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Guidelines and Best Practices for Planning, Design and Development of Summer Off-Highway Vehicle Trails



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Preface

There has been considerable work done throughout North America to better understand and describe sustainable management practices for recreation trail construction and in particular trail design and construction for off-highway vehicles. There is a wide body of literature, numerous publications and manuals describing trail planning, design, construction and maintenance techniques. Appropriate and effective trail construction and management depends on an interaction of many local social as well as bio-physical site specific and geographic factors. This document attempts to capture and communicate the broad range of widely applicable practices that can be used in combination with more detailed knowledge and information specific to certain geographic areas, within the varying bio-physical landscapes of British Columbia.

This document draws from a number of resources, most notably California State Park's *2008 Soil Conservation Standard and Guidelines* as well as the International Mountain Bike Associations' *Trail Solutions: IMBA's Guide to Building Sweet Single Track* and is in no way an exhaustive summary of the extensive topic of sustainable trail development and management. For additional information a comprehensive list of resources is included in the Additional Information Sources section of this document.

Introduction

British Columbia has a vast land base of over 95 million hectares with 95% of those lands being public. This vast land base supports diverse ecosystems, unique and varied environments and holds great resource values for British Columbians. These public lands are managed to support multiple uses both economic and cultural, within a framework of environmental stewardship.

Recreation use in British Columbia is growing both in the number of users and the way users are recreating. Recently, growing numbers of British Columbians and visitors are using motorized off-highway vehicles (OHV's) to explore and recreate throughout the Province. Much of this recreation occurs on an extensive network of built resource roads; yet there is a growing appetite for off-highway, trail based motorized recreation experiences throughout the Province.

The impact of trails on the surrounding environment often varies according to the type of use, in addition to other factors. Not surprisingly, the potential for damage to the environment is typically greater with motorized vehicles than some non-motorized activities. Yet it has been shown throughout North America that trails properly planned, designed, constructed and maintained for OHV's can be managed to have minimal environmental impact. Further, appropriately constructed trail networks that satisfy the needs of OHV riders, limit the development of poorly constructed damaging trails in other locations.

Trails can impact the environment and other resource values in a number of ways, yet the most significant and common impacts result from trail degradation and soil erosion leading to sedimentation. Due to the nature, extent and connectivity of water courses across the landscape, particularly in British Columbia, impacts from inappropriately located, poorly constructed, or insufficiently maintained trails can unduly impact the immediate environment as well the aquatic environment at much greater distances.

This document provides land managers, trail stewards and OHV trail builders with guidelines and recommended practices that when utilized, provide a starting point for the design and construction of sustainable trails. Used in combination with gained experience, professional expertise and knowledge of local conditions, they will contribute to the longevity and viability of great trails and trail networks in British Columbia.

Scope

These Guidelines and Best Practices focus on the technical aspects of planning, design, development, construction, maintenance, rehabilitation and monitoring for recreation trails for off-highway vehicles.

It is recognized that comprehensive management of OHV riding opportunities and areas includes much more than the technical trail related aspects. For instance use management including educating users, modifying undesirable behaviours, resolving conflict and ensuring compliance requires considerable effort and expertise; however those important aspects of recreation management are not included in this discussion. Resources related to those topics are listed in the Additional Information Sources section at the end of this document.

Applicable Legislation, Regulations and Standards

British Columbia and Canada have a number of acts, regulations, policies and standards to ensure management and protection of the environment and water courses, water quality and other environmental values. Specific legislative and regulatory requirements that OHV trail builders and planner should be aware of in British Columbia include:

Water Act

The [Water Act](#) is the main provincial statute regulating water resources in British Columbia. Under the Act, it is an offence to divert or use water, or alter a stream, without formal approval from the Province.

Section 9 of the *Water Act* regulates changes in or about a stream. Under this section, the *Water Act Regulation* ensures that water quality, riparian habitat, and the rights of water users are not compromised. If your work involves making a change in and about a stream, work cannot proceed unless it is:

- Compliant with the requirements of the *Water Act*, and
- Authorized by an approval, license or order under Section 9 of the *Water Act*, or
- Authorized through a Notification as permitted by Part 7 of the *Water Act Regulation*.

Note: Instream works conducted under the authority of the *Forest and Range Practices Act* (FRPA) or a regulation made under FRPA, do not require *Water Act* referral or notification. Guidance for working in and about water in compliance with FRPA is provided in the [Fish Stream Crossing Guidebook](#), [Riparian Management Area Guidebook](#) and [other guidebooks](#).

For additional information on the *Water Act* and Best Practices for instream works see the BC Ministry of Water, Land and Air Protection's [Standards and Best Practices for Instream Works](#).

Forest and Range Practices Act

The [*Forest and Range Practices Act*](#) (FRPA) and its regulations govern the activities of forest and range licensees in B.C. The statute sets the requirements for planning, road building, logging, reforestation, grazing, recreation and other resource values.

FRPA also contains provisions for management of public recreation resources on Crown land. Under Section 57 of the Act, authorization is required to construct, maintain or rehabilitate trails on Crown land. Failure to obtain authorization for trail construction may result in an offense under the Act and a fine up to \$5,000.

Under the Act, authorization is not required for marking a route with ribbons, cairns or other directional indicators, or minor clearing of brush, downed trees or repairs to a trail. For additional information on trail authorization requirements under the Act, visit the [Recreation Sites and Trails BC](#) website.

Section 46 of the *Forest and Range Practices Act* prohibits a person from carrying out any activity that results in damage to the environment. Known as ‘mud-bogging’ legislation, a primary intent of the section is to protect sensitive environments from damage caused by irresponsible use of off-highway vehicles.

Wildlife Act

The provincial [*Wildlife Act*](#) protects wildlife and wildlife habitat in British Columbia.

Drinking Water Protection Act

The [*Drinking Water Protection Act*](#) and the [*Drinking Water Protection Regulation*](#) sets out certain requirements for drinking water operators to ensure the provision of safe drinking water to their customers.

Fisheries Act

The *Fisheries Act* is the federal legislation affecting all fish, fish habitat and water quality. Any activities that has the potential to deposit a ‘deleterious substance” or if you are seeking a permit to destroy or alter fish habitat, the *Fisheries Act* is invoked.

he Act is administered federally by the Fisheries and Oceans Canada (DFO) and provincially by Ministry of Forests, Lands and Natural Resource Operations. Contact DFO to determine if proposed works require you to inform DFO or acquire Section 35(2) approval under the Act.

Trails, Soil Erosion, Sedimentation and Water Quality

Erosion is the wearing away of rock or soil by the detachment of soil or rock fragments by water, wind, ice and other mechanical and chemical forces. Erosion is the greatest threat to long-term sustainability of recreation trails and therefore minimizing erosion is the trail builder's single most important task. Erosion of soils on a trail or increased erosion of surrounding soils resulting from poor trail drainage typically leads to sedimentation - the process by which soils, debris and other materials are deposited either on land or in water.

Sedimentation decreases water quality. Decreased water quality is harmful to aquatic ecosystems as well as water supplies for domestic consumption.

Reducing the potential for trail erosion is a multi-phased process. Steps must be taken in the assessment, planning, implementation, construction, maintenance and monitoring phases of trail management to ensure erosion is minimized. Well planned trails incorporate erosion minimizing techniques into the initial construction, thereby reducing the long term maintenance requirement and thereby increasing the sustainability of the trail.

"Erosion of the trail tread is a function of the mechanical energy of the vehicle, the drainage controls on the trail and surrounding area, and the nature of the underlying soil. Therefore, with proper planning, design, construction and maintenance a trail can perform well (exhibit little erosion) in an area that is naturally more sensitive to erosion; while a poorly planned, designed, constructed, or maintained trail may erode in an area that is not naturally prone to erosion."

