAULT — A deep, vertical crack across a concrete joint or slab.

FENCE — A structure that provides a barrier between a trail and adjacent areas, such as roads, railroads, private or restricted properties, or potentially hazardous natural features.

FENCE, SPLIT-RAIL — A type of fence that uses horizontal timber rails that are inserted into vertical timber posts. Split-rail fences are common features alongside trails, especially in rural areas.

FIBERGLASS — A reinforced plastic material composed of glass fibers embedded in a resin matrix.

FILLSLOPE — The downhill side of a trail edge built up, leveled, and strengthened using material excavated from above.

FINES — See GRAVEL, CRUSHED.

FIXED MAINTENANCE SCHEDULE — See MAINTENANCE SCHEDULE, FIXED.

FLEXIBLE PAVEMENT — Hard-surfaced pavement material is slightly elastic, temporarily bending or deflecting its original shape on encountering a traffic load. The dominant type of flexible pavement used for trails is asphalt (blacktop).

FLOATING MAINTENANCE SCHEDULE — See MAINTENANCE SCHEDULE, FLOATING.

FOG SEAL — See SEAL, FOG.

FOOTING — A structural support that provides additional stability to a structure's foundation, such as the pilings of a bridge. Also see PILING.

FOUNDATION, TRAIL — See SUBGRADE.

FREEZE/THAW CYCLE — A form of erosion that occurs when water enters porous rocks or permeable surfaces. As the water freezes, it expands, exerting pressure, and this repeated cycle of freezing and thawing causes the cracks to widen, resulting in fractures and degradation over time.

FRENCH DRAIN — A drain consisting of an underground passage made by filling a trench with loose stones and covering it with earth.

FRENCH MATTRESS — A structure under a trail consisting of clean, coarse rock wrapped in geotextile fabric, used in wet areas to support the trail foundation while allowing unrestricted water movement.

FRONT LOADER — A piece of heavy machine machinery with a scoop or bucket on an articulated arm at the front for digging and loading earth.

FROST HEAVE — The upwards swelling of soil during freezing conditions caused by the growth of ice upward from the groundwater table toward the surface.

FULL-DEPTH REPAIR — See REPAIR, FULL-DEPTH.

GABION BASKET — A wire basket filled with rocks and stacked or wired with other such baskets for use as a retaining wall.

GALVANIZED STEEL— Standard steel coated with zinc to protect it from rust and corrosion, a process called galvanization.

GATEWAY SIGN — See SIGN, GATEWAY or SEPCIAL FEATURE.

GEOGRAPHIC INFORMATION SYSTEM (GIS) — A computer system that captures, stores, analyzes, edits, outputs, and visualizes geographic data. This data is tied to specific geographic (spatial) positions, often expressed as coordinates of the earth (longitude and latitude), and is stored in a database hosted on a cloud server.

GEOFABRIC — See GEOTEXTILE.

GEOTEXTILE — A water-permeable textile material used for multiple purposes, including stabilizing overlying crushed gravel trail surfaces to prevent migration of fines into the subgrade, controlling weed growth, deterring moisture and water intrusion, and preventing soil erosion. Geotextiles allow water to pass through but keep trail and soil layers from mixing and breaking down. Also known as GEOFABRIC or GEOSYNTHETIC.

GEOSYNTHETIC — See GEOTEXTILE.

GIRDER BRIDGE — A bridge supported by longitudinal beams (girders), with the deck located on top of or in between the girders.

GPS — The abbreviation of ‘global positioning system,’ which refers to a satellite-based navigation system that provides the geographic position (the latitude, longitude, and altitude) of an electronic device equipped with the technology.

GRADE — The slope of a trail surface; in other words, the degree to which the surface is angled to aid in the drainage of water. Also see: SLOPE, CROSS SLOPE, and LINEAR GRADE.

GRADE BREAK — An intentional rise or leveling in a trail surface on a downhill slope, designed to shed, slow, and direct runoff toward a side swale and/or to give uphill trail users an opportunity to rest. Also known as a LANDING AREA.

GRADE, LINEAR — See LINEAR GRADE.

GRADER — A piece of heavy construction machinery used for grading and leveling trails, roads, highways, and other surfaces.

GRADING — The process of smoothing a trail surface and shaping its slopes (such as through insloping, outsloping, or crowning).

GRAFFITI — A form of visual communication, usually illegal, involving the unauthorized marking of public space by an individual or group.

GRATE — A metal or plastic cover with holes or slits that allow water to flow through and into a drainage system, while also preventing large debris from entering and clogging the system.

GRAVEL — A loose aggregation of rock fragments typically ranging from 1/4 to 3 inches in size.

GRAVEL, CRUSHED — See CRUSHED GRAVEL.

GRAVEL, SCREENED — See CRUSHED GRAVEL.

GRAVEL, UNSCREENED — See BANK RUN.

GROOMING, TRAIL — See TRAIL GROOMING.

GUARDRAIL or GUIDERAIL — See RAILING.

HARD-SURFACE TRAIL — A trail that is surfaced using a solid pavement material such as asphalt or concrete. Hard-surface trails can be subdivided into two pavement types: FLEXIBLE PAVEMENT (e.g., asphalt) and RIGID PAVEMENT (e.g., concrete). Also known as a PAVED TRAIL.

HDPE — High-density polyethylene, a material used for a flexible plastic pipes. HDPE pipes have low permeability, are relatively low-cost, and are often preferred in modern applications over concrete and steel.

HEADWALL — A small retaining wall built at the inlet of a pipe or culvert to control water flow, support the pipe or culvert, improve drainage, and protect the integrity of the area above. Headwalls are differentiated from endwalls by their location at the inlet, rather than the outlet, or water flow.

HEAVE, FROST — See FROST HEAVE.

HMA — See ASPHALT, HOT-MIX (HMA).

HONEYCOMBING — See BUGHOLES.

HORIZONTAL CLEARANCE — See CLEARANCE, HORIZONTAL.

HOT-MIX ASPHALT — See ASPHALT, HOT-MIX (HMA).

IMPERVIOUS — Describing a surface that does not allow for absorption of water and that hence increases the volume and quantity of runoff.

INFILTRATION — The portion of rainfall, snowmelt, or stormwater runoff that is absorbed into the subsurface rock and soil.

INFRARED — A type of radiant energy that lies beyond the red end of the visible light spectrum and is invisible to the human eye but that is detectable as heat.

IN-KIND CONTRIBUTION — A non-monetary contribution, such as a donation of goods, services, or expertise.

INLET — An opening in a drainage structure leading to a pipe, culvert, catch basin, or sewer system, where water first enters the structure.

INSLOPING — To shape a trail so that its surface is sloped toward a natural hillside of higher elevation. Insloping allows surface water to drain toward the backslope (uphill side) of the trail, into a parallel swale. Water collects in the swale, flowing along this backslope until a relief pipe or culvert crossing underneath the trail directs the flow to the downslope side of the trail.

INSPECTION ENVELOPE, TRAIL — See TRAIL INSPECTION ENVELOPE.

INTERPRETIVE SIGN — See SIGN, INTERPRETIVE.

INVASIVE PLANT SPECIES — See INVASIVE VEGETATION.

INVASIVE VEGETATION — An aggressive, nonnative plant species whose presence is likely to cause environmental or economic harm and that spreads rapidly and outcompetes native plant species. Also known as INVASIVE PLANT SPECIES or EXOTIC PLANT SPECIES.

JOINT — The interface where two adjacent asphalt mats (newly laid asphalt surfaces) or concrete slabs meet.

JOINT, CONTROL or CONTRACTION — A joint in concrete pavement that is saw-cut about 1/2 inch deep to control the location of cracks and relieve the tensile stress of the concrete. Cracks located along control joints are preferred to random cracks in the middle of a concrete slab, as random cracks tend to be larger and more unsightly.

JOINT, EXPANSION — A joint that is intended to prevent or reduce expansive cracks in concrete and asphalt pavements as well as bridge structures. Expansive cracks typically form due to thermal expansion and contraction.

JOINTED PLAIN CONCRETE PAVEMENT (JPCP) — A type of rigid pavement that uses strategically placed joints to control cracking, without the use of reinforcing steel, by allowing cracks to form predictably at those joints.

JOINT SPALLING — See SPALLING, JOINT.

KIOSK — A sign structure, usually freestanding, multisided, and located at or near a trailhead, that includes displays that are infrequently updated, such as a trail map, trip planning information, interpretive signage, rules/etiquette signage, and/or donor/sponsor recognition signage.

LANDSCAPE FABRIC — See GEOTEXTILE FABRIC.

LANDSCAPE RAKE — A device consisting of a row of strong metal tines for use in grooming or grading/regrading a soft-surface trail. Landscape rakes can be towed behind a compact utility tractor, a utility-terrain vehicle (UTV), a truck, or any other similar type of vehicle that allows for rear attachments. Also known as a STEEL TINE RAKE or YORK RAKE. Also see: DRAG HARROW.

LANDSLIDE — A movement of a mass of rock, debris, and/or earth down a slope (along with the objects on that slope). Landslides occur when gravitational forces acting down the slope exceed the strength of the earth that comprises it.

LEAN-TO — See ADIRONDACK SHELTER.

LEGACY TRAIL — Multi-use trails, especially rail trails, that are pioneers in the recreational trail system, representing the oldest examples of such trails.

LINEAR GRADE — The average slope of a contiguous section that is in the same direction as the trail; measured by averaging the values of slope measurements taken periodically at different points along the trail. Also known as the trail's LONGITUDINAL SLOPE.

LOAD — The maximum weight that a trail surface or structure (bridge, boardwalk, etc.) can carry at any point along its length. Service and emergency vehicles need to be considered when determining the design load of trails and trail structures.

LONGITUDINAL CRACK — See CRACK, LONGITUDINAL.

LONGITUDINAL SLOPE — See LINEAR GRADE.

MAINTENANCE — Repair, improvements, or other work that is carried out on or near a trail to keep a trail in its originally constructed serviceable condition or to improve the safety and longevity of the trail corridor. The term is usually limited to minor repair or improvements that do not significantly change trail location, width, surface, or structures.

MAINTENANCE, DEFERRED — Maintenance of trails or trail amenities that was not performed when it should have been or when it was scheduled and which, therefore, was put off or delayed to a future period. Deferred maintenance leads to deterioration of performance, increased costs to repair, and a greater likelihood of needing replacement or reconstruction.

MAINTENANCE, ONGOING — Routine activities performed to ensure that trail assets are clean, safe, and operational. Examples include picking up litter and emptying waste receptacles, clearing debris and sediment from swales, pruning overhanging trees, mowing grass, cleaning restrooms, and painting and sealing wood decking. Ongoing maintenance is a type of PREVENTATIVE MAINTENANCE and ROUTINE MAINTENANCE.

MAINTENANCE, PREVENTATIVE or PREVENTIVE — A maintenance approach by which routine inspection and minor repairs are done to avoid potential failures and to extend an asset's life, well in advance of any significant structural failures or damage. It can be contrasted with REACTIVE MAINTENANCE.

MAINTENANCE, PROACTIVE — See MAINTENANCE, PREVENTATIVE OR PREVENTIVE.

MAINTENANCE, REACTIVE — A maintenance approach involving the quick response to crises and issues as they arise rather than performing maintenance in advance to better prevent the crises and issues from happening in the first place.

MAINTENANCE, ROUTINE — Maintenance work that is performed on a continuing basis, generally annually or more frequently. Also see: MAINTENANCE, ONGOING.

MAINTENANCE SCHEDULE — The management plan for executing maintenance tasks, which are to be performed according to a specific timeline or level of usage of a trail asset.

MAINTENANCE SCHEDULE, FIXED — A trail maintenance schedule based on tasks that either use specific equipment or materials or occur at specific time intervals. A fixed maintenance schedule is based on a calendar; it focuses on future planned tasks, regardless of whether previous scheduled tasks were completed.

MAINTENANCE SCHEDULE, FLOATING — A trail maintenance schedule based on a specified performance metric or standard. Floating maintenance schedules are typically informed by a trail asset's past use or maintenance history. For example, they may call for drainage swales to be brush hogged once the vegetation has reached a specified height (rather than on a specific calendar date).

MANHOLE — See STORMWATER MANHOLE.

