Upland Pathwork

Construction Standards for Scotland

Upland Path Advisory Group

3rd Edition 2015

HIE
Highlands and Islands Enterprise
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2015 Edition

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Hard copies of the manual are no longer available.

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1. Introduction to Upland Pathwork

1.0 Introduction

This good practice guide describes the basic principles and techniques of upland path work and the context in which they should be used. It complements the Upland Path Management Manual which covers the process of managing an upland path project from developing a proposal, through project delivery and aftercare. Both manuals have been designed for use by all involved in upland path management, although many of the principles also apply to lowland paths.

The overall aim of this manual is to achieve high quality management and sustainable use of upland paths, thereby protecting the exceptional scenic quality of Scotland's mountains. To achieve this it is essential that anyone using the manual is familiar with this 'Introduction to upland pathwork' section before using the technical guidance in the remainder of the manual.

- Section 1 introduces the basic principles of path management and the factors that need to be considered before commencing any pathwork.
- Sections 2, 3 and 4 cover the practicalities of upland pathwork. They include guidance on when and where to use different techniques as well as how to construct and maintain paths.

With all pathwork, the sites and materials differ from area to area, and variations will necessarily occur. It is therefore not practical, or desirable, for the examples given to be followed slavishly. Instead the guidance needs to be carefully applied to different sites, guided by experience. The principles will generally be the same for all upland paths and should be the minimum standards observed.

This manual sets the standards in relation to Scottish Vocational Qualifications (SVQ), and provides the supporting material for trainee pathworkers following the SVQ in Environmental Conservation at Level II. Whilst this manual can inform and guide path construction, it cannot replace experience gained from working on a variety of upland path sites. It takes time to gain this necessary experience but by training and assessment towards a recognised level of competence, the skills gained will be recognised and can be developed.

The guidance contained in this manual is accepted best practice at the time of writing but cannot cover all eventualities. All path sites are different so there is no substitute for risk assessment and good planning to ensure the safest and most appropriate ways of working are identified for each particular work site. Path management practice and techniques continue to develop, particularly as more challenging sites are tackled and the Upland Path Advisory Group (UPAG) intends to continue to update the guidance in the manual accordingly. Since first produced additional information on mechanised equipment was added in 2004 and the manual was updated in 2015. This includes more information on light touch work and changes to techniques, such as turf lined ditches. This latest version also

includes changes to the legal framework which impact on the design and management of upland paths, particularly the Land Reform (Scotland) Act 2003 and Equality Act 2010.

UPAG is an association of path building contractors, environmental and statutory organisations, landowners, hill user groups and others interested in working together to agree and improve the standard and design of path management in Scotland. Comments, notes and information on new techniques are welcomed by UPAG through recreationandaccess@snh.gov.uk.

Upland Path Advisory Group (UPAG)

UPAG is an association of path contractors, countryside management charities, statutory organisations, landowners, hill user groups and others interested in sharing information and working together to improve the standard and design of path management in Scotland. UPAG is the successor body to the Path Industry Skills Group (PISG).

1.1 Principles of Upland Pathwork

There are a variety of factors influencing the need for upland pathwork. As well as the overriding need to maintain the unique scenic quality of Scotland's mountain landscapes, consideration must be given to recreation, safety, tourism, equality and the needs of rural communities and economies.

Techniques are continually developing in response to these factors. There is demand for repair of more remote sites, but with less visible impact on the landscape, and combined with more durable surfaces. The aim should always be to build or repair using techniques that will withstand the pressures of path users, and climate, but will not detract from the experience of walking through an unrivalled and wild landscape.

To achieve this, the following principles were formulated by the Path Industry Skills Group (the predecessor to UPAG) for pathwork in Scotland. They are based on the British Mountaineering Council's policy statement on upland pathwork, later endorsed as 'Guiding Principles' by the House of Commons Environment Select Committee, in 1995.

- Pathwork will be carried out within a coherent management framework, including a commitment to long-term maintenance. It will integrate with other management objectives.
- An understanding of the underpinning philosophy and practice of path improvement is required of managing and funding agencies.
- Pathwork will be generated by area survey and prioritisation.
- Priority will be given to curtailing and restoring environmental damage, while also enhancing visitor experience.
- Environmental sensitivities will be given stringent regard, particularly in sites of outstanding landscape and/or natural heritage quality.
- Management of the path will be informed by suitable consultation with interested parties.
- The purpose of the path and its expected use will be defined and the path built to fit this purpose.
- Pathwork will be of the highest standard of design and implementation, preferably using locally sourced materials in harmony with the site.
- Good environmental practice will be paramount. No material won in works will be wasted. Techniques used will protect existing vegetation and cultural remains and the site will be left in as natural a state as is practicable.
- Those involved in the design, implementation and supervision of pathwork should be demonstrably professionally, and technically, competent.
- All work will be carried out in accordance with legal obligations and the requirements of current Health and Safety legislation.

Members of the Upland Path Advisory Group are striving to implement these principles to the highest standards. UPAG aims to encourage and ensure that all organisations involved in the funding, management and repair of paths in Scotland's mountains and remote areas, subscribe to these principles. The industry is developing the skills and techniques to meet the needs and demands for quality pathwork.

The principles give guidance, and are supported in this manual by practical advice and information on construction standards, including the development of practical, judgmental and aesthetic skills. It is these standards that are used for assessment towards pathwork qualifications.

Since the original publication there have been significant changes to the legal framework which impact on the design and construction of upland paths in Scotland. An overview is given here with more detail in the upland path management manual. The Land Reform (Scotland) Act 2003 gives everyone the right of access to most land and inland water, provided they behave responsibly (including not taking part in activities that will damage the path). The right of responsible access includes cycling and horse riding as well as walking and may influence how and where people choose to take part in recreational activities www.outdooraccess-scotland.com.

Strategic planning for shared use paths should be considered holistically, such as through Local Authority or National Park Authority access strategies. This enables planning for upland paths in the context of overall path provision and visitor pressures, together with the benefits this will provide in terms of visitor dispersal, making better use of public transport, etc.

The Equality Act (2010) makes it illegal to discriminate against people, including on grounds of their disability. For path providers this means that 'reasonable adjustments' must be made to allow disabled people to use their services. Whilst these have yet to be defined in case law this is likely to relate to:-

- the nature of any provision for access;
- the level of use;
- the resources available (including financial assistance); and
- whether taking any particular action would be effective.

In practical terms this may include replacing a cross drain with a culvert or re-routing a path to reduce gradient. Before spending money on pathwork, ask yourself whether what you are designing is as accessible as possible and if not, are there good reasons to justify your action if challenged. Details of best practice and additional information can be found in Further Reference.

Neither of these pieces of legislation means that all paths should be fully accessible to everybody, but there does need to be a range of provision. Accessibility needs to be balanced with the need to build upland paths as sensitively and in-obtrusively as possible.

1.2 Environmental Impact

Introduction

Most upland paths are visually prominent in the landscape, whether created for traditional access for stalking, or for walking in the hills. Today, paths are predominantly used for outdoor recreation, with use concentrated on particular mountains or areas. The increase in the popularity of hillwalking has led to informal paths developing, which can suffer wear and serious erosion, with some very large and obtrusive scars causing unacceptable visual impact, particularly in areas which otherwise appear wild and natural.

This has led to the need to build or repair paths in a way that minimises the impact of use and erosion, and restores sites to an acceptable and durable state. Only when this is done, and the work maintained, can access be sustained and environmental benefits seen.

Approach to Pathwork

The approach to pathwork should always be to keep intervention to the minimum possible to solve the problem, so a path may have some fully engineered sections; others light touch and some in between. The best way of reducing the environmental impact of pathwork is to ensure that quality work is carried out timeously - from initial design to finished pathwork and onwards into maintenance. This is achieved through effective planning, taking into account path use and site characteristics. To ensure that the best solution is found and environmental requirements met, it is essential that a path assessment is carried out prior to any work on the ground.

An early intervention approach of regular maintenance and minor pre-emptive work, incorporating durability, is the best solution in most circumstances Small scale pre-emptive works, particularly basic drainage, can protect a path from acute erosion and ultimately reduce the intrusiveness of the path and any path work. However in many cases, often due to a lack of early intervention, the impact of erosion has already exceeded what is acceptable and urgent major repair is necessary. This situation is exacerbated by funding mechanisms which make it easier to secure funding for large scale construction, rather than maintenance and pre-emptive work, which can lead to over-engineered work.

After repair all paths will continue to require monitoring and maintenance to protect the investment in the path and ensure that the path remains in good condition

Repaired section of damaged stalkers path; on-site boulders, turf and aggregate used to mimic the original 19th century design. Coire Dubh, Glen Torridon. See path assessment for the path pre-repair work.

Design

To avoid failure, and subsequent increased environmental impact, pathwork must be designed to cope with the pressures exerted on it, by climate and users. The design should ensure that the quality of finished work is of the highest standard with techniques selected to blend in with the surrounding landscape. By understanding the level and condition to which the path needs to be constructed, techniques can be adapted to produce much more naturalised built features.

Key design principles:

- keep construction to a minimum; avoid over specifying the work required, e.g. do not religiously place waterbars every ten metres if fewer are required
- make sure that the path alignment suits the site; avoid long straight stretches of even width path
- landscape path edges and areas of erosion to blend in naturally with the surroundings
- the path on completion should be less obtrusive than before work was started

Short flight of pitching designed to look like a natural pile of boulders on Cairngorm

Light touch work

The use of light touch techniques places great emphasis on creating natural looking features and is a dynamic approach using the minimum amount of work to keep people on the path line. Light touch can be particularly suited to high or wild landscapes, where the ground condition allows, or where the path line is highly visible. It represents ongoing management of a path, rather than a one-off, capital-intensive approach. However, as highlighted above, all upland pathwork should keep construction to a minimum as the basis of design.

Light touch work is just as robust as standard construction and may use distinctive techniques and/or variations in standard construction including:

- de-roughening, which is the process of creating a more desirable walking surface by removing or altering the existing stones in the path surface, rather than digging out a more formal line
- braid blocking to help close down multiple path lines
- turf lined ditches, rather than open
- stone water bars that are less regular than a “typical” bar
- pitching with an informal appearance - uneven rises, large treads contouring around existing bedrock and boulders, utilising these natural features, rather than covering or removing them
- mixed sections with pitching and stretches of path that are barely defined in between
- realigning paths to more robust ground

Because more emphasis is on working with what is already there, the work is more reactive and only the necessary sections of the path (or desire line) will be worked by the contractors.

Sites higher up in the mountains with no formal/constructed paths can be protected by using light touch techniques on desire lines. This includes re-aligning the path line onto more robust ground by the addition of well-placed blockers, or an occasional step. Line definition includes removal of turf islands, or moving a boulder to create a line of sight. This is often used with de-roughening, to ensure that the user will not deviate from the path line because

it has become indistinct. Line definition and de-roughening mainly re-arrange what is already there, with little need to use additional materials from outwith the path line.

Pre-emptive light touch work, for example drainage work, can be highly beneficial in halting damage and holding sites in their present state allowing them to be tackled when resources are available. Without pre-emptive intervention, damage can increase rapidly leading not only to a larger visual scar, greater loss of soils, stone and vegetation but also much higher financial and visual restoration costs.

The light touch approach is also suited to sections of path which are highly visible in the landscape as it allows for a more natural looking line to be used, there is less disturbance to sensitive ground and often less materials are required. All of which can help the route to blend in better than a fully constructed line (whilst it can be possible to hide a full build path, resource requirements will always be high.)

It is particularly important that light touch paths are regularly visited to assess any damage, a task best suited to a maintenance team who can assess and repair/add to any work which has failed or not been adequate.

This option is not suited to all sites and a good understanding of what will work where is required. Some sites are too steep, peaty, mobile, damaged, busy, etc. to hold light touch work and will require a more heavily engineered approach. Even when a heavily engineered approach is necessary every effort to camouflage the work should be taken to reduce the visual impact of the line and to keep the line to a minimum width.

Materials

Materials should be natural and selected to blend with the landscape.

- use local materials for constructing path and drainage features, preferably collected from the area around the path
- collect material sensitively taking care not to cause further damage to the surrounding landscape
- re-instate any damaged areas caused by excavating borrow pits or collecting stone and turf

Where local material cannot be used or is not available, stone or revegetation material may have to be imported to the site.

- check the requirements of any statutory designations
- match imported stone in geology, colour and mineral content to that around the path
- use weathered stone rather than freshly quarried stone
- if imported aggregates are used, try to surface over them with a locally won material

Timing

Pathwork should be carefully planned to avoid further damage to the site. Programme work to take place at times of the year when the ground conditions are dry and stable - working on water-logged, soft soil and fragile vegetation can result in rapid damage. If extensive landscaping is required it is best to avoid this during dry spells or frosty conditions. Giving vegetation time to establish within one growing season will increase the chances of successful landscaping, and it may be necessary to revisit some late season works.

Access

Routes to the site for daily access should be carefully chosen, normally using the existing path line. Where this is not practical the route selected should be varied to avoid establishment of alternative path lines.

Remote Working

Where on site accommodation is considered for remote working, think carefully about the positioning and potential visual impact. Ensure there are adequate resources for minimising visual intrusion, as well as waste management, maintaining the accommodation system, re-instatement and tidying of the site on completion of the pathwork.

Construction

The impact of undertaking pathwork should be carefully controlled to avoid further damage to the site.

- keep disturbance of the site to a minimum, even if this takes more time
- protect the surrounding environment, particularly water courses, from pollution or sediment
- protect surrounding vegetation from damage, e.g. lay stored materials on matting
- make good use of all excavated materials, e.g. re-use turf from ditching for path edges, and soil for site restoration
- keep the work site tidy and complete a section at a time if possible, to reduce visual impact and damage to vegetation through die back.

Liaison and Permissions

It is essential to have the appropriate permission and approval for works, especially on environmentally sensitive sites - if in any doubt ask. Lack of communication between the appropriate interests can give rise to misunderstandings and inadvertent environmental damage. Those who should be approached include:

- Scottish Natural Heritage (SNH) local office - work on Sites of Special Scientific Interest (SSSI), or Natura sites, will require prior consent.
- Historic Scotland - for the historic environment including archaeological sites and historic monuments, e.g. military roads.
- SEPA - Controlled Activity Regulations (CAR). These apply to any activity which may affect Scotland's water environment, such as bridge construction, fords, culverts or bank protection. Authorisation is required for some activities.
- Local or National Park Authority - planning consent may be required depending on the site and proposed work, particularly for remote working accommodation.
- Landowners and tenants – owner's permission is required for most pathwork, and consultation to avoid an adverse impact on land management.

1.3 Path Assessment

Introduction

Before any upland pathwork takes place, it is essential that a full assessment is undertaken, in context with the surrounding environment. This can encompass an administrative or land ownership area; a geographical upland area or mountain range; a network of local paths on a popular mountain; or a single path corridor. It will consider all of the influencing factors which may be crucial to future management: the land through which it passes; the people who use the land; the people who use the paths; the visual impact of use, and potential work; environmental and physical features.

The Path Assessment is essentially a path management desk exercise - all available sources of information and understanding of the site will be used to identify and decide where condition and specification surveys are required. The full assessment will therefore include results of path survey work, as detailed in Path Survey. The Path Assessment is a mini management plan for recreation on a mountain site - it is likely to be implemented over several years and will need to be updated. Path assessments should link directly to other plans, where they exist - for instance, designated site management plans, bio-diversity, habitat and species action plans, and area based access strategies.

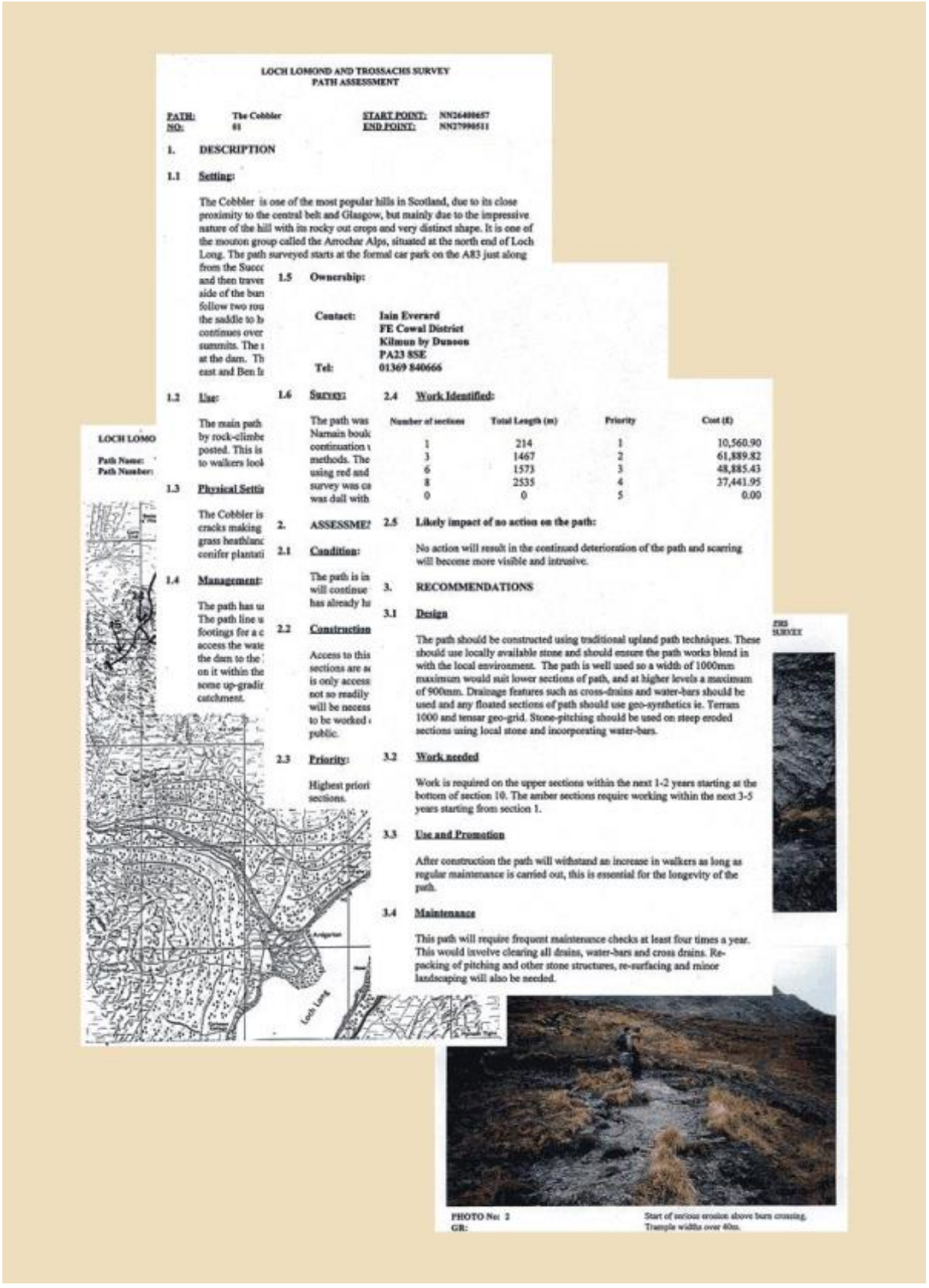
Function

The assessment makes sure that all factors are considered, and integrated with the practical aspects of the pathwork. A comprehensive assessment will gather all relevant background information about the area, as well as detail about the path network or path, in order to produce a strategic report or 'management plan'.

This will:

- identify factors and causes attributing to the path condition and the scale of work required
- prioritise work and quantify the resources required and any constraints
- influence the solution and design for pathwork required
- establish a plan of action for current and future levels of work
- determine the overall level of funding required
- enable resources to be targeted and work implemented

Coire Dubh, Glen Torridon. A path assessed within a mountain area with increasing recreational use. Surveys identified the spread of severe trampling and water gullying in a fragile environment. The assessment indicated a high priority for sensitive path repair work. (See Environmental Impact for the repaired path.)



LOCH LOMOND AND TROSSACHS SURVEY
PATH ASSESSMENT

PATH: The Cobbler
NO: 01
START POINT: NN26480657
END POINT: NN27990511

1. DESCRIPTION

1.1 Setting:

The Cobbler is one of the most popular hills in Scotland, due to its close proximity to the central belt and Glasgow, but mainly due to the impressive nature of the hill with its rocky out crops and very distinct shape. It is one of the mouton group called the Arrochar Alps, situated at the north end of Loch Long. The path surveyed starts at the formal car park on the A83 just along from the Succ and then traver side of the burn follow two rou the saddle to h continues over summits. The r at the dam. Th east and Ben Ir

1.2 Use:

The main path by rock-climbe posted. This is to walkers look

1.3 Physical Settin

The Cobbler is cracks making grass heath/arc conifer plantati

1.4 Management:

The path has u The path line u footings for a c access the wate the dam to the on it within the some up-gradir catchment.

1.5 Ownership:

Contact: Iain Everard
FE Cowal District
Kilmun by Dunoon
PA23 8SE
Tel: 01369 840666

1.6 Survey:

The path was Narnain bouk continuation v methods. The using red and survey was ca was dall with

2. ASSESSME

2.1 Condition:

The path is in will continue has already ha

2.2 Construction

Access to this sections are a is only access not so readily will be necess to be worked public.

2.3 Priority:

Highest priori sections.

2.4 Work Identified:

Number of sections	Total Length (m)	Priority	Cost (£)
1	214	1	10,560.90
3	1467	2	61,889.82
6	1573	3	48,885.43
8	2535	4	37,441.95
0	0	5	0.00

2.5 Likely impact of no action on the path:

No action will result in the continued deterioration of the path and scarring will become more visible and intrusive.

3. RECOMMENDATIONS

3.1 Design

The path should be constructed using traditional upland path techniques. These should use locally available stone and should ensure the path works blend in with the local environment. The path is well used so a width of 1000mm maximum would suit lower sections of path, and at higher levels a maximum of 900mm. Drainage features such as cross-drains and water-bars should be used and any floated sections of path should use geo-synthetics ie. Terram 1000 and tensar geo-grid. Stone-pitching should be used on steep eroded sections using local stone and incorporating water-bars.

3.2 Work needed

Work is required on the upper sections within the next 1-2 years starting at the bottom of section 10. The amber sections require working within the next 3-5 years starting from section 1.

3.3 Use and Promotion

After construction the path will withstand an increase in walkers as long as regular maintenance is carried out, this is essential for the longevity of the path.

3.4 Maintenance

This path will require frequent maintenance checks at least four times a year. This would involve clearing all drains, water-bars and cross drains. Re-packing of pitching and other stone structures, re-surfacing and minor landscaping will also be needed.

PHOTO No: 2
GR:
Start of serious erosion above burn crossing. Trample widths over 40m.

A management report on one path, assessed within a wider area.
The written site description, maps and photographs are accompanied by condition survey sheets (see Path Survey).

Sources of Information

Information can be gathered from a variety of sources. Local authority records, in planning, countryside or recreation departments, may include old survey data, maps and photographic records. Landowners and local residents can also provide useful information, which should be gathered by talking and meeting with the appropriate people. Community councils will often help with this type of research and survey. Information should include:

- background detail, maps, photos - on geography, historical and current land use, user profiles, patterns, numbers, etc
- views of users, land owners, special interest groups etc. - information from people familiar with the site is invaluable, particularly regarding changeable local factors such as water flow, alternative local routes and short-cuts and seasonal variation in use
- promotion of areas or routes - information from local tourist businesses, guide books or specialist use
- past and new path survey data - on path use, condition, problems and work required - obtained from results of path condition and work specification surveys (see Path Survey)

Communication and consultation

A variety of people are concerned with path management. They may all play a role in the path assessment whether providing information or involved in consultation.

- Landowners - including the factor, land agent or estate manager - can provide information on many areas of the path assessment.
- SNH - government agency - involved in designated areas and recreation management as well as conservation and funding issues.
- Path or property manager - working on behalf of the landowner, charitable trusts or local authorities - normally responsible for the assessment, generating path surveys and strategic reporting.
- Surveyor - trained specialist working for the path manager or landowner - carries out condition or specification surveys.
- Users - organised groups, local community, or simply people who use and know the path - an invaluable source of local information about the path use and area.
- Funding partners - public, voluntary and private - potentially contribute to the funding of path management and the pathwork, and often have views on how their resources should be applied.