*2008 Soil Conservation Standards and Guidelines for OHV
California State Parks*

Guidelines and Best Practices

Best practices are recommended techniques that have been demonstrated to be an effective and practical means of preventing or limiting the likelihood of soil erosion, trail degradation, sedimentation and other harmful impacts to resources.

Best practices presented in this document provide a starting point for ensuring trail design, development and management activities are planned and completed in a manner that seeks to minimize environmental impacts. This is not an exhaustive list of practices but rather provides initial direction and points to more comprehensive sources of information to guide trail development activities. New techniques and practices are constantly being developed; as well advice from qualified professionals may provide you with additional means of ensuring your works minimize risks to the environment and meet existing regulations, legislations and standards.

Objectives

- To provide guidance for trail planners and developers that will assist them in the design, development and construction of sustainable off-highway vehicle trails for long-term use that does not adversely impact natural and cultural resources and not cause undue erosion or sedimentation.
- To provide guidance for trail planners and developers that will assist them in developing trail projects at the outset to minimize erosion, sedimentation and resulting water degradation prior to the initiation of construction and maintenance activities.

Guiding Principles

- OHV trails shall be managed for sustainable long-term use without causing adverse affects to other resource values beyond the trails themselves.
- OHV trails shall be developed, managed and maintained for sustainable long-term use without causing erosion or sedimentation which compromises water quality or other resource values beyond the trails themselves.
- When areas or trails or portions of trails cannot be maintained to appropriate established standards for the sustained long-term use, they should be closed to use and repaired, to prevent accelerated erosion. If areas cannot be repaired to acceptable condition, they will be permanently closed and restored.

Trail Location and Site Assessment Best Practices

Proper assessment of area conditions prior to OHV project design and implementation affords the opportunity to design the project with sensitivity toward the long-term sustainability of the trail network. This section outlines general and specific considerations that should be made during the planning and design phase of OHV trail or network area construction.

Numerous design features and structures discussed in this document are intended to remove water from the trail. While drainage structures are an important tool used to reduce trail erosion, proper trail location is often the most important and effective method for managing and minimizing erosion. A properly located trail will reduce the number of drainage structures required, minimize the amount of soil disturbance required and lower long term maintenance costs, all contributing to the sustainability of the trail. The most effective method for managing drainage is to locate the trail in the best possible location during the planning and design phase.

General Assessment Considerations

Existing land use direction

Prior to considering the design and development of OHV specific recreation trails, consideration must be given to existing land use direction that may be relevant to the area. Relevant land use plans may range from broad government policy and

direction through Land and Resource Management Plans (LRMP's) to operational resource planning such as forest stewardship plans.

Trail planners should consult with land managers from various provincial and local agencies to determine what land use planning has been completed and how to ensure trail development remains consistent with direction and objectives within those plans.

Trail user types /vehicle types, anticipated skill levels

OHV trail planners and developers should have basic knowledge and understanding about the anticipated users of an OHV trail or network. Impacts to trails and the surrounding environment will likely vary depending on the type of users (dirtbikes or ATV's) and the skill sets of the users. If trails are designed for novice to intermediate riders but the area is used by expert riders, user created inappropriately located trails will be constructed. Providing adequate opportunities for the various user groups avoids unintended impacts from inappropriate use types on specifically designed trails. For example, if wider ATV trails are not available in an area frequented by ATV riders, narrow single track dirt bike trails may be impacted and thus widened by ATV riders, leading to erosion and trail degradation.

Anticipated numbers of users

Trails with greater numbers of users require increased maintenance over time. Consideration of user numbers in the design and planning phase is the most effective way of reducing long term maintenance. Trails with anticipated high number of users can be surfaced and hardened with natural or manufactured products (geoweb, geotextiles, blocking, hardening additives etc.) to withstand heavier use.

A trails relative location within a trail network will also determine the amount of use. Main 'connector' and arterial trails will see increase use and should be considered for increased erosion protection measures.

Sensitive areas including grasslands alpine areas and wetlands

Sensitive areas including grasslands, alpine areas and wetlands are highly susceptible to environmental damage and are slow to recover. In British Columbia, various legislation and regulations limit access to sensitive areas and prohibit damage to sensitive environments. When considering areas for OHV trails, planners and managers must consider proximity to sensitive environments, implications for increasing access to sensitive environments as well as mitigative measures where use may occur in those environments.

Information from a variety of sources is available and should be consulted by trail planners and developers including:

- British Columbia's *Wildlife Guidelines for Backcountry Tourism/ Commercial Recreation in British Columbia*

- BC and the Grasslands Conservation Council of British Columbia's *Best Management Practices for Recreational Activities on Grasslands in the Thompson and Okanagan Basins*
- North American Wetlands Conservation Council (Canada): Wetland Evaluation Guide

Community Watersheds

In a community watershed in British Columbia, the water source is from a stream where the water is used for human consumption, the stream is licensed under the *Water Act* for a domestic purpose controlled by a water user's community and the drainage area is not greater than 500 km².

Most of the population of British Columbia derives its drinking water from surface water from small and medium sized streams. In community watersheds, protection of water quality is of paramount importance. The [*Drinking Water Protection Act*](#) sets out certain requirements for drinking water operators to ensure the provision of safe drinking water to their customers.

Recreation trails, developed and managed within community watersheds must be carefully designed and maintained to ensure protection of water quality. Consideration must be given to measures to negate sedimentation from trail erosion as well as limit human contributions to pathogens such as *e. Coli* in the water. Prior to considering trails within community watersheds, trail planners and developers must consult with local communities, water purveyors, and provincial water authorities to ensure comprehensive planning can be undertaken and sustainable trail development will reduce rather than increase potential for impacts to water quality.

Other rights holders and users

The public land base in British Columbia is managed for multiple uses in an integrated management framework. Increasing uses of the land in concentrated areas, means trails and recreation users are likely to interact with other stakeholders, rights holders and users of the land.

In British Columbia, the recreation provisions of the *Forest and Range Practices Act* provide a mechanism for ensuring trails construction, rehabilitation and maintenance and management is carried out in a manner that respects the interests of other parties and resource users and is consistent with legal requirements and broad government objectives. Construction, maintenance and rehabilitation of trails must be authorized under Section 57 of the *Act*. Managed trails are established under Section 56 of the *Act* and managed according to an integrated management framework. Prior to undertaking the design, development or maintenance of recreation trails, OHV trail developers must ensure appropriate authorizations are in place and they are working with the responsible land managers.

Various guidelines and documents are available to assist trail developers work with other interests including:

- BC Ministry of Agriculture and [Land's A Guide to Using and Developing Trails in Farm and Ranch Areas.](#)
- Draft [Trails Strategy for British Columbia](#)

Specific Assessment Considerations

Topographic information

Sustainable trails should be planned and constructed to minimize soil disturbance. Trails traversing steep slopes require greater cut slopes and greater potential for bank failure. Increased volumes of displaced soil are more likely to cause sedimentation. Conversely, trails built on flat or low lying areas tend to become catch basins for water and provide little opportunity for dispersement of water off the trail. Ideally trails are located on appropriate slopes with acceptable grades, utilize natural terrain and features to provide adequate grade reversals and avoid areas of sensitivity or high risk such as landslides or highly erodible slopes.