MAP/HAIRLINE CRACK (CRAZING) — See CRACK, MAP/HAIRLINE (CRAZING).

MICRO SURFACING — An asphalt preservation and preventative maintenance technique similar to a slurry seal but that relies on additives in the asphalt emulsion, rather than on heat and sunlight, to dry and harden the emulsion.

MILDEW — A black, green, or whitish area caused by a fungus that grows on materials such as plants, paper, cloth, or buildings in damp environments.

MILE MARKER — A post and/or sign that shows the distance from the beginning or end of a trail, typically found at each mile and expressed as a number value of miles. Mile markers often include the name or logo of the trail for reinforcement, assurance, and branding purposes.

MINI EXCAVATOR — A small piece of heavy machinery that combines the digging ability of an excavator (using a digging arm at the front of the vehicle) with the mobility and flexibility of a compact tractor.

MOLD — A type of fungus that thrives on moist surfaces such as soil, plants, dead or decaying matter, and buildings with moisture problems.

MORTAR — A mixture of sand, water, and cement or lime that is used to fix bricks or stones to each other when building walls.

MULCHING — The laying of a loose covering such as hay or bark mulch over exposed soils.

MULTI-USE TRAIL — A paved or unpaved path open to use by bicyclists, pedestrians, and other authorized (usually only nonmotorized) users. A multi-use trail allows for two-way travel and is typically located in its own right-of-way separate from roadways. Also known as a SHARED-USE PATH or SHARED-USE TRAIL.

MUTCD — The *Manual on Uniform Traffic Control Devices*, a document issued by the Federal Highway Administration (FHWA) of the United States Department of Transportation (USDOT) that specifies the standards by which traffic signs, road surface markings, and signals are to be designed, installed, and used.

NATURAL-SURFACE TRAIL — A type of soft-surface trail whose tread is made simply by clearing and grading the native soil, with no added trail surface materials.

ONGOING MAINTENANCE — See MAINTENANCE, ONGOING.

OUTLET — The end of a pipe or culvert where runoff or drainage discharges to a receiving body of water.

OUTSLOPING — To shape a trail so that the trail surface is sloped in the same direction as the slope on which it is located. Outsloping allows surface water to flow across the trail and into the downslope below the trail. While outsloping can aid in preventing pooling of water on the trail, care should be taken to avoid the formation of intermittent streams or erosive runoff concentrations. When a trail's cross slope exceeds 3%, insloping shall be used instead.

OVERLAY, ASPHALT — See PATCH, ASPHALT.

OVERPASS — See BRIDGE, TRAIL.

PARTIAL-DEPTH REPAIR — See REPAIR, PARTIAL-DEPTH.

PATCH, ASPHALT — A repair to distressed asphalt or concrete that involves the use of heated or unheated asphalt material to fill and level the distressed area, creating a smooth and uniform overlay when it hardens.

PATCH, CONCRETE — A repair to distressed concrete that involves the application of mortar, ready-mix concrete, or another similar concrete-based compound to fill and level the distressed area.

PAVED TRAIL — See TRAIL, HARD-SURFACE or PAVED.

PAVEMENT DISTRESS — See DISTRESSED PAVEMENT.

PAVEMENT, FLEXIBLE — Hard-surfaced pavement material is slightly elastic, temporarily bending or deflecting its original shape on encountering a traffic load. The dominant type of flexible pavement used for trails is asphalt (blacktop). A flexible pavement structure consists of a subbase,

PAVEMENT, PERMEABLE — A pavement type that allows water to infiltrate through surfaces that would normally be impermeable (not allowing water to pass through). Permeable pavement includes permeable concrete pavers (decorative pavers with slightly wider gaps than normal), porous concrete (a concrete mix that has fewer fines, resulting in many small voids through which water can pass), and porous asphalt (similar to porous concrete). Permeable pavements are designed to allow water and melted snow to recharge the groundwater table, to reduce the volume of runoff, and to filter contaminants and pollutants in stormwater before infiltration. Also known as PERVIOUS PAVEMENT.

PAVEMENT PRESERVATION TREATMENT — Preventative maintenance that occurs in the context of trail surfaces.

PAVEMENT, RIGID — Hard-surfaced pavement material with a high degree of stiffness, distributing encountered traffic loads over a wider and shallower area than in the case of flexible pavement. The dominant type of rigid pavement used for roads and trails is concrete.

PAVILION — A sheltered structure, typically open on all sides, that is used for picnics, seating, gatherings, and other similar temporary activities.

PERMANENT RESTROOM — See RESTROOM, PERMANENT.

PERMEABLE PAVEMENT — See PAVEMENT, PERMEABLE.

PERVIOUS PAVEMENT — See PAVEMENT, PERMEABLE.

PET WASTE STATION — A small structure, usually affixed to a post, that provides waste bags and a receptacle for disposing of pet waste (primarily from pet dogs).

PIER — A vertical column that supports the deck of a bridge or boardwalk. While pilings are underground, piers are above ground.

PILING — A metal, concrete, or wooden post (i.e., a pile) driven or bored into the ground that serves as a foundational support for a bridge or boardwalk pier, a signpost, a bollard, or any other similar vertical structure.

PIPE — A hollow tube through which a liquid or gas can flow. A pipe that is installed beneath a travel path such as a trail, road, or railroad is known as a CULVERT.

PIPE CULVERT — See CULVERT, PIPE.

PIT RUN — Material excavated directly from the ground, consisting primarily of unprocessed, unsorted gravel with rocks up to 6 inches in diameter. Pit run is used primarily as fill material and to strengthen the water permeability and lower the plasticity of a trail's subgrade.

POPOUT — The displacement of a small chunk of a concrete surface caused by expansion and loss of aggregate particles.

PORTABLE RESTROOM — See RESTROOM, PORTABLE.

PORTLAND CEMENT — A binding material that is the basic ingredient of concrete. Portland cement is a finely ground powder, usually gray, that is manufactured by burning and grinding a mixture of limestone, clay, and other materials. Concrete is formed when Portland cement creates a paste with water that binds with sand and rock to harden into a strong material.

POTHOLE — A crater in a trail surface resulting from gradual damage to the surface. Potholes in asphalt often result from alligator or block cracks that have been left untreated, causing pieces of asphalt to become dislodged. Potholes in concrete similarly form from untreated cracks that result in the breaking apart of the pavement. In both cases, the cavities grow in size as additional wear erodes their edges.

PRECAST CONCRETE — A construction product produced by casting concrete in a reusable mold or “form” which is then cured in a controlled environment, transported to the construction site, and maneuvered into place.

PREVENTATIVE or PREVENTIVE MAINTENANCE — See MAINTENANCE, PREVENTATIVE or PREVENTIVE.

PUBLIC ART — Visual artworks displayed outdoors on property owned by government or nonprofit entities.

RAIL or RAILING — A horizontal member, such as that found on a fence or a bridge, that provides a barrier between a trail’s travel path and adjacent areas off the trail. Railings are particularly important if there are potentially hazardous natural features or areas situated at a different elevation just beyond the edge of the trail.

RAIL TRAIL — A path, typically for walking, biking, or other recreational activities, created from a former railway line.

RAILBANKING — Retaining a rail corridor for future railroad uses after service has been discontinued. The National Trails System Act provides for interim public use of the corridor, allowing the establishment of recreational “rail trails.” While a return of an established trail to active railroad use is rare, it has occasionally happened.

RAILROAD TIE — One of the cross braces that support the rails on a railway track.

RAVELING — A process in which an area of a trail’s surface slowly wears down and disintegrates, leading to the loosening and separation of aggregate particles from the surface.

REACTIVE MAINTENANCE — See MAINTENANCE, REACTIVE.

RECYCLED ASPHALT MILLINGS (RAM) — See ASPHALT MILLINGS, RECYCLED (RAM).

REFLECTION CRACKING — See CRACKING, REFLECTION.

REGRADING — A trail maintenance process that involves grading an existing trail to improve its smoothness and to reshape its slopes. Also see: REPROFILING and TRAIL GROOMING.

REPAIR — The process of fixing or restoring damaged or broken elements of an asset, such as filling a pothole in a trail surface, removing the graffiti from a sign, or replacing an indi-vidual splintered rail on a split-rail fence.

REPROFILING — To reshape a trail for improved drainage, safety, or accessibility, by restoring the linear grade and cross slope back to original specifications or by improving them based on best management practices for a well-draining trail. Also see: REGRADING.

RESTROOM, PERMANENT — A toilet facility located within a permanent building or structure (i.e., typically built or placed on a foundation).

RESTROOM, PORTABLE — A toilet facility not permanently affixed to the ground that can be moved by people or mechanical equipment. Also known as a PORT-A-POTTY or PORT-A-JOHN.

RETAINING WALL — A structure used to provide stability and strength to the edge of a trail, road, railroad, or slope and which is typically comprised of stones, concrete, or timber. Retaining walls are designed to prevent soil or rocks from sliding or falling.

RETAINING WALL, STONE GRAVITY — A retaining wall structure that uses its own weight and mass to hold back soil or other materials, typically built with stacked stones or blocks without mortar.

REVEGETATION — The practice of seeding or planting grass, shrubs, or trees to stabilize disturbed or barren soils. See also: STABILIZATION, SOIL.

RIGID PAVEMENT — Hard-surfaced pavement material with a high degree of stiffness, distributing encountered traffic loads over a wider and shallower area than in the case of flexible pavement. The dominant type of rigid pavement used for roads and trails is concrete.

RIPRAP — A layer of rough, large stones or rocks placed on a sloped surface (such as a stream bank) to provide support and prevent erosion.

ROCK FALL — A quantity of rock that has fallen freely from a steep slope or cliff face.

ROT — Decay of a material such as wood caused by fungi that digest the structure of the material, weakening its integrity.

ROTARY MOWER (BRUSH HOG) — A mower attached to a tractor, skid steer, or other similar heavy machinery that uses a rotating blade or blades to cut vegetation.

ROTARY/ANGLE BROOM — A broom attached to a tractor, skid steer, or other similar heavy machinery that operates at an angle to the left or the right for sweeping snow, dirt, leaves, and other debris off a surface.

ROUTINE MAINTENANCE — See MAINTENANCE, ROUTINE.

ROUTING — Purposeful widening of a crack in concrete pavement using a specialized tool to create a channel or reservoir, which is then filled with a sealant to prevent further damage.

RUNNING SLOPE — See LINEAR GRADE.

RUNOFF — Surface water not absorbed by the soil that flows over the land, including trail surfaces, and ultimately reaches a receiving body of water.

RURAL TRAIL — See TRAIL, RURAL.

RUST — A reddish-brown coating that forms on iron or steel when it reacts with oxygen and water, a process known as oxidation or corrosion.

RUTS/RUTTING — Sunken tracks or grooves in a trail's surface cut in the direction of travel by the wheels of trail users or by water. Ruts are typically found on soft-surface trails.

SATURATION — A condition in which all of the pore space in soil or in a crushed gravel trail surface is filled with water.

SCALING or FLAKING — Surface deterioration of concrete that is typically due to defects of the concrete mix or construction and does not generally affect the structural integrity of the concrete slab.

SCREENED GRAVEL — See CRUSHED GRAVEL.

SEAL, CHIP — See CHIPSEAL.

SEAL, CRACK — A liquid asphalt material, typically hot and rubberized and often mixed with additives, that is used to fill small to moderately sized cracks in asphalt or concrete pavement.

SEAL, FOG — An asphalt preservation and preventative maintenance technique that involves machine-spraying a highly diluted application of an asphalt emulsion onto an existing asphalt pavement to seal cracks, reduce raveling, restore flexibility, and extend the life of the pavement.

SEAL, SLURRY — An asphalt preservation and preventative maintenance technique that involves machine-spraying a mixture of water, asphalt emulsion, fine aggregate, and additives onto an existing asphalt pavement, spreading it uniformly, and letting it cure over a few hours in hot, dry weather, forming a protective layer over the pavement.

SEALCOATING — An asphalt preservation and preventative maintenance technique that involves applying a protective layer of a coal tar emulsion sealant over an existing asphalt surface. Sealcoating is a cosmetic surface treatment to smooth out and restore the look of the existing pavement. It does not fill cracks or provide additional structural integrity to the underlying asphalt beyond protecting it from gas and oil spillage, deicing chemicals, rain and snow, and solar oxidation.