Assessment information format

This wide range of information and views is structured into categories. A common format of Path Assessment includes:

Location

- Reason for path, and setting
- Map
- Photographs
- Access to path and access restrictions

Physical Setting

- Geology
- Geomorphology
- Habitat and vegetation
- Altitude
- Weather trends

Path use
- Type
- Numbers
- Patterns

Land-use
- Owners
- Managers
- Boundaries and maps
- Designations

Path Condition
- Previous management
- Overall and path section survey results
- Dynamism of the path and sections
- Likely impact of no action

Work Required
- Priority sections for work
- Specification survey details
- Extent and style of work
- Techniques to be used
- Path alignment
- Quantity of work, work days and length
- Future monitoring and maintenance programme

Other Factors
- Costs and funding
- Contracts and supervision required
- Programming and timing of work
- Availability of materials, on or off site
- Access to site for workers, plant and materials
- Health and Safety considerations
- Additional constraints or restrictions

The use of a database for storing data and compiling results is useful on all large scale assessments where paths are being assessed as part of an area network.

Having gathered together all the detail under suitable headings, and identified problem areas and potential solutions, the assessed information is used to make decisions and plan the programme of work for the path or paths in question. A draft should be circulated to all relevant interested parties for consultation. Consultation responses should be incorporated into the plan. The next steps in the path management process can then be taken.

- Bid for resources, with the aim of securing funds to carry out the work required, staged over several years if necessary.
- Implement pathwork, according to the results of the path assessment and the principles and techniques set out in this manual.

1.4 Path Survey

Introduction

Path Surveys gather physical information about the path from detailed on-site inspection and measurement. They form the backbone of a good Path Assessment. The results provide the basis for funding strategies and pathwork implementation.

Two survey methods are predominantly used for upland pathwork in Scotland.

- **Condition** (sometimes known as amber) survey - collects data about the existing condition and indicates where problem lengths will require work and a specification survey. The data should provide a 'base line' for repeat monitoring.
- **Specification** (sometimes known as red) surveys - essentially a 'quantity survey', which provides further detail on problem sections, assesses the problems and prescribes and quantifies the work required to repair the path.

Condition surveys are usually carried out over a wide area to assess paths and decide which ones to manage first. The information is useful for up to 5 years and can be used to monitor changes in conditions. Specification surveys are usually carried out on sites where work will take place in the next 1-3 years. They are more detailed, take longer to survey and are used to specify the work required. Ideally the condition survey will identify where specification surveys are needed - but where damage is evident and urgent action needed, both types of information are gathered on one survey visit.

There are several factors common to both survey methods.

Surveyor and Timing

Surveys are normally carried out by one person who may be an experienced path surveyor, a path management specialist, or a competent pathworker with at least two years' experience. The more familiar the surveyor is with the site the better. All surveyors should be trained and familiar with the survey method and reporting.

Surveys should be undertaken on as wet a day as practicable, or after spells of wet weather, so that path and drainage problems are seen at their worst. However high winds and heavy rain slow the survey down; still days are always preferable. Winter should be avoided for obvious reasons; increased likelihood of snow on the path, and the difficulties of recording on survey sheets with cold, wet hands.

On average it takes one day to cover 6 kilometres of path for a condition survey and 2 kilometres for a specification survey. However, path condition, access time and weather can influence this dramatically. Additional days are required for writing up survey sheets, for data input, and report preparation. Particularly if you don't know the site additional days will be highly beneficial for visiting the site in different weather conditions and times of year to familiarise yourself with the path and confirm decisions.

Path Identification and Sectioning

Paths to be surveyed will be marked on a map base and identified with a numbering system. Grid references for the map based start and finish points will be required for the field survey sheets, and reporting.

Surveys usually start at the base of the route and work uphill. The start point should be the most obvious point of access, i.e. where the path leaves the road, a main path or track, or at its junction with another path in the network being surveyed. For 'stand-alone' specification surveys it may be at the position where damage starts on the path.

During the survey each path is divided into sections. Section start and end points are best made at places with distinct changes in physical condition of the path or terrain. These will become apparent as the surveyor progresses along the path. Change points may include:

- path type, character or direction
- path gradient
- path surface or width
- nature of erosion
- vegetation type
- path junctions
- notable physical features

Section changes should be at measurable points which are clearly identifiable and permanent for further monitoring and specification surveys. Section lengths are progressively numbered, and uniquely referenced to the path identifier number, before marking on a map base and grid referenced. Any additional spurs or loops attached to the path should be annexed to the main path, with additional numbering. Depending on their length, and level of use, a separate path identifier and sectioning may be required.

Section lengths are variable, and not pre-set. It may be useful for a path manager to define a minimum or maximum length for ease of data handling and analysis, future monitoring or work programmes. For example, a specification survey that will be used to let contract work may have a larger number of shorter sections, to help identify separate elements of future work. Sections can be subdivided, either during or after the specification survey, mainly where obvious changes in the pathwork alignment, design and technique occur.

The survey sheets do not have any restriction on the number of sections or length of path recorded on one sheet - the scale is elastic. Some sections may be complex and require a lot of detail to be recorded; maybe covering only 50 metres of a section on one sheet. Others may be straight forward with very little variation in condition, with up to 300 metres on one sheet.

Equipment required

Basic equipment required for both survey methods includes:

- Standard survey sheets - preferably prepared on waterproof paper
- Map and compass - for geographical location and defining path direction
- Clinometer - for measuring path and slope gradients
- Tape measure - for path or damage widths or short treatment lengths
- Cane or similar probe - for investigating waterlogged ground, peat depth, etc.
- Camera - for fixed point photographs of typical condition, and erosion problems
- GPS (Global Positioning System)
- Measuring wheel

A data capture device (a hand held computer with specifically designed software for logging survey data) may be used on-site for direct data input or for rapid data input after each day's survey.

Condition (Amber) Survey

Function

The purpose of a condition survey is to record the present condition of the path, in order to inform management decisions. The resulting data gives invaluable indications as to where priorities for work lie. It may prescribe where work is required but does not provide a detailed specification. The survey method can be repeated for future monitoring.

Condition survey results are generally used by path managers, landowners and funders to:

- identify the worst sections of erosion and potential problem routes and sections
- define and prioritise where pathwork and specification surveys are required
- integrate with the management plan for the surveyed area
- provide baseline detail for future condition monitoring and the measurement of any change
- draw comparisons with other paths and sites to enable informed decisions to be made for prioritising resources
- aid funding bids and estimate maintenance times
- Assess effectiveness/success of previous work.

Method

The surveyor details quantitative and qualitative information about the present path condition, including all constructed features, and notes significant work requirements. Photographs are useful for illustrating specific sections needing repairs. This information can then be used to estimate the cost of work and scale of resources to repair the path or for maintenance.

Full training in recording site data and analysing and interpreting the results is required to make best use of the information in condition surveys but an overview is given here.

Weather	Date	Path Name	Surveyor	Start: NC1673919632
Sunny, dry	22/10/12	Suilven	Chris Goodman	End: NC1578418106

Section °	Length °	Grid Ref °	Surface Type	Features °	Paths/ Braids	Bare Width	Tramp Width	Gully Depth	LG/ XF	Rough-ness	Drain-age	Erosion	Cond-ition	Dyna-mism	Priority	Built Features							
																XD		Pitching		SD		Revett	
1	760	NC1673919632	peat/ grass	cairn at track	1/3	2.00	20	0.2	17/18	4	2	3	3	4	4	WB		Agg.		Pipe C		……	

Description: Generally flat peaty ground with a few short rises which are more stoney. Path fairly braided and quite boggy in places. Erosion probably not worsening rapidly and not a hugely visible scar at present but likely to continue to widen and become more peaty as vegetation trampled. Only solution would be to excavate and lay a path which would change nature of experience but if kept narrow and with a sensitive line would be in-keeping with the environment. Imported surfacing would not be appropriate, would hope to win hard core and surfacing from borrow pits on site. No building stone for drainage features though, would probably need to airlift from boulder fields at base of Suilven. May be able to quarry surfacing with excavator.

Section °	Length °	Grid Ref °	Surface Type	Features °	Paths/ Braids	Bare Width	Tramp Width	Gully Depth	LG/ XF	Rough-ness	Drain-age	Erosion	Cond-ition	Dyna-mism	Priority	Built Features							
																XD		Pitching		SD		Revett	
2	184	NC1636119132	stone/ scree/ bedrock	steeper slope	1/3	4.50	7.00	0.4	30/15	2	3	3	3	3	3	WB		Agg.		.....		…..	

Description: Steeper section more eroded and visible on the approach, worst after 114m where water running down path. More dynamic due to gradient and more urgent to stabilise as earlier intervention will help minimise works required. Probably enough rock, scree and fines on site (although scarce at top of site) to build pitching, steps and drainage features. Would prob need to build path over exposed bedrock and substantially landscape the path edges.

Section °	Length °	Grid Ref °	Surface Type	Features °	Paths/ Braids	Bare Width	Tramp Width	Gully Depth	LG/ XF	Rough-ness	Drain-age	Erosion	Cond-ition	Dyna-mism	Priority	Built Features							
																XD		Pitching		SD		Revett	
3	581	NC1629719018	peat/ grass/ stone	top of slope	1/2	2.20	4.00	0.5	15/20	3	3	3	3	3	3	WB		Agg.		.....		…..	

Description: Path contours up and round slope with bleached white stone exposed and new peaty braid developing on left. Exposed stone awkward to walk on and pushing walkers onto vegetation causing erosion to spread. Would probably need a full build path although would be best done by hand so as to be more natural and in keeping. Some signs of mineral deposits present and should be enough stone available although generally unweathered.

Extract from a Condition Survey of Suilven by the John Muir Trust, 2012

Data Collected

Four types of data are collected for a condition survey:

1. Description

- date, and weather before and during survey
- path and section number and reason for change of section
- map location and grid reference, for start/end of each section
- section length and cumulative path length
- type of path and surface
- surrounding vegetation type and cover

2. Measures

- number of 'main' paths and number of braids
- bare width range - minimum and maximum width of bare un-vegetated ground across the path
- trample width range - minimum and maximum width of trampled ground across the path
- gully depth range - minimum and maximum depth of eroded gullying or soil loss on the path
- long gradient and cross-fall - average gradient along the path; average gradient up the fall-line

3. Indices

Assessment of non-measurable factors uses indices on a scale of 1 to 5, where 1 = the worst or most active, and 5 = the best or least active. The factors are:

- Roughness - the condition of the surface, how hard or easy it is to walk on
- Drainage - the effects of water on the path, standing water, seepage and water flow
- Erosion - the present rate of damage to the path line
- Condition - the overall condition of the path
- Dynamism - the predicted rate of change to the path condition

4. Prescription

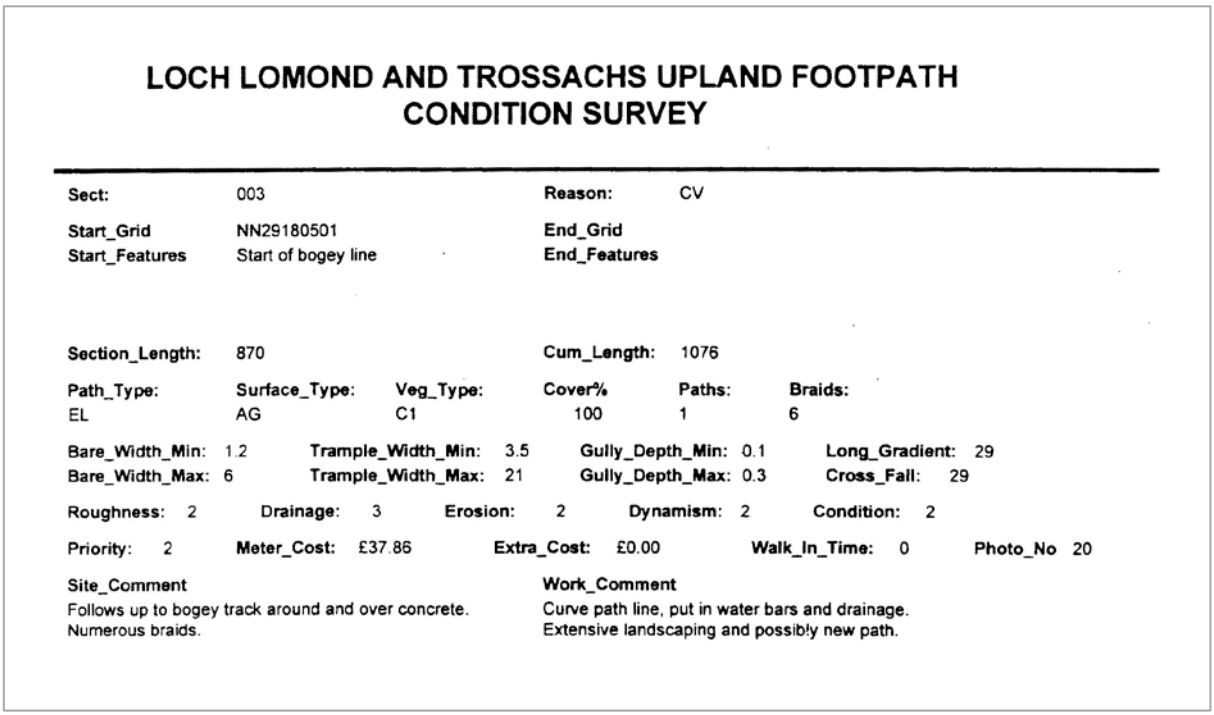
The final set of data recorded includes additional information relating to path management. These may be comments on work required, ancillary structures, access, availability of materials, etc.

Photos illustrate the nature of measured or non-measurable indicators, particularly where dynamism is active, or specific problems which are difficult to quantify. Photos are numbered and positions recorded, with the direction taken along, or across the path.

Results

Using specially designed software, the data can be analysed to provide a wide variety of information, from simple summaries to elaborate cross-tabulations, for each section. These may compare dynamism to gradient; drainage to roughness etc.; presented in a number of formats including tables, graphs and charts; with percentages, averages and total numbers. They can be a useful management tool, enabling data comparison for networks of paths, and throughout different regions.

The analysis results can then be integrated with the path assessment, to help formulate a management plan for the path.



LOCH LOMOND AND TROSSACHS UPLAND FOOTPATH CONDITION SURVEY

Sect:	003	**Reason:**	CV
Start_Grid	NN29180501	**End_Grid**	
Start_Features	Start of bogey line	**End_Features**	

Section_Length:	870
Cum_Length:	1076

Path_Type:	**Surface_Type:**	**Veg_Type:**	**Cover%**	**Paths:**	**Braids:**
EL	AG	C1	100	1	6

Bare_Width_Min:	1.2	**Trample_Width_Min:**	3.5	**Gully_Depth_Min:**	0.1	**Long_Gradient:**	29
Bare_Width_Max:	6	**Trample_Width_Max:**	21	**Gully_Depth_Max:**	0.3	**Cross_Fall:**	29

Roughness:	2	**Drainage:**	3	**Erosion:**	2	**Dynamism:**	2	**Condition:**	2

Priority:	2	**Meter_Cost:**	£37.86	**Extra_Cost:**	£0.00	**Walk_In_Time:**	0	**Photo_No**	20

Site_Comment	**Work_Comment**
Follows up to bogey track around and over concrete. Numerous braids.	Curve path line, put in water bars and drainage. Extensive landscaping and possibly new path.

Extract from the Cobbler path survey data report, as entered on the survey database.
Data was generated by The Footpath Trust as part of the Loch Lomond and Trossachs Upland Footpath Condition Survey; 1998

Specification (Red) Survey

Function

The main purpose is to provide detail of the work required to restore the path to a good condition. The detail includes the number and location of structures and features required, as well as estimated work days to carry out the work.

It provides path managers and land agents with work quantities, timings and costings, and can be used to draw up specifications and bills of quantity for letting contracts. It is also intended as a working document for use by the pathworker to locate the work required on site. It is an essential part of any contract for pathwork.

Method

The surveyor details information about the present path condition and records cumulative measurements. The need for treatment and the appropriate techniques are considered, prescribed, detailed and measured, along the equivalent path length. The path condition and potential treatment is depicted on the survey sheet using a standard set of symbols (see Glossary of Symbols). Obvious landscape features are also depicted, to help locate the position along the path.

The surveyor also lists and quantifies each element of pathwork, assesses the site conditions and calculates the number of workdays required. As the conditions affecting construction time vary from site to site there is no set number of days per work element.

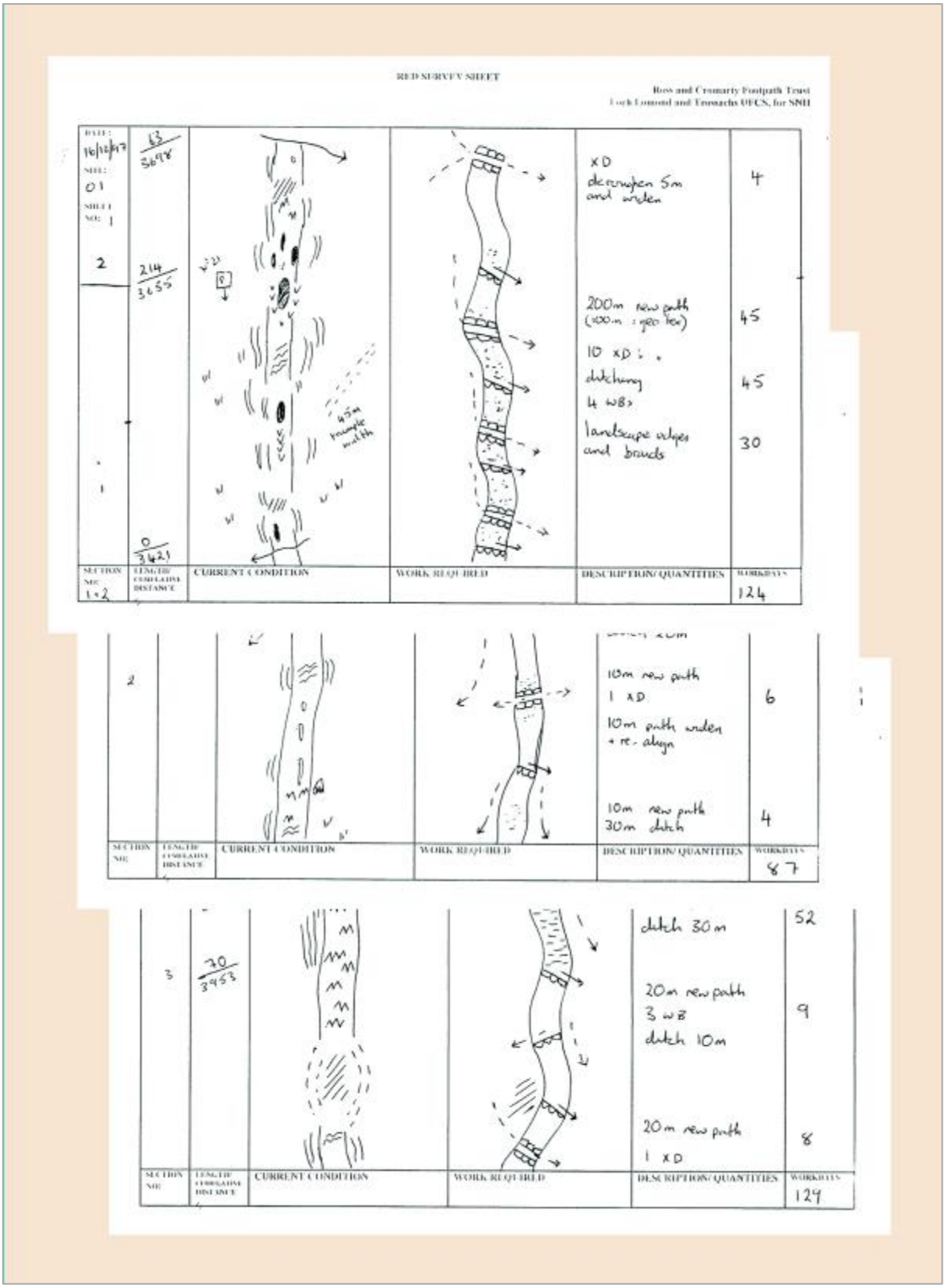
A typical pathworker day is eight hours, but this must allow for walk in times, which may be accounted for separately.

Being able to locate and re-locate the exact place of survey is one of the most difficult parts of a good survey. Record as many locating features as possible - they must be easily located and permanent for identification by the pathworker.

Survey Sheet

DATE SITE SHEET NO.	**Distance to next feature, and total length from start of survey**	**Pathline and current condition representing using survey symbols. Progress along the path, as symbols are entered up the page.** **Sections mark distinct lengths of the path, with differing conditions and clear markers at each end**	**Pathline and work required, using survey symbols. Sections match equivalent lengths of path in conditions column.**	**List of work required, plus any extra notes. Useful in drawing up specification for work and estimating resources needed to repair route.**	**Time estimate for each section, based on number of pathworker days.**
SECTION NO.	LENGTH/ CUMULATIVE DISTANCE	CURRENT CONDITIONS	WORK REQUIRED	DESCRIPTION/ QUANTITIES	WORKDAYS

Target notes on information contained on a standard specification survey sheet.



Completed survey sheets illustrating the use of symbols to depict path condition and work required. See Glossary of Symbols for key. Loch Lomond and the Trossachs Upland Footpath Condition Survey, 1998. The Footpath Trust, for Scottish Natural Heritage

Data Collected

Four types of data are collected for a specification survey:

1. Description

- name of surveyor, weather conditions
- date of survey
- path and section identifier

2. Measures

- cumulative length along the path
- measurement at path condition and landscape features
- linear measurement of prescribed path repair
- path gradient where it steepens
- damaged path width and number of braids

3. Pictorial

- path condition - drainage problems/features, path damage and erosion features
- pathwork - drainage systems and techniques, path repair techniques, restoration work
- notable landscape features - fencing, dykes, trees, obvious bed-rock
- photograph points

4. Prescription

- work to be carried out in note form, including sourcing of materials
- estimated number of constructed features required and work lengths or areas
- number of work days estimated for the work

Results

The written up survey sheets can be used as the pathwork specification, or the detail extracted to complete a full contract specification.

The path manager can use the quantified work and estimated work days to cost and plan the work.
The labour costs will be calculated by taking the total number of work days expected and multiplying them by the average day rate charge for a qualified pathworker.

These figures, and a summary of specification details, may then be integrated with the path assessment management plan to provide a complete record of the proposed path management.

1.5 Maintenance

Introduction

Maintenance of upland paths is essential to enable the path network to sustain increasing pressures of use and weather, and to extend the life of rebuilt paths.

If routinely maintained to a high standard the path can last indefinitely, assuming pressures remain constant, with only minor repairs ever needed. However, freak weather events such as torrential rain are happening more frequently due to climate change and well maintained paths can better withstand these events. On-going routine maintenance also helps to ensure value for money and is the distinguishing mark of good path management.

Maintenance Programmes

An established maintenance programme will incorporate regular monitoring to check that the path is sustaining the pressure of use and weather. If pathwork has taken place, monitoring will check that it is performing to the standard required, with no drainage features failing or damage occurring on the path or restored areas. Minor maintenance work is undertaken at the same time as monitoring checks; more extensive maintenance should be reported for work programming.

If resources are available, it is preferable that a path is monitored about four times a year. However, two maintenance inspections per year will make a big difference, particularly at times most prone to problems. The timing and extent of maintenance will depend on a number of factors which will vary from path to path, depending on its characteristics:

- weather trends and altitude - rates of precipitation and areas prone to late snow
- path dynamics - steep or level gradients, mobile or consolidated surfaces, older or newly constructed
- user numbers and seasonal variations - how many people walk on the path and when.

These characteristics should have been identified during the path assessment. Every path varies but on a typical upland path with regular cross drains and water bars, one person can maintain about 3-4 km of path a day if clearing the drainage features is all that's required. Other maintenance such as resurfacing, blocking braids and repairing any failed features is harder to anticipate but extra days will need to be allowed for this sort of work too. As your familiarity with any path builds you get to know what sort of work it requires and how often but for estimating times remember that drains on a steep mobile path will fill in weeks, whereas a flat solid path may only require annual maintenance visits.