When planning trail alignment, landscape features to avoid include:

- Unstable and highly erosive soils
- Valley and hill slope bottoms, low lying flat areas.
- Rock, land, or snow slide areas
- Alpine areas
- Major abrupt changes in elevation
- Areas that will require extensive use of switchbacks

Climate

Consideration should be given to annual rainfall, annual snowpack, snowmelt and freshet timing. Heavy rainfall and snowmelt events will contribute to erosion and trail degradation. Consideration should be given to timing of trail construction, maintenance and monitoring activities relative to periods of significant soil saturation. Heavy precipitation may saturate hillsides or overwhelm drainage structures. Trail monitoring should be scheduled to coincide with heavy flow periods.

Soils and Geology

Soil types and conditions are often the most important factor in determining the potential for trail erosion and degradation. The composition of the soil will determine how well the soil will compact, how well it drains and how well it withstands erosion. The composition of soil is determined by the composition of the underlying rock. An understanding of underlying geology and soil types is

important during the planning and design phase to properly assess the best trail alignment, taking advantage of soil and rock formations as well as appropriately planning for water management based on the unique soil properties.

Soil conditions can vary widely and often vary along the length of a single trail. Soil type is largely characterized by texture, which is in turn characterized by the size of soil particles. There are three basic types of particles, sand, silt and clay. The varying particle sizes affect physical properties of the soil including the ability of the soil to drain, compact and thereby withstand erosion.

Sand is the largest particle size, drains well but is the least cohesive (does not bind) of the three types. Silt has moderate draining properties, binds better than sand but does not bind well when very wet. Clay, with very small particles and small pore spaces between particles absorbs large amounts of water and does not drain well. Clay particles do stick together when the soil is dry, making it very hard and durable.

Loam is a mix of different types of soil with none of them dominating the mix. Loam is the ideal trail building material. However, since most trail projects are faced with utilizing existing soil conditions the most important consideration is often understanding your local soil properties and properly assessing the construction methods, techniques and frequency of required water diversion features required to construct a sustainable trail based on existing soil types.

Information on local geology and soil types is available from a wide variety of sources and by consulting local geotechnical and engineering professionals.

Vegetation

Vegetation provides the most cost effective method for reducing erosion and potential for sedimentation to watercourses from recreation trails. Native vegetation increases water absorption, reducing the potential volume of water being intersected by trails. As well, vegetation provides a highly effective buffer between potential sources of sediment (trails) and water courses.

A primary objective of any trail construction or maintenance project is to conserve the maximum amount of vegetation. Tread and overhead clearing specifications should be sufficient for the anticipated use types without extending beyond required widths. Table 1. provides recommended tread clearing widths for trails based on various OHV user types.

Table 1. Recommended tread width based on use type

Use Type	Tread Width (cm)
Motorcycle-novice	60-75
Motorcycle – intermediate	45-60
Motorcycle-most difficult	30-45

ATV-novice	180-210
ATV – intermediate	150-185
ATV-most difficult	120-155

Trail planners and developers must ensure they do not impact plant species determined to be at risk or endangered. Trail planners should be familiar with local 'blue and red listed plant species' in their area. For further information about species at risk visit the B.C. Ministry of Environment, [Endangered Species and Ecosystems Website](#).

Native vegetation and ecosystems are vulnerable to invasive plant species. Invasive plants are often transported by recreation trail users and establish in areas of exposed soils. Trail construction activities should be planned and carried out to minimise disturbed soils. Exposed soils adjacent to trails should be planted and/or seeded immediately following disturbance with appropriate native plant and seeds. Trail developers should educate work crews and trail users about the harmful effects of invasive species and methods of identification and removal. For further information about invasive plants in British Columbia visit the [Invasive Plant Council of BC website](#).

Terrain stability and sediment potential mapping

Susceptibility of soils to erosion varies across the landscape. Terrain stability mapping and sediment potential mapping are two useful tools to assist trail planners and developers.

Terrain stability mapping in British Columbia identifies areas prone to landslides and slope failures. Terrain stability maps usually contain information about terrain, soil drainage, slope steepness and terrain stability classes. Terrain stability or slope stability is the susceptibility of a terrain polygon to slope failure. Terrain stability mapping may be available for many areas in the Province and is typically done at a reconnaissance or detailed level. Reconnaissance level mapping identifies only those polygons that are either unstable or potentially unstable. Detailed mapping provides a 5 class system of classification from I-very stable to V-unstable for all polygons in a study area.

Terrain mapping conducted in community watersheds in British Columbia often contains additional *soil erosion potential* and *risk of sediment delivery to streams* information. Soil erosion potential ratings are derived from terrain mapping, based on slope gradient, generic material, texture and soil drainage. The risk of sediment delivery to streams indicates the likelihood that sediment derived from erosion sources in a specific terrain polygon will be transported or delivered to a stream.

Terrain stability mapping and associated information can be very useful for conducting a preliminary assessment of a planned or existing trail route as well as

identifying areas of concern on existing trails. Terrain mapping can assist trail managers to set priorities for trail monitoring and rehabilitation efforts.

Trail planners and developers should consult with local land managers and professionals to determine what terrain mapping may be available in particular areas or to assess the feasibility of conducting terrain mapping where it has not been completed.

Riparian Areas

Riparian areas are the areas bordering on streams, lakes, and wetlands that link water to land. Riparian areas are vital in the natural maintenance of stream health and productivity. Vital features, functions and conditions provided by riparian areas are numerous and varied and include such things as:

- Sources of large organic debris, such as fallen trees and tree roots;
- Buffers for streams from excessive silt and surface runoff pollution;
- Areas for stream channel migration;
- Vegetative cover to help moderate water temperature;
- Provision of food, nutrients and organic matter to the stream; and,
- Stream bank stabilization.

Intact and functioning riparian areas play a key role in mitigating sediment delivery to streams. A primary objective of trail location assessment is to avoid riparian areas where possible and where trails do occur in riparian areas, special provisions are required to protect the ecological integrity of the stream and minimize impacts to water quality.

Special provisions for trail development, construction and maintenance will be required within riparian management areas (RMA's). In British Columbia, RMA's are typically described as consisting of a reserve zone and a management zone. The width of these zones is a function of the size of the stream, the fish habitat values of the stream and whether or not they are within a community watershed.

Determination of riparian management area width for trail construction and management activities authorized under the *Forest and Range Practices Act* will be guided by the *Forest Practices Code of British Columbia: Riparian Area Management Guidebook* and the *Forest Practices Code of British Columbia: Community Watershed Guidebook*. Table 2 below taken from the Riparian Management Area Guidebook provides an indication of RMA boundaries for streams. Consult the guidebook for additional guidance for determining RMA boundaries and achieving objectives for management within RMA's.

Table 2. Specified minimum RMA slope distances for stream riparian classes.

Stream Class	Stream Width (m)	Reserve Zone (m)	Management Zone (m)	RMA Width (m)
S1	>20	50	20	70
S2	5-20	30	20	50

S3	1.5-5	20	20	40
S4	1.5	0	30	30
S5	>3	0	30	30
S6	≤ 3	0	20	20
	Fish stream or community watershed			
	Not a fish stream and not in a community watershed			

To contribute to healthy riparian areas that preserve water quality, the following general guidelines for trail construction should be followed:

1. Avoid trails within riparian areas

- a) Trail planning and development should be conducted to avoid riparian areas where possible.
- b) Trails should avoid riparian reserve zones except in the case of carefully selected stream crossings. The number of stream crossings should be minimized, and carefully planned to minimize impacts to riparian areas.
- c) Where trails are required within riparian management zones they should follow guidelines as described below.