SEDIMENT — Fragments of rock, soil, and organic material transported and deposited by water, wind, or other natural processes.

SEDIMENTATION — The end product of erosion, resulting from the deposition of soil particles that have been detached and transported by water (i.e., through stormwater runoff). Sedimentation occurs when the moving water in which the soil particles are suspended is slowed to a degree that the particles settle out of suspension. Larger, heavier particles, such as sand and gravel, settle more quickly than smaller, lighter particles, such as clay and silt. Sedimentation is reduced through erosion control and its effects can be minimized by trapping sediment transported by runoff before it reaches swales, culverts, and other drainageways.

SHARED-USE PATH — See MULTI-USE TRAIL.

SHARED-USE TRAIL — See MULTI-USE TRAIL.

SHEET FLOW — Runoff that occurs in a shallow, continuous sheet across a trail surface, resulting in a quick shedding of water from the surface.

SHOULDER, TRAIL — The surfaced or unsurfaced area at the side of a trail just off the trail tread.

SHRINKAGE — See CRACKING, SHRINKAGE.

SICKLE MOWER — A mowing device that uses a bar with a series of reciprocating blades (like a scissor action) to cut grass and other vegetation.

SIGN (SIGNAGE) — A board, post, or placard that displaces written, symbolic, pictorial, or tactile information about a trail or the surrounding area. Signage increases safety and comfort for trail users.

SIGN, ADVISORY/CAUTIONARY — A sign that warns trail users of upcoming road/trail crossings, steep grades, blind curves, and other potential trail hazards.

SIGN, BULLETIN BOARD — See BULLETIN BOARD.

SIGN, DIRECTIONAL — A sign that shows trail names, road names, directional arrows, mileage to points of interest or upcoming trailheads, and other navigational information.

SIGN, DONOR/SPONSOR RECOGNITION — A sign, typically affixed to a post in the ground or to a fence, that identifies and recognizes donors or sponsors.

SIGN, GATEWAY or SPECIAL FEATURE — A sign, marker, or public art piece, typically decorative in nature, that is used to announce the presence of a trail at a trailhead or trail crossing or to identify scenic or historical points of interest along a trail.

SIGN, INTERPRETIVE — An educational display that provides information about a natural, historical, or cultural point of interest on or along a trail.

SIGN, KIOSK — See KIOSK.

SIGN, MILE MARKER — See MILE MARKER.

SIGN, REGULATORY — A sign used to indicate or reinforce regulations, requirements, or traffic laws that must be obeyed, such as "Stop," "Yield," and "Do Not Enter" or trail rules and etiquette.

SIGN, TRAIL IDENTIFICATION — A sign used to identify the trail associated with a particular trailhead, parking area, or trail crossing and that is typically designed to be prominent enough to be seen by drivers and passengers in motor vehicles.

SIGN, TRAIL RULES/ETIQUETTE — A sign, typically affixed to a post in the ground or to a fence, that displays the rules of using a trail and/or trail etiquette.

SIGN, WAYFINDING or DISTANCE — A sign that provides navigational information, such as mileage to upcoming trailheads and other points of interest, along with directional arrows. Also known as a DIRECTIONAL SIGN or GUIDE SIGN.

SILT — A fine sediment with particles larger than those of clay but smaller than those of sand, often found in soil and carried by water or wind.

SLOPE — The gradient of a trail surface, calculated as “rise” over “run” and expressed as a percentage; in other words, the degree to which the surface is angled to aid in the drainage of water. Also see: GRADE, CROSS SLOPE, and LINEAR GRADE.

SLOPE, CROSS — See CROSS SLOPE.

SLOPE, RUNNING — See LINEAR GRADE.

SLURRY SEAL — See SEAL, SLURRY.

SNOWMELT — Surface runoff produced from melting snow.

SOCIAL TRAIL — An informal, unofficial side trail that has been established by consistent use as a shortcut, often to bypass wet or muddy parts of the official trail or to navigate around obstacles in the official trail such as fallen trees or rocks.

SOFT-SURFACE TRAIL — A trail that features a surface comprised of loose or pliable material such as crushed gravel or natural earth (i.e., dirt).

SOIL STABILIZATION — Establishing vegetation on highly erodible or disturbed soils by sowing seed, planting native vegetation, and/or mulching.

SPALLING — The phenomenon of surface patches of concrete chipping, flaking, or pitting away.

SPALLING, JOINT — Cracking, breaking, or chipping of concrete at or along a joint.

SPLIT-RAIL FENCE — See FENCE, SPLIT-RAIL.

STORMWATER MANHOLE — The opening on an aboveground surface that provides access to a below ground stormwater and/or sanitary sewer system.

SUBBASE — The layer of a trail’s cross section between the base course and the subgrade. The subbase generally consists of lower-quality materials than the base course but better-quality materials than the subgrade soils. Common materials used include gravel, crushed stone, reclaimed material, or a combination of these. A subbase course is not always needed or used, but it is an effective way for raising the profile of the trail for better drainage.

SUBGRADE — The existing native soil mass that makes up the primary foundation of a trail and that serves as its bottom layer. Proper trail construction methods involve the compacting of this layer to a specified density. Also known as the TRAIL FOUNDATION.

SUBSIDENCE — Sinking of the ground because of underground material movement.

SUBURBAN TRAIL — See TRAIL, SUBURBAN.

SUPERELEVATION — The amount by which the outer edge of a curve on a trail is banked above the inner edge.

SURFACE COURSE — See TRAIL SURFACE.

SURFACE EROSION — See EROSION, SURFACE.

SURFACE MATERIAL, TRAIL — Material placed on top of the base course of the trail (or sometimes directly above the subgrade) that provides the trail tread. Multi-use trails are usually surfaced in crushed gravel, asphalt (blacktop), concrete, or a combination of these surface materials.

SURFACE WATER — Water that is flowing or standing on top of the ground.

SUSTAINABILITY — The design and maintenance techniques that limits asset degradation, minimizes unpredictable maintenance needs, improves asset quality, reduces environmental impact, increases user safety, and ultimately saves money in the long run.

SUSTAINABLE TRAIL — A trail that limits degradation, minimizes unpredictable maintenance needs, creates little environmental impact, ensures user safety, provides a positive experience, and ultimately minimizes costs to the trail owner, independent of the trail type or location.

SWALE — A shallow ditch with gently sloping sides designed to handle stormwater runoff for conveyance and absorption. Manmade swales typically run parallel to roadways, trails, and other travel ways. Swales both infiltrate and divert water as opposed to letting it pool on the trail surface or to flow uncontrolled downhill. Also known as a DRAINAGE DITCH, though swales are always vegetated or lined with rocks whereas drainage ditches sometimes consist of impermeable manmade materials such as concrete.

TAR AND CHIP — See CHIPSEAL.

TENSILE STRESS or STRENGTH — The resistance that a pavement material has against a force that attempts to stretch or tear it apart. The ultimate tensile strength of the material is the maximum stress it can withstand while being stretched or pulled apart before ultimately breaking.

THERMAL/TRANSVERSE CRACKING — See CRACKING, THERMAL/TRANSVERSE.

TRACTOR, COMPACT UTILITY — A small, versatile agricultural vehicle designed for various tasks involving the movement of dirt and offering the ability to attach different implements for tasks such as mowing, plowing, and hauling.

TRAFFIC LOAD — See LOAD.

TRAIL — A travel route that is designed, designated, or constructed for recreational use or as an alternative to a route used by automobiles and trucks.

TRAIL AMENITY — Any object, structure, or other physical element meant to enhance a trail user's experience, comfort, convenience, and/or enjoyment in their use of a trail.

TRAIL ASSESSMENT — A diagnostic tool enabling a clearer understanding of a trail and its assets, including an inventory of the assets and their physical conditions.

TRAIL ASSET — Any physical item of value used for the operation, management, and/or enjoyment of a trail, including amenities, signs, drainage features, and other structures.

TRAIL BRIDGE — See BRIDGE, TRAIL.

TRAIL CORRIDOR — The zone including the trail and the land and drainageways to the sides of it.

TRAIL COUNTER — A device used to count the number of users traveling along a specific section of a trail.

TRAIL CROSSING — The point at which a trail intersects with a roadway or another trail.

TRAIL CROSSING, ADJACENT PATH — A trail crossing that involves the crossing of a roadway or railroad after a significant trail length paralleling the roadway or railroad.

TRAIL CROSSING, COMPLEX — A trail crossing that does not fit within the definition of a midblock or adjacent path trail crossing and whose design AASHTO instructs engineers to treat on a case-by-case basis.

TRAIL CROSSING, MIDBLOCK — A trail crossing that involves the crossing of a roadway or railroad when there are no other adjacent intersections or crossings.

TRAIL CROSSING, PRIVATE — A trail crossing that involves the crossing of a privately-owned road or driveway.

TRAIL FOUNDATION — See SUBGRADE.

TRAIL GROOMING — Maintenance of the surface of a soft-surface trail to improve smoothness, clear debris, and remove imperfections such as depressions, ruts, and potholes. Also see: REGRADING.

TRAIL, HARD-SURFACE or PAVED — See HARD-SURFACE TRAIL.

TRAIL INSPECTION ENVELOPE — The physical area on and around a trail that should be inspected for potential or present issues. The trail inspection envelope should extend beyond the limits of the trail's shoulders and drainage swales to also include adjacent hillsides, vegetated areas, and abutting land uses.

TRAIL MAINTENANCE PLAN — A written document that outlines (primarily routine) maintenance tasks and identifies responsible parties for addressing those tasks.

TRAIL, MULTI-USE — See MULTI-USE TRAIL.

TRAIL, NATURAL-SURFACE — See NATURAL-SURFACE TRAIL.

TRAIL PROFILE — The shape of a trail, including its slopes and grades.

TRAIL, RURAL — A multipurpose trail, typically consisting of a soft trail surface, that primarily serves recreational and long-distance users in a rural setting.

TRAIL, SOFT-SURFACE — See SOFT-SURFACE TRAIL.

TRAIL, SUBURBAN — A multipurpose trail, either hard-surface or soft-surface, that is located in an area of lower population density and trail traffic than the typical urban trail, is often a few feet narrower in width, and usually features vegetated buffers and generous setbacks along its length.

TRAIL SURFACE — The top layer of a trail, which is in contact with and distributes traffic load; in other words, the travel surface of a trail. Also known as the TREAD, SURFACE COURSE, or WEARING COURSE.

TRAIL SURFACE MATERIAL — See SURFACE MATERIAL, TRAIL.

TRAIL SURVEY — A survey conducted with trail users to help trail operators understand how their trail is perceived, any problems users are facing, conditions that the operator may not be aware of, what users find most important about their experience on the trail, and other largely subjective information that can help inform future maintenance and capital projects.

TRAIL, SUSTAINABLE — See SUSTAINABLE TRAIL.

TRAIL SYSTEM — A collection of individual trails that may or may not be connected to one another, whereby each retains its distinctiveness but belongs to the system by association within a federal, state, or local context.

TRAIL, URBAN — A multipurpose trail, most often consisting of a paved trail surface and located in or near a densely populated area, that is generally designed to serve a high volume of users, which may include walkers, runners, recreational bicyclists, commuter bicyclists, rollerbladers, and wheelchair users, among others.

TRAILHEAD — A designated trail access point that typically includes a parking lot, amenities (such as restrooms, picnic tables, and trash cans), and signage.

TRANSVERSE CRACK — See CRACK, TRANSVERSE/THERMAL.

TREAD — See TRAIL SURFACE.

TRESTLE — A bridge, formerly used by a railroad and often repurposed for rail trails, that is comprised of numerous short spans on top of many closely-spaced support frames.

TRUSS/TRUSS BRIDGE — A bridge support structure comprising one or more triangular units constructed with straight slender members whose ends are connected at joints. Trusses rest on top of the abutments and support the bridge deck. They are commonly seen on old railroad bridges that have been repurposed for rail trails.

TUNNEL — A travel passage running underneath the ground that allows trail traffic to pass directly through a natural barrier, such as a mountain.

UNDERPASS — A passage that separates a trail and its users from a roadway, railroad, or another trail above, eliminating a direct, at-grade intersection between the two travel paths. Underpasses found along trails are typically either comprised of bridges or short box culverts.