With problems arising from effects of weather and seasonal use the preferred timing for monitoring and maintenance work will be:

- end of winter/early spring (April/May) - once the worst of any snow-melt and prolonged periods of rain are over; and damage by frost heave is past its worst
- mid-summer (July/August) - when pressure of use is at its highest; particularly on well used paths with a mobile surface, where cross-drains and water-bars quickly become blocked causing surface water damage to the path surface
- autumn (October/November) - at the end of the summer season; to check drains before the heavier rains and snow of winter arrives
- winter (if site allows) - throughout winter when dead grass is blown around and is likely to block drainage features

Maintenance Tasks

Most of the tasks required are included at the end of each pathwork technique described in Sections 2, 3 and 4. The tasks generally involve:

- clearing out accumulated debris or silt from blocked drains and ditches
- re-packing loose stone work where it has settled or washed out
- re-surfacing washed out or worn away surfaces or compaction behind drains etc.
- re-turfing or blocking path braids, or short cuts and off-path use

Any material won from carrying out these tasks should be re-used, e.g. to resurface where compaction has occurred, to pack gaps in stonework, to re-turf path sides or restoration areas.

Maintenance Recording Sheets

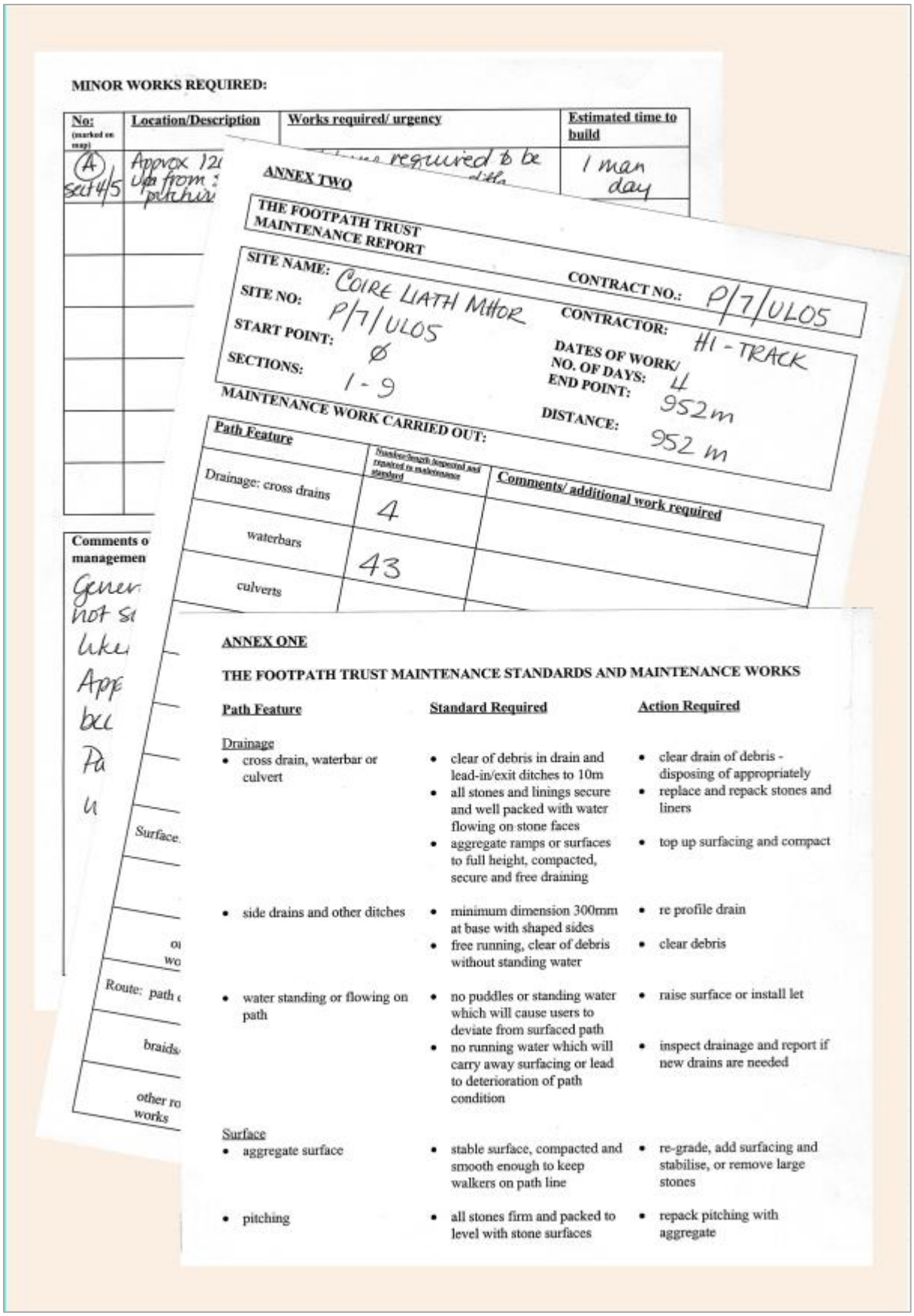
Using a recording system can ensure that maintenance work is carried out to required standards. Details of maintenance tasks carried out are recorded, as well as information on the number of drainage features and length of path inspected, and how much time was required. As it becomes apparent when maintenance is required and how often, they provide a work record for the path manager and assist in the programming of future maintenance.

Minor Works

Changes in use and extreme weather may cause drains and path surfaces to fail or wash away. Damage which involves time consuming re-building, and possibly new pathwork to rectify, is more than routine maintenance. Minor works that are required should be recorded on the maintenance sheet with as much information as possible, including:

- location (referenced to the path and section identifier where possible)
- quantity of work and materials required
- urgency of the work
- length of time required to carry out work
- photograph

It should then be brought to the attention of the path manager or client as soon as possible, for appropriate action and repair work.



MINOR WORKS REQUIRED:

No: (marked on map)	Location/Description	Works required/ urgency	Estimated time to build
(A) sect 4/5	Approx 12 Up from pitchin	required to be	1 man day

ANNEX TWO

THE FOOTPATH TRUST MAINTENANCE REPORT

SITE NAME: COIRE LIATH MHOR
CONTRACT NO.: P/7/ULO5
SITE NO: P/7/ULO5
CONTRACTOR: HI-TRACK
START POINT: Ø
DATES OF WORK/ NO. OF DAYS: 4
SECTIONS: 1-9
END POINT: 952m
DISTANCE: 952 m

MAINTENANCE WORK CARRIED OUT:

Path Feature	Number/length inspected and repaired to maintenance standard	Comments/ additional work required
Drainage: cross drains	4	
waterbars	43	
culverts		

Comments o management

Gener not si like App bu Pa u

Surface

Route: path

braids

other ro works

ANNEX ONE

THE FOOTPATH TRUST MAINTENANCE STANDARDS AND MAINTENANCE WORKS

Path Feature	Standard Required	Action Required
Drainage		
• cross drain, waterbar or culvert	• clear of debris in drain and lead-in/exit ditches to 10m • all stones and linings secure and well packed with water flowing on stone faces • aggregate ramps or surfaces to full height, compacted, secure and free draining	• clear drain of debris - disposing of appropriately • replace and repack stones and liners • top up surfacing and compact
• side drains and other ditches	• minimum dimension 300mm at base with shaped sides • free running, clear of debris without standing water	• re profile drain • clear debris
• water standing or flowing on path	• no puddles or standing water which will cause users to deviate from surfaced path • no running water which will carry away surfacing or lead to deterioration of path condition	• raise surface or install let • inspect drainage and report if new drains are needed
Surface		
• aggregate surface	• stable surface, compacted and smooth enough to keep walkers on path line	• re-grade, add surfacing and stabilise, or remove large stones
• pitching	• all stones firm and packed to level with stone surfaces	• repack pitching with aggregate

1.6 Working Practice

Introduction

Upland pathwork in Scotland is generally organised through contracting to path contractors. The main responsibilities within each contract are outlined below. Different organisations vary the terminology, but the roles are essentially the same.

- Client - for whom the work is being done - often in partnership with landowners and funders, e.g. National Trust for Scotland, Highlands and Islands Enterprise, COAT.
- Contractors - contracted by the client to carry out the work. If the path project is notifiable to the Health and Safety Executive - the contractor is appointed as a 'Principal Contractor'.
- Designer – either an employee of the client or a contractor who carries out the site specification survey and design work.
- Contract co-ordinator, work supervisor, clerk of works - responsible for over-seeing the contract on behalf of the client - liaises with the contractor to make sure that the contract is undertaken and completed satisfactorily.
- Team leader or Contractor's supervisor - responsible for the work team and ensuring successful completion of the work.
- Pathworkers - responsible for constructing the path to the standard required - usually working as members of a team.

Good working practice involves effective communication and co-operation between all parties, resulting in a well-planned and organised site that will run efficiently and safely - producing quality work on time and to budget and minimising environmental impact.

There are a number of key areas that should be addressed by all involved in work on a path.

Planning

- The work should be timed to fit in with the seasons - avoid harsh winter conditions, and busy summer months, on very popular routes.
- The quantity of work to be completed must be achievable and the quality not compromised by rushing to complete works.
- The site should be assessed before work starts, from this specification survey, a plan for carrying out the actual work can be made, for use by both client and contractor.

Communication

- Good communications are essential between everybody involved in the pathwork - bad (or insufficient) communication is one of the most common reasons for problems arising with work and for injuries and accidents.
- If all parties concerned are properly informed about what is happening on site, how it is organised, who is responsible and who to approach for information, then all should run well.
- Regular meetings should be held particularly between the client, the team leader and pathworkers - and include weekly site safety meetings.
- Landowners, tenants and sometimes neighbours, should be contacted and informed about the work - permissions should be agreed for access to the site.
- The public should be informed about work that is taking place, particularly the local community, interest groups, path users, and any other interested bodies.

Team work

- A team that works well together will operate efficiently, safely and with good productivity.
- All teams vary, with individual preferences on how work is done - some prefer working by themselves, bringing in help to move large stone - others prefer working in pairs.
- Upland path work is labour intensive - working as a team can help to ease the pressure and avoid double-handling or wasted journeys. This is particularly relevant to tasks that involve re-using excavated material on the site.

Safety

- The relevant safety procedures (see Health and Safety) should be followed at all times. All path workers should be made aware of these procedures before working on the site.
- Path workers should have site inductions before starting work on the site. Inductions should inform workers of rules, emergency procedures, etc.
- Where path work activities create significant risks, provide health and safety training before starting the work.
- Being aware of colleagues and public safety at all times is essential (see Health and Safety).
- Consult with path workers concerning health and safety issues via site meetings. Encourage path workers to discuss issues and concerns and respond to those concerns promptly.
- Pathwork should always be carried out by a team of at least three, in case of an accident; maintenance tasks may be carried out by two due to the lighter nature of the tasks.

Safe working practice

Pathworkers are responsible for their own safe working practice, and must be aware of others. They should ensure they are adequately trained, and undergo specialist training as required. Issues that should be covered include the following.

- **Safe working site**: keeping tools stored safely when not in use; keeping access areas and routes clear; shoring up excavations above chest height; watching and signaling when using plant or moving materials; securing unstable boulders or other large objects.
- **Safe working distance**: keeping a safe distance between workers, particularly when using hand tools such as mattocks, picks and sledge hammers; keeping a safe distance between moving plant and workers and public.
- **Safe and correct use of work equipment**: using machinery according to safety limits, manufacturer's safety and user instructions; using trained machine operators; only using tools and equipment that are maintained in a safe condition and checked for damage or faults; carry tools properly so that you don't get hurt or hurt someone else nearby.
- **Safe lifting techniques**: manual handling to ensure materials are lifted properly, minimising the risk of injury; use of mechanical means wherever possible.
- **PPE**: making sure that appropriate equipment is provided and used; steel toe-capped boots when excavating, moving and using large stone; safety goggles when smashing stone; hard-hats when working in excavations above chest height, or in areas of stone-fall danger, when moving machinery and attaching lifting slings to stone bags beneath a hovering helicopter; ear-defenders when using or standing by noisy plant such as power barrows, vibrating plates, excavators and helicopters.

- **Personal welfare**: avoiding working above personal capabilities; take regular breaks during strenuous activity, fatigue can lead to mistakes and accidents; wear appropriate clothing; stop work in adverse weather conditions; provide shelter and means of heating food; pay attention to and provide facilities for personal hygiene; drink plenty of water during and after strenuous work especially in hot weather conditions.
- **Team working**: lone working should always be avoided; work in pairs or within sight of other pathworkers; have procedures for 'logging in' at the start and end of a work day.
- **Health risks**: awareness and precautions against illnesses encountered whilst working outdoors - most commonly tetanus, Lyme disease, Weils disease, Orf virus and hogweed blisters. Be aware of and guard against sunstroke and hypothermia (see mountain safety training).

Quality

- The quality of path construction should be of the highest standard and minimise environmental impact.
- Only competent pathworkers should be used to carry out sensitive pathwork.
- The quality of work should not be compromised - poor quality work will not last or withstand the pressures exerted on upland footpaths.

Supervision of the pathwork should be by a competent and experienced manager - regular inspections should be made to ensure that working practice standards are being met.

1.7 Tools and Equipment

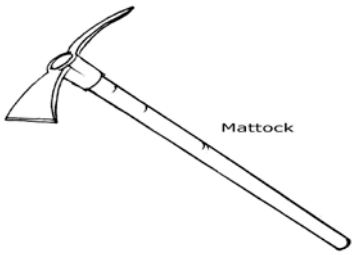
Introduction

Most upland pathwork uses hand tools for manual construction techniques, with the assistance of small mechanical equipment to move materials around or to the site. Personal protective and safety equipment is also required on site for both personal safety and in the event of an accident.

Hand Tools

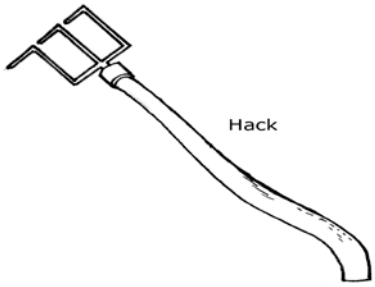
A variety of tools have been traditionally used on the land for many years by estate workers or crofters. Some have been adapted for use in pathwork, but most remain the same, though names vary from area to area. The basic hand tools required are:

- Pinch-bar
- Mattock
- Spade
- Shovel
- Mash hammer
- Sledge hammer



Some of the extras or alternatives include:

- Rake
- Hack (hooked three pronged fork, for moving turf)
- Rutter (very heavy, big ditching spade)
- Pick axe
- Tamper
- Buckets
- Wheelbarrows



The hand-tools and type selected for use will depend largely on the particular task being carried out, but will also vary with the individual preference of the pathworker. There is also a wide variety of types of mattock, spade, shovel, pinch bar, rake and hammer to choose from.

Safety and Care

Hand tools should be checked daily and regularly maintained to ensure that they are safe to use, as well as prolonging their life.

- Steel edges and heads should be kept free of burrs
- Cutting edges should be kept sharp
- Heads should be checked to ensure that they are firmly fixed to the shaft, wedges should be undamaged and secure
- Shafts should be checked for damage, such as cracks and splits in the wood, and replaced when necessary

Tools should be safely transported to site. In vehicles they should be in a separate compartment from the passengers and driver. If this is not possible they should be boxed or firmly tied and secured. When carrying tools to the work site, overloading should be avoided and tools carried at the side rather than over the shoulder.

Small Mechanical Equipment

The two most commonly used pieces of equipment are:

- Power barrows
- Manually operated winches

Used for gathering and moving materials, they reduce the need for manual handling and lifting of materials. Before using them it is essential that the operator has received training in use and safety, and is familiar with manufacturer's guidelines. Mechanical equipment should only be used after maintenance checks have been made by a competent person.

Power Barrows

These are small tracked "wheel-barrows", powered by a small four stroke engine. Running on rubber tracks they spread the load over a larger area and minimise damage to vegetation. Depending on the size and make they can carry approximately 400kgs on level ground, and 250kg on a gradient, e.g. the Honda HP400. Some models have a hand operated tipping mechanism. They can be used to carry boulders, stone, aggregate, turf and soil to and from the path, as well as equipment to the work site.

They are robust and cope well with most rough upland terrain, if used properly. Terrain that is not suitable includes rocky, boulder strewn sites on steep gradients. Power barrows are not very stable traversing across steep slopes. They are better used straight up or down, but do have maximum gradient restrictions.

The site should be carefully assessed before barrows are brought on to it. On soft ground the tracks can cause damage if they lose traction, or are turned sharply. Users should vary the route taken to and from the path to reduce tracking and the likelihood of environmental damage.

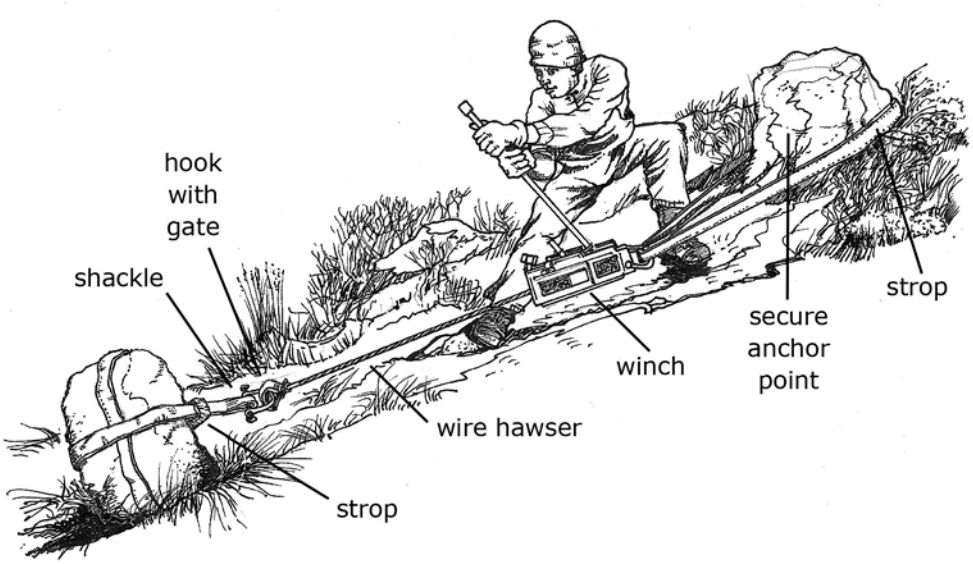
Winches

The most common type of winch used in upland pathwork, suitable for moving large boulders, is the manually operated ground winch, made by Tirfor. These are capable of pulling up to either 800kgs or 1600kgs. The winch has a shear pin that will break if the load maximum is exceeded. Larger winches, including powered winches, can be used, but they weigh more and are cumbersome to move around and transport to upland sites.

The main part of the winch is the gear box, where a rope is pulled using gripping jaws and a lever mechanism. The winch is used in conjunction with a wire rope, nylon strops, shackles and anchor points.

Anchor points will normally be in-situ boulders, or bedrock, which must be larger than the stone being winched. They need to be secure, with no possibility of moving once the winch is attached and operating, and combined with steel pins if necessary. They must also be a suitable shape to secure a nylon strop, to which the winch is attached. If none can be found in the location, purpose made anchor points can be set up using steel pins and chains. Anchor points must withstand the force of the winch and wire rope when the boulder is being

lifted. Once a stable anchor point has been set up it should be used for winching as many boulders as possible.



The boulder to be moved is secured with nylon strops, tape or rope, with no possibility of the boulder slipping. A system of self-tightening strops is the most effective. The winch and wire rope are attached to the anchoring and load strops with suitably sized shackles.

Safety and Care

Both power barrows and winches have restrictions and should never be used beyond their specification. They should be serviced according to the manufacturer's instructions. Safe working procedures should be followed at all times, particularly with regard to public and pathworker safety (see Working Practice).

They are subject to Health and Safety Regulations, which require regular maintenance with daily and weekly checks. Testing must be undertaken by a competent person at six month intervals. It is a legal requirement that the correct certificates are held.

The strops, ropes and shackle used with the winch should be more than capable of withstanding the maximum weights to be lifted, and marked with their safe working load. They should also be routinely tested by a competent person and checked daily for wear and damage prior to use.

Other Mechanical Equipment

Where access is suitable use may be made of ATVs for speedier transport of material, particularly where imported materials are stockpiled at a location near to the path. On remoter sites where large quantities of materials need to be imported, or moved to the path line, helicopters will need to be used. Although subject to more demanding work planning, working practice and safety management, they minimise time required, manual handling and environmental impact. Helicopters are generally contracted from specialist companies: loads lifted varying from 500kg to 1000kg.

Again where access is suitable, compaction machinery may be brought in to aid aggregate path construction. This may vary from vibrating plates to driven, twin drum, vibrating rollers. The provision and use of all compaction machinery is subject to Health and Safety Regulations.

Personal Protective Equipment

The appropriate protective equipment must be available and worn during relevant pathwork operations. Items will vary depending on the work being undertaken and the tools or plant being used. The following lists the minimum requirements.

- Steel toe-capped boots
- Gloves made of robust material
- Safety goggles
- Ear defenders
- Hard hat

A personal rucksack containing the following should also be carried.

- Waterproof clothing
- Spare warm clothing
- Food and hot drink
- Sun protection - filter or clothing
- Insect repellent
- Personal first aid kit

Safety Equipment

Most upland sites will require an extensive safety kit, to deal with situations that can arise in an exposed and changeable mountain environment. The following lists the essential items that should be available on site for the work team, at all times.

- Team First-aid kit
- Whistle, flares, strobe light
- Team bivi bag
- Survival bag
- Maps and compass
- Communication link - mobile phone or radio if possible
- Safety plan with evacuation procedure and contact numbers.

See Health and Safety for further information.

1.8 Mechanised Equipment

Introduction

The use of mechanised equipment has become increasingly popular in recent years. This section provides rudimentary practical advice on the potential application of different types of mechanised plant in path work within an upland environment and covers:

- the array of activities where plant might be applied;
- the considerations which will need to be taken into account in determining the advantages and disadvantages of using mechanical aids for these purposes; and
- the responsibilities which rest with both client and contractor in managing plant effectively, safely and with minimum impact on the work site.

Machine build can cause less environmental damage, particularly on open ground with heavily eroded paths or tracks, but it is not suitable for all projects, such as on steep, complex terrain. Because of the machinery, excavation in particular can be much faster, so there is a greater chance of more damage being done if things go wrong. When considering machine build remember that a sensitively worked path will need to be finished by hand. This advice is therefore not a substitute for the knowledge and experience needed to be able to fully assess what can be achieved under varying terrain and conditions, which can only be gained through practical experience on the ground. There is however broad experience on hand amongst path managers, consultants and contractors who can give such advice, as well as skilled operators within the contracting industry who are capable of undertaking path work with plant to a very high standard.

An Expanded Capacity

The use of mechanised equipment as an aid to constructing, repairing and maintaining upland paths has expanded rapidly in recent years, and has become a key consideration for both client and contractor in planning, managing and implementing various types of upland path work. This change has stemmed from the availability of an expanding array of specialised lightweight yet robust, powerful equipment designed to do different path work tasks with limited adverse impacts. This has been coupled with a growth in the capability of upland path contractors who now own and are able to skillfully employ machinery to great effect.

The successful application of these techniques in upland path work beyond the bounds of what was earlier thought possible has led in turn to a broader understanding and acceptance amongst path managers of the potential economic, logistic, environmental and safety advantages of mechanised plant as an aid to or in preference to handwork balanced with limited and acceptable levels of environmental impact.

Planning Ahead with Plant in Mind

It cannot be overstressed that the time to think about whether plant might be applicable to a path work project is at the beginning, at the initial planning stage. Material excavation, transportation and handling is often the single greatest task in a path project along with path excavation and drainage and equally the dominant cost. For every metre of path to be repaired there could be anything up to a metric ton of materials to excavate, move out of the way and replace with either materials close by or at a distance. Multiply this by the length of path to be repaired and the scale of the task becomes apparent. Yet because these

processes are masked by the end design and construction of the finished path, they are often overlooked, and are the key areas where machinery excels.

The knowledge of how different equipment might be applied may fundamentally change the way a project is planned and executed, and the means by which path work materials are sourced, transported and used. At almost every stage in the construction process there are mechanical aids to reduce human effort, time and cost, and to perform tasks that would otherwise be impossible to achieve. These include:

- excavation of soil, stone, gravel and turf;
- transportation of these materials to the site and along the line of the path; drainage and ditching tasks
- path excavation;
- surface grading, construction and rolling; and
- wider path landscaping.