2. Guidelines where trails impact riparian areas

Where trails within riparian areas are necessary the following guidelines should be observed:

- a) Approach stream crossings at right angles.
- b) Trails should not be constructed within riparian areas, running parallel to streams.
- c) Minimize trail width within RMA's.
- d) Construct crossing approaches to minimize potential for sedimentation to the streams (see Water Course Crossing section of this document)
- e) Strict adherence to design principles applicable to minimizing erosion as described in this document.
- f) Where trails are located on areas of high or very high potential of sediment delivery and areas of high likelihood of stability problems within riparian areas, review of the location to verify ratings will be conducted by a professional engineer or professional geoscientist. If in the opinion of the professional, engineered designs are required to adequately mitigate impacts to water quality, professional designs will be completed.

Environmentally Sensitive Area (ESA) mapping

Environmentally sensitive areas (ESA's) are terrestrial and aquatic places that have special environmental attributes worthy of retention or special care. These areas are critical to the maintenance of productive and diverse plant and wildlife populations. ESA's include rare ecosystems, habitats for species at risk, and areas that are easily disturbed by humans.

ESA mapping, widely available throughout British Columbia provides trail planners and developers with a tool to identify areas that need to be avoided or where special measures need to be taken. Trail planners and developers should use information from the mapping and inventories available to identify ESA's and plan appropriate avoidance or mitigative strategies. Trail planners are encouraged to work with the appropriately qualified professionals when planning and designing trails that may directly or indirectly impact ESA's.

Trail Design and Construction Best Practices

Slopes are especially susceptible to erosion due to the relationship between the grade of the slope and the potential for increased water velocity. Trail construction or maintenance work that is to be performed on hillsides should be carefully planned so as to minimize the trail grade and to incorporate proper cross-drainage. The most effective way to decrease erosion is to avoid modifying slopes. Trails in areas with long, steep slopes should be designed to follow the contours to minimize accelerated soil churning and erosion. Modifying a slope by clearing existing vegetative cover also increases its vulnerability to erosion. Vegetation helps filter runoff water and holds soil particles in place. Vegetation also maintains the soil's capacity to absorb precipitation.

General Principles of Design and Construction

Sustainable trails share common traits. They are based on broad and simple yet important principles that seek to minimize their influence beyond the tread itself. Further, sustainable trails meet the needs of the trail users and discourage behaviours that lead to further damage. The following general principles are intended to guide planning, design and development stages of trail construction.

1. Hydrologic Invisibility

A hydrologic invisible trail has minimal impact on the natural flow of water across the landscape. It allows runoff water to flow in a natural pattern and avoids the unnatural concentration of flows, and disperses it before it reaches volumes and velocity that cause erosion.

2. Natural Water Management Features Increase Sustainability

Use of natural and built terrain features including rolling profiles, grade reversals and drain dips are preferable to culverts, inside ditches and water bars. Culverts, inside ditches, water bars and similar features require frequent maintenance and hinder sustainability.

3. Trail Construction Should Minimize Soil Disturbance

The layout and grade of a trail should be designed to minimize the creation and size of cuts made into the natural grade of the landscape.

4. Trail Design Must Satisfy Users Needs

User created trails, without the benefit of planning and design pose the greatest threat to a sustainable trail networks. Creating trail networks that suit the needs of the users is the most effective way to reduce the potential for user created trails. Factors to consider include difficulty level, appropriate routing and connections, subtle design elements and strategically place staging, trail head facilities and stream crossings.

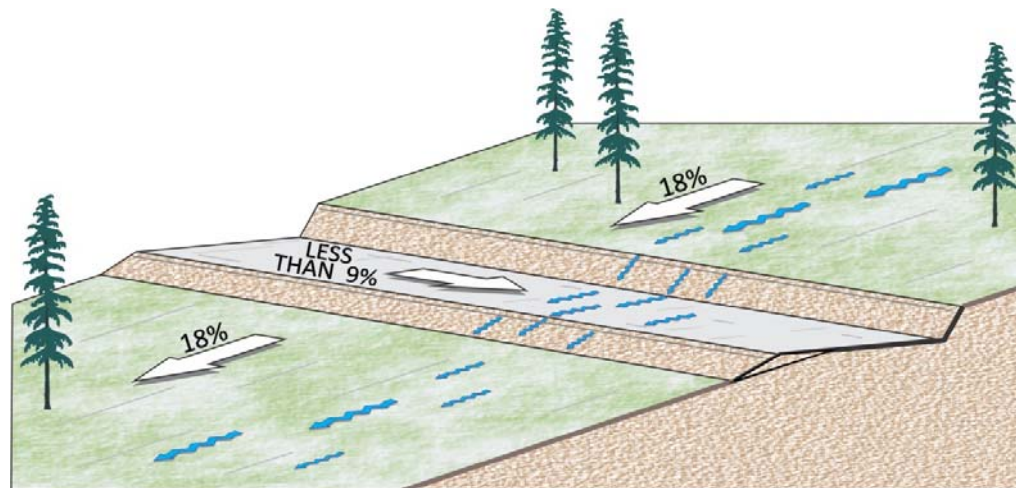
Specific Elements of Sustainable Trail Construction

The primary objective in trail construction is to avoid erosion that damages the trail and can lead to sedimentation of nearby watercourses. Four key elements to trail design and construction reduce potential for erosion based on the principles of trail grade and shape:

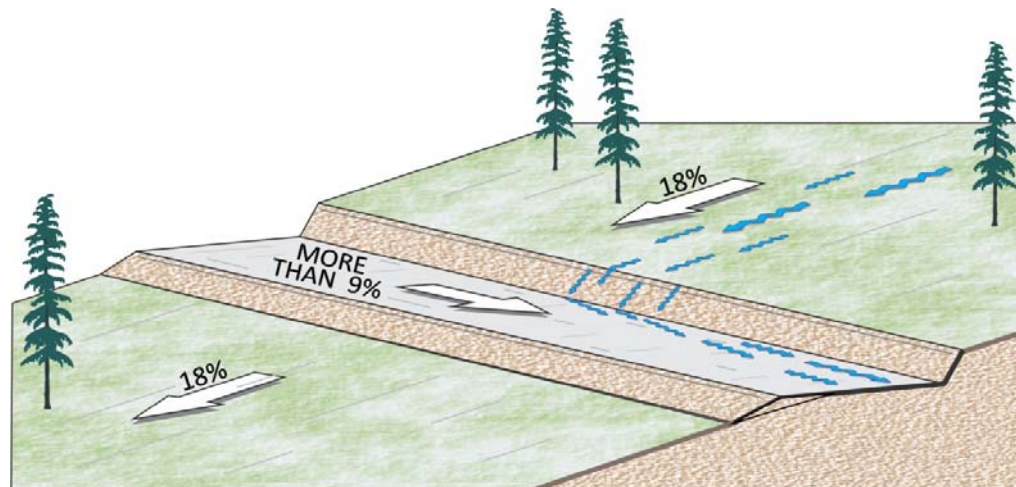
1. Managing Trail Grade

The Half Rule

A trail's grade should not exceed half the average grade of the hillside or side slope the trail traverses. Where trails exceed more than half the prevailing grade of the slope, water will flow down the trail rather than run across it- it will not achieve hydrologic invisibility.



LESS THAN HALF



MORE THAN HALF

For example, where a trail is constructed across a hill slope of 18%, the average trail grade should not exceed 9%. A trail with a grade greater than half the grade of prevailing slope is considered a fall line trail. Fall line trails are often prone to erosion and require additional effort to ensure sustainability.

10 % Average Grade

The average grade of the trail, determined by dividing the total elevation gain of the trail by the length of the trail, should generally not exceed 10%. Sections of trail may exceed 10% for short distances; however trails that have an average grade of 10% or less are more likely to achieve hydrologic invisibility. For trails that undulate over long distances, average grade can be calculated and planned in sections.