UNSCREENED GRAVEL — See BANK RUN.

UPHEAVAL — A localized upward movement of a trail surface that occurs when tree roots that have penetrated the subgrade push the trail surface upward or when frost heave or excess moisture cause the subgrade to swell. Also known as UPLIFTING.

UPLIFTING — See UPHEAVAL.

UPSLOPE — The natural slope of the hillside above the trail. Also known as BACKSLOPE or SIDESLOPE.

URBAN TRAIL — See TRAIL, URBAN.

VANDALISM — Action involving deliberate destruction of or damage to public or private property.

VEGETATION MANAGEMENT — Tasks such as mowing, trimming, tree prining, fallen tree removal, tree removal as a preemptive safety concern, and removal of invasive plant species.

VERTICAL CLEARANCE — See CLEARANCE, VERTICAL.

WARPING — A deformity in wood occurring when the moisture content of different parts of a piece of wood changes unevenly.

WASHBOARDING — Sunken tracks or grooves on the surface of a soft-surface trail, either perpendicularly aligned to the direction or travel or parallel to the direction of travel. Also see: RUTS/RUTTING.

WASHOUT — Damage to a soft-surface trail resulting from a large amount of water severely eroding a section of the trail over a short period of time, such as during a flash flood. Also known as BLOWOUT.

WATER TABLE — The area below the surface of the ground where the soil or rock is permanently saturated with water.

WAYFINDING SIGN — See SIGN, WAYFINDING or DISTANCE.

WEARING COURSE — See TRAIL SURFACE.

WEATHERING — The general term used to define the slow degradation of wood exposed to the elements.

WEATHERING STEEL (CORTEN) — A type of steel alloy designed to form a stable, rust-like patina (a protective layer) on its surface when exposed to the elements, eliminating the need for painting and offering a unique aesthetic.

WEEP HOLES — Small openings or perforations, typically at the base of a retaining wall, that allow water to escape from behind the wall, preventing water buildup and potential damage to the structure.

WETLAND — An area of land where soils are flooded or saturated with water for a significant part of the year or semi-permanently.

WINGWALL — Extensions that project from the sides of a headwall or endwall, often used to direct water flow and prevent erosion.

WOOD DECKING — See DECKING, WOOD.

APPENDIX B: TRAIL MAINTENANCE TOOLKIT

B.1 ABOUT THE TRAIL MAINTENANCE TOOLKIT

INTRODUCTION

To help trail owners and organizations enhance their maintenance capabilities and adjust their approaches towards a preventative mindset, the Pennsylvania Environmental Council (PEC) and the McCune Foundation have partnered to develop the **Trail Maintenance Toolkit**, a suite of mobile and computer-based diagnostic tools intended to mitigate the challenges of trail maintenance efforts.

The following part of this ***Assessment Guide*** provides an overview of the **Trail Maintenance Toolkit** as well as brief instructions on each individual tool, outlining the purposes and utilities of the tools and how they can be used together as part of a trail maintenance regimen. For additional information, please visit the PEC webpage on trail sustainability: https://pecpa.org/trailsustainability/.

BENEFITS OF USING THE TRAIL MAINTENANCE TOOLKIT

The **Trail Maintenance Toolkit** provides trail organizations with an online trail map and a mobile app used for trail assessments. With these tools, a trail organization is able to complete an in-the-field assessment of its trail's surfaces, features, and amenities using the mobile app and to visualize and evaluate the results from a desktop, laptop, or tablet computer. The trail organization is then capable of creating an annual maintenance plan and formulating a Capital Improvement Plan on their own. As discussed throughout this ***Assessment Guide***, this proactive style of maintenance can help trail operators improve the sustainability of their trails.

The benefits of using the **Trail Maintenance Toolkit** include:

- ✓ No special software or equipment are needed beyond a standard smartphone and a desktop, laptop, or tablet computer.
- ✓ No special training or educational classes are necessary to operate either the mobile app or the online maps or dashboards.
- ✓ No resources beyond the **Toolkit** itself are needed to develop background maps, collection tools, and analyses.
- ✓ Real-time data and conditions assessments can be procured and shared during ordinary maintenance activities and shared.
- ✓ The information gathered can inform decision-makers (i.e., who spends the money or who may provide grants to the trail organization) and the decision-making process (i.e., how capital dollars should be spent).
- ✓ The cloud-based Toolkit reduces silos of information and communication between parties responsible for trail maintenance.

DEVELOPMENT OF THE TOOLKIT

The **Trail Maintenance Toolkit** is a natural outgrowth of PEC's long-standing focus on trail sustainability. Years of collaboration with trail organizations and involvement in the Industrial Heartland Trails Coalition, Circuit Trails Coalition, NEPA Trails Forum, and other regional trail networks throughout Pennsylvania, New York, New Jersey, Ohio and West Virginia — as well as co-founding the Collaboration of Regional Trail Initiatives (CRTI) — have equipped PEC with a keen understanding of trail operations, maintenance issues, and challenges. From these experiences, PEC saw traditional practices of managing trail maintenance were jeopardizing the sustainability of many mature multi-use trails.

Hence, PEC developed the **Trail Maintenance Toolkit** to support trail owners and organizations with a comprehensive, integrated, resource-efficient, and customizable trail management product. Built around Esri's ArcGIS® geospatial platform, which includes ArcGIS Online® webmaps, Field Maps, and Dashboards, the **Toolkit** is accessible from anywhere. Data and information is stored in a cloud-based server so that anyone with the proper permissions can view and edit it and instantly share the results of trail assessments in real time.

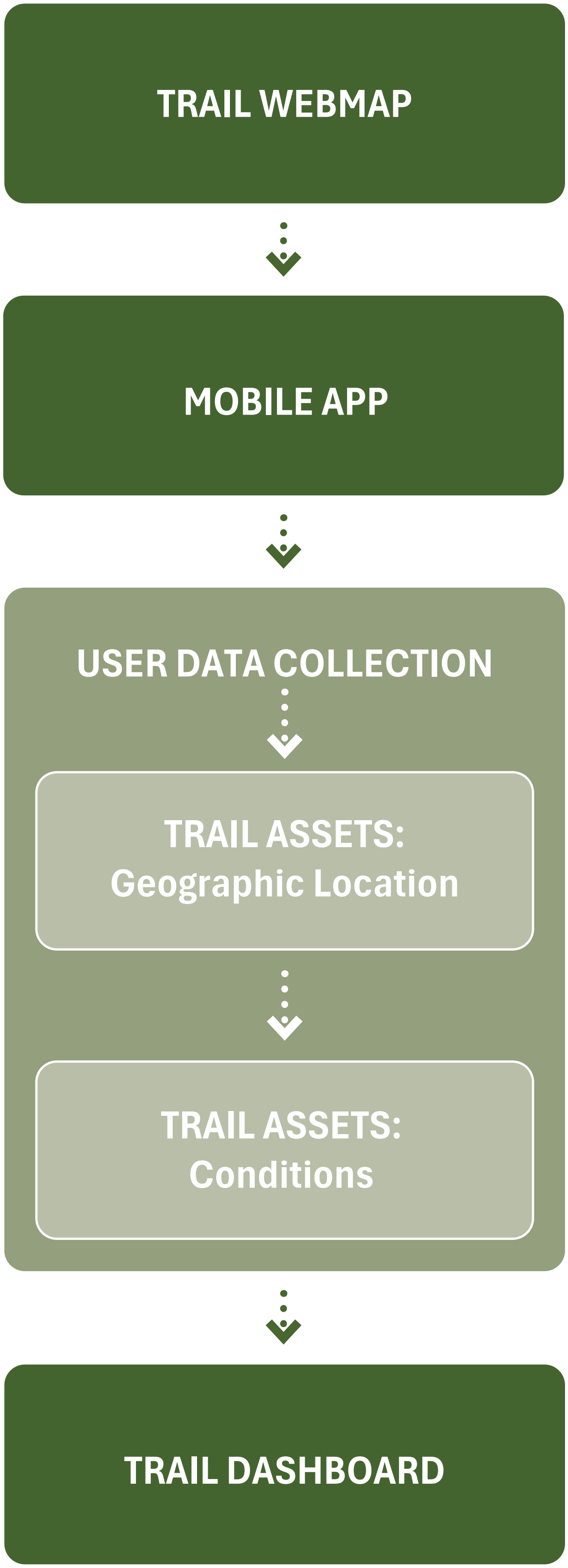
Now in its fourth generation, the **Toolkit** reflects hundreds of trail miles of "lessons learned" in performing assessments, organizing data, and visualizing issues. It has been shaped by the input of numerous trail operators and volunteer assessors, and its tools have been tested and honed by those who regularly perform trail maintenance.

B.2 CREATING AN ACCOUNT

STEPS FOR ACTIVATION

The following steps run through what your organization will need to do to set up a **Trail Maintenance Toolkit** account with PEC:

1. Contact PEC and request an account for your organization's trail or trail system.
2. Receive PEC's applicant package via email.



3. Complete and return the following to PEC:
    a. Data Sharing Agreement
    b. Applicant Enrollment Form
        - Organization
        - Contact information
        - Trail Segment/Area to be Assessed
        - Anticipated timeframe for completing your trail assessment(s)
        - Whether the applicant has access to an existing ArcGIS Organizational Account
4. Receive links to the Apple App Store/Google Play Store for download of the Field Maps app.
5. Download the app onto a mobile device.
6. Receive a QR code with login credentials.
7. Login and select the Trail Webmap file for your trail.
8. Receive a web address to your organization's Trail Webmap for viewing on a computer.

B.3 THE TRAIL WEBMAP

FUNCTIONALITY

The **Trail Maintenance Toolkit** is anchored by an online GIS-based **Trail Webmap** customized for each trail organization. This map shows the geographic location, alignment, and extent of the organization's trails. Trail Webmaps can be viewed with background layers such as roads and political boundaries, aerial photography, and topographic contours.

For each organization, PEC initially creates a webmap that aggregates trail alignment information from numerous open-source GIS datasets. The GPS-enabled map can be viewed both through ArcGIS Online (from a computer) or through Esri's Field Maps mobile app and is intended to provide geographical context when completing a trail assessment. In other words, the Trail Webmap is the "canvas" upon which the trail's features, amenities, and characteristics can be "painted."

In addition to the background map and the trail's alignment, additional GIS data layers can be added to a Trail Webmap. Layers can be set up as "static" (i.e., for information-only datasets) or "active" (i.e., layers on which additional data can be recorded and which can be further edited). A Trail Webmap's layer control permits layers to be toggled on and off by users so that they can customize their work environment how they see fit.

Not only can a Trail Webmap user control the layers they see, but they can also control line weights, colors, and symbols attached to a recorded point representing a specific trail asset or maintenance issue. PEC determines the initial set of symbols and graphical representations, but Trail Webmap users can modify these assignments to fit their own needs.

USER INTERFACE

Trail Webmaps look and behave like many other digital maps such as Google Maps or Apple Maps. Webmaps can be both manipulated and customized by users to some degree. Controls for these actions are placed along the left and top edges of the map pane, as shown in **Figure 22**.