Large excavator with long reach

Things to watch out for

A note of caution - don't let the machinery take over! Once mechanised equipment is out on site, there is a natural temptation by all the parties involved to cut corners or undertake tasks that ought to be done by hand in order to save time, cost and effort. If not carefully managed, this can result in the design and finished appearance of the path being compromised as a function of the equipment dictating activities on the site. The standard by which the finished path will be judged, and the aim that all path managers should aspire to is that it should be very difficult to tell if the path has been constructed or repaired by machine or by hand.

Things to guard against include;

- moving naturally occurring boulders out of the way to assist excavation of the path tray or overland movement of plant;
- removing bends from the natural alignment of the path; and
- producing straight ditches, uniform path surfaces, widths and lengths.

All plant operations need to be prescribed in the contract, and controlled through clear understanding between the client and contractor about how the path should look and feel at the end of the contract, and therefore what activities are acceptable. It also requires regular site visits to make sure these procedures are being adhered to.

Finally, in almost all cases mechanised operations will require varying degrees of "hand construction and finishing" to do the things which a machine cannot do and to help soften the appearance of the finished path to give it a natural and unobtrusive feel It includes all of the obvious construction activities such as forming drainage features, revetments and stone pitching but also includes softening hard lines and edges, grading surfaces, positioning edging boulders and turfs and other important landscaping tasks. This requires a range of skills, not least of which is an aesthetic eye, attention to detail and a commitment to landscaping. This needs to be prescribed and costed into the contract and understood by all the parties involved. In some instances the main plant contractor may not be able to provide this service, and it may require bringing in additional hand skills to do it.

APPLICATIONS OF PLANT

Transport of plant and materials to the site

Function:

To transport plant and path work materials (e.g. earth, stone, gravel and turf) to the site.

Method:

For larger jobs with robust site access (road access, hard surfaced tracks and strong bridges) it may be possible to transport plant and materials with a tipper lorry, tractor and trailer or dumper truck (single loads of between 1 and 20 metric tons). For short approaches to the site with sensitive terrain use a mechanised carrier, small tracked dumper truck or quad bike and trailer (single loads of up to 500kg). For long approaches to the site with difficult terrain and where ground tracking is unacceptable, materials should be carried as under slung loads by helicopter (widely available single loads of up to 1000kg, but typically between 750 – 900kg as these will lift faster in most conditions allowing flexibility and speed). The most common method of transporting plant is to track machinery onto the site by a pre-selected and agreed route. It is also possible to airlift small plant (or in extreme cases dismantle larger excavators into smaller loads) and airlift into the work site.

Troubleshooting/ things to consider:

Carefully evaluate location of materials needed on and off the site to reduce transportation distances and cost. Use on-site materials wherever possible as this significantly reduces overall costs as well as potential impact to the approach route. Determine plant carrying capacity of terrain to and on the site. If ground access is appropriate, survey and agree line to be taken with contractor. Ensure permissions have been obtained from all owners of land that machinery will cross.

Options:

There is a wide range and type of machinery for carrying materials, and all options should be carefully explored. Consider mix of transport methods to the site but avoid multiple handling of materials which is costly. Some small dumper trucks and carriers (400kg upwards) have a narrow track base that can be kept within the width of a surfaced approach path. In addition to flying materials to the work site, helicopters can be used to pre-position stone, gravel or other materials along the length of the path, thus reducing material handling and movement around the site. They can also be used to place surfacing materials directly into a prepared path tray with a hopper

Transporting materials to site

Movement of materials around the site

Function:

To carry path work materials, e.g. earth, stone, gravel and turf around the site and to stockpile or place them in position.

Method:

For sensitive sites with complex terrain it is likely that only a mechanised carrier, quad bike and trailer or small mini-digger will be appropriate. For less sensitive sites with easier terrain and where plant can be kept to harder ground, (e.g. in track restoration projects) it may be possible to use much larger machinery. Material movement should be reduced by careful site planning and in some instances prepositioning by helicopter or other aid (e.g. winch). In the case of using a larger excavator and boom, there is sometimes no need to use a carrier as the reach of the machine can both excavate and deposit the material where needed in one operation.

Troubleshooting/ things to consider:

Operations should be carefully planned and agreed to reduce movement of plant across the site, and kept to the harder ground. In general plant should be worked from the furthest to the nearest point as the path is repaired, followed by any landscaping and hand finishing to eradicate plant tracking.

Options:

There is a wide range and type of machinery for carrying materials (400kg upwards), and all options should be carefully explored.

Mini digger and power barrow

Drainage Work (*See Introduction to Drainage Techniques*)

Function:

To cut and dig out path work materials from side ditches, drainage channels and cross drains.

Method:

Various sizes of mechanical excavator can be used with different profile and size of bucket for these operations. Extensive ditching excavations, particularly in forming low profile water channels is an operation where plant can achieve a result that would be too labour intensive and costly to achieve by hand. Won materials can be stock piled, landscaped or transferred directly to a mechanised carrier.

Troubleshooting/ things to consider:

Operations should be carefully planned and agreed to reduce movement of plant across the site, and kept to the harder ground. In an upland setting and particularly across wet open ground where drainage is needed, careful consideration should also be given to the visual impact of ditch excavations which may intrude on the landscape and spoil the appearance of the finished path. Turf lined ditches may be less intrusive and more in keeping with the surrounding landform but take longer to build and are not appropriate for all habitats. With careful positioning, profiling and finishing by a skilled operator, turf lined ditches can be very effective and produce a drainage channel that will require far less maintenance in the long term. In general, plant should be worked from the furthest to the nearest point as the path is

repaired, followed by any landscaping and hand finishing to eradicate plant tracking. Ensure that drains are free from obstacles and no pooling of water occurs.

Options:

There are various sizes of mini excavator (0.9 to 1.5 tons), as well as medium and large excavator (2 to 15 tons) available. Shaped buckets designed to form drains to the exact measurements required can be used to good effect. Angling buckets can also be used to shape and form ditching.

Maintenance Tasks:

Drains should be checked regularly for any obstructions and cleaned out accordingly.

Excavation of Materials

Function:

To win path work materials, (e.g. earth, stone, gravel and turf) form, landscape and construct.

Method:

Various sizes of excavator can be used depending on quantities to be handled and any site restrictions imposed. For sensitive sites with complex terrain there are now a range of small but powerful mini-diggers available (0.9 to 1.5 tons). For less sensitive sites with easier terrain and where plant can be kept to harder ground, (e.g. in track restoration projects) it may be possible to use a larger excavator (2 to 15 tons). Methods must follow H&S guidelines that include depositing material a safe distance from the excavation and avoiding unstable sides. Earth, stone, gravels and turf can be dug by excavator and transferred to a mechanised carrier. In the case of larger machinery there is sometimes no need to use a carrier as the reach of the machine can both excavate and deposit the material where needed in one operation.

Troubleshooting/ things to consider:

There is often a trade-off between the size and effectiveness of an excavator and its impact on the surrounding terrain. A large excavator may be more efficient and capable of handling larger loads but may cause more damage to the work site. Small mini excavators with retractable tracks (which can be spread out to improve stability) are now commonly employed for this work. The contractor should limit any path work excavations within what they can reasonably expect to take to a “weatherproof standard” within the day’s work. This is so that they don’t get caught out by unexpected weather conditions which could cause wash out of over-extended excavations. Excavation is often made inefficient and more damaging by the mishandling of materials around the sides of the dug hole, and requires a skilled operator. A sensitive approach should be taken when handling soil and turf which should be laid on terram with turfs laid soil side down to keep them in good condition.

Path Construction and Repair

Function:

To assist in the construction process by excavating the path tray, forming and laying path work materials.

Method:

Depending on restrictions relating to the site and the type of terrain, an excavator can perform many of the tasks needed to construct a path. It can be used to excavate the path tray and cross drains, cut turf to form the edges of the path, lift and lay stone in position, as well as grade, spread and roll surfacing materials. An alternative construction method, unique to the application of mechanised plant is the formation of “as dug paths”. This approach is dependent upon the suitability of naturally occurring materials within the substrate, the terrain and landform, and for these reasons has thus far been more commonly applied in a low ground setting. Within this operation the grading, spreading, turf cutting and landscaping is all carried out without the re-handling of any of the material. For more details see the Lowland Paths construction Manual.

Grading Materials

Troubleshooting/ things to consider:

Care should be given as to the size and weight of machine used to minimise its impact on the site. Path design should take into account future access by machinery where appropriate for path maintenance and repair tasks. Once plant is on site, there is often a temptation to undertake or supplement all handwork tasks with these aids. Watch out that the use of equipment does not dictate the design or result in the finished work looking uniform in character. All machine work should be followed up on site to maintain a hand crafted finish. Diesel storage/transportation is often logistically challenging, this should be well planned before commencement of works.

Options:

There are various sizes of excavator that can be used as discussed earlier.

Track Restoration

Function:

To assist in the restoration and reconstruction process, by excavating the surface of the old track, forming, laying and re-landscaping materials.

Method:

This type of work requires very large amounts of material to be moved and formed to eradicate the line of the track, and/or create a new path line and is therefore ideally suited to mechanised plant. Depending on the size of track to be restored, the terrain and site conditions, excavators from 3 to 15 tonnes are best suited. The reach of the machine will be one of the key factors that influence the decision on what size of machine is the most suitable for any given site.

Troubleshooting/ things to consider:

Care should be taken when handling soils and turf to maintain their integrity.

Revegetation *(See Restoring Vegetation)*

Function:

To assist in restoring eroded areas back to their original vegetated state.

Method:

Not the most obvious task for an excavator, but depending upon the size of the area to be restored it may be more efficient to spread soils by machine prior to seeding.

Troubleshooting/ things to consider:

Care should be taken when handling soils and turfs to maintain their integrity, for example a deep root block is required for 'leggy' heather to survive.

Project Evaluation

The purpose of the table below is to help objectively evaluate whether mechanised plant is appropriate within the environment for the pathwork being considered, and to weigh up the practical and economic advantages that might be accrued. The aim is to provide a checklist so that all the different factors are properly considered.

Checklist Item	Evaluation	Yes/No
Planning stage	• Has the specification been objectively assessed and designed to take advantage of mechanical aids where these are appropriate to the site? • Can the work be undertaken with machinery to the design standards required? • Can hand finishing be used to complete and enhance the mechanised plant operations on this site? • Have the cost benefits of using mechanised plant been properly assessed for all the different path work tasks? • Have all the options been evaluated?	

Checklist Item	Evaluation	Yes/No
Site sensitivity, natural & cultural heritage designation	• Are there any restrictions on the use of mechanised plant (including the use of helicopters) imposed by site designation? • Have the landowner(s) and appropriate statutory bodies been consulted? • Has the local community and hill users been consulted about the proposed path work? • Have all the options been evaluated?	
Access to and from the site	• Is there an appropriate route to and from the site over which mechanised plant can travel? • Has this route been agreed in detail by both client and contractor? • Can the work be scheduled in the year when site conditions and access to it are more likely to be favourable? • Have landowner(s) permission(s) been obtained? • Should machinery be transported to the site by helicopter? • Have all the options been evaluated?	
Site operation of plant	• Do the path work operations lend themselves to be undertaken by mechanised plant? • Can plant be operated effectively, safely and with minimum environmental impact on the site? (i.e. has an assessment been made of the terrain, substrates, long and cross slopes and drainage) • Have all the different path work tasks been fully considered? • Should the work be limited to specific operations to limit wider environmental damage? • Have appropriate risk assessments been undertaken? • Has the storage and handling of fuel and oil been considered and a contingency made for any spillage? • Have all the options been evaluated? • Has the contractor taken full account of intended plant positioning to, on and from the site in their Health and Safety Plan?	
Source/excavation of materials	• Do the quantities of materials required, site excavation or imports to the site justify the environmental and economic case for mechanical assistance? • Can the right quality and quantity of materials needed be found on site from within the path tray and/or from adjacent ground? • Are there suitable borrow pit sites along or close t the length of the path to augment this?	

Checklist Item	Evaluation	Yes/No
	• Has any exploratory excavation been carried out along the length of the site to help determine this? Where else can suitable materials be found? • Has an appraisal been made following the above as to the form of path construction to be used, e.g. an aggregate/subsoil path as dug on site or through the import of materials? • Can these materials be efficiently excavated by machine and stored on site? • Have all the options been evaluated?	
Movement of materials	• Can mechanised plant be used to bring materials to the site and along the length of the site whilst limiting wider environmental damage? • Can machinery be operated effectively and safely within the damage zone? • Has an airlift of materials been considered? • Have all the options been evaluated?	
Availability of skilled operators and plant	• Are there suitably skilled pathwork contractors with accredited qualifications and the necessary experience of the type of situation to operate the plant and undertake the work? • Is the type of equipment needed available from the contractor or can this be hired for the period required? • Are there suitably skilled contractors available at the time work is proposed? • Have all the options been evaluated?	
Client and contractor	• Has the nature of the work been clearly communicated and understood between the client and contractor? • Are the operations and restrictions on the use of plant fully understood? • Has the client fully explained this in the contract document and obtained a signed agreement by the contractor? • Have appropriate and effective working arrangements been made and agreed for site supervision and monitoring?	

Managing Plant

Specifying plant application in path work contracts

- Weigh up the suitability of plant for the proposed task within the worksite – e.g. wheeled/tracked/walking;
- Specify any limitations on machinery size, capacity, number of machines on site, and prescribed activities;
- Agree approach route to the work site and how plant may be used once on the site;
- Make arrangements for fuel storage and pollution control, and additional (secure) storage for peripheral plant equipment;
- Cover all site safety issues; both general public as well as workforce on the site;
- Carry out an appropriate environmental survey where necessary;
- Obtain all permissions; e.g. owner, statutory, utilities, archaeology, ecology;
- Check the location of utilities – underground and /or overhead services;
- Ensure there is adequate insurance cover for the prescribed operations;
- Cover site equipment security and storage, and guard against vandalism;
- Specify team capabilities and training;
- Cover awareness of CDM and responsibilities; and
- Check that the contractor has current Public Liability Insurance and Employer's cover to all the appropriate levels.

Control over plant operations

- Ensure all plant operators have validated training and an industry approved certificate and relevant experience;
- Specify in the contract that any operator employed by the contractor must be qualified for the specific machine to be used. ('Ticket' only valid for certain classes of machine);
- The use of a competent 'banksman' may be necessary to escort the machine and ensure safe access to the site;
- Consider the duration and timing of plant operations, and the need to regulate or phase plant activities to accommodate other interests e.g. helicopter flying; and
- Note CDM regulations.

Training Operators

- All plant operators need to be trained and should have experience in path work - either in the field experience or on a recognised path-building course;
- Other workers on site need training in working with plant and site safety;
- All site staff /personnel should have undergone Safety Awareness Training (Plant); and
- Note CDM regulations.

1.9 Health and Safety

Introduction

An introduction to health and safety is given here, but please note that this is intended as a guide only and is neither exhaustive, nor a definitive interpretation of the law. Comprehensive information is available from the Health and Safety Executive (HSE) and you are advised to seek further specialist advice if you are unclear about any aspect of your health and safety duties and responsibilities.

The environment in which upland pathwork takes place presents hazards that cannot be eliminated. They slow down any emergency evacuation: terrain is rough; sites are remote and exposed; weather and ground conditions are very changeable. During all pathwork, providing for the health and safety of workers and the public is therefore essential. It is a legal requirement and an integral part of the planning for pathwork projects, from the planning stage onwards. Health and safety risk management should be in place, even for minor works, and should take precedence over considerations of cost, time, and effort.

Health and safety management is about looking ahead to identify potential hazards connected with the design, the work site and the pathwork, and wherever possible eliminating the hazard altogether and reducing the remaining risk to 'as low as reasonably practical' by use of suitable controls. Pathwork involves physical effort, manual movement of heavy weights and working with hand tools and mechanical work equipment on steep slopes and wet ground. It is therefore essential that health and safety awareness training is given to all involved in pathwork. Four main Health and Safety issues should be addressed.

- Legal obligations
- Safety planning
- Risk assessment
- Safety training

Legal Obligations

Health and Safety Legislation

The Health and Safety Executive (HSE) are responsible for the preparation, review and amendment of health and safety legislation. They are also the principal enforcement agency for most of the legislation that covers health and safety at work. There are a number of pieces of health and safety legislation that are relevant to pathwork, some of which apply all the time and others which apply in particular situations. The following gives an outline of some of the principal legislation, but as mentioned previously, this is not a fully comprehensive list, nor a definitive interpretation of the law.

Health and Safety at Work etc. Act (HSWA) 1974

It is the legal requirement for employers, self-employed and employees to comply with the responsibilities of HSWA.

It is the duty of employers to ensure, 'so far as is reasonably practicable' the health, safety and welfare at work of all employees. The employer must do this by providing:

- Health and Safety Policy, or statement – this must be brought to the attention of all employees
- Safe place of work

- Safe working environment with adequate welfare facilities
- Safe plant and equipment
- Safe systems of work
- Safe methods for use, handling, storage and transport of hazardous substances
- Protective clothing and equipment
- Any necessary information, instruction, training and supervision

It is the responsibility of employees to:

- Take reasonable care for themselves and others who may be affected by their acts or omissions at work
- Co-operate with their employer to enable them to carry out their statutory duties
- Not to interfere or misuse anything provided in the interests of health and safety

It is the responsibility of employers to persons other than their employees to:

- Make sure that persons, not in their employment, e.g. a sub-contractor or member of the public, who may be affected by their work activities, are not exposed to risks which may affect their health and safety
- Provide information about any risks which might affect persons not in their employment e.g. self-employed path worker, member of the public

Management of Health and Safety at Work Regulations 1999

These regulations require employers to introduce management procedures in to the working environment to ensure that health and safety issues are managed properly. Requirements include but are not limited to:

- Employers, and self-employed people, **must** carry out 'suitable and sufficient' assessments of the risks to their employees and anyone else who is affected by their work activities and put in place controls to manage these risks to as low as reasonably practicable
- Employers must appoint a competent person to advise and assist them in health and safety matters
- Employers must ensure there are appropriate arrangements to deal with all foreseeable emergency situations
- Employees must be provided with relevant information and training to ensure their safety at work
- Employees must follow any health and safety procedures or instructions, and report any concerns

Construction (Design and Management) Regulations 2015 (CDM)

CDM is the main set of regulations for managing the health, safety and welfare of path construction projects, from the planning stage through to the end of construction. The aim is to ensure that a path construction project is planned, designed and managed to eliminate hazards and reduce remaining risks to acceptable levels for workers involved in the pathwork, and for those using the path and carrying out future maintenance work.

CDM defines roles and legal responsibilities for the client, principal designer, designers, principal contractor, contractors and workers. In particular the CDM regulations require that designers (including a principal designer) and contractors (including a principal contractor) must have the skills, knowledge and experience to fulfil their duties in a way that secures the health and safety of any persons who might be affected by the project. Organisations

fulfilling these roles also need to have the organisational capability necessary. There must be effective communication and co-operation between all duty holders involved in the project so that everyone contributes to health and safety. There is a duty on all workers to co-operate with others and report any health or safety issues to those in control. HSE have produced a summary of duties under CDM 2015.

The regulations apply in full to all construction work and if the path construction work is expected to last more than 30 days and have more than 20 workers working on the project at any one time, or if it will involve more than 500 person days' work then the project must be notified to the Health and Safety Executive.

Manual Handling Operations Regulations 1992 (as amended)

These regulations cover all aspects of manual handling of loads in all working environments. They are particularly relevant to pathwork as some kind of lifting, pushing, pulling or supporting a load by hand is inevitably involved in all pathwork.

The employer is required to ensure that manual handling is carried out in a safe manner, with minimal risk. It is the responsibility of the employer to assess the risks from manual handling activities prior to carrying them out and identify ways to eliminate or reduce the need for manual handling, including the provision of mechanical aids. Where manual handling is still required then other ways of reducing the risks are required, e.g. changing the work method, providing additional assistance, making loads smaller and providing training on safe moving and handling techniques.

Personal Protective Equipment (PPE) at Work Regulations 1992 (as amended)

These regulations cover all types of protective clothing and safety equipment. Where a risk cannot be controlled by any other means then PPE must be supplied and the contractor has a legal duty to provide their path workers with suitable PPE. The workers have a legal responsibility to wear and care for the PPE correctly. The most common types of PPE used in pathwork are used to protect head (safety helmet), eyes (safety spectacles or goggles), ears (ear plugs or ear defenders), hands (hard wearing gloves), and feet (safety footwear). PPE also includes hi-visibility vests and warm, waterproof clothing. The regulations also state that PPE should be of a suitable standard and be maintained and stored correctly. The requirement to wear hearing protection is covered within the Noise at Work Regulations 2005.

Control of Substances Hazardous to Health Regulations (COSHH) 2002 (as amended)

These regulations are designed to protect people at work from being exposed to hazardous substances. The principles behind the regulations are that:

- Employers must carry out an assessment of the risks to the health of employees and anyone else affected by the use of hazardous substances and introduce suitable control measures to protect those working with such substances
- Employees are required to properly use the control measures provided by their employer to protect them from any harmful effects of such substances

Examples of harmful substances which may be encountered on pathwork sites are some fertilisers for ground restoration work and fuel and oils for plant.

Provision and Use of Working Equipment Regulations (PUWER) 1998

Work equipment includes all hand tools, equipment, vehicles and plant used at work. The requirements of the regulations must be viewed in relation to the type of work equipment to be used. Regardless of whether a shovel or a tracked excavator is to be used the requirements must be followed wherever there is a risk of injury from work equipment. The main requirements for work equipment are:

- Work equipment must be suitable for the work it is being used for
- Work equipment must be regularly inspected and maintained by a competent person in an 'efficient state and good repair'
- Path workers should be given sufficient information, instruction and training to allow them to properly and safely use the equipment
- Any dangerous parts of work equipment should be guarded to prevent anyone coming into contact with them
- All site vehicles must be suitable for the use they are put to, maintained in accordance with the manufacturers servicing schedules, and checked regularly by competent operators to ensure they remain safe to use
- All site plant must be suitable for the intended use, in good working condition, and well maintained by competent operators. Large plant should be inspected in accordance with the manufacturer's servicing schedules
- Plant operators of tracked excavators must be competent and certificated to ensure safe operation of the plant

Lifting Operations and Lifting Equipment Regulations (LOLER) 1998

LOLER applies to all mechanical lifting equipment and to lifting operations using that equipment. Lifting equipment must be suitable for use and properly examined, inspected and maintained (as appropriate) and lifting operations must be properly planned, supervised and carried out safely. The regulations require the following to be carried out (this is not an exhaustive list):

- A competent person properly plans all lifting operations
- All lifting equipment is thoroughly examined by a competent person at least once every 12 months or more frequently if recommended by the competent person and weekly by the operator
- Lifting slings, chains, eyes, etc., are thoroughly examined by a competent person every 6 months and weekly by users
- Written records must be produced and kept for all inspections

The employer must ensure that:

- Lifting equipment operators are trained to the required standard not just to operate the machine but to inspect it weekly
- Those supervising lifting operations are trained to the standard required to plan each lift correctly
- Those responsible for slinging loads are trained to inspect the lifting accessories and sling the load safely

Reporting of Injuries, Diseases & Dangerous Occurrences Regulations (RIDDOR) 2013

RIDDOR 2013 requires that accidents which injure a person causing them to be off work for more than seven consecutive days are reported to the Health and Safety Executive (HSE). If a specified injury occurs (as listed in the regulations) e.g. a bone fracture other than to a

finger, thumb or toe; as a result of a work-related accident then a report must be made to HSE. If a person is diagnosed with certain defined diseases which are caused by working practices or occupational exposure to a hazardous substance or biological agent, e.g. Lyme Disease, that must also be reported to HSE. RIDDOR also defines when a 'dangerous occurrence' – i.e. an accident occurs but no one is injured – should be reported to HSE. For example, if the load-bearing part of any lifting equipment (but not an accessory for lifting) collapses, overturns or fails then this must be reported to HSE. Further information is available on the HSE website which can also be used to report certain incidents.

Control of Vibration at Work Regulations 2005

These regulations provide a direct duty on employers to assess and manage the vibration risks associated with the use of vibrating tools and equipment, which includes power barrows. This may impact on the work of upland path teams by limiting the amount of time equipment is used per day per individual as the only controls are to reduce the amount of vibration given off by a machine or reducing the amount of time spent in contact with the machine. When selecting machinery, always choose the machine with the lowest vibration emissions.