Maximum Grade

Maximum trail grade is the steepest section of trail that is more than about 3 meters in length. Maximum trail grades will vary depending on many site specific factors; however typically maximum trail grade is typically 15-20%. Factors to consider when determining maximum grade include:

Half Rule – a trail's maximum grade should not exceed half the grade of the sideslope. Where the sideslope is less than 20%, the maximum grade should be less than 10%.

Soil Type – Some soil types may be less susceptible to erosion and allow for increased maximum grades.

Rock – rocky areas or trails on solid rock can support steeper grades.

Rainfall – trails in areas with very high or very low annual rainfall may require gentler grades.

Grade Reversals – A grade reversal is a short dip followed by a rise, forcing water to drain off of the trail. Frequent grade reversals may allow for greater slopes.

Number and Type of Users – depending on the number and types of use, trails may be able to sustain greater or gentler grades. Typically for motorized trails, more intermediate or advanced trails will require gentler grades over novice trails, as will trails with higher anticipated use.

2. Rolling Profile and Grade Reversals

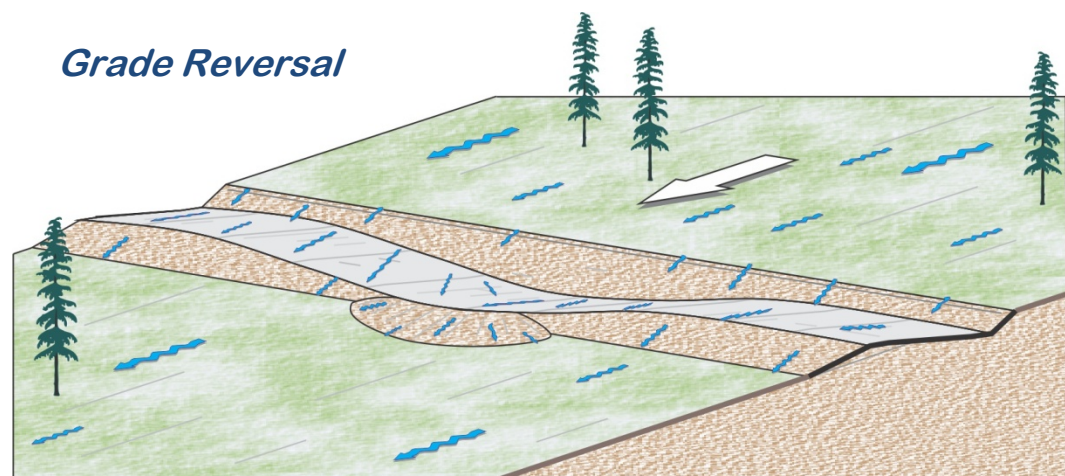
Rolling Profile

A trail with a rolling profile prevents long sustained grades that capture and transport water at increasing velocity and volume thereby increasing the erosive force of water. A rolling profile trail undulates across the slope and provides areas for water to both slow and be transported across the slope.

Incorporating rolling profiles into a trail is a primary design consideration during the planning and layout phase of the project. Trail design can and should take advantage of natural terrain features to incorporate a rolling profile.

Grade Reversals

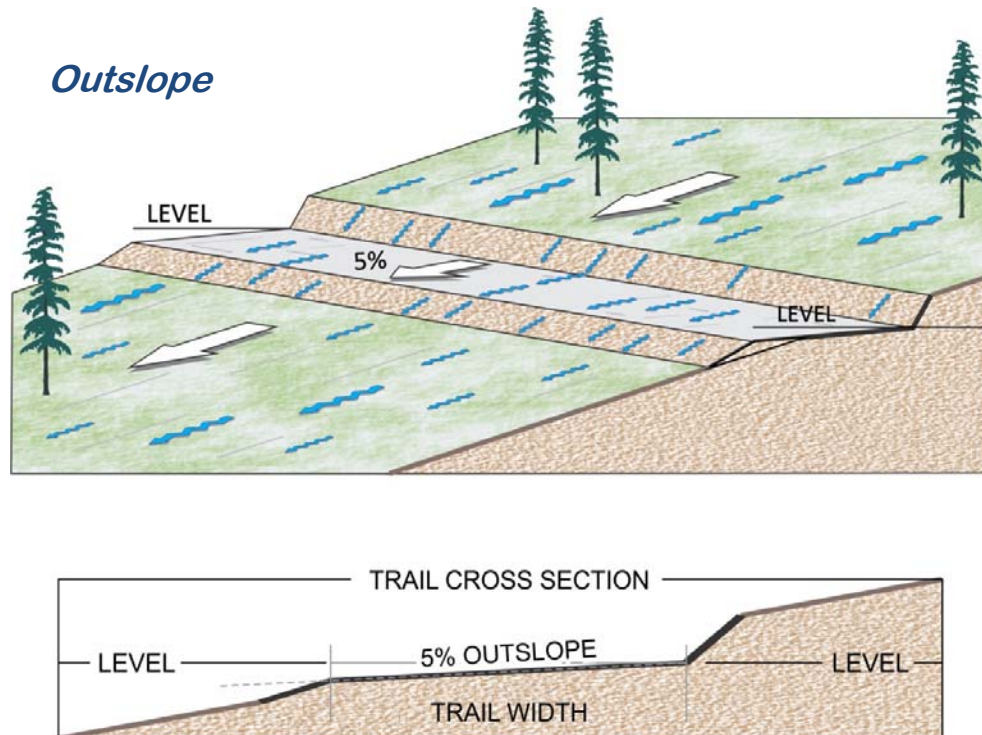
A grade reversal or rolling dip refers to subtle changes in the prevailing grade of a trail for 3 to 15 meters, before resuming the previous grade. The grade reversal forces water to exit the trail at the low point.



Grade reversals are a critically important, low maintenance method for managing water on trails and achieving hydrologic invisibility. Many trails will benefit from grade reversals as often as every 7-15 meters. Grade reversals and rolling dips can be retrofitted into existing, poorly designed trails but incorporating them into the original trail design requires much less work.

3. *Outslope*

Providing and maintaining an outslope on a trail is one of the most important design features to be considered in trail construction. As a trail crosses a sideslope, the outer or downslope side of the trail tread should slope slightly down and away. This outslope, ensures water travels across the trail tread and off the trail rather than travelling down the centre or inside of the trail, gaining velocity and increasing erosive power.



An outslope of 5% is recommended but may vary depending on local site conditions. Outslopes can be difficult to maintain, particularly on trails with high and intensive use where the tread is typically worn in the centre. As outside berms form from ongoing use, grading berm material back onto the tread with sufficient compacting to re-establish the outslope is required. Berm material should not be cast down slope to re-establish an outslope.