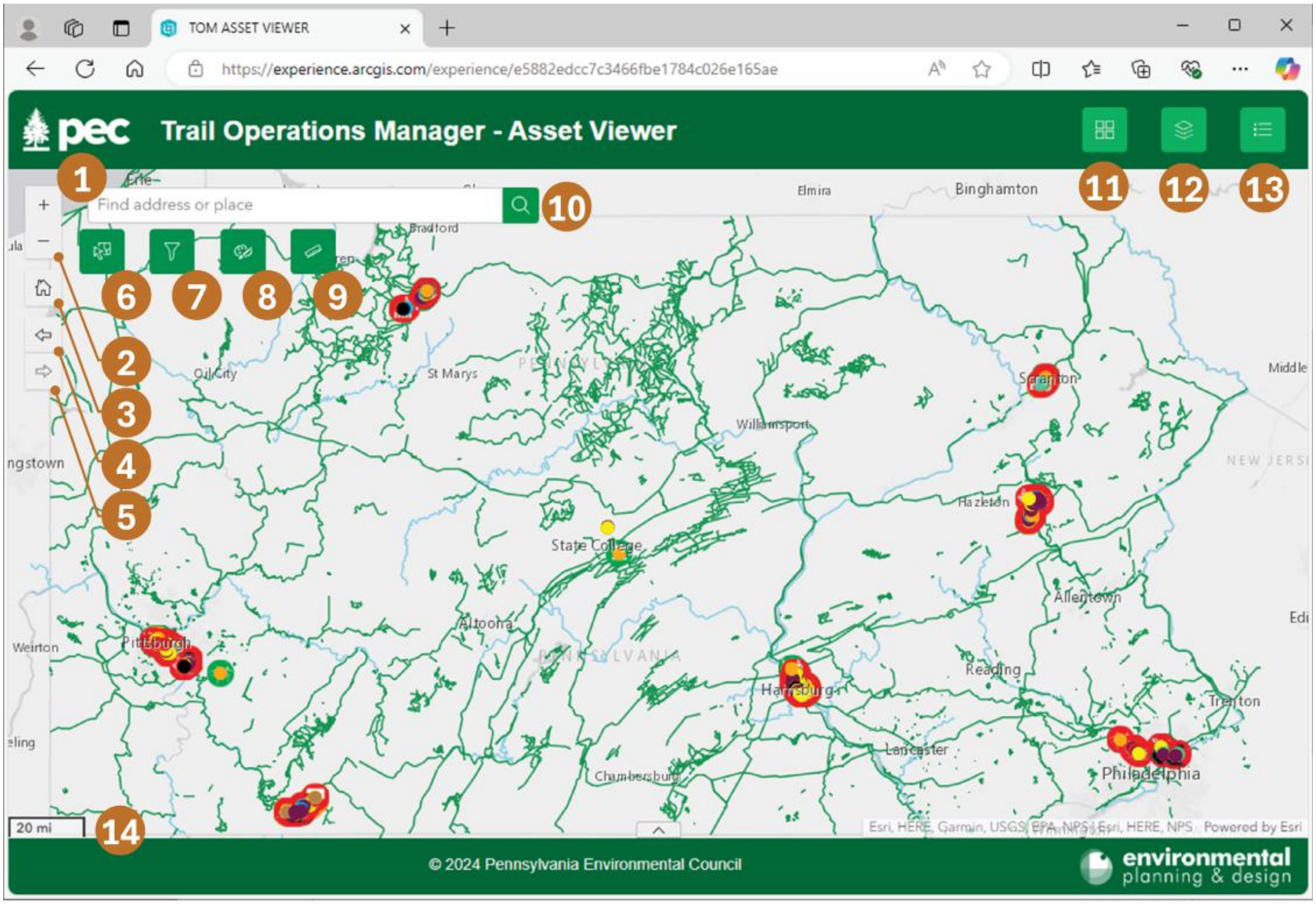


Figure 22: The Trail Webmap Tool of the Trail Maintenance Toolkit. Shown from a computer desktop.

The following is a summary of the available controls for the Trail Webmap. Refer to **Figure 22** for the corresponding numbered item.

1. Always located in the upper left corner of the map pane is the **Zoom Control** for the map pane itself. The “+” button allows a user to zoom in (increase the scale of the map context). Conversely the “-” button allows a user to zoom out (decrease the scale of the map context).

2. When using the Zoom Controls, the scale and detail of the map’s base information (e.g., roads, political boundaries, topographical contours, etc.) changes as well as the specific map layers that overlay the base information (e.g., the layers showing trails and individual trail assets).

3. A **Home** button that recenters the map to a pre-determined location and scale based on the individual trail organization’s “home” trail. When the button is selected, the view will move back to the center of the map content and will adjust the zoom settings to show the full extent within the map pane.

4. The **Back** button returns the geographic position, extent of the map content, and previous scale as per the user’s most recent settings. Each subsequent press of the button will reset the map content’s position, extent, and scale to the next most recent setting.

5. The **Forward** button has the same functionality as the Back button but in reverse order. The two buttons allow a user to scroll through a series of map views based on the user’s specific settings and adjustments.

6. The **Layer Control** button opens a menu that lists the layers integrated into the Trail Webmap itself. This menu also permits the user to toggle on and off the visibility of each individual layer.

7. The **Filter Control** button opens a menu that allows a user to toggle on and off a set of pre-programmed filters. A filter will isolate and illustrate only the trail features that meet the specific conditions defined through the filter itself. For instance, the pre-programmed filter incorporated into the Trail Webmap isolates trail features that have a condition rating of '4' or '5' (see **Part 3** of this ***Assessment Guide***). Consequently, any trail features that have been rated '1,' '2,' or '3' are automatically hidden in the map pane.

8. The **Annotate** button allows users to add text, shapes, symbols, or lines to a specific view within the map pane. When a user adds annotations, the object is not permanently incorporated into the Trail Webmap. The annotations remain visible and will be geographically anchored to the map itself until the user closes the Trail Webmap. Annotations are useful when trail operators are formulating maintenance plans or strategies and need to delineate areas or work order boundaries. Any record of these annotations must occur through screen captures or hard copy printouts of the information, as it does not save.

9. The **Measure** button allows users to measure the length or area of an object or trail alignment on the map. When clicking the button, a menu appears that allows users to choose their a method of measuring and their preferred unit of measurement.

10. The **Search** button initiates a search of the database of pre-programmed or inputted information for an exact match to a phrase or name typed into the search field located to the left of the button. Users need to be mindful that the search condition is an exact match, so spelling errors or partial names will not return results.

11. The **Basemap Gallery** button allows users to select from five different base maps. The base map is not embedded within the Trail Webmap's GIS data. Rather, it functions as scalable "wallpaper" that the GIS layers are superimposed upon. Examples of basemaps include road maps and aerial photography (recent satellite imagery). Basemaps are not editable.

12. The **Map Layer** control functions differently than the one described in item #6. This button activates a right sidecar panel that enables a user to customize the visibility of the Trail Webmap's layers. Users are able to change the order of each layer's appearance. For instance, a user may change which layer appears on top of all others. The panel also permits a user to adjust the transparency of the selected layer.

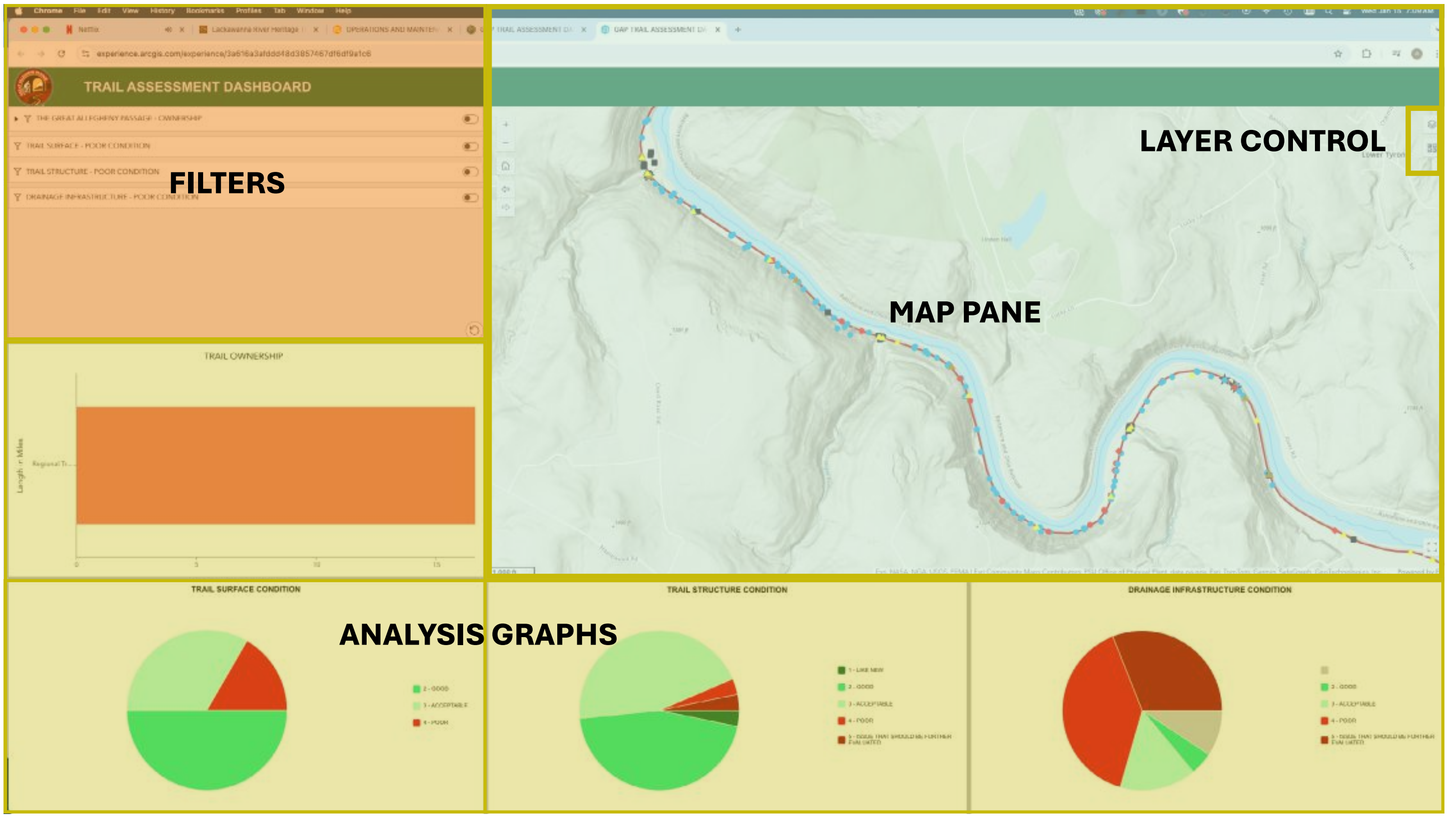
13. The **Legend** button reveals a legend of the map layer's various symbols, areas, and lines.

14. The **Scale Bar** automatically adjusts its reading based the user's current zoom setting.

B.4 THE TRAIL DASHBOARD

FUNCTIONALITY

The information collected as part of a trail assessment can become intensely populated with data and observations. That's where the **Trail Dashboard** comes in. The Trail Dashboard is a tool designed to enable users with Trail Webmaps to convey information using interactive data in the form of charts and graphs for a better understanding of patterns and issues. It is both an interpretive and diagnostic tool, providing a simplified representation of pertinent information such as the number of a certain type of trail asset or an asset's current condition. In the Trail Dashboard, trail operators can quickly review and isolate the trail assets most in need of attention (e.g., those rated '4' or '5' on the condition scale).