Control of Noise at Work Regulations 2005

These regulations are similar in nature to the Control of Vibration at Work Regulations 2005 and require employers to assess the risks from noise and put in place measures to ensure that exposure to noise doesn't exceed certain values. Depending on exposure levels, the employer may be required to provide hearing protection, ensure that it is worn by employees and properly maintained. As with vibrating machinery look for quieter types when selecting new equipment.

Working Time Regulations 1998

These regulations define the maximum weekly working time, as well as the pattern of work and holidays, plus rest periods. The regulations include maximum weekly working hours of an average of 48 hours for most workers, although individuals can choose to 'opt out'. There are also specific regulations for young people. Further information can be obtained from ACAS.

Safety Planning

Most health and safety time and effort goes into the planning stage of site work and identifying actual and potential safety hazards (but it also includes work on site). Once potential hazards have been identified it may be necessary to modify the work and how it is carried out to reduce the risks from those hazards to a minimum. Safety plans must be produced and aim to:

- identify the potential hazards for your project;
- evaluate the risk associated with each hazard, identifying who will be affected, and the frequency, exposure and severity of the outcome if something goes wrong;
- evaluate the solution, i.e. consider the standard ways of managing the hazard and whether these are appropriate on the site and will reduce the risk to an acceptable level on the site;
- modify the work planned and the way it is carried out to further improve safety and make the solution specific to your project and site.

This is largely covered by CDM, which applies to **all** path construction projects and the Management of Health and Safety at Work Regulations 1999. Under CDM, a construction

phase plan must exist for all projects and it must be drawn up by the contractor or principal contractor (for multiple contractor projects) before the construction phase begins.

Risk Assessment

Risk assessments consider the whole site, the work activities and the safety of the worker and any other person that may come into contact with the site whilst works are carried out. In the case of upland pathwork this is predominantly walkers, but may also be mountain bikers or horse riders.

All risks arising from hazards associated with the work that may endanger the pathworkers or the public must be identified and assessed in advance of any work taking place. The assessment considers the severity and likelihood of accidents and injuries occurring and what action or controls should be taken to remove or reduce any significant risks to an acceptable level. This is normally recorded on a Risk Assessment Form. Risk assessments will help inform the arrangements for managing safety that are set out in the construction phase plan.

Risk assessments should be carried out at all stages of the project by designers and contractors (and principal designers and principal contractors) and should be discussed and reviewed with all parties whose safety might be affected by the risks identified within them. If significant risks are identified that have no controls in place, action must be taken to rectify the situation, prior to work starting.

Public Safety

The safety of the public must be considered at all times by pathworkers: when accessing the site; working on the path; gathering materials in the surrounding area. Some paths have very high numbers of walkers or mountain bikers using them, particularly during the summer months. It is the responsibility of the team supervisor and path worker, to ensure that any possible risk to the public from the pathwork is controlled. 'Suitable and sufficient' controls may be signing the works, cordoning off the work site, and re-routing the path.

Clearly worded signs should be erected at all access points to the work site to advise the public of:

- when and where pathwork is taking place
- alternative routes, particularly on very busy paths
- diversions around the work site
- hazards, and procedures, if walkers or mountain bikers need to walk or ride through the site

It is also good practice to provide such information at other locations where path users may access the route, e.g. start of a route, or an information panel in a car park. This alerts people to the fact that pathwork is taking place on a particular route, enabling them to choose to go elsewhere if they prefer.

Any excavations must be clearly protected to prevent any persons, materials or equipment falling into them. Warning tape would not be considered sufficient. This is essential when the site is left unattended, particularly at weekends and when work is over for the day.

Safety Training

The training given to all pathworkers involved in on-site work should include the following as a minimum:

- Health and Safety legislation
- Safe working practice
- First-aid training
- Mountain safety training

Health and Safety legislation

All workers should be aware of the regulations that apply to pathwork and how they are affected as individuals. They should know how to undertake work in a safe manner, and raise any issues of concern with their team supervisor or employer.

Safe working practice

Pathworkers have a duty to take reasonable care for themselves and of others who might be affected by what they do or fail to do at work. They should ensure they are adequately trained, undergo specialist training as required and cooperate with their employer in complying with their statutory duties. More detail is provided in Working Practice.

First-aid training

At least one member of a work team should be a qualified first-aider, i.e. possess a valid, in-date, First Aid at Work qualification; one first-aider to four workers is advisable. All other workers should receive basic first-aid training. This should be relevant to working in an upland environment and the situations that a pathworker is likely to come across, e.g. crush injuries, lacerations, sprains and fractures, hypothermia. The minimum standard of first-aid equipment for the number of workers should be available on the work site, positioned at an identified first-aid point. All workers should be aware of procedures in case of an emergency situation – this procedure must be in the construction phase health and safety plan. This should include knowing who first-aiders are, where the nearest phone and mobile reception is, the details needed for calling emergency services: location, grid references, and casualty numbers. The remoteness of some sites may require special communication links in case of such situations. It may also be necessary to have additional equipment, such as splints, casualty bags and stretchers in case the need to evacuate a casualty arises. The use of such equipment should be covered in the training given.

Mountain safety training

It is essential that pathworkers are aware of the dangers of working in an upland environment, particularly on exposed steep slopes, ridges, high altitude or remote sites. Upland pathworkers may often be exposed to extreme and very changeable weather conditions: high winds; torrential rain; snow blizzards; low cloud; poor visibility; freezing temperatures. Adequate warm and waterproof clothing and kit should always be carried. Training should include map reading, the use of navigational equipment, flares and bivvy bags; procedures in case of an emergency; weather assessments, logging in and out procedures.

Information on Mountain Safety training and assessment can be obtained from Mountain Training Scotland.

1.10 Climate Change

Introduction

Upland path erosion is caused by the interaction of human pressure, vegetation and soils, and the weather. Scotland's weather, with high rainfall, variable snow cover and regular freeze/thaw cycles, is conducive to the rapid development of path erosion once protective vegetation is worn through.

Washout in the Cairngorms potentially related to climate change. © Upland Access Limited

Climate change is recognised to be changing weather patterns in the uplands and it is predicted that these changes, and their impacts, will become more marked in the years ahead.

It seems likely that there will be:

- a continuing reduction in snow cover
- shorter periods when the ground is frozen
- potential for an increase in freeze/thaw events at higher altitude in winter
- increased precipitation in the winter months, either as rain or snow that quickly melts
- drier and warmer summers
- more frequent thunderstorms and torrential rain events

Potential impacts of this changing pattern of weather may include:

- path surfaces being less protected by snow and ice, becoming water-logged and losing coherence
- path surfaces and adjacent bare or recovering ground being exposed to more frequent freeze/thaw and breaking up as a consequence
- path surfaces being washed out by the above processes, and by increasingly heavy rain and unconsolidated snow, and rapid snow-melt
- drainage features being unable to cope with torrential downpours
- bridges and associated revetments being undermined or washed away in flood conditions
- ditches being eroded by pressure of water flow
- land slippage when ground becomes super-saturated
- fines being blown out of path surfaces during drought conditions
- revegetation works not taking during drought conditions
- revegetation rates enhanced by longer growing season
- personal safety of path workers being compromised during extreme weather conditions

Risk assessment during project development should take account of possible weather impacts. It may be useful to think of chronic and acute impacts derived from a changing climate.

Acute impacts, such as major land slippage or overwhelming of path infrastructure by water after a deluge, are unpredictable and difficult to plan and manage for. But path planning may be able to identify where such events are likely to occur and to suggest an alternative route or alignment on higher or more stable ground.

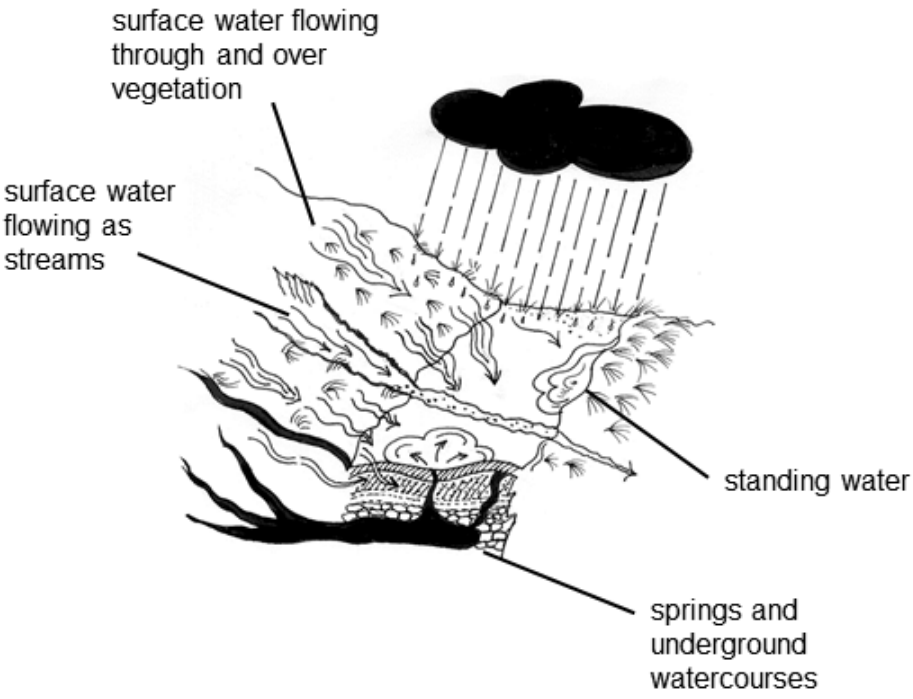
Chronic impacts, such as higher winter rainfall on path surfaces less protected by ice and consolidated snow, require more obvious management responses, for instance in terms of well-compacted path surfaces, frequent anchor bars, more frequent inspection and regular maintenance.

2. Upland Path Drainage

2.0 Introduction to Drainage Techniques

The purpose of drainage is to keep water away from the path and to remove surface water from the path to prevent damage to it. An effective drainage system is essential for a well-managed upland path. If the drainage system does not function properly erosion scars become severe, and any path surface work can be destroyed after one winter of rainfall, if not less.

Water Flow Systems



There are three main sources of water on the path:

- rain falling directly onto and running down the path surface, or snow melting
- surface water from surrounding land flowing directly onto the path
- underground water running onto the path surface, in the form of springs or seepage

An assessment of the climate and altitude can give clues about these water patterns:

- naturally high rainfall, e.g. western mountain areas
- altitude, and latitude, indicating the likelihood of snow cover
- seasonal snow fall and problems associated with potentially sudden snow-melt

Assessing the site

The site must be assessed before any decisions can be made about which drainage features are appropriate, how many are needed and the positioning to achieve adequate protection of the path. At the same time the impact of changing the natural drainage system must be considered, particularly in environmentally sensitive areas where natural vegetation of ecological value is dependent on a particular source or level of water.

Assessment, or specification survey, should preferably take place on a wet day, or just after a particularly wet period of weather. If this is not possible clues will be found on the path and the surrounding landscape.

The full length of the path should be walked, noting where water is coming from, both on the way up and on the way back down. These two perspectives should help to ensure that all aspects are considered. It is often the case that a drainage problem further up the path can be causing the problems below. For instance a stream at the top end of the path may have burst its banks or erosion debris diverted its course, directing flow straight down the path line.

The first clues come from the path itself. It should be possible to identify:

- damage caused by water flowing down or across the path - evident as gullies or eroded channels
- damage caused by water lying on the path - evident as puddles, boggy areas often saturated with water, signs of walkers skirting round and causing braiding
- where water has come from - evident by signs of springs, surface water, or water flowing onto the path from the slopes above
- where water is going - evident by signs of silt at the path edge, or vegetation may show signs of being flattened by water flowing off the path

The immediate landscape can also provide information about how the site reacts after periods of rain, and where and what drainage features are required.

- Geology of the area can indicate whether water flows close to the surface of the ground - evident by large areas of bedrock; or if it soaks away - evident as vegetated areas of deep soil or peat.
- Topography of the area can indicate where the water flows - quickly downhill if steep gradients are present and streams have formed; soaking away in flat areas of lush vegetation growth.
- Vegetation type can indicate areas of permanently wet ground by high presence of mosses, cotton grass or rushes. It can also show where water has flowed over it, flattening long grasses or deposited silt, inhibiting growth.

The drainage system

Having assessed the site, an appropriate and effective drainage system can be designed to combat the problems identified and protect the path.

There are two basic methods of drainage which are generally used in combination. Ditching is integral to both methods.

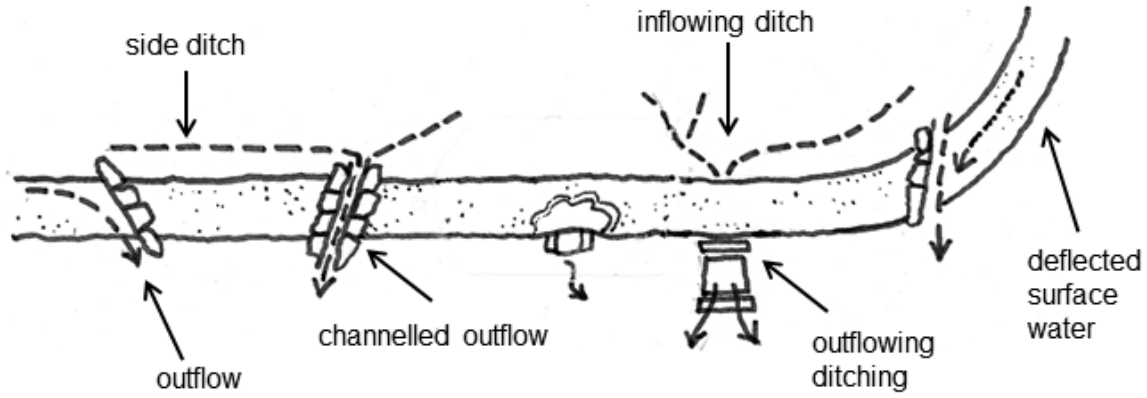
Off path drainage - to protect the path from water flowing onto it from the surrounding land

- Ditching intercepts the water before it reaches the path and drains it away
- Culverts or cross-drains channel the intercepted water across the path

On path drainage - to divert water off the path surface

- Cross-drains collect water at low points and channel it away into ditches
- Water-bars deflect running water off the path
- Letts drain away puddles that have formed on the path

Design and use of different techniques should also take account of the existing or expected path users. For instance, a boxed culvert is preferable to a cross-drain if a path is used by ATVs for deer management; a cross drain with a narrower channel is preferable to a water bar for use by cyclists.



Problems and Solutions

Some typical situations that arise on upland paths are illustrated below, showing a typical drainage problem and the potential solution, most of which will be in conjunction with path surfacing.

Drainage Problem	Solution
Boggy wet patch on path 	Cross-drain 
Puddle of standing water on path 	Lett 
Gully caused by water flowing down path 	Waterbar at top of gully 
Burn crossing path 	Ford 
Water flowing onto path from slope above path 	Intercepting side ditch and cross-drain 

Materials

Successful drainage work keeps water from the path and removes surface water before problems with scouring and gullying can occur. Ditching is an integral part of this and selecting the right line and type of ditching helps to protect the path and encourage site regeneration.

Block stone is used for most drainage features including cross drains and water bars. Whenever possible this should be found in the local area, and within easy reach of the path. The following points should be noted when looking for suitable stone.

- do not select stone from too close to the path - this will leave an obvious scar, and may damage the path edge
- be selective in choosing the right stone for the drainage feature - there is no point in moving stone to the path and then not using it
- choose natural weathered stone - lichen covered stone looks natural and will blend in with the surroundings
- collect stone randomly, and do not trample along the same line - this will quickly become visible particularly with repeated use by a power barrow
- turf over any scars or sockets where stone has been removed that are visible from the path

The nature of the available stone will affect the style of the constructed drainage feature.

There is a variety of stone types found in Scotland including:

- Sandstone - provides good block stone with angular edges and flat faces
- Schists - thinner, slabby or slate-like stone; two stones may need to be placed together
- Granite - tends to be large but more rounded in shape, and lacking angular edges

Problems to avoid

There are three main reasons why a drainage feature will fail to solve the drainage problem.

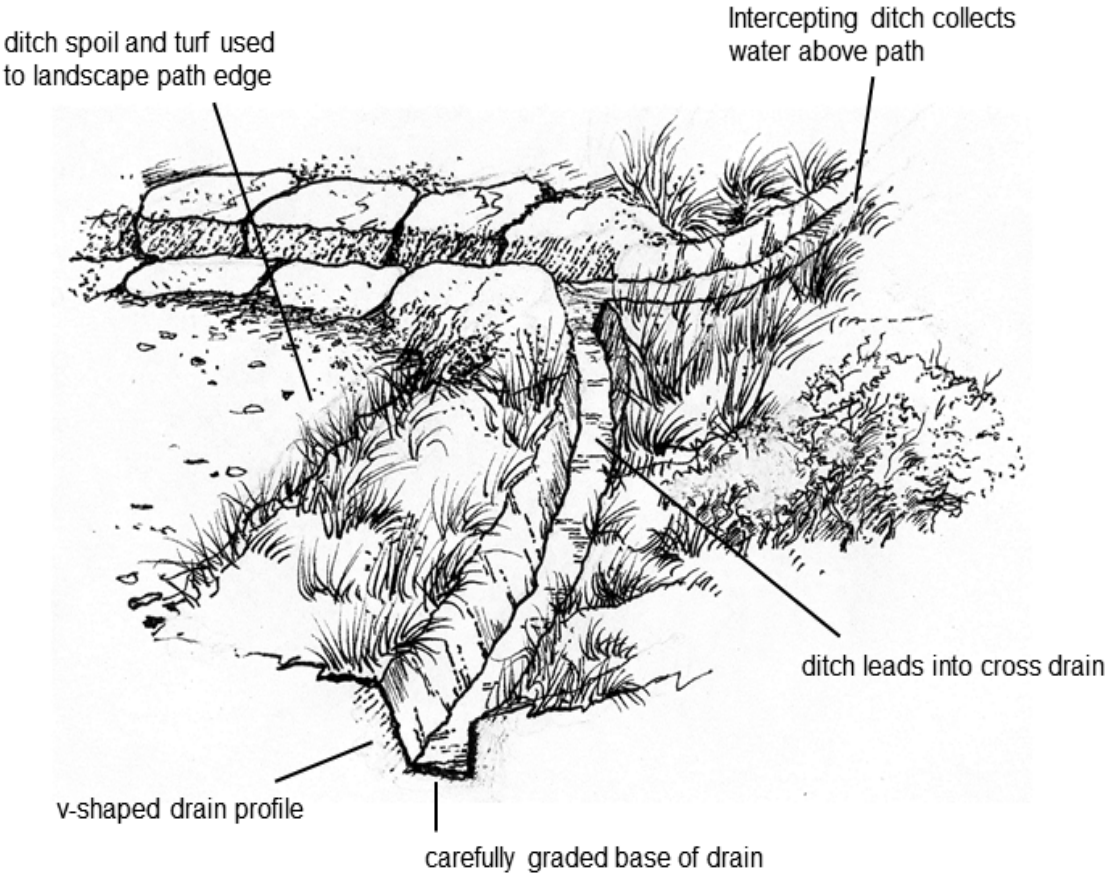
- **Wrong position** - misses the problem if drains too high or low on the path, or ditches not placed to intercept and disperse the flow
- **Wrong size** - not able to cope with the highest water flows if too small or short; visually obtrusive if too big or long
- **Poor construction** - not able to withstand the pressures of water and climate; stone becomes loose or ditches collapse

It is important to get the assessment, design and construction right, in order to avoid these problems occurring.

The following technical sheets give guidance on the drainage features that can be used and how to combat drainage problems. Each sheet has a section on positioning the feature, as well as the technical detail required for construction.

2.1 Open Ditching

The drainage ditch is fundamental to the success of any drainage system. It is essential wherever there is a problem of water running onto the path from the surrounding ground. Open (also known as cut) ditches are the most basic form of ditching and tend to be more visible from a distance. Turf lined ditches have become increasingly popular because they blend better into the landscape and help to slow down the flow of water. However, on low to middle robust ground with complex topography and/or higher vegetation (for example leggy heather) the open drain is still a good option, providing it does not get undercut. Open ditches are also the preferred option on some designated sites.



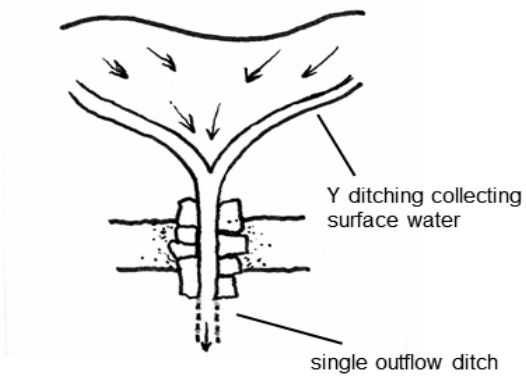
Function

The key function of the ditch is to collect water and direct it away from the path. The ditch will intercept water above the path; direct it through path drainage features; direct it away from path drainage to soak away in the surrounding area. Spoil and turf can be an invaluable by product of this type of ditching, which can be used for landscaping and site restoration.

Bill of Quantities (example)

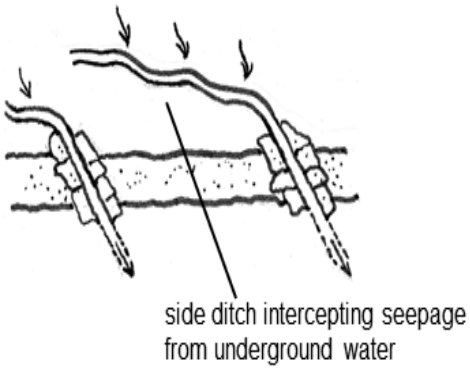
Excavate drainage ditch 300mm deep and 300mm wide at base, chamfered to 500mm wide at top. Ensure that water drains freely along the ditch and away from the path.

Ditch positions are crucial to the success of the drainage system. The most efficient layout, with maximum effect must be the aim. Maintaining a low impact approach is essential, in landscape terms as well as any adverse effect on natural land drainage and associated ecology. The temptation to cover the hill with ditches must be avoided.



When assessing the site, the surrounding ground and options that exist for directing surface water away from the path must be considered. The water may need to be directed across the path with culverts or drains. Y-shaped ditching is often used in conjunction with these, creating two inflow arms above the path which join and flow through the drain and away through a single outflowing ditch. The use of a soakaway may be required if there is nowhere for water to drain to.

The presence of underground water is an important factor to consider. A traversing path often requires side ditch protection from seepage on the uphill side. To intercept as much water as possible, ditches should be positioned as low as possible on the slope.



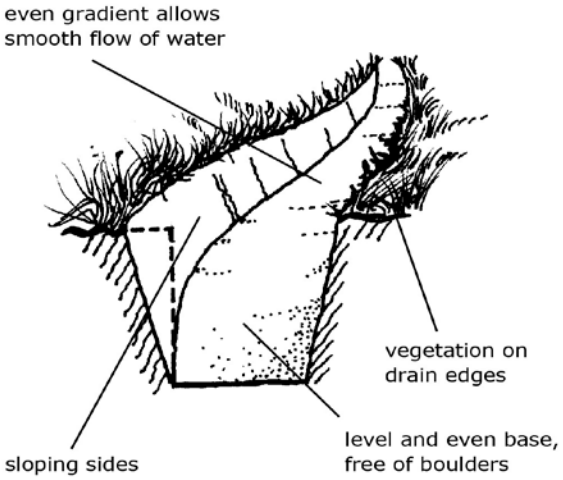
A ditch line should:

- follow the lie of the land
- avoid steep gradients and long straight lines
- incorporate curves to blend with surroundings and slow down the water flow
- avoid sharp corners or sudden changes in direction that cause flowing water to erode the ditch sides
- be effective and maintain a draining fall, or run, throughout its length
- avoid obstructions, such as boulders or bedrock

Construction

Components

The open ditch is a simple drainage feature comprising base and sides. It normally requires no stone or other materials.



Ditch Dimensions

The ditch should be wide and deep enough to cope with the highest volume of water expected. It will quickly overflow if it is too shallow, or erode if water flow is too fast through a narrow channel.