4. Water Management Features

Water breaks and water bars

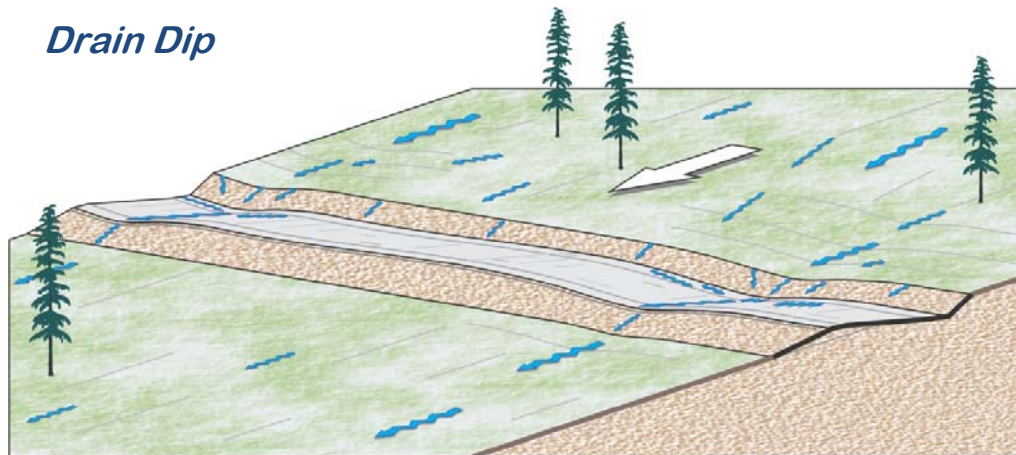
A water break or water bar is a built or constructed feature, incorporated into the trail tread to intercept water and direct it off of the trail. Water breaks can include a ditch, dike, French drain, box culvert, rocks, timbers or in some cases flexible water breaks. Water breaks require ongoing maintenance, are prone to blockage failure and deterioration. Water breaks can be effective in limited cases but should only be used where necessary and in combination with other sustainable trail design features such as grade management, grade reversals, and outslopes.

For more information on water break specifications see the *BC Ministry of Forests Recreation Manual, Chapter 10* and other publications listed in the Additional Information Sources section.

Drain Dips

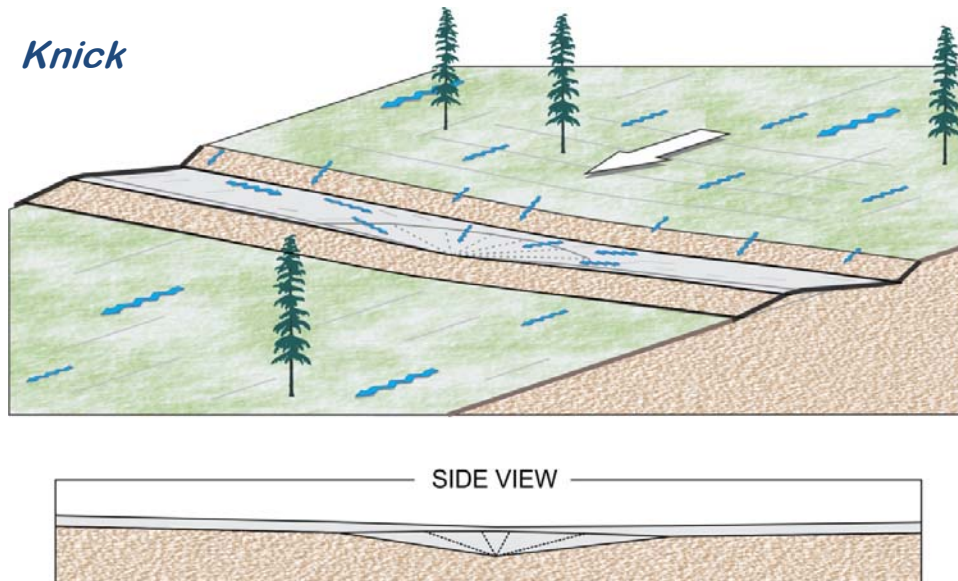
Drain dips are short grade reversals that take advantage of natural dips in the trail, to force water off the trail. Drain dips can be cut into the existing grade and are particularly effective on log grade trails. A drain dip is used in combination with outsloping to ensure the dip acutely tilts the trail down slope.

Drain Dip



Knicks

Knicks can be used to direct pooling water from low points in the tread surface off the trail to lower ground next to the trail. Like drain dips, knicks can be constructed into existing trails. A knick is an outsloped drain, typically a shaved down semi-circle about 3 meters long, outsloped up to 15% in the centre. Knicks are smooth and subtle and should be unnoticeable to users.



Inside ditches and culverts

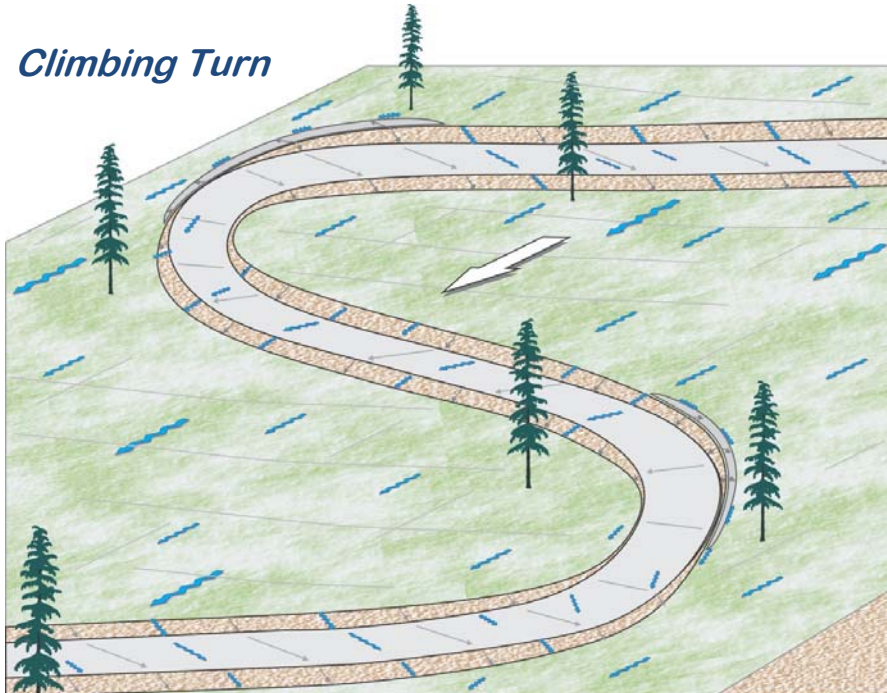
Inside ditches capture water from slopes above the trail, channel it along the trail, where it increases in velocity and erosion power. Culverts can be used to capture water from inside ditches and transport it onto slopes below the trail. Culverts require maintenance, are prone to blockage and reduce the sustainability of the trail. Further, concentrated flow of water from culvert outlets tends to be more erosive than sheet flow from properly outsloped trails.

Generally, inside ditches and culverts reduce the sustainability of the trail and should be avoided. In some circumstances, where other solutions are not available, inside ditches and culverts can be used in combination with more sustainable solutions. The length of the ditch should be minimised with culvert placement at short and regular intervals. Trails with culvert and inside ditches must be monitored regularly. Culvert capacity must be capable of passing the 1 in 200 year maximum daily flow without the water level at the culvert inlet exceeding the top of the culvert. Seek professional advice for further information on correct culvert size and placement.

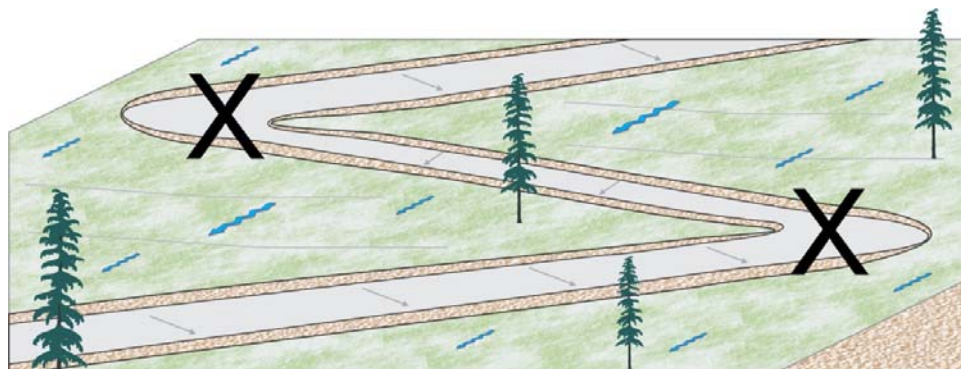
Climbing Turns

Climbing turns offer a more sustainable alternative to vertically stacked switchbacks on slopes less than 25%.