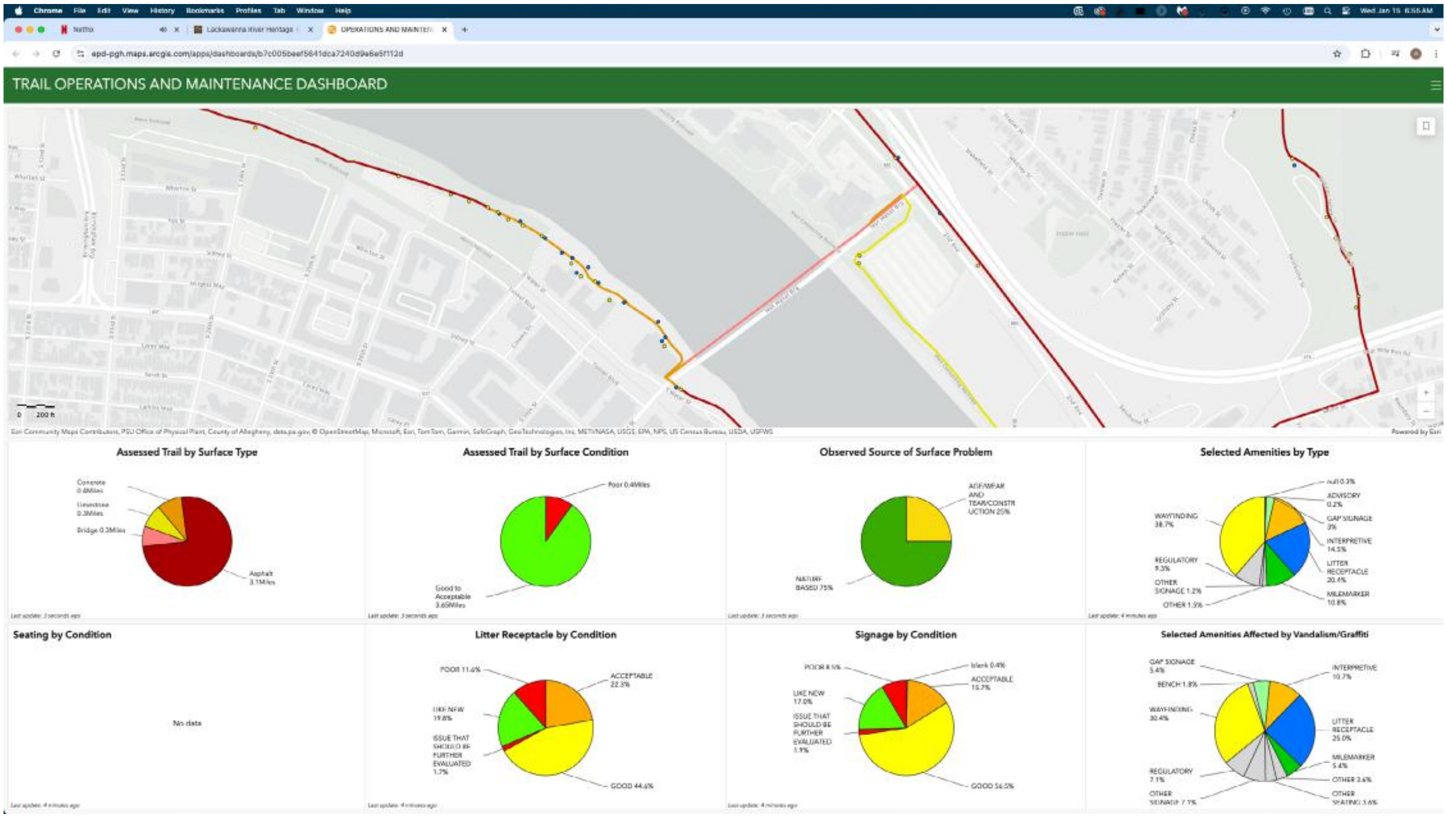


Figure 23 (top)**: Trail Dashboard Organization.** The four components of the Trail Dashboard.

Figure 24 (bottom)**: The Trail Dashboard.** The Trail Dashboard is formatted for viewing and manipulation on a desktop or laptop computer. Use of the Trail Dashboard on a mobile device is not supported.

USER INTERFACE

The Trail Dashboard is a single-screen view of the data collected for a particular trail through the trail assessment process. It's designed for an "at-a-glance" review of the data and minimizes the need for exhaustive manual analysis. There are four main components to the Trail Dashboard:

MAP PANE

The main part of the Trail Dashboard layout is the **Map Pane**, which shows the Trail Webmap and contains zoom and navigation controls. A critical function of the Map Pane is to serve as the "porthole" for the collected data to be viewed and accounted for. This data is then reflected in the **Analysis Graphs**. As the extent of the Trail Webmap shifts or resizes, the underlying datasets and content displayed in the Analysis Graphs adjust accordingly.

LAYER CONTROLS

Embedded in the upper right corner of a Trail Webmap, the **Layer Control** button allows a viewer to display or hide layers with a simple on and off toggle, customizing what trail features are depicted in the Map Pane. This can expand or limit the underlying datasets of the Trail Webmap from being analyzed elsewhere in the Trail Dashboard.

FILTERS

A **Filter** is a tool to categorize, show, and hide the collected data illustrated in the Map Pane, such as a specific type of trail feature with a '4' rating. Filters can be used to hone in on key issue areas within the Trail Webmap and are defined based on the underlying datasets of the Trail Webmap. A set of filters has also been pre-programmed for every trail organization.

ANALYSIS GRAPHS

Analysis Graphs are visual representations of the underlying datasets being depicted in the Map Pane. They include pie charts, bar graphs, and numeric lists that itemize the results of pre-programmed mathematical formulas or operations related to the dataset. Counts, proportions, summations, and averages for specific analysis are most often used. The pre-programmed graphs will automatically update as the Filters and Layer Controls are adjusted and the viewable extent of the Map Pane changes.

SOME TIPS FOR USING THE TRAIL DASHBOARD

Trail operators will find utility in the Trail Dashboard when reviewing the results of a recent trail assessment. The Trail Dashboard enables viewers to mine specific factors and areas of interest from both pre-programmed and collected datasets. This process will identify issues, patterns, and areas of concern.

The Trail Dashboard is also an invaluable tool when determining maintenance priorities. For instance, a viewer can filter a specific trail feature such as an asphalt trail surface and then further filter the features by condition ('1' through '5'). After analyzing the results from the Analysis Graphs, common maintenance actions, material and equipment needs, resources, and deployments of staff or volunteers can be identified to expedite the preparation of work orders or the execution of remedial maintenance tasks.

Finally, the Trail Dashboard and the data gleaned from it can be used as a source of reported on-the-ground conditions to effectively communicate needs for funding pursuits or public outreach efforts. The power of the data collected through the completion of trail assessments can be brought to life and visually shown to decision-makers and funders.

B.5 THE MOBILE APP

FUNCTIONALITY

In addition to the computer-based Trail Webmap and Trail Dashboard, the **Trail Maintenance Toolkit** also relies on the use of a **Mobile App**. The Mobile App uses Esri's Field Maps app (available via the Apple App Store and Google Play Store), which can run on both iPhones and Android devices, including smartphones and tablets.

The Mobile App allows trail assessors to plot points (with map coordinates recorded) on their organization-specific Trail Webmap to document trail assets, rate the assets' conditions, take and save photographs or video content, and attach comments. The trail organization and its various maintenance partners can subsequently prioritize issues and organize resources to address these needs accordingly.

Since many trail sections are located in "dead zones" where neither broadband nor cellular service is reliable or even available, the Mobile App is designed to "cache" or temporarily store any data captured within the mobile device's internal memory. The app will then "push" the data to the cloud server once wi-fi or cellular service is once again available.

The advantage of caching is that the background trail data is stored on the mobile device even without an immediately available internet connection, and the trail assessor can continue performing data collection even if they're in a dead zone. The trade-off is that the opportunity to provide real-time data to staff members back in the office is not immediately available without a live connection.

USER INTERFACE

Once a locational point is captured by the Mobile App, its design allows the trail assessor to navigate through input screens via a series of screen taps.

The following summary of "views" provides a step-by-step run-through of the Mobile App, demonstrating how to record the presence of a specific trail amenity (e.g., a bike rack) at a specific location along a trail. The selection used in the example is highlighted in the screenshots.

◀ **View 1**

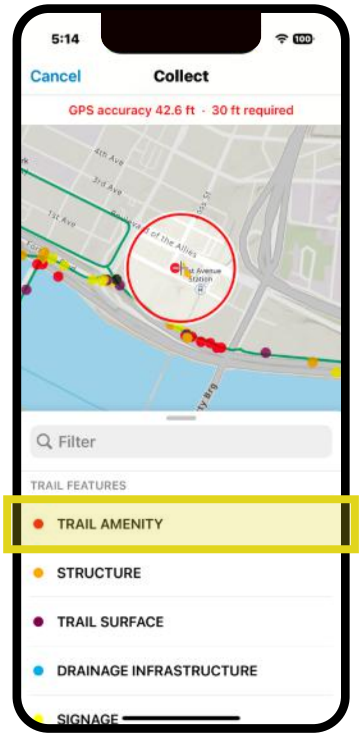
This screenshot depicts the login prompt for ArcGIS Field Maps. Sign in to your **Trail Maintenance Toolkit** account here. If you remain signed in even after closing out of the app, you should only need to select a "home trail" the first time using the app. If inadvertently signed out, just sign in and select your "home trail" again.

Action: Type in the login credentials and select the specific Trail Webmap for your "home trail."

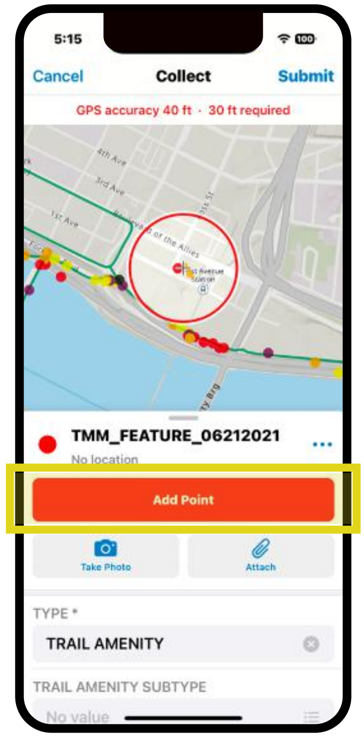
View 2 ▶

The initial view once logged in will show your organization's specific Trail Webmap and the points recorded in any trail assessment to date. You can also record new points on your map here. This is initiated by tapping the blue button with a "+" symbol situated at the lower right corner of the screen.

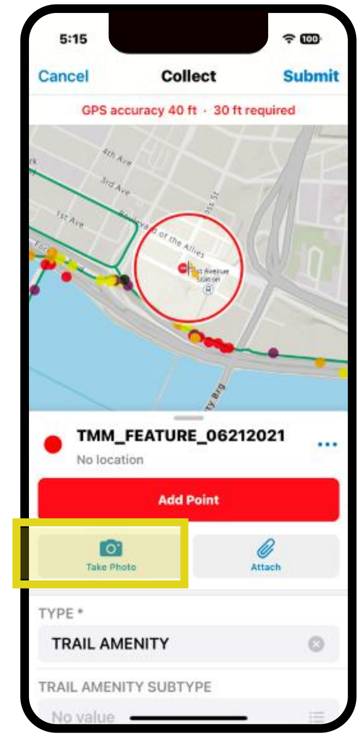
Action: Tap the blue circular button with a "+" symbol.



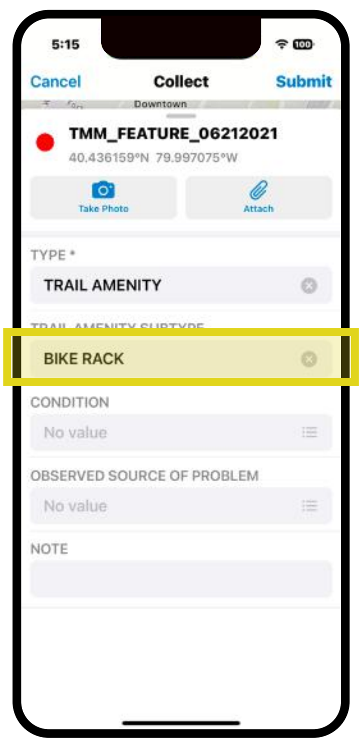
View 3



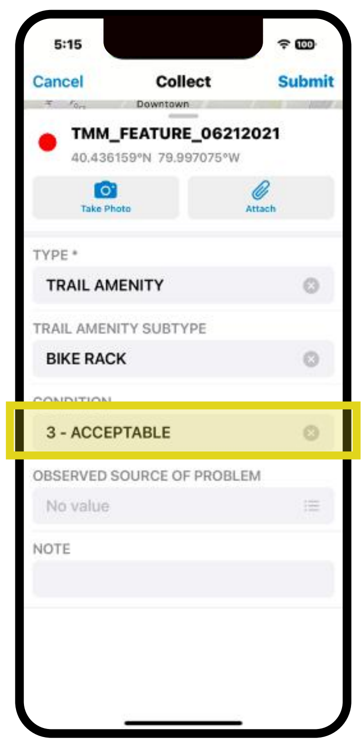
View 4



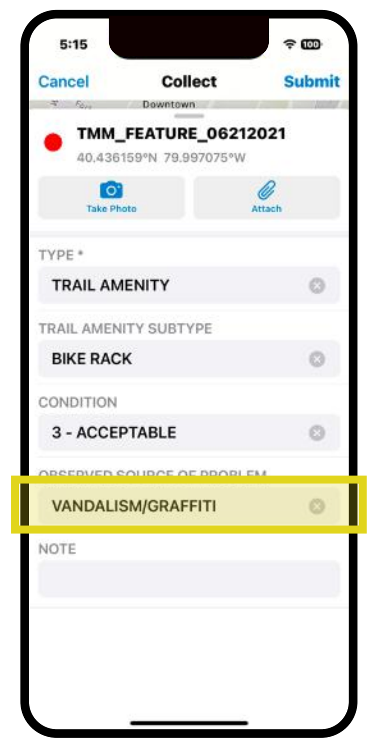
View 5



View 6



View 7



View 8

View 3

The **Collect** tool allows users to place trail features on the Trail Webmap. Tap the appropriate item for the type of trail feature you would like to record on the map. This will reveal a set of trail feature subtypes.