Ditches should be:

- at least 300mm deep and 300mm wide at the base
- chamfered and widening to approximately 500mm at the top; vertical sides may collapse with the weight of saturated ground above the ditch sides, or if water erodes the base and undercuts the sides
- at least 500mm away from the path edge to avoid path collapse into the ditch

These dimensions also provide good spade room for clearing during maintenance.

Method of Construction

Step 1

Start digging at the bottom end and work uphill - maintain a good draining run from top to bottom

- keep the ditch deep and wide enough - angle the side walls by chamfering
- keep the ditch base smooth and even - avoid creating hollows by digging too deeply
- incorporate gradual curves and avoid long straight ditches

Step 2

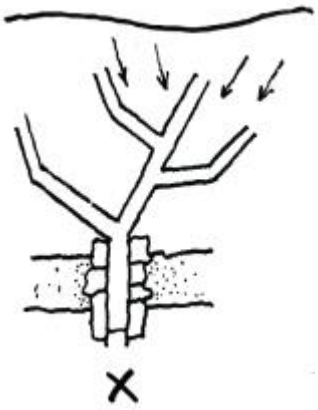
Check that the base is graded and the side walls angled. If this is not achieved whilst digging the ditch line, do it immediately afterwards. Give the base of the ditch a final levelling, for a smooth water flow.

Step 3

Use the turf and spoil removed from the ditch for landscaping and site restoration work, or in-fill for borrow pits. Excess turf may be used to turf the ditch sides. If no suitable use is found it should be hidden on site.

Troubleshooting

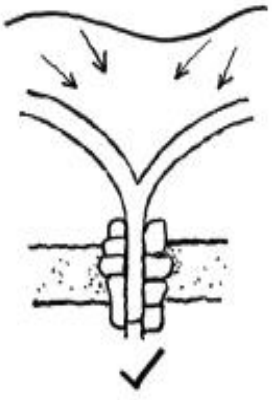
Key points to watch out for:



- avoid creating unnecessary ditches
- avoid sharp angles - put in curves to dissipate the rate of flow
- avoid steep gradients - fast water flows will result in ditch erosion
- ensure that water flows smoothly from top to bottom
- avoid collapse of path edge into side ditch - keep far enough away
- avoid collecting too much water into one ditch

Variations

Where bedrock has to be crossed the creation of side walls will be necessary. This is achieved by mounding with spoil and turfs.



Turfs can also be used to stabilise ditch sides where problems are encountered with weak edges such as in deep, soft peat. Turfed ditch sides will also reduce environmental impact.

Scalloped ditches are generally dug by machine and tend to be larger. They are curved in profile rather than hard edged and so form less of an obvious feature from a distance.

A soakaway, also known as a catchpit or sump, may be required where there are no options available to ditch water away from the path. These are dug wide and deep enough to take the expected quantity of water. They may be filled with clean stone if available to allow the water to drain through. The sides should be built up with turfs to form a natural looking hollow.

Maintenance Tasks

Ditching easily becomes blocked and over-flows; or sides fall in from the pressure of water eroding the bottom of the ditch. The following maintenance tasks must be carried out on a regular basis.

- clear out debris and silt that may choke or block the ditch
- deepen and widen ditches that block quickly; regrade if water is not flowing
- re-chamfer side walls where collapse has occurred or is likely; stabilise with any available turf
- use removed silt or gravel to re-surface the path behind water features
- use removed turf on path edge or landscaping repairs; or hide tidily on site

ENVIRONMENTAL SENSITIVITIES

- Choose a ditch-line that is both effective and fits in with the surrounding landscape.
- Leave the site looking as natural as possible; use or dispose of all excess spoil and turf properly.

HEALTH AND SAFETY HAZARDS

- Conditions underfoot may be wet, muddy and slippery, particularly when digging in the ditch.

TAKE CARE

- Do not under estimate the amount of water expected at its wettest; carefully assess the direction of water flow in relation to the path.

2.2 Turf lined ditching

Turf lined ditches were developed in the 1990s to address issues with landscape and scouring. From a distance on open ground the most obvious part of a path can be an open ditch. The path itself may blend in reasonably well to the surrounding landscape, but the open cut ditch can be very visible. Turfed side drains on the other hand blend in incredibly well, even at short distances.

On soft or steep ground in Scotland drains are very vulnerable to being undercut in high flow. This can lead to ditches collapsing inwards, as the faster water lifts the material in the bottom of the drain and the sides collapse. Turf lined ditches work particularly well on grassy areas, or short heather.

Construction of a turf lined ditch in Coire Lan, Arran

Function

The turf lined ditch serves the same function as the open ditch - to collect water and direct it away from the path. Turf lined ditches both slow down the flow of the water because the vegetation absorbs water and has higher friction, and protect the bottom of the drain through vegetation and root matter. They are also a very unobtrusive method of dealing with seasonal problems, such as snow melt and seasonal flooding. These lie dormant for most of the year, coming into use when needed, but because they are vegetated they don't stand out as much as an 'empty' open ditch.

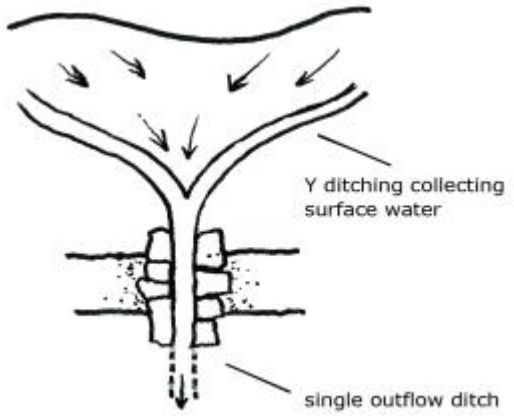
Bill of Quantities (example)

Peel turf back from centre for up to 2m each side, remove spoil and re-lay turf. Ditches are to have sloping sides and be 300mm wide at base and up to 1500m wide at top, with a minimum depth of 450mm. The ditches are to be as unobtrusive as possible. They should be graded to allow water flow without gullying and be completely lined with turf, to give a more natural appearance. All turf must be secure, and well placed to avoid lifting.

Positioning of Ditching

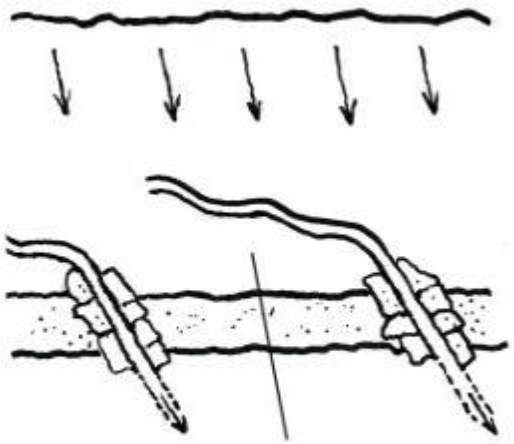
The assessment for positioning turf lined ditches is largely the same as for open ditching, with ditch positions crucial to the success of the drainage system. The most efficient layout, with maximum effect must be the aim. Maintaining a low impact approach is essential, in landscape terms as well as any adverse effect on natural land drainage and associated ecology. The temptation to cover the hill with ditches must be avoided.

When assessing the site, the surrounding ground and options that exist for directing surface water away from the path must be considered. The water may need to be directed across the path with culverts or drains. Y-shaped ditching is often used in conjunction with these, creating two inflow arms above the path which join and flow through the drain and away through a single outflowing ditch. The use of a soakaway may be required if there is nowhere for water to drain to.



The presence of underground water is an important factor to consider. A traversing path often requires side ditch protection from seepage on the uphill side. To intercept as much water as possible, ditches should be positioned as low as possible on the slope

Turf lined ditches are also often used for off path drainage, to divert water, including snow melt, from the path before it reaches it. Another alternative is to use a ditch to help dry out the path line, which can help increase the amount of foot pressure that the ground can sustain. This can work particularly well on less busy paths, or paths that are still vegetated which become softer and more vulnerable to becoming poached or trampled when wet. This can help avoid more intrusive construction *work.*



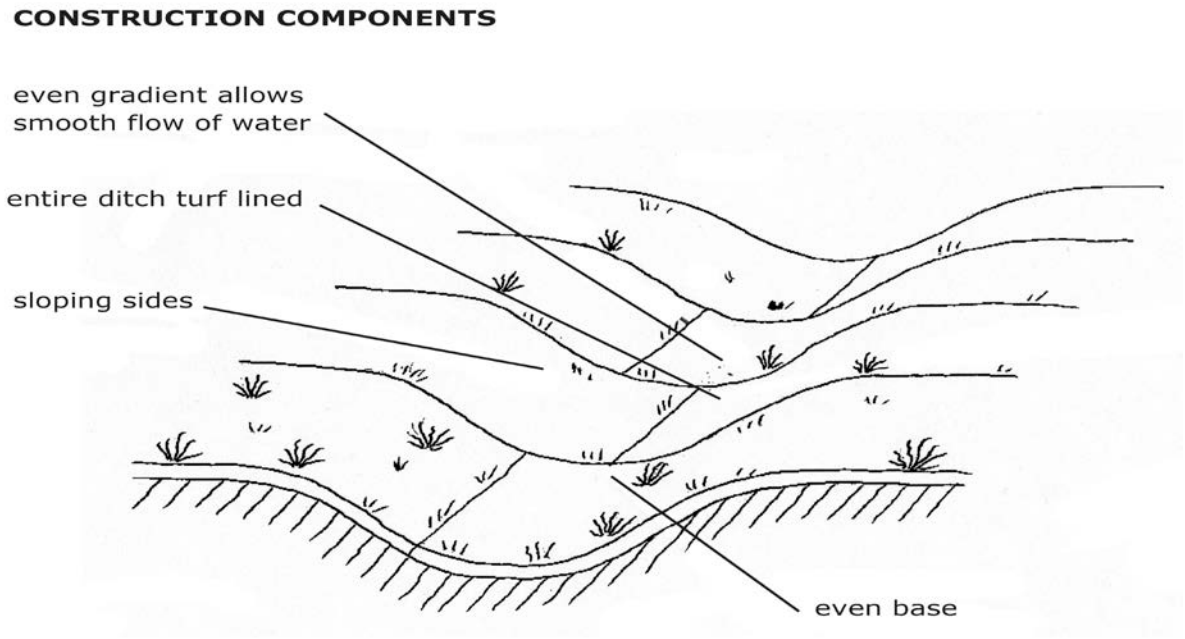
A ditch line should:

- follow the lie of the land
- avoid steep gradients and long straight lines
- incorporate curves to blend with surroundings and slow down the water flow
- avoid sharp corners or sudden changes in direction that cause flowing water to erode the ditch sides
- be effective and maintain a draining fall, or run, throughout its length
- avoid obstructions, such as boulders or bedrock

Construction

Components

Turf lined ditches comprise base and sides. They do not normally require stone or other materials.



Ditch Dimensions

The ditch should be wide and deep enough to cope with the highest volume of water expected. A shallow gradient of less than 10° works best, on steeper slopes the turf may need to be pinned for around two years to allow the roots to take. It may be desirable to reduce the gradient further away from the path to slow water down.

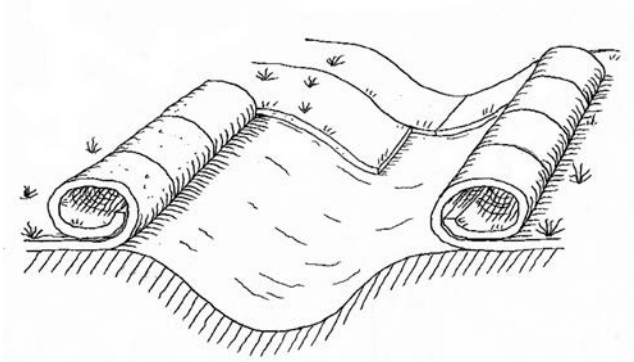
Ditches should be:

- at least 400mm deep and 300mm wide at the base
- chamfered to 45° and widening to approximately 500mm at the top;
- at least 500mm away from the path edge to avoid path collapse into the ditch

Method of Construction

Step 1

Start digging at the bottom end and work uphill - maintain a good draining run from top to bottom



- Cut at roughly the centre of the drain and peel back the turf without breaking it. Vary the central point each time the turf is peeled back to prevent a weak central point
- Excavate material to create a deep and wide enough ditch - angle the side walls by chamfering
- keep the ditch base smooth and even - avoid creating hollows by digging too deeply
- incorporate gradual curves and avoid long straight ditches

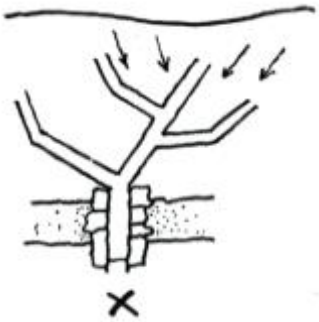
Step 2

Check that the base is graded and the side walls angled. If this is not achieved whilst digging the ditch line, do it immediately afterwards. Give the base of the ditch a final levelling, for a smooth water flow.

Step 3

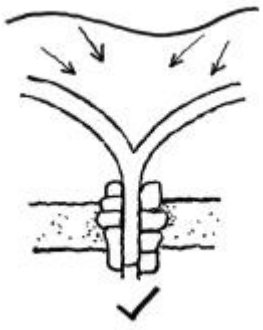
Lay the (still connected) turf back down and add any additional turf required to ensure that the ditch is completely lined with turf. Use the spoil removed from the ditch for landscaping and site restoration work or in-fill for borrow pits. If no suitable use is found it should be hidden on site.

Troubleshooting



Key points to watch out for:

- avoid creating unnecessary ditches
- avoid sharp angles - put in curves to dissipate the rate of flow
- avoid steep gradients - fast water flows will result in ditch erosion
- ensure that water flows smoothly from top to bottom
- avoid collapse of path edge into side ditch - keep at least 500mm away
- if turf lined ditches are very wet the turfs can float and get washed down the ditch. Medium sized stones may need to be dug into the ditch to help anchor turfs in place but placed so as not to block the flow of water through the ditch
- avoid collecting too much water into one ditch



Variations

A soakaway, also known as a catchpit or sump, may be required where there are no options available to ditch water away from the path. These are dug wide and deep enough to take the expected quantity of water. They may be filled with clean stone if available to allow the water to drain through. The sides should be built up with turfs to form a natural looking hollow.

Turf lined ditches can also be made in the same way but much smaller, provided the catchment is minimal.

On steeper slopes, or sites where there is little available turf in situ, the turf may need to be pinned for around two years to allow the roots to take. This can be achieved with wooden or metal pins.

Maintenance Tasks

Well-built turf lined ditches are not as prone to blocking as open ditches but following maintenance tasks still need to be carried out regularly.

- clear out debris and silt that may choke or block the ditch
- deepen and widen ditches that block quickly; regrade if water is not flowing
- re-chamfer side walls where collapse has occurred or is likely
- use removed silt or gravel to re-surface the path behind water features

ENVIRONMENTAL SENSITIVITIES

- Choose a ditch-line that is both effective and fits in with the surrounding landscape.
- Leave the site looking as natural as possible; use or dispose of all excess spoil and turf properly.

HEALTH AND SAFETY HAZARDS

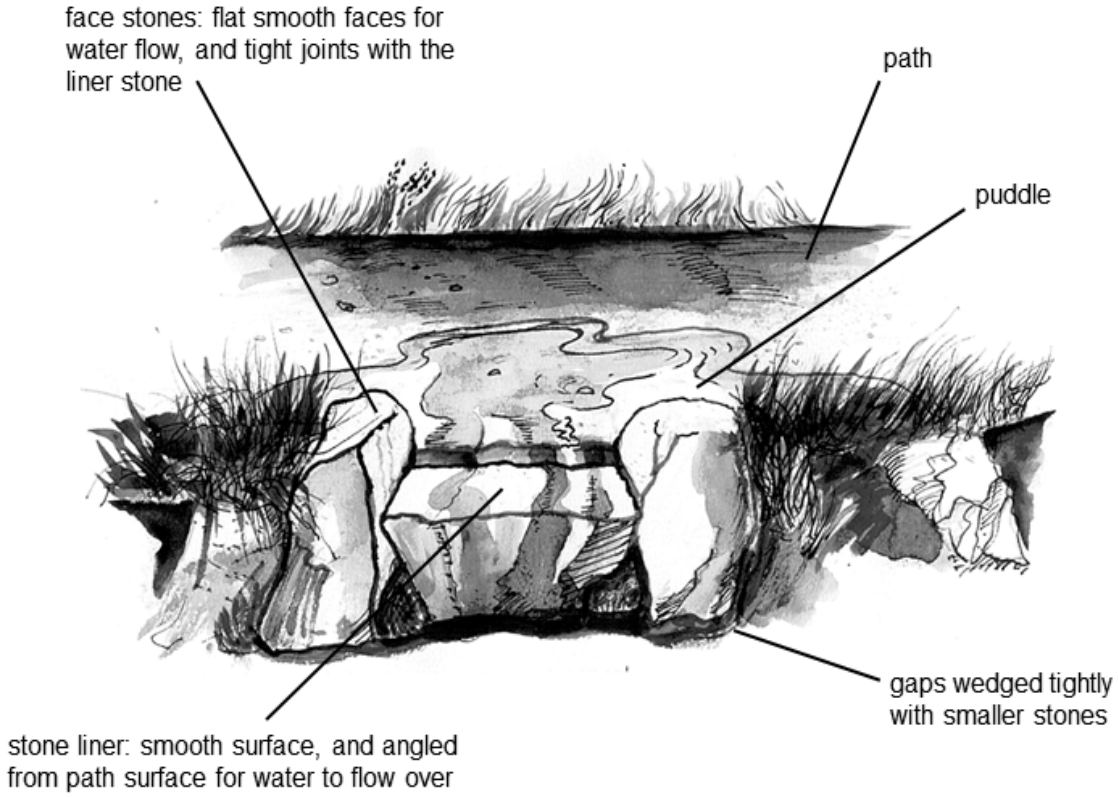
- Conditions underfoot may be wet, muddy and slippery, particularly when digging in the ditch.

TAKE CARE

- Do not under estimate the amount of water expected at its wettest; carefully assess the direction of water flow in relation to the path.
- Do not under estimate the amount of time required to build turf lined ditches. They will generally take around three times as long to construct as open ditches, but will be more effective and require less maintenance if built well on appropriate sites.

2.3 Stone Lett

The stone lett is a development of a simple drainage channel cut through the turf at the path edge; a technique often used on upland paths. A stone structure prevents the channel from becoming overgrown, and is therefore easier to maintain. It should hardly be noticeable, as it is built on the edge of the path using only a few well placed stones.



Function

The purpose of the lett is to create a short open channel at the path edge to allow small amounts of standing or running water to drain through, and away from the path surface.

Bill of Quantities (example)

Use local weathered stone to construct a stone lett with the lining flush with the path surface to collect standing water, and angled to allow water to drain away freely.

Positioning of Stone Letts

Positions for letts will be apparent if the path is assessed immediately after heavy rainfall. Letts will be required where standing water collects; but only if this is causing erosion of the path edge or braiding where users avoid the puddle. Being at the path edge the lett should not have to withstand the pressure of path use, only water flowing through it. This should

never be excessive. If it is, a cross-drain is probably required.

The stone lett should be positioned at the lowest point of the standing water, where the amount of water released from the path edge can be maximised. Further positioning of letts may be required to remedy bad puddling following new path surfacing.

Construction

Components

The lett is a simple design consisting of only three or four stones. Face stones create the side walls for the water to flow between with a liner stone, or stones, placed between them to provide a smooth surface for the water to flow over.

Dimension Guidelines

- the width of the lett should be at least a spade width, for ease of maintenance
- the liner surface should be flush with the path surface at the path edge
- the liner should have a draining run of approximately 5°
- the top surface of the face stones should be approximately 100mm above the path surface, and at the same height as the vegetation on the path edge

Materials

Block stone does not need to be substantial in size, as letts are subjected to less pressure than cross-drains. Local stone should be used in its natural form, preferably weathered.

- the side stones should be at least 300mm deep
- the faces that form the sides should be without any protrusions
- the liner stone should be at least 200mm deep; if it is too thin it may be undermined by water and wash out of position
- the liner stone should have a smooth top surface and fit the side face stones as tightly as possible.

Method of Construction

Step 1

Excavate a shallow trench

- excavate wide and deep enough to accommodate the selected stone and achieve the required dimensions and draining levels

Step 2

Position the side face stones

- set to the height required above the liner and so that half their depth will be below the top surface of the liner stone
- set to accommodate the width of the liner stone, and at least a spade's width apart, to allow easy cleaning out of debris and silt
- the top surfaces should be at the same height as the vegetation on the path edge

Step 3

Position the liner stone

- set to fit tightly between the side stones
- set the liner surface flush with the path edge for water to flow freely off the path; if it is too high it will block the out-flow
- set at approximately 5° to ensure a drainage run for the water to flow out of the lett
- wedge and pack gaps with smaller stones so that the whole structure is solid and immovable when completed

Step 4

Depending on the stone available one larger liner stone may be adequate. If not it will be necessary to extend the liner using a splash plate stone, set slightly lower than the liner. A short length of ditching may also be required to ensure that the water is dispersed from the path and soaks away into the surrounding ground.

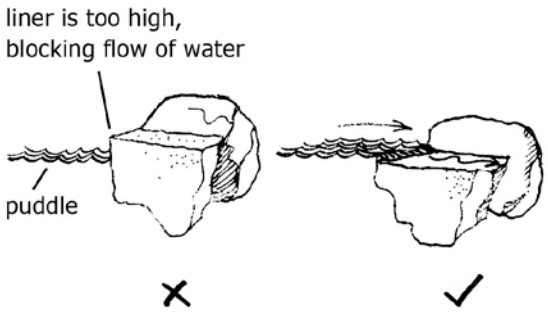
Step 5

Once the lett construction is complete, re-instate vegetation by turfing up the path edges behind the side stones. Additional turfing may be required if the path edge has been eroded or trampled by walkers avoiding the puddle.

Troubleshooting

Key points to watch out for:

- set the liner stone at the correct level - too high will block water draining from the path; too low can create a weak path edge and erosion of the path surface
- avoid making the lett too big - it is only needed to channel small amounts of water; minimal impact is essential



Variations

Where there is no suitable stone available, or the drainage problem is not serious, a simple drainage channel cut into the path edge can be used.

Letts can also be used to extend simple drainage channels formed in the surface across the path.

Maintenance Tasks

Stone letts should only require minimal maintenance. However it is essential to keep them free from silt as they can become blocked.

- clear out debris and silt blocking the lett or the out-flow
- check the stability of stonework; re-pack where there is any movement or gaps
- re-pack path edge surfacing in front of the lett if there has been any compaction or erosion

- top up the path level if the puddle is not draining away fully
- silt or gravel cleared from the lett can be reused in packing and re-surfacing

ENVIRONMENTAL SENSITIVITIES

- Use natural looking weathered stone, that will blend in with the surrounding landscape turf over damaged or eroded areas around the lett to look as natural as possible.