Climbing Turn



Climbing turns differ from switchbacks by having a larger turning radius and greater separation distances between upper and lower tread sections, thereby more area for dispersion of water. Climbing turns should be constructed with banked or bermed corners. Trail drainage that flows around banked turns should be diverted off the trail immediately above and below the turn. Care should be taken to ensure that water diverted from the turns is sufficiently dispersed to avoid accumulation on lower portions of the trail. Sequential climbing turns should be constructed laterally across the slope to minimize 'stacking'.



UNSUITABLE

Water Diversion Frequency

Table 3 provides an example of the recommended number of water diversionary features per foot, based on soil type and trail grade. The requirement for water management features depends on numerous local variables; however the table is useful for demonstrating the relationship between soil types, grade and erosion potential.

Table 3. Recommended distance between water diversion structures based on soil type and trail grade.

Soil							
	2%	4%	6%	8%	10%	12%	15%
Loam	350	150	100	75	50	*	*
Clay-Sand	500	350	200	150	100	50	*
Clay or Clay-Gravel	+	500	300	200	150	100	75
Gravel	+	+	750	500	350	250	150
Shale or Angular Rock			800	600	400	300	250
Sand	Various with local amount of fine clay and silt. Drainage diversions are generally not required in pure sand due to the fast rate of water absorption. For sand with appreciable amounts of fine binder material, use 'clay-sand' distances as shown above.						

Source: U.S. Forest Service, USDA, Trails South.

Trail Surfacing, Hardening and Armouring

Trail surfacing, hardening and armouring are techniques of modifying trail surfaces so they will support use without unacceptable environmental impacts to vegetation, soils, hydrology, habitat, or other resource values. Trail hardening should be considered under the following conditions:

- Existing trail impacts are causing or are projected to cause unacceptable onsite or offsite impacts, and
- More suitable alternative trail locations are not available, or
- Alternative trail locations are not environmentally acceptable or economically feasible.

Trail hardening provides the following benefits:

- Defines a single trail alignment for vehicle travel.
- Stabilizes surface soil conditions along the hardened trail section.
- Provides a stable, durable trail surface for OHV traffic.
- Halts trail widening and the development of braided trail sections.
- Allows formerly used trail alignments to naturally stabilize and re-vegetate.

Trail Surfacing

Trail surfacing is an intensive trail-hardening technique. It involves the removal of problem or susceptible soils (typically with high organic content) and replacement with well draining, compacting and more erosion resistant materials, typically aggregate gravels of varying size with suitable proportions of binding materials.

The most important consideration in trail surfacing is finding appropriate materials with the correct balance of compaction (binding) and drainage. Often aggregate material referred to as $\frac{1}{8}$ inch minus (referring to the maximum size of soil particles to pass through the sorting sieve) up to $\frac{1}{4}$ inch minus is suitable. In addition material should be analysed to ensure individual particles are highly angular – referred to as minimum fracture content. For more information on appropriate crush aggregate specifications for trail surfacing refer to Additional Information Sources section of this document.

Trail Hardening

Trail hardening refers to a technique that augments existing soil structure by adding materials to reduce susceptibility to erosion. Hardening usually involves soil binder or structural additives.

Soil binders can be chemical or physical based. Chemical binders are not recommended for reasons including potential effects to the environment, lack of proven ability on grades greater than 5% and non-ideal effects on the trail surface.

Physical binders are additives that attempt to bring balance to soils that are either too high in clay content (high compaction, poor drainage) or sand content (high drainage, poor compaction). These binders range for manufactured products to crushed oyster shells. Use of physical binders is labour intensive, costly and should only be considered where other alternatives are not available and in consultation with land managers.

Structural additives augment soil structure by adding a physical component to the native soil. A number of geo-synthetics are available and have proven successful at stabilizing sandy soils. These include geotextile sheets to separate well drained aggregate materials from underlying saturated soils and geocells, a cellular confinement system of honey-combed grids that hold fill soils in place over saturated soils. Geocell walls limit the transfer of shear forces within the soil.

Structural additives, although often effective can be costly and maintenance intensive. They are not a substitution for good planning and layout. Alternative trail routing is usually a preferred solution, however hardening can be an appropriate solution over short trail lengths in problem areas.

Trail Armouring

Trail armouring is an effective technique to increase the erosion resistance of a trail. It can be used to elevate a trail tread above wet or saturated areas where an alternate route is not available as well as harden a trail tread to reduce erosion by users. Armouring is particularly effective over short portions of trails constructed at steeper grades that exceed guidelines discussed earlier in this document.

Trail armouring utilises rock to 'pave' a trails or section of trail. The practice has been around for thousands of years and there are extensive resources available describing varying techniques and practices for specific situations. For a more details discussion of useful rock armouring techniques for trail construction see Trail Solutions: IMBA's Guide to Building Sweet Singletrack.

Water Course Crossings –Requirements and Best Practices

Constructing of water crossings in British Columbia may be regulated by *Water Act* or the *Forest and Range Practices Act*. Detailed guidance, requirements and regulations related to water crossings can be found in the following publications:

1. B.C. Ministry of Water, Land and Air Protection's [Standards and Best Practices for Instream Works](#)
2. B.C. Ministry of Environment's [A Users Guide to Working In and Around Water - Understanding the Regulation under British Columbia's Water Act](#)
3. Forest Practices Code of British Columbia: [Fish Stream Crossing Guidebook](#)
4. Forest Practices Code of British Columbia: [Riparian Management Area Guidebook](#)

Water crossings may include culverts, bridges and in some limited cases rocked fords for ephemeral crossings of small, non-fish bearing streams. The following guidelines must be considered when planning a water crossing for recreation trails:

- Water course crossings must conform to legislative and regulatory requirements and adhere to established standards and Best Management Practices.
- Construction of a water crossing does not destabilize the stream channel and does not alter the gradient of the water course at the crossing.
- The crossing and the approaches do not produce a back water effect or increase the head in the stream.
- Each water course crossing must be designed based on anticipated flood flows and appropriate fish passage measures by personnel with the appropriate expertise.
- Approaches to watercourse crossings must be designed and constructed to minimize sediment delivery to the watercourse. Appropriate drainage features including grade breaks (reversals, dips, knicks), outsloping, water breaks, trail surfacing and hardening should be incorporated into the trail prior to reaching the crossing.

- The trail at the crossing location must be the lowest point of the trail to prevent diversion of the water course onto the trail tread.

Development and construction of built water crossings should additionally be guided by Appendix 14.7, Section 14.7.3 Operational or Construction-related Best Practices in *Standards and Best Practices for Instream Works* by BC Ministry of Water, Land and Air Protection.

Trail and Sediment Monitoring

Trail construction, development and maintenance activities require ongoing monitoring and evaluation to ensure objectives are achieved. Monitoring plans are required to effectively detect changes, assess effectiveness of construction practices and prioritise further requirements for maintenance, rehabilitation or closures.