Action: Tap "Trail Amenity" button.

View 4

Once the trail feature type is selected, record the geographic coordinates to the Trail Webmap by selecting the "Add Point" button. Once the operation has been completed, a symbol and a dataset is added to the Trail Webmap. If a point was accidentally recorded or you wish to adjust the location, select the recently added point on the Trail Webmap and then hit "Edit" or "Delete" to modify or remove the recorded point.

Action: Tap "Add Point" button.

View 5

When adding a point to your Trail Webmap, you can also attach a photograph, plan, sketch, or other type of digital file. Note that if a photograph is added to the recorded point, that particular image will not be incorporated into your mobile device's photo album or camera roll. Rather, the image is integrated into the Trail Webmap and stored within the GIS database itself. These images can be separated, exported, and added back into your camera roll through a separate action.

Action: Take a photo and select "Use Photo" or "Retake" as appropriate.

View 6

Select the trail feature subtype. "Bike rack" has been chosen for this example.

Action: Tap "Trail Amenity Subtype."

View 7

Then, select the appropriate condition rating. **Part 3** of this ***Guide*** provides a series of visual examples of '1' through '5' ratings for various trail features.

Action: Tap "Condition."

View 8

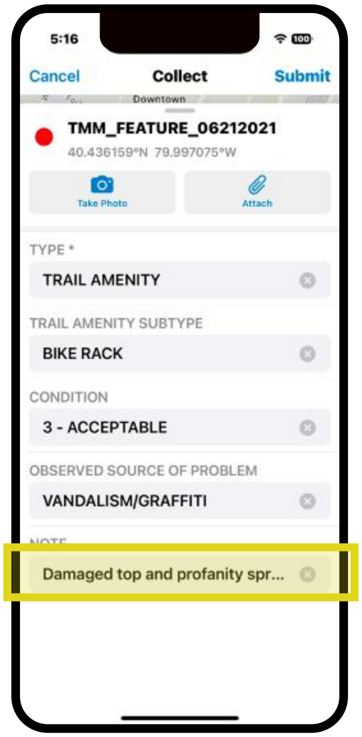
When appropriate, you can record any observed source of a problem or issue related to a recorded trail feature. The selections are pre-programmed to simplify data entry. If you do not feel any of the selections are applicable for this particular recorded point, then select "Other" to add a written note.

Action: Tap "Observed Source of Problem."

View 9

This view depicts the "Note" box where you can type in unique information about the recorded point. Up to 256 characters can be entered into the box. You can also use the Note box to add information or context beyond the general maintenance conditions you have selected. For instance, if you recorded the condition of the bike rack as '4' (Poor) because of vandalism, you could further elaborate in the Note box about the specific part that needs to be repaired or replaced, or to otherwise indicate a priority level beyond the general condition rating.

Action: Type in the note, comment, or message.



View 9

B.6 ASSESSMENTS USING THE TRAIL MAINTENANCE TOOLKIT

Building upon an understanding of the features of the **Trail Maintenance Toolkit**, you are now better prepared to perform a trail assessment. The following discussion goes through the recommended steps to completing a trail assessment using the Mobile App. The process, which is straightforward and fairly linear, is presented in a step-by-step sequential order below. It's a process based on actual testing and use of the Mobile App in the field as well as lessons learned from users.

☐ **Step 1:** Contact PEC representatives to get a Trail Webmap established for your trail.

☐ **Step 2:** Organize a group of trail assessors to train. Assessors should work in groups or teams of three or four. Each team should assign a team leader. Plan for up to four hours to complete the full training battery. This ***Guide*** can be used as the foundation for training the various trail assessment teams, with particular focus on **Part 3** and **Appendix B** (this chapter). A thorough understanding of common trail issues as well as variations in the conditions of various trail features is important and will speed up the performance of the trail assessment.

☐ **Step 3:** Download the Mobile App to the handheld devices that the trail assessors will be using in the field. When PEC initially creates your Trail Webmap, the staff representative will simultaneously activate a Mobile App version for your trail. PEC will generate and distribute a QR code to you, the trail manager, for distribution to your trail assessors. Each trail assessor should use the QR code to connect to your organization's Trail Webmap through the Mobile App. Now they can begin recording data.

☐ **Step 4:** Create a trail assessment work plan based on the teams of trail assessors that have been assembled. The work plan is a strategy for deploying your trail assessors to complete the trail assessment in the most resource-efficient manner possible. It should subdivide your trail corridor into individual sections for assessment. (You can use milemarkers, trailheads, or other similar points to delineate the individual sections you want to assign.) The work plan should consider the number of team members, the general fitness of the assessors, the mode of travel to be used during the assessment (e.g. walking, bicycling, or driving a UTV/ATV), transportation logistics to get your teams to their individual trail sections on their assigned day, the surrounding terrain and weather, the availability of cellular service, and the general character of each trail section. The work plan should ultimately determine how many person-hours will be needed to complete the assessment.

☐ **Step 5:** Perform the trail assessment as per the work plan. If multiple days are expected, the assessment team leaders should debrief with the trail manager at the end of each day and discuss any procedures or approaches that could be modified to improve accuracy, completeness, or speed. If offline maps were used as part of the trail assessments, the collected data should be "synced" with the Trail Webmap each day once internet service is regained. If additional data collection is expected the next day, this is especially important to complete before going out in the field again, to make sure that the data from the first day is appropriately saved.

☐ **Step 6:** The trail manager should carefully review the data collected to date and determine if the Trail Webmap is being populated correctly. If issues, discrepancies, duplicates, or gaps appear on the Trail Webmap, the trail manager may need to facilitate a discussion with the assessment team leaders to correct or adjust the input.

☐ **Step 7:** Once the trail assessment is complete and the Trail Webmap has been populated, the trail manager can review and evaluate the Trail Dashboard for patterns and findings.

B.7 IMPORTANT TIPS FOR COMPLETING A TRAIL ASSESSMENT

The following tips provide additional guidance on performing a trail assessment using the **Trail Maintenance Toolkit** and the work plan you developed in **Part B.6**:

Tip #1 Each member of a trail assessment team should be assigned a set of trail features to largely focus on within their trail section geography. Assessors should then record the locations and conditions of their assigned features over the length of their teams' trail sections. For instance, one person of the assessment team may be responsible for recording trail surface conditions, while another team member is responsible for recording the location and conditions of drainage improvements. This type of "specialized" approach is more time-efficient and will produce more uniform, consistent data.

Tip #2 Anticipate additional time to record conditions at or near trailheads. Many trails have intense concentrations of amenities, surface materials, and signs in the vicinity of trailheads. The more in an area to assess, the more time is needed to focus in that area.

Tip #3 When evaluating hard (paved) trail surfaces such as asphalt or concrete, expect the trail assessor assigned with the responsibility to record *trail surface conditions* to work at a slower-than-average pace. With crushed gravel trail surfaces, on the other hand, expect the assessor responsible for recording *drainage improvements and conditions* to be the slower worker.

Tip #4 Initially assume that a three-person assessment team can cover 8 to 10 miles per 6 to 8-hour assessment period. As the assessment team becomes more experienced with using the Mobile App and better at anticipating what they are looking for, you may be able to improve coverage to 12 to 15 miles per assessment day.

Tip #5 Don't overestimate your chances of having reliable cellular service. If there is any doubt or even uncertainty over the strength of the signal, use the available offline maps to complete the trail assessment. Trail assessors who gamble on their connectivity may end up having to redo portions of their assessment.

Tip #6 An unlimited number of photographs or videos can be attached to a recorded point. Don't be afraid to add multiple images of a problem or issue. The photographs attached to the recorded point are extremely useful when reviewing the trail assessment results on a computer back at the office. To reduce the number of points on your Webmap, you might choose to take more photos of just one point, even if the locations of the photos are not all in the same precise location.

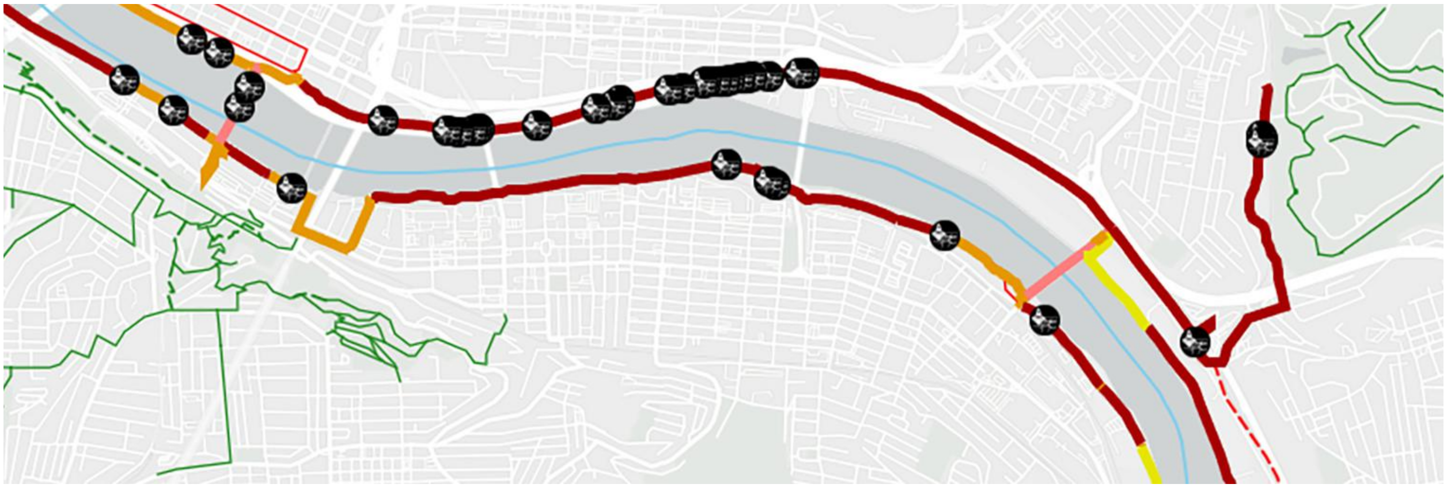


Figure 25: The Trail Maintenance Toolkit accurately displays not only the alignment of a trail segment but also the geographic location and conditions of individual assets and amenities. Other information such as the surface material of an individual trail section is also provided.

APPENDIX C: INDEX OF FIGURES

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APPENDIX D: LIST OF REFERENCES

1. Bachensky, Lois. “Maintenance Management Systems for Trails.” *American Trails*, 19 Feb. 2020, www.americantrails.org/resources/maintenance-management-systems-for-trails.

2. Bachensky, Lois. “What You Need to Know About Building Trails with Crusher Fines.” *American Trails*, 20 Aug. 2019, www.americantrails.org/resources/building-crusher-fines-trails.

3. *Best Management Practices For Erosion Control During Trail Maintenance and Construction*. State of New Hampshire, Department of Resources and Economic Development, Division of Parks and Recreation, Bureau of Trails, 2004, cdn2.assets-servd.host/material-civet/production/images/documents/BMPmanual2004.pdf.

4. *Best Management Practices For Erosion Control During Trail Maintenance and Construction: NH Trail Construction and Maintenance Manual*. State of New Hampshire, Department of Resources and Economic Development, Division of Parks and Recreation, Bureau of Trails, 2017, www.nhstateparks.org/getmedia/3c45de00-e174-4df0-b678-4670b254290d/Best-Management-Practices-For-Erosion-Control-During-Trail-Maintenance-and-Construction.pdf.

5. Bloser, Steve, et al. *Environmentally Sensitive Road Maintenance Practices for Dirt and Gravel Roads*. U.S. Department of Agriculture, Forest Service, 2012, dirtandgravel.psu.edu/wp-content/uploads/ESM_Field_Guide.pdf.