HEALTH AND SAFETY HAZARDS

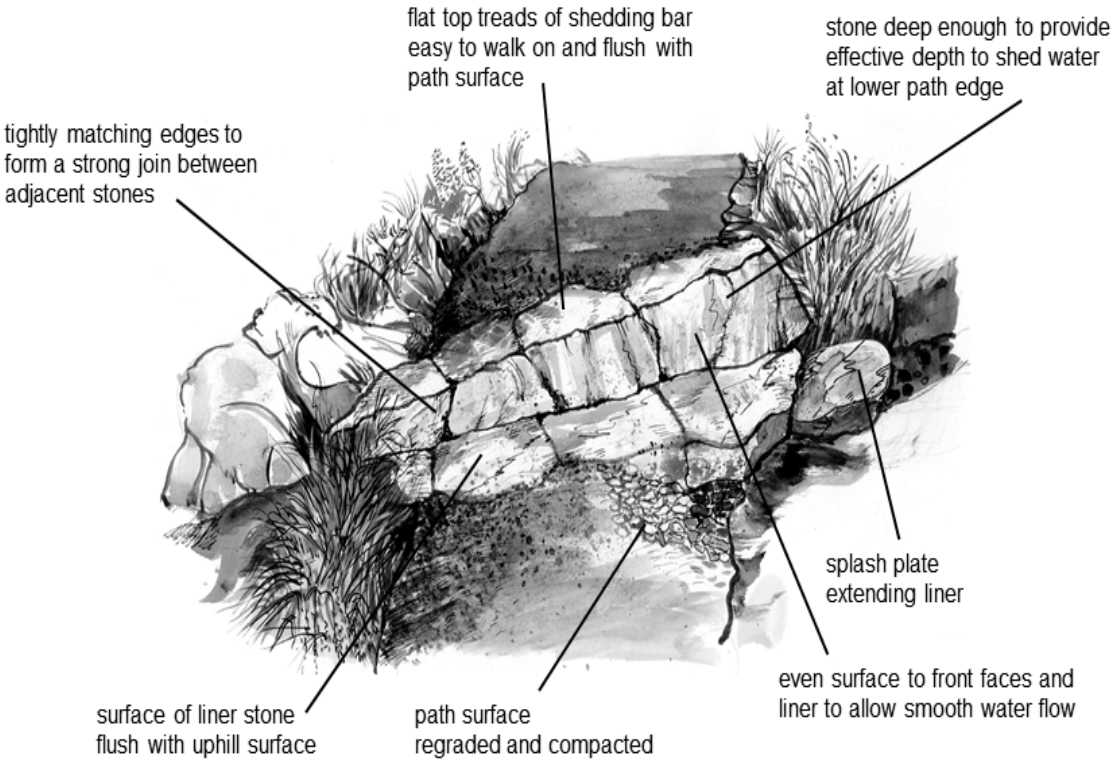
- Use safe lifting techniques when moving and positioning stone for the lett.

TAKE CARE

- Do not be tempted to use a lett to solve every standing water problem. They may have minimal effect; or cross-drains may be more effective in dealing with the problem; one drain higher up the path may reduce the formation of several puddles further down. A proper assessment of the site will ensure that the correct decision is made.

2.4 Stone Waterbar

The waterbar is used in a range of styles of path construction, on low ground as well as upland. In forested areas waterbars are often built using timber. Stone waterbars are predominantly used on upland gravel, soil, or grass paths. On steeper gradients they can be an integral part of a stone-pitched surface.



Function

The key function of a waterbar is to divert running surface water off a sloping path. Without them the path surface scours and gradually becomes so rough, gullied and wet that walkers will not use it. Waterbars can also help to stabilise the path surface, by providing a solid anchor. A waterbar does a different job from cross-drains, which are generally used to take water from uphill ground, across the path.

Bill of Quantities (example)

Use local, weathered stone to construct a waterbar, between 30°- 45° to the path line. Bar depth should be a minimum of 100mm rising to approximately 150mm. Liner should provide a draining fall of 5° minimum. Extend by 300mm on each path side. Include splash plate if ground drops steeply. Re-construct the path at least 2 metres above and below the waterbar.

Positioning Waterbars

Positioning bars for effective collection and dispersal of surface water is essential. Key positions include path corners and above a steepening in the path. The location of other bars will depend on the source of water coming on to the path; the volume expected; and the scope for dispersal. Waterbars should deflect surface water off the path at the earliest available point, and then frequently to prevent the flow gathering volume and erosive force. Frequency will depend on the path gradient, and the associated mobility of the path surface. Higher angles of bar are needed on steeper gradients. The following table gives a general guide.

Gradient Material	Mobility of path surface	Distance
Steep > 10°	High	< 10m
Moderate 5°-10°	Medium	10m-25m
Slight 5°	Low	> 25m

Once the position is determined waterbars should be angled to deflect water away from the path and not flow back on further down. It may be necessary for extra ditching, to catch and re-direct the water, especially in the case of a zigzag path line.

Be aware of obstructions such as bedrock, boulders etc. These may prevent building a bar in the best position; alternatively they may provide a natural barrier or channel.

Construction

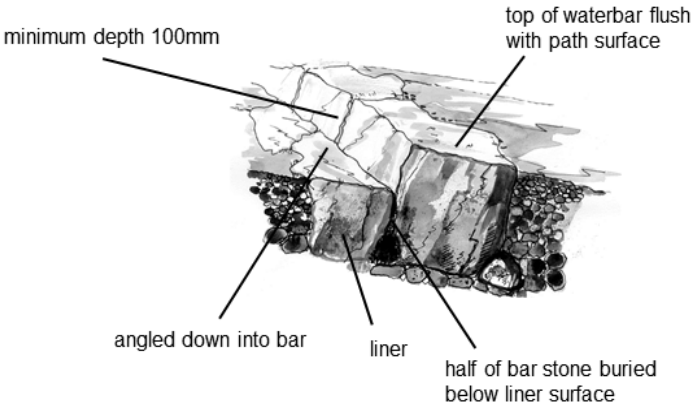
Components

The classic waterbar has two key components:

- the shedding bar
- the front liner, or channel

The shedding bar comprises a line of stones placed together at an angle across the path forming an upstand above the liner. Its purpose is to:

- form a low barrier to the water flow
- shed the water across the path to the downhill side and away



Section through a waterbar

The front liner comprises one or possibly two courses of stone set in front of the bar face on the uphill side. Its purpose is to:

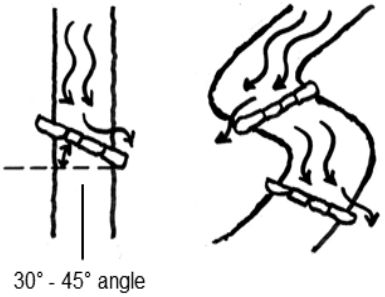
- prevent the bar stones from being undermined by the water flow
- provide a smooth channel that is relatively self-cleansing, but easy to clear of silt and debris

Depending on the downhill slope, a waterbar may need a splash plate at the outflow, to prevent edge erosion.

A ditch for the outflow will ensure that water is dispersed away from the path edge and does not come back on to the path lower down.

Dimension Guidelines

- the angle of the waterbar across the path should provide an adequate fall and be between 30°- 45° to the path
- the draining fall in the liner across the path should be no less than 5°, and up to 15°
- the bar upstand above the liner should effectively catch and disperse the water and be a minimum of 100mm depth at the upper path edge rising to approximately 150mm at the lower edge, but not present a barrier to path users
- the top surface of the bar stone should be flush with the downhill surface
- the surface of the liner stones should be flush with the uphill surface and slightly angled down to the bar stone

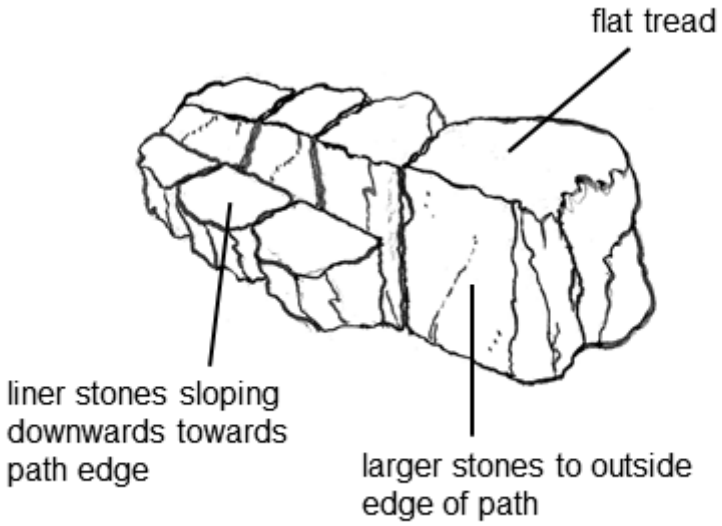


- the bar should extend approximately 300mm either side of the path, as the site allows, to prevent water flowing back onto the path, and walkers from walking around and damaging the path edges

Materials

Local stone should be used unless unavailable and should be in its natural form (not shaped) and preferably weathered. The amount of stone needed will depend on the path width. The following points should be noted when selecting stone.

- block stone for the bar should be large enough to withstand the pressure of path use, the greatest waterflow, and frost heave - if it can be moved and lifted easily it will be too small
- bar stones should be deep enough for half the depth to be below the liner level, and to provide the required upstand depth
- the front face of the bar stone should have no protrusions and provide an even surface with adjacent bar stones
- the top face, or tread, of bar stone should be large enough and suitable for walkers to step onto
- liner stones can be smaller, but must be at least 200mm deep to prevent under-mining and movement by heavy water flow
- the upper surface of liner stones should have no protrusions and provide an even surface with adjoining liners



Method of Construction

Step 1

Excavate a trench across the path.

- dig the trench wide and deep enough to allow for the liner width and depth, and the required upstand of the bar stone with tread flush with the downhill path surface
- the line for the trench should be at an angle to provide the required fall and disperse the flow of water

Step 2

Position the bar stones ensuring that the required angle and fall is maintained.

- set the bar stones vertically, butted tightly together, to provide an even face and even tread surface, level with the path surface
- wedge and pack gaps with smaller stone, allowing no movement of the bar

Step 3

Position the liner stones, starting at the outflow end and working up, to achieve at the required draining fall.

- set the liner stones, tightly butted up to the bar stones, to give the required bar upstand depth above the liner; this will be higher at the outflow end for effective flow catchment and dispersal
- join liner stones tightly with top faces even to provide a clear water run
- liner stone joins should be off-set from bar stone joins, to provide a stable construction and reduce the risk of water getting through
- wedge and pack all gaps with smaller stone, so that the whole waterbar is solid and immovable once completed and will not allow water into the structure

Step 4

Rebuild or grade the path surface

- grade the path surface below the bar, and compact the surface to be flush with the bar stone surface; this is a common erosion point at waterbars
- grade the path surface above the waterbar over at least 2m, falling gradually to be flush with the liner; compact soundly to the required level, to prevent loose material washing onto the liner

Step 5

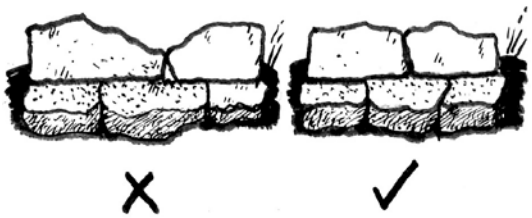
A splash plate or extension of the liner may be needed where there is a steep drop, or soft ground at the path edge. Ditching may be required to channel the water away from the path edge, and to ensure it does not flow back onto the path, further down.

Step 6

The area around the waterbar should be restored if there is any damage or erosion. The path edges may require turfing up, particularly below the bar where it breaks the path edge; but NOT immediately above the drainage channel.

Troubleshooting

Key points to watch out for:



- maintain a good draining angle on the bar to prevent it silting up
- avoid gaps or low points on the bar stones - they let water through
- make sure there are no protrusions that could catch and hold dead grass and other debris
- make sure the water-bar extends far enough beyond the path edge to collect and shed away all the water flow
- if there is a risk that the bar will push walkers off the path line, install a blocking boulder or a landscaped mound below the bar at the path edge.

Variations

Where there is sedimentary geology, it may be necessary to use upstanding slab stones to create the bar. These can be butted end to end, placed in a double row, or overlapped.

On steeper paths the use of anchor bar stones, or stone-pitching below the bar can stabilise the structure.

High user numbers on a mobile surface may cause rapid silting-up of the waterbar and compaction on the downhill side of the bar. It may be necessary to pitch 1-2 metres either side to provide a harder wearing path surface, and prevent mobile material blocking the waterbar.

Where the path is used by cyclists consider using fords, or wide shallow cross-drains, as an alternative to waterbars.

Waterbars can be constructed less formally by off-setting some of the stones or altering the tread angles slightly. Using bigger stones laid flat rather than small stones dug in upright can also soften the constructed look of them.

Maintenance Tasks

Waterbars are the most likely of all drainage features to stop functioning due to the channel and outflow becoming blocked with silt and debris. It is essential that the following maintenance tasks are carried out on a regular basis.

- clear out debris and silt from the bar channel and the outflow ditch
- re-pack the path surface above and below the waterbar, particularly where there has been compaction or scouring and erosion
- check the stability of all stonework; re-pack where there is movement or visible gaps
- check the landscaping around the water bar and path edge, re-instate as required
- cleared silt or gravel can be re-used in resurfacing and packing; spare material should be carefully hidden

ENVIRONMENTAL SENSITIVITIES

- Select local stone away from the path edge and out of sight; if this is unavoidable ensure that holes left are reinstated.
- Use surplus turf and spoil from excavations for site restoration, or hide discretely.

HEALTH AND SAFETY HAZARDS

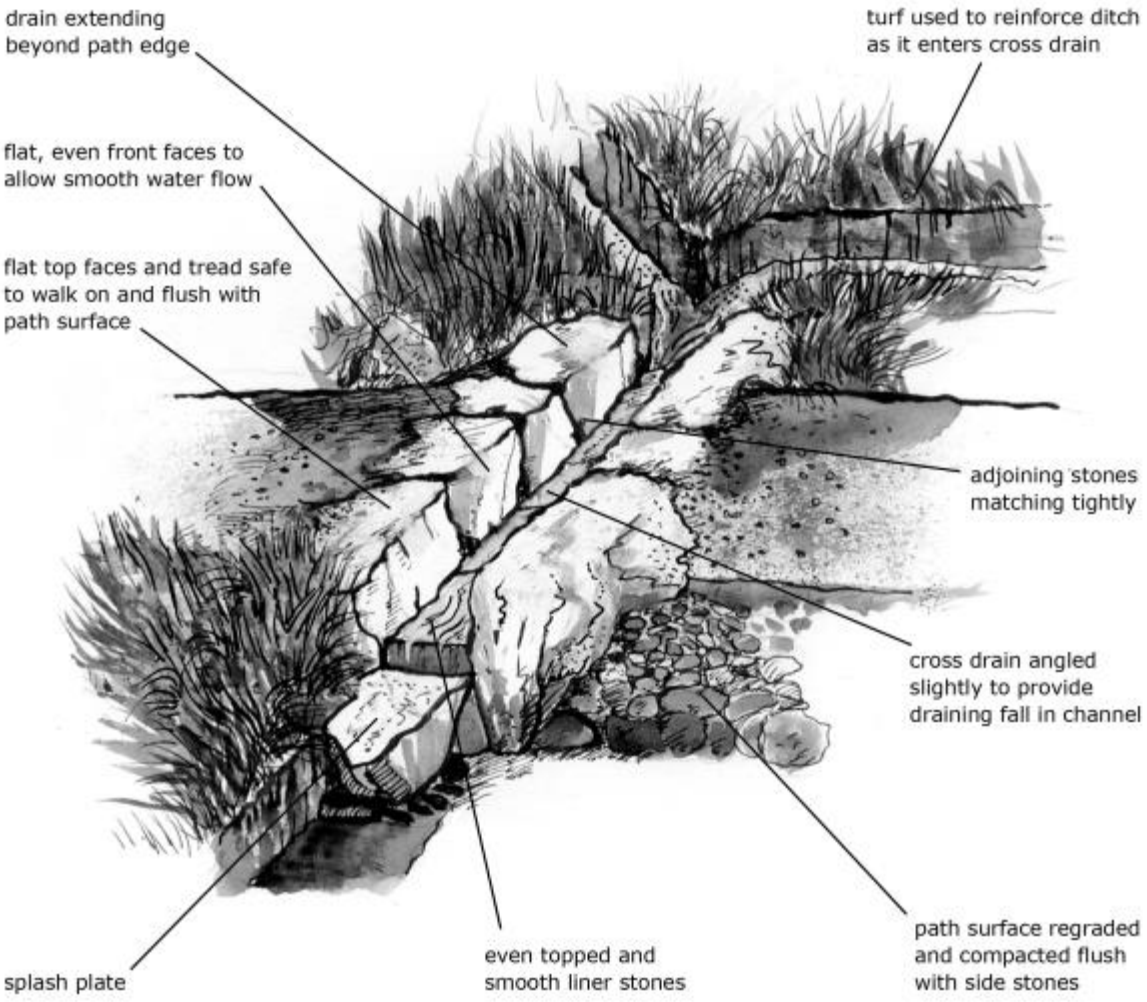
- Take particular care moving large stone; when manoeuvring stones into position beware of crushing fingers.
- With water flowing down the path the trench can become very wet and slippery; erect a temporary bar further up the path or take extra care.

TAKE CARE

- Do not under estimate the amount of water that can flow down a path; and the number of waterbars required to disperse its erosive power.

2.5 Stone Cross-drain

The stone cross-drain is a traditional, and versatile, drainage feature, sometimes referred to as a stone lined ditch. The elements of the design used today remain relatively unchanged from those used on stalkers paths and hill tracks.



Function

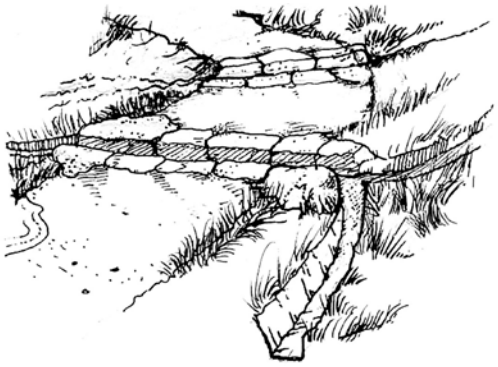
The main purpose of the cross-drain is to channel water from above the path to the lower side. The source of the water may be from small streams, springs, mossy flushes, areas of uphill surface water or seepage. Cross-drains are also used to collect and disperse path surface water at low points on the path; or on sloping paths where water bars are not suitable for the path use.

Bill of Quantities (example)

Use local weathered stone to construct a stone cross-drain with a minimum channel depth and width of 300mm. Extend by 300mm on each path side. Stone line the full length of the drain base, with a gradient of 5° minimum. Allow for an outflow splash plate and approximately 10 metres of in and out flow side ditch. Construct path at least 2 metres either side of the drain.

Positioning of the Cross-Drain

When assessing the location for cross-drains it must be remembered that an inadequate drainage system with too few or wrongly positioned drains can lead to extensive path damage. Frequent cross-drains are needed where the path is traversing a slope, and consequently all water flows have to cross the path.



Typical locations where drains will be required are:

- where a continuous water flow crosses the path - a burn or stream
- where water flows onto the path from above after heavy rainfall – ditching will also be needed to intercept the water
- where there is underground water seepage from above or under the path - path side protective ditching may also be required
- where path surface water collects at low points and cannot drain away naturally

Positioning should also be:

- at the best place for water to cross the path, normally at the lowest point, or where the flow is intercepted
- connected directly, and frequently with protective side ditching
- where there is scope for dispersing water away from the path, and not back on to it lower down
- away from obstructions such as bedrock, unless it can form the drain side or channel - more often than not it will cause a problem rather than help

Construction

Components

The cross-drain has two main components - side walls and a lined channel base. They provide a solid channel across the path which is easy to clear of silt and debris, and is relatively self-cleansing.

- side walls provide the channel width and depth, and are comprised of two lines of block stone across the path, placed with faces to channel the water flow - essential ‘stone extensions’ of drainage ditch or water course sides
- lined channel base is comprised of a row of liner stones, between the side walls, which helps to stabilise the side stones and prevents undermining by water

A splash plate stone extending the liner stones at the outflow may be required to prevent erosion, especially where there is a steep drop, or soft ground is present.

Inflow ditches collect the water flow to be taken across the path from the water source. The ditch for the outflow may connect with the drainage system, or lower water courses, and will ensure that water is dispersed away from the path edge.

Dimension Guidelines

These will vary according to the nature, source and volume of water to be channelled, and the direction and dispersal of waterflow.

- the cross-drain is normally at a shallow angle across the path, depending on the nature and direction of flow; the angle may need to be increased in order to provide an adequate fall in the channel
- the draining fall in the channel should be no less than 5°, and up to 10°, to ensure a clear run
- the channel width and depth can be variable, but will normally be a minimum of 300mm deep and 300mm wide; this will allow room for a spade during maintenance, and less chance of being choked with larger debris.
- the channel should not be so wide as to provide an obstacle to path users
- the top surface of the side stones should be flush with the path surface, to allow collection of path surface water, and to provide a tread surface for walkers stepping across the channel
- the cross-drain should extend approximately 300mm either side of the path, as the site allows, to protect path edges and prevent water flowing onto the path

Materials

Large block stone is required, preferably available, from within reach of the path. It should be large enough to withstand the pressure of path use, the greatest waterflow, and frost heave. If it can be moved and lifted easily by one person it is probably too small.

Stone should be used in its natural form, preferably weathered (see Introduction to drainage techniques), although it may be necessary to shape the stone slightly by chipping off minor protrusions. The quantity of stone required, will depend on the size of cross-drain to be built and the path width.

Points to note when selecting stone:

- side, or face stones should be deep enough for at least 1/3 to be below the surface of the liner, and to provide the required channel depth above the liner
- faces forming the channel side should be as even as possible, with no protrusions that may hamper water flow or collect debris
- tread faces should be as even as possible, with no protrusions for walkers to trip on
- the shape should match evenly and tightly with the adjacent side stones
- liner stones can be smaller, but must be wide enough for the required channel width, and at least 1/3 of the depth of the side stones; also large enough to prevent undermining by fast and high volumes of water
- upper surfaces should provide an even channel surface with adjoining liners, and have no protrusions to hamper water flow and collect debris

Method of Construction

Step 1

Excavate a trench across the path.

- dig the trench deep enough for the liner stones and the required channel depth, and wide enough for both rows of side stones and the required channel width
- the angle of the trench across the path must provide the required fall
- the angle and depth of the trench must complement the drainage ditching or watercourse.

Step 2

Construct the drain side walls.

- set the side stones vertically, or angled slightly back from the channel - stones leaning into the channel will be unstable and make cleaning difficult
- allow at least 1/3 of the stone to be below the liner level
- set top faces at a height that will be flush with the re-constructed path surface, with treads as level and flat as possible
- butt stones tightly to form even front faces to the water channel, with no protrusions
- wedge and pack gaps firmly with smaller stones so that each side wall is solid and immovable once the liner is in position

Step 3

Position the liner stones

- set the liner stones to fit tightly between the side stones and give the required channel depth
- maintain the drainage fall by working from the lower to the higher end
- join liner stones tightly, with joins off-set from the side stones to provide a stable construction and reduce the risk of water getting through
- adjoining stones should have top faces even, with no protrusions
- if required add a splash plate at the outflow, set slightly lower than the channel, to prevent erosion
- wedge and pack all gaps firmly with smaller stones so that whole drain construction is solid and immovable, and will not allow water to sink in

Step 4

On completion of the cross-drain, connecting turf lined or open ditching should be completed, or re-dug, to ensure effective inflow and outflow away from the path.

Step 5

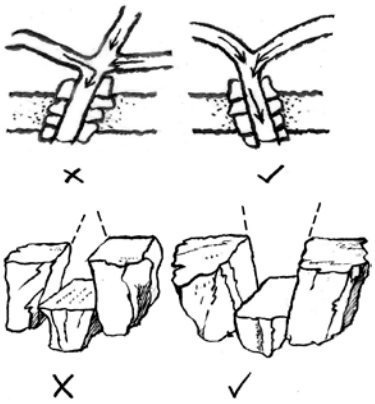
Re-construct the path on either side of the cross-drain. Grade the path surface, over approximately 2m length, down to the level of the side stones, and compact well to prevent surface debris washing into the drain.

Step 6

Restore any damaged areas, particularly the path edges immediately above and below the cross-drain, turfing slightly over the side stones to ensure that the feature appears as natural and unobtrusive as possible.

Troubleshooting

Key points to watch out for:



- make sure the angle and depth complement the ditching
- avoid over-hanging face stones - they make the channel unstable and too narrow to clean
- make sure there are no protrusions - they cause debris to block the drain
- don't be tempted to use thin liner stone - it will quickly be under-mined and wash out

Variations

Variations will depend on the stone available, the location of the path and the volume of water expected. Where a high flow is common, for instance a small stream in spate, a double cross-drain may be constructed with two channels, flowing around a central stepping stone.

Specific path use may dictate a change in dimensions, such as a wide, shallow cross- drain if the path is used by cyclists. Alternatively, a ford could be considered particularly if used by cyclists or quad bikes.

Cross-drains may be incorporated in stone-pitching, with the side stones forming part of the pitched path surface.

Maintenance Tasks

Cross-drains can be subjected to very fast flowing and high volumes of water particularly after snow melt or periods of heavy rain. This can result in undermining of stonework, and drain blockage by large debris. It is essential that the following tasks are regularly carried out.