Monitoring plans will vary widely based on the local site conditions and objectives and in many cases will incorporate management objectives beyond technical trail performance parameters. However a number of key objectives and considerations should be incorporated into most monitoring plans:

Clearly defined objectives

The purpose of the monitoring program should be clear. Key overarching objectives might include reduction of sedimentation, levels of user compliance with closure areas, or reduction in creation of user built trails

Clearly stated monitoring parameters

The monitoring plan should stipulate parameters to be monitored and describe how those parameters will be monitored and measured. The scope of the parameters being monitored should be consistent with the overall monitoring objectives and resources available.

Defined Accountabilities

The monitoring plan should clearly identify the parties or groups responsible for monitoring each parameter, responsibilities for reporting and retaining monitoring information as well as responsibilities for addressing concerns identified through monitoring activities.

Monitoring schedule

A schedule describing the frequency of monitoring for each parameter should be clearly describes. Consideration should be given to circumstances that may require increased monitoring such as higher than usual rain fall or freshette events.

Reporting and follow up procedures

Responsibility for reporting and follow up should be identified in a monitoring plan. Responsibilities need to be appropriately assigned based on levels of expertise, levels of authority and responsibility and available resources.

Glossary

ATV's – For the purpose of this document, an all-terrain vehicle (ATV) refers to a three or four wheeled, motorized vehicle designed to travel on rough and uneven ground in which one or two riders sit astride the vehicle and is generally considered to have a wheel base ranging from 100cm to 125cm.

Best Management Practices (BMP's). A recommended technique that has been demonstrated to be an effective and practical means of preventing or limiting harmful impacts to the environment. Best Management Practices include any program, technology, process, siting criteria, operating method, measure and device that controls, prevents, removes or reduces pollution.

Best Practices (see Best Management Practice): A method or technique that should be followed to ensure the standard are met and impacts to the environment are mitigated.

Berm. A low earth ledge constructed at the side of a road or trail to divert the direction of flowing water or prevent the dispersion of channelled water.

Channel. A waterway that contains moving water either periodically or continuously. A channel has a definite bed and banks that confine the water.

Closure: A permanent or temporary prohibition of use in a certain area or trail.

Conservation: Activities, practices, and programs that sustain soil, plants, wildlife and their habitat, and natural and cultural resources.

Deactivation: Physical removal of features associated with a trail and trail tread to permanently eliminate use.

Erosion: The wearing away of rock or soil by the detachment of soil or rock fragments by water, wind, ice, and other mechanical and chemical forces.

Engineered: To be planned designed and certified by a professional engineer (see Professional).

Geotextile. Water permeable textile material (fabrics, etc) used as an underlay to conserve gravel on trails and stabilize erodible surfaces. Textile allows for water to pass through it but keeps soil layers from mixing and breaking down.

Hardening. A technique of modifying trail surfaces so they will support use without unacceptable environmental impacts to vegetation, soils, hydrology, habitat, or other resource values. The application of materials to a trail or trail section such as rock or cement or additives such as calcium carbonate to better resist erosive forces.

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Hydrology. The science dealing with the properties, distribution, and circulation of water on the surface of the land, in the soil, and below the ground surface in the underlying rocks, and in the atmosphere. Commonly used to describe the distribution and circulation of water in a particular area.

Long-Term: At a minimum, 25 years.

Maintenance: The work required to ensure effective and efficient use of physical facilities, OHV recreational opportunities, and the protection of natural and cultural resources.

Professional: An applied scientist or technologist specializing in a relevant applied science or technology including, but not necessarily limited to, agrology, forestry, biology, engineering, geomorphology, geology, hydrology, hydrogeology or landscape architecture, and who is registered in British Columbia with their appropriate professional organization, and acting under that association's Code of Ethics and subject to disciplinary action by that association, and who, through demonstrated suitable education, experience, accreditation and knowledge relevant to the particular matter, may be reasonably relied on to provide advice within their area of expertise.

Restoration: Returning lands to as close to a natural, pre-disturbance state as possible. Restoration should include closure, deactivation and restoration of natural drainage patterns and vegetation.

Rehabilitation: Returning a trail to a sustainable condition to allow use that would not materially impact the environment.

Riparian Area: The banks and other adjacent terrestrial environs of lakes, watercourses, estuaries, and wet areas, where transported surface and subsurface freshwaters provide soil moisture to support mesic vegetation.

Runoff. The part of precipitation and snowmelt that reaches streams by flowing over the ground.

Sediment. Fragments of rock, soil, and organic material transported and deposited by water, wind, or other natural phenomena. The term can refer to any size of particles but often refers to fragments smaller than 6mm.

Sedimentation: The process by which soils, debris and other materials are deposited, either on land or in water.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and runoff.

Significant: Having a substantial or potentially substantial effect.

Soil Erosion: Detachment and movement of topsoil, or soil material from the upper part of the profile, by the action of wind or running water, or as a result of changes brought about by human activity. It includes: rill erosion, gully erosion, sheet erosion and wind erosion.

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Staging/Parking/Camping Areas: These areas include all sites (designated and undesignated) that are used for these activities. Staging areas commonly include areas to unload off-highway vehicles from trucks or trailers and areas to fuel, maintain, and wash the vehicles during and after use.

Standard: Any definite rule, principle, or measure established by authority.

Trail: Any route that is not designated as a road.

Watercourse: Any well-defined channel with distinguishable bed and bank showing evidence of having contained flowing water indicated by deposit of rock, sand, gravel, or soil.

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- B.C. Ministry of Forests. Forest Practices Code Guidebook: Community Watershed Guidebook.
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Additional Information Sources

- 1) **A Guide to Using and Developing Trails in Farm and Ranch Areas.** B.C. Ministry of Agriculture and Lands
- 2) **B.C. Parks, Park Facility Standards**
<http://www.env.gov.bc.ca/bcparks/operations/facstand/starthere.pdf>
- 3) **B.C. Ministry of Forests, Recreation Manual, Chapter 10**
<http://www.sitesandtrailsbc.ca/documents/manual/chapter10.pdf>
- 4) **Best Management Practices for Recreational Activities on Grasslands in the Thompson and Okanagan Basins.** BC and the Grasslands Conservation Council of British Columbia
- 5) **Forest Practices Code Guidebook: Fish-stream Crossing Guidebook.** BC Ministry of Forests
<http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/FishStreamCrossing/FSCGdBk.pdf>
- 6) **Forest Practices Code Guidebook: Riparian Area Management Guidebook.** BC Ministry of Forests
<http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/riparian/rip-toc.htm>
- 7) **Forest Practices Code Guidebook: Trails and Recreation Facilities Guidebook.** BC Ministry of Forests
<http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/trail/trailtoc.htm>
- 8) **Management Guidelines for OHV Recreation.** National Off Highway Vehicle Conservation Council
- 9) **Planning Trails with Wildlife in Mind: A Handbook for Trail Planners.** Trails and Wildlife Task Force, Colorado State Parks.
- 10) **Standards and Best Practices for Instream Works.** BC Ministry of Water, Land and Air Protection. 2004.
<http://www.env.gov.bc.ca/wld/documents/bmp/iswstdsbpsmarch2004.pdf>
- 11) **Trail Construction and Maintenance Notebook.** US Department of Transportation – Federal Highway Administration
- 12) **Trail Solutions: IMBA's Guide to Building Sweet Singletrack.** International Mountain Bike Association.
- 13) **Wetland Evaluation Guide.** North American Wetlands Conservation Council (Canada): Wetland Evaluation Guide
- 14) **Wildlife Guidelines for Backcountry Tourism/ Commercial Recreation in British Columbia.** BC Ministry of Tourism Sports and the Arts
- 15) **Natural Surface Trails by Design: Physical and Human Design Essentials of Sustainable, Enjoyable Trails.** Troy Scott Parker