6. Boone, Tony. “The Art of Building Crushed Stone Trails.” *American Trails*, 3 May 2018, www.americantrails.org/resources/the-art-of-building-crushed-stone-trails.

7. Bruggemann, Jonas, and Bill Glezentanner. “Sustainable Trails: Pathways to Nature.” Massachusetts Land Conservation Conference, 28 Mar. 2020, Worcester Technical High School, Worcester, MA. massland.org/sites/default/files/files/apr_27_sustainable_trails.pdf.

8. Brunswick, Nancy, et al. *Sustainable Recreation Site Design Guide*. U.S. Department of Agriculture, Forest Service, 2024, cdn2.assets-servd.host/material-civet/production/images/documents/Sustainable-Rec-Site-Design-Guide-2024.pdf.

9. Camp, Amy. *Deciding on Trails: 7 Practices of Healthy Trail Towns*. Plug & Play Publishing, 2020.

10. *Common Maintenance Problems in Pavements – Causes and Treatments*. Louisiana Transportation Research Center, www.ltrc.lsu.edu/ltap/pdf/pavement_repair_handout.pdf.

11. “Concrete Slab Surface Defects: Causes, Prevention, Repair.” *Concrete Information*, Portland Cement Association, 2001, www.concreteisbetter.com/wp-content/uploads/2013/06/Slab-Surface-Prevention-Repair-a.pdf.

12. Crosby, Stewart. "Maintenance of Recreational Trails." 2019 Minnesota Chapter of the American Public Works Association (APWA-MN) Fall Conference, 20 Nov. 2019, Earle Brown Heritage Center, Brooklyn Center, MN. www.apwa-mn.org/userfiles/ckfiles/files/Trail%20Maintenance%20Best%20Practices(1).pdf.

13. *Culvert Identification Field Guide*. North Carolina Department of Transportation, Hydraulics Unit, 2021, connect.ncdot.gov/resources/hydro/DrainageStudiesGuidelines/Culvert_Identification_Field_Guide.pdf.

14. "FAQ: Tips and Techniques for using Crusher fines surfacing for trails." *American Trails*, 21 Mar. 2019, www.americantrails.org/resources/faq-tips-and-techniques-for-using-crusher-fines-surfacing-for-trails.

15. *Gravel Roads Construction & Maintenance Guide*. U.S. Department of Transportation, Federal Highway Administration, 2015, www.fhwa.dot.gov/construction/pubs/ots15002.pdf.

16. Groenier, James, et al. *A Guide to Fiber-Reinforced Polymer Trail Bridges*. U.S. Department of Agriculture, Forest Service, July 2006, www.fs.usda.gov/t-d/pubs/htmlpubs/htm06232824/index.htm.

17. Gross, Jerod, and Rich Voelker. *Guide to Concrete Trails*. National Concrete Pavement Technology Center, Iowa State University, 2019, www.intrans.iastate.edu/wp-content/uploads/2019/08/concrete_trails_guide.pdf.

18. Hansen, Derek, and Colby Fangman. CDM Multi-Use Trails – Systemic Condition Analysis & Management. American Trails, 08 Feb. 2024, cdn2.assets-servd.host/material-civet/production/images/20240208-American-Trails-Webinar-City-of-Des-Moines-Final.pdf.

19. Harrington, Dale. "Concrete Distress – Assessments and Solutions." 2017 Municipal Streets Seminar, 15 Nov. 2017, Scheman Building, Iowa State University, Ames, IA. cdn-wordpress.webspec.cloud/intrans.iastate.edu/uploads/sites/7/2018/08/5Concrete-Distress_Harrington.pdf.

20. Hesselbarth, Woody, et al. *Trail Construction and Maintenance Notebook*. U.S. Department of Agriculture, Forest Service, July 2007, www.fs.usda.gov/t-d/pubs/htmlpubs/htm07232806/index.htm.

21. International Mountain Biking Association (IMBA). *Trail Solutions: IMBA's Guide to Building Sweet Singletrack*. Johnson Printing, 2004.

22. Knoch, Carl, and Tom Sexton. *Maintenance Practices and Costs of Rail-Trails*. Rails-to-Trails Conservancy, 2015, www.railstotrails.org/wp-content/uploads/2024/01/Maintenance-Practices-and-Costs-of-Rail-Trails.pdf.

23. *Lamoille Valley Rail Trail Management Plan*. Vermont Agency of Transportation, 2022, railtrails.vermont.gov/wp-content/uploads/2023/05/LVRT-Management-Plan-FINAL-2022.10.20-wAppendix.pdf.

24. *Lamoille Valley Rail Trail Trailside Facility Design Guidelines*. Vermont Agency of Transportation, 2023, railtrails.vermont.gov/wp-content/uploads/2023/05/2023-05-04-58600.06-LVRT-Design-Guide-FINAL-LowRes-v2.pdf.

25. "Maintaining Asphalt Paths." *Productive Parks*, 23 June 2023, www.railstotrails.org/trail-building-toolbox/maintenance-basics/.

26. "Maintenance Basics." *Rails to Trails Conservancy*, www.railstotrails.org/trail-building-toolbox/maintenance-basics/.

27. *Manage a Trail*. West Virginia Rails-to-Trails Council, wvrailtrails.org/manage/.

28. *Mn/DOT Pavement Distress Identification Manual*. Minnesota Department of Transportation, Office of Materials and Road Research, Pavement Management Unit, 2011, www.dot.state.mn.us/materials/manuals/pvmtmgmt/Distress_Manual_2011V_edited_2-3-2021.pdf.

29. Nagakyrie, Syren. "Trail Surface Types: Pros and Cons for Accessibility." *Disabled Hikers*, 15 Mar. 2023, www.disabledhikers.com/2022/01/18/accessible-trail-surface-types/.

30. *Naugatuck River Greenway Trail Operations, Management, and Maintenance Guide*. Naugatuck Valley Council of Governments, 2022, nvcogct.gov/wp-content/uploads/2022/07/NRG-D_M-Guide_FinalDraft.pdf.

31. Palmer, Bill. "Concrete Repair - The Best Products & Methods." *ConcreteNetwork.com*, 25 Sept. 2020, www.concretenetwork.com/concrete-repair/.

32. Parker, Troy Scott. *Trails Design and Management Handbook: Open Space and Trails Program, Pitkin County, Colorado*. Natureshape, 2007.

33. Pennsylvania Trail Design & Development Principles: Guidelines for Sustainable, Non-motorized Trails. Pennsylvania Department of Conservation and Natural Resources, 2013, cdn2.assets-servd.host/material-civet/production/images/documents/Pennsylvania_Trail_Design_and_Development_Principles.pdf.

34. *Pennsylvania Yearly Routine Rail-Trail Maintenance Costs Per Mile*. Rails-to-Trails Conservancy, 2022, weconservepa.org/wp-content/uploads/2022/10/TrailMaint2022_RailsToTrails-All-PA-Trails-Info.pdf.

35. Poole, Tim. *Rail-Trail Maintenance and Operations*. Rails-to-Trails Conservancy Northeast Regional Office, 2005, cdn2.assets-servd.host/material-civet/production/images/documents/railtrailmaint.pdf.

36. *Reference Desk*. Pavement Interactive, pavementinteractive.org/reference-desk/.

37. Saitta, Steve, and Mike Snyder. "Choosing the Right Trail Surface." *Parks and Recreation - City of Columbia Missouri*, 2021, www.como.gov/wp-content/uploads/2021/02/choosing-trail-surface-presentation.pdf.

38. Searns, Robert. "Operations, Maintenance, and Stewardship 101." *American Trails*, 5 Feb. 2018, www.americantrails.org/resources/operations-maintenance-and-stewardship-101.

39. "Shared Use Path Design." *Design Manual*, Iowa Department of Transportation, 2023, www.iowadot.gov/design/dmanual/12b-02.pdf.

40. "Shared Use Paths." *Maryland SHA Bicycle and Pedestrian Design Guidelines*, Maryland State Highway Administration, 2005, www.roads.maryland.gov/oots/Chapter%206%20-%20Shared%20Use%20Paths.pdf.

41. Sleep, Matthew D., and Damian K. Matzen. ADA Accessible Trail Improvement with Naturally Occurring, Sustainable Materials. National Institute for Transportation and Communities, 2020, cdn2.assets-servd.host/material-civet/production/images/documents/dot_54564_DS1.pdf.

42. "Trail Design Concepts." *The 2011 Eastern Continental Divide Loop Trail Master Plan*, Garrett Trails, 2011, www.larsondesigngroup.com/wp-content/uploads/2016/06/GarrettTrails.pdf.

43. *Trail Design Guidelines*. Sullivan O&W Rail Trail, 2019, sullivanoandw.com/wp-content/uploads/2020/09/Sullivan_06_Trail-Design-Guidelines__20200228.pdf.

44. *Technical Bulletin: Crown & Cross-Slope*. The Pennsylvania State University, Center for Dirt and Gravel Road Studies, 2019, dirtandgravel.psu.edu/wp-content/uploads/2022/06/TB_Crown_and_Cross_Slope.pdf.

45. *Technical Bulletin: Raising the Road Profile*. The Pennsylvania State University, Center for Dirt and Gravel Road Studies, 2019, dirtandgravel.psu.edu/wp-content/uploads/2022/06/TB_Raising_Road_Profile.pdf.

46. *Technical Bulletin: Underdrains*. The Pennsylvania State University, Center for Dirt and Gravel Road Studies, 2019, dirtandgravel.psu.edu/wp-content/uploads/2022/06/TB_Underdrains.pdf.

47. West, Eric. "Building Better Asphalt Trails." *American Trails*, 23 May 2018, www.americantrails.org/resources/building-better-asphalt-trails.

48. Wood, Thomas, et al. *Preventive Maintenance for Recreational Trails*. Minnesota Department of Transportation, Research Services Section, 2009, mdl.mndot.gov/_flysystem/fedora/2023-01/200925.pdf.

49. *Yearly Routine Rail-Trail Maintenance Costs Per Mile*. Rails-to-Trails Conservancy, 2022, www.railstotrails.org/wp-content/uploads/2024/02/Routine-Trail-Maintenance-Costs-Per-Mile.pdf.

50. Zeller, Janet, et al. *Accessibility Guidebook for Outdoor Recreation and Trails*. U.S. Department of Agriculture, Forest Service, Technology & Development Program, Aug. 2012, www.fs.usda.gov/recreation/programs/accessibility/pubs/htmlpubs/htm12232806/index.htm.

APPENDIX E: EXAMPLE TRAIL MAINTENANCE SCHEDULE

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TRAIL MAINTENANCE SCHEDULE (ASPHALT TRAIL)

Maintenance Activity	Optimal Frequency							Notes
	Weekly	Monthly	Quarterly	Annually	Spring/Fall	After Storm	Other	
General								
1 Safety inspection								
2 General debris and trash pickup								
3 Vandalism inspection								
4 Encroachments							Ongoing	
Pavement								
1 Pavement survey					X			Conduct Spring and Fall surveys
2 Crack sealing							Reactionary	
3 Patching							As needed	
4 Fog seal							As needed	Lifespan approximately 4-6 years
5 Sealcoat							As needed	Lifespan approximately 6-10 years
6 Slurry seal							As needed	Lifespan approximately 8-10 years
7 Overlay							As needed	Lifespan approximately 15 years
8 Reconstruct							As needed	
9 Inspect pavement markings								
10 Repaint pavement markings							As needed	
Vegetation								
1 Mowing - clear zones, trailhead areas								
2 Brush trimming/overhead trimming								Spring activity
3 Clear zone weed control							As needed	Noxious weed spraying/ removal
4 Sight line trimming at intersections								Roads, other trails, driveways, etc.
5 Tree removal							As needed	Storm cleanup
6 Rain garden maintenance								
7 Trail sweeping/blowing							As needed	Up to weekly frequency in Fall
8 Seeding								Spring activity
9 Root cutting							As needed	Monitor root activity along trail
Drainage								
1 Erosion repair								After spring snowmelt, storm cleanup
2 Culvert/catch basin clearing								Storm cleanup
3 Ditch maintenance (clear of debris, trash, branches)								Spring activity
4 Standing water repair								

(Content source: Minnesota Local Road Research Board [LRRB].)

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