- clear out debris and silt blocking the channel and connecting ditching
- check the stability of stonework - re-pack where there is any movement or gaps
- re-pack surfacing behind drain stones if there has been compaction or erosion of the surface
- check the landscaping around the cross-drain and path edge, re-instate as required
- cleared silt or gravel can be re-used in packing and re-surfacing; any spare material should be carefully hidden

ENVIRONMENTAL SENSITIVITIES

- Select local stone away from the path edge and out of sight; if this is unavoidable ensure that any visible scars are reinstated.
- Use surplus turf and spoil from excavations for site restoration, or hide discretely.
- Restore damage from cross-drain construction to look as natural as possible.

HEALTH AND SAFETY HAZARDS

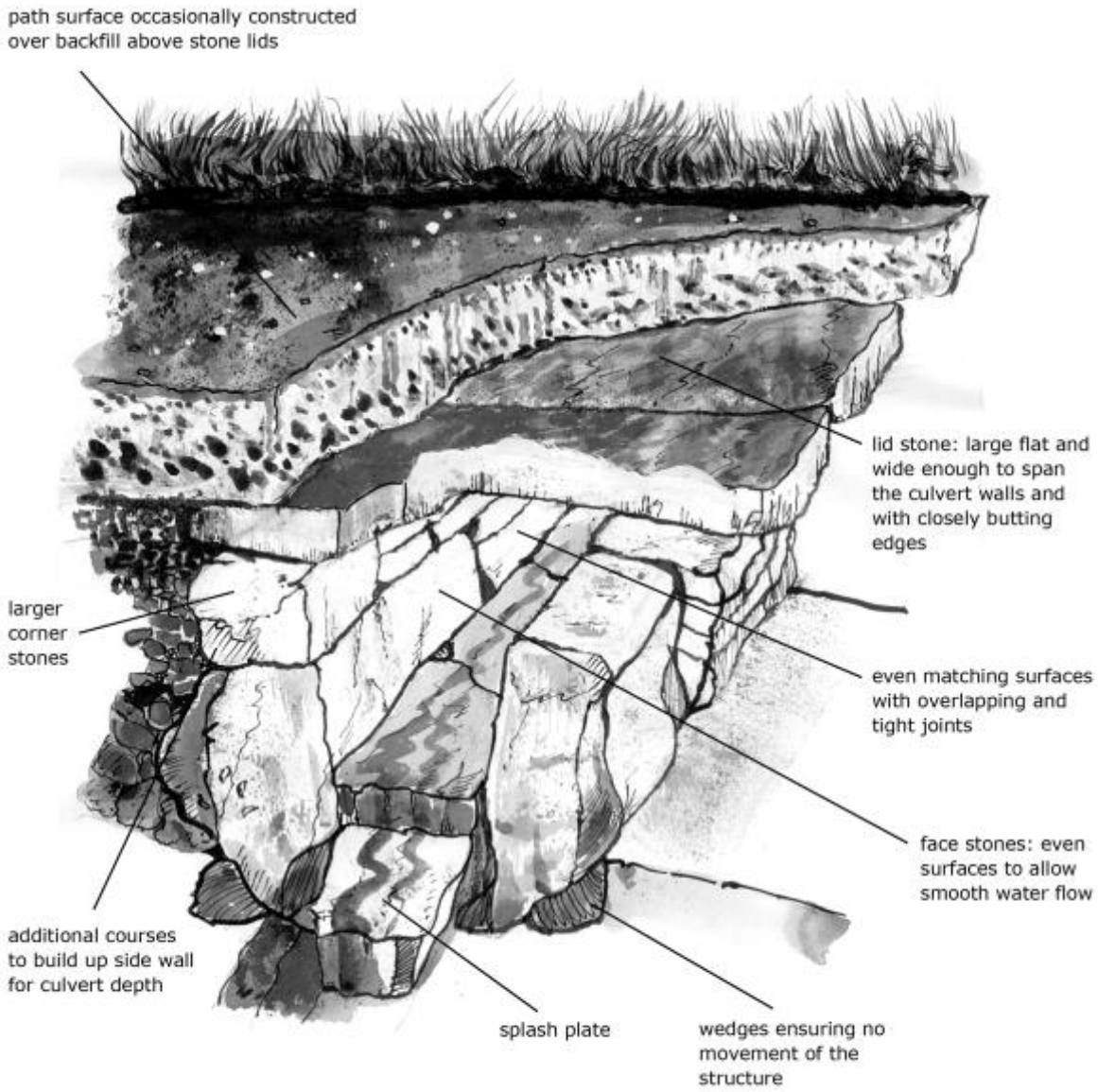
- Take particular care moving heavy side stones and when manoeuvring into position; use safe manual handling techniques; beware of crushing fingers or dropping stone onto feet.
- When wedging large face stones, watch out for stone movement that may cause crush injuries.
- The trench of a cross-drain will become very wet and slippery; divert or block water flow during construction, if feasible.

TAKE CARE

- Do not under estimate the amount of water to be channelled in the wettest conditions. Too few, or inadequate size drains can lead to extensive damage to the path surface.
- However, the size of the drain needs to relate to the volume of water and the landscape. If the drain is too large it will look out of place and over-engineered.

2.6 Stone Culvert

Stone culverts, also known as box culverts, are traditionally used on stalkers paths, military roads, and estate roads, as well as upland paths. They allow all path users to pass over the drainage feature without difficulty, and are ideal for ponies, bikes and wheeled traffic. However, culverts are prone to blocking, particularly after rapid increases in water level and therefore need maintaining regularly. They may not cope with extreme weather events as well as an open system such as cross drains or stone fords.



Function

The purpose of the culvert is to channel water from one side of the path to the other. It can be wider and deeper than a cross-drain to cope with larger volumes of water. Normally used for water courses crossed while traversing a glen or hillside, it can also be used with ditched waterflow. A continuous walking surface is provided over the top of the drain - it does not catch water draining down the path.

Bill of Quantities (example)

Use local stone to construct a stone culvert with a depth and width of approximately 500mm. Extend by 300mm on each path side. Side walls and lid stones must be large and stable enough to support the path surface and use. Stone line the culvert base, with a minimum gradient of 5°. Allow for splash plates at the inflow and outflow, and approximately 10 metres of ditch to or from the culvert. Construct the path surface to 300mm depth over the culvert and at least 3 metres on each side.

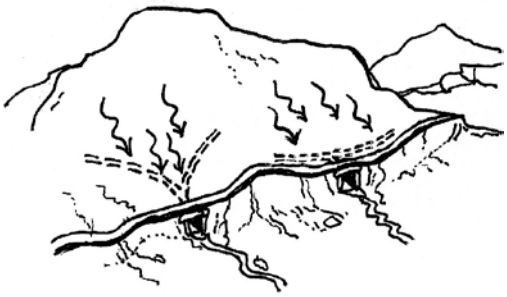
Positioning of the Stone Culvert

The assessment for positioning culverts is largely the same as for cross-drains. The key situations where they will be required are:

- where a watercourse flows across the path from small streams, springs or mossy flushes
- where uphill surface water is ditched, or side ditches protect the path

The most suitable positions will be:

- at the best place for water to flow under the path, preferably at a low point, close to where the flow is intercepted
- connected directly, and frequently with protective side ditching
- where there is scope for dispersing water away from the path, and not back on to it lower down

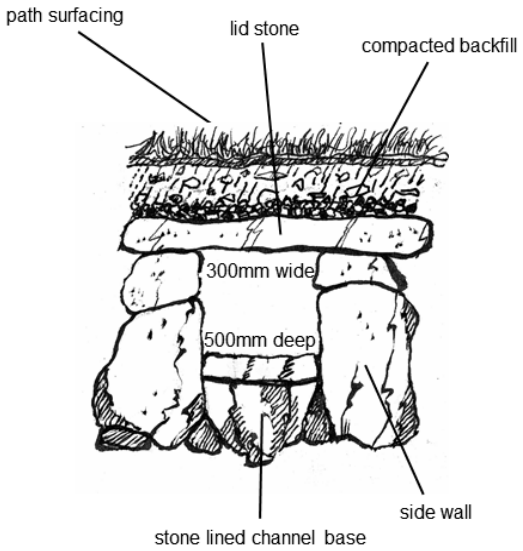


Construction

Components

The culvert has three main components: side walls, a lined channel base, and a lid. These create a boxed and solid hard-wearing channel under the path which should not become damaged from path use, does not collect path surface silt, and is relatively self-cleansing.

- The side walls provide the channel width and depth, and support the lid, they are comprised of two lines of large block stone across the path, placed with faces to channel the water flow and with additional courses as required to achieve the channel depth and support the lid stones.



Cross section through a stone culvert

- the lined channel base, between the side walls, is comprised of a row of liner stones to prevent undermining of side walls by water
- the lid encloses the channel and supports the path surface on large flat stone slabs, capable of spanning the culvert width

Splash plate stones extend the liner stones to prevent erosion, especially at the outflow where there may be a steep drop from the culvert channel. A splash plate extension may also be required if the inflow ditch drops steeply to enter the culvert below the path surface.

Where the culvert is connected to drainage ditches, the in and out flowing ditches must be carefully aligned, allowing extra depth to connect with the culvert channel under the path.

An aggregate path surface will usually be required over the top of the lid stones, tying in with the adjoining surface levels.
These may need regrading to accommodate the depth of the culvert. If the lid stones are large and stable enough they may serve as the path surface

Dimension Guidelines

Dimensions will vary according to the volume of water to be channelled. The channel must be large enough to take the greatest expected volume of water. Culverts are prone to blocking with large debris. A larger channel will reduce this risk, will be relatively self-cleansing, and easier to maintain as a result.

- the culvert normally passes straight across the path, but may need slight angling to provide a fall in the channel.
- the draining fall of the channel should be no less than 5°, to ensure a clear run.
- the channel size will be variable, the larger the better - on average 500mm deep and wide, but an absolute minimum of 300mm; the availability of lid stone may dictate the channel width.
- the level of the lid stone surface should allow for a layer of backfill material compacted to approximately 50mm, and a minimum of 150mm path surface over the top, increased to 300mm if heavy, wheeled traffic use is expected.
- the full culvert structure should extend at least 300mm either side of the path, to prevent path edge collapse into the ditch or watercourse.

Materials

A large amount of good size stone is required to build culverts. Selecting the right stone is fundamental, especially for the lid, which must span the full culvert width and support the weight of the path. Large block stone must support this lid. It should also be large enough to withstand the pressure of the greatest waterflow, and frost heave. Some sites may not have suitable stone available and stone culverts will not be an option (see variations).

If possible local stone should be used, found within reach of the path. All visible stone in the structure should remain in its natural form, preferably weathered on visible surfaces. Permanently hidden stone may be shaped as required.

Points to note when selecting stone:

- if possible, large side stones should make up the full channel depth required; if not additional courses of block stone should be used to gain the required depth
- all side stones should be of a size to provide a stable wall, which supports the lid
- side stone faces forming the channel side should be as even as possible, with no

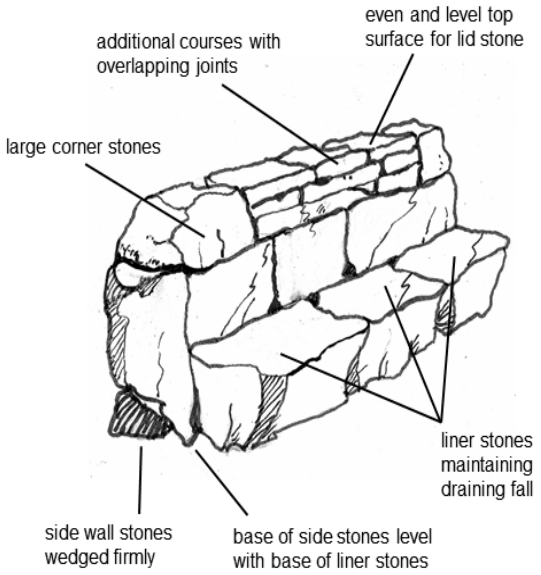
protrusions to hamper water flow or collect debris
- channel liner stones can be smaller, but must be wide enough for the required channel width, and at least 200mm deep, to prevent undermining by fast, high volumes of water
- upper surfaces should provide an even surface with adjoining liners, and have no protrusions which hamper water flow and collect debris
- lid stones must be wide enough to span the full width of the culvert and side walls, and deep enough to support the path and its expected use
- there must be enough lid stone available to cover the full length of the culvert
- if lid stone is to provide the path surface it should be as even as possible, with no protrusions for walkers to trip on
- the shape of all construction stones should match evenly and tightly with adjoining stones

Method of Construction

Step 1

Excavate a large trench, or clear the bed of the watercourse, across the path.

- dig the trench wide enough for both side walls and the required channel width; and deep enough for the liner stones, the required channel depth, the lid stones, backfill and the depth of the aggregate surface over lid stones
- the angle and depth of the trench must complement the watercourse or drainage ditch, and provide an adequate fall



Step 2

Construct the bottom course of the side walls.

- set the side stones vertically, or angled slightly back from the channel - stones leaning into the channel will be unstable
- the base of the side stone should be at the same level as the base of liner stone
- the top surfaces should be as level as possible to provide a base for additional courses or the lid stone
- butt stones tightly to form even front faces to the water channel, with no protrusions
- wedge and pack gaps firmly with smaller stones so that each side wall is solid and immovable once the liner is in position

Step 3

Position the liner stones

- set the liner stones to fit tightly between the side stones to give the required channel depth
- maintain the drainage fall by working from the lower to the higher end

- join liner stones tightly, with joins off-set from the side stones to provide a stable construction
- adjoining stones should have top faces even, with no protruding edges
- add two splash plates; at the outflow this should be set slightly lower than the channel, and at the inflow it should be set slightly higher than the channel
- wedge and pack all gaps firmly with smaller stones so that whole drain construction is solid and immovable; and will not allow water to sink in

Step 4

Construct additional courses for side walls to achieve the channel depth and support the lid.

- tightly match adjoining stones with all joins over-lapped and front faces even, with no protrusions
- use larger stone for side wall ends, or corners, for a strong structure
- the top course must be even and horizontal to provide a solid platform for lid stones
- pin from behind, wedge and pack gaps firmly with smaller stones so that each side wall is solid and immovable

Step 5

Position the lid stones over the culvert side walls.

- place lid stones so that they extend over the channel walls, and will not collapse into the channel
- butt lid stones tightly together, with any gaps filled to prevent the over-laid path falling through
- pin and wedge lid stones securely to ensure that there is no movement
- use material excavated from the trench to backfill over the lid stone, to provide a compacted base for the path surface

Step 6

Construct an aggregate path over the backfill. Soundly compact the base and surfacing material, to prevent the path eroding and exposing the lid from pressure of path use. If wheeled traffic or heavy use is expected the depth should be increased to 300mm. Re-construct the path either side of the culvert as far as required for regrading levels to accommodate the culvert.

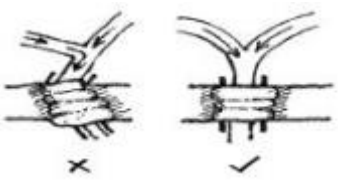
Step 7

Restore all areas damaged during construction, particularly broken path edges and the ground above and below the culvert. Continue path edge turfing over the top of the culvert, along the end of the lid stones, to stabilise the edge and ensure the feature is as natural and unobtrusive as possible.

Troubleshooting

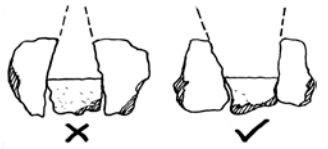
Key points to watch out for:

- make sure the angle of the culvert compliments that of the waterflow



- make sure all joints overlap for a strong, stable structure

- make sure side walls and channel have no protrusions - debris caught in culverts is difficult to clear



- don't use thin liner stone - it will quickly be under-mined and wash out

Variations

Most variations to this design reflect the type of stone and its availability on the site. Good quality lid stones can be used as the path surface, particularly if large and stable with a level and flat top surface. They will need to tie in carefully with the adjoining path surface which may need regrading to provide the height required over the culvert.

A simple variation often used is a standard cross-drain with lid stones over the top. This avoids building up the sides with additional courses, but relies on large enough side stones to make up the required height. The capacity of the culvert will be reduced by the reduction in the channel size.

Where a continuous surface is required over a larger volume of water, and there is no large stone available there are two other options. If there is plenty of small stone a ford may be the answer, if not, a piped culvert may be the only option.

Maintenance Tasks

Stone culverts can be subjected to very fast flowing, high volumes of water, particularly after snow melt or periods of heavy rain. This can result in undermining of stonework, and blocking with large quantities of debris. They are difficult to maintain due to their enclosed structure, however it is essential that the following tasks are carried out regularly.

- clear out debris and silt that is blocking the culvert; use long handled tools or drain rods
- clear debris and silt from in and out-flow ditching
- check stability of stonework - re-pack where there is any visible movement or gaps
- re-pack surfacing over the culvert if there has been compaction or erosion
- check the landscaping around culvert and path edge, re-instate as required
- cleared silt or gravel can be used in packing and re-surfacing; spare material should be carefully hidden

ENVIRONMENTAL SENSITIVITIES

- Select stone away from the path edge and out of sight; if this is unavoidable ensure that holes are reinstated.
- Use surplus turf and spoil from excavations for site restoration, or hide discretely.
- Restore damage from culvert construction to look as natural as possible.

HEALTH AND SAFETY HAZARDS

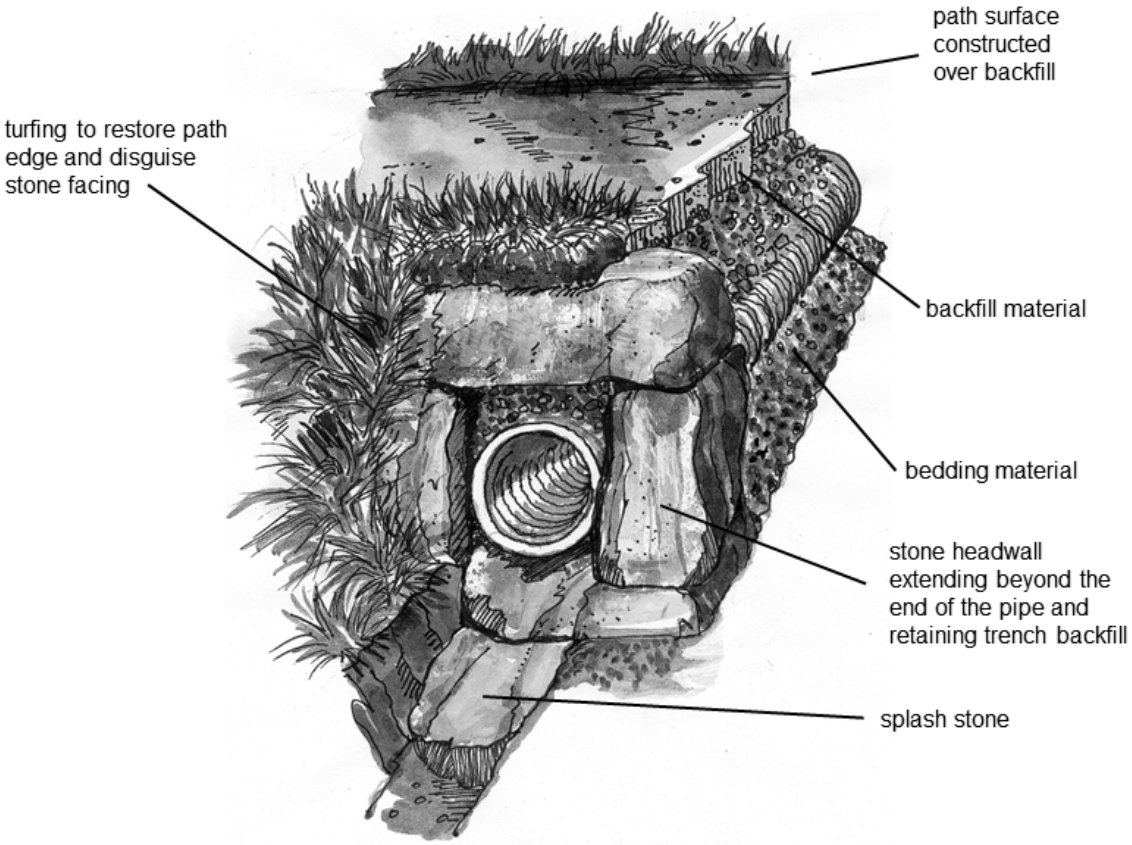
- Take particular care when moving and manoeuvring heavy wall and lid stones; use safe manual handling techniques; beware of crushing fingers or dropping stone onto feet.
- When wedging side wall and lid stones watch out for movement that may cause crush injuries.
- Use eye protection when shaping stone.
- The trench will become very wet and slippery; divert or block water flow during construction, if feasible.

TAKE CARE

- Do not under estimate the amount of water that culverts will channel in the wettest conditions. An inadequate capacity can lead to extensive damage to the path surface.

2.7 Piped Culvert

The piped culvert is one of the few cases where synthetic material is introduced into upland pathwork. In remote areas, or areas with few signs of land management they should only be used where traditional drainage techniques are not possible because it is very difficult to hide the pipes entirely. This is mainly when a path crosses soft ground, particularly deep peat, and it is impractical to build cross-drains, or where there is no suitable material for stone culverts and covered drains are needed. In less sensitive areas they are increasingly used because they are cheaper and easier to construct than stone culverts. Stone facing, or headwalls, help to hide the plastic pipe by extending beyond it. Culverts are prone to blocking, particularly after rapid increases in water level and therefore need maintaining regularly.



Function

The piped culvert serves the same function as a cross-drain, or stone culvert - to channel water from one side of the path to the other, generally from drainage ditches installed to protect the path. This situation commonly occurs when the path is traversing wet hillsides or stretches of poorly drained ground. The culvert does not catch water draining down the path because a continuous walking surface is provided over the top.

Bill of Quantities (example)

Construct a piped culvert under the aggregate path, using 300mm diam. twin-walled black pipe bedded on 100mm depth of gravel material. Compact the backfill material to 300mm minimum depth. Use local weathered stone to build headwalls, and landscape to hide exposed pipe ends. Allow approximately 10m of ditching.

Positioning of the Piped Culvert

The assessment for positioning piped culverts is largely the same as for stone culverts and cross-drains. When installed with a new path over soft ground, the path alignment can affect location and frequency. To reduce the visual impact of too many piped culverts design the path to reduce the need for water to cross it. Avoid using piped culverts on steeper gradients, where they block quickly and are prone to becoming exposed.

Positions to consider include:

- the best place for a ditched waterflow to cross under the path, often the lowest point
- where water crosses the path, from a small stream, spring or mossy flush
- the best place for water to be dispersed away from the path

Construction

Components

The piped culvert consists of:

- synthetic pipe laid in an excavated trench
- bedding material in the base of trench to hold the pipe in position and level
- backfill material over the pipe to protect it from pressure of path use; also provides a compacted base for path construction
- headwalls around exposed pipe ends, comprising base stone, two side walls supporting one top stone (or sometimes layered turf), and splash stones at both ends

With careful turfing, headwalls hide the existence of the synthetic pipe, minimising the visual impact in the landscape. Headwalls also serve to retain the backfilled trench and stabilise the path edge. These are weak points of the feature. Without protection they may erode and collapse with path use.

The inflow and outflow to the pipe are also weak points, particularly if there is a steep drop to or from the culvert in soft ground. Without large splash plates they become undermined and eroded. Ensure there is sufficient fall for water to flow into the pipe under the path. The outflow ditch will also need careful alignment to ensure dispersal away from the path edge.

Dimension Guidelines

These will depend on the situation in which the piped culvert is being used, and the size of pipe required.

- the culvert will normally be straight across the path, but may need angling to allow for the fall in the pipe, and the alignment and fall of the inflow and outflow ditches
- the drainage fall of the pipe for culverts with a very small amount of water flow should be at least 5° so that water will flow easily and reduce the amount of silting

- the drainage fall of the pipe for the majority of culverts should be no more than 5° to avoid erosion at the outflow because the plastic culvert can accelerate water flow
- the pipe diameter depends on the volume of water as this may quickly block with debris. A minimum of 300mm is essential
- bedding material should be approximately 100mm depth to provide a level base and retain the pipe alignment
- backfill material should be compacted to a depth of at least 300mm, to protect the pipe from pressure of path use, and exposure through path damage; it also provides a firm base for the path surfacing
- the trench and bedded pipe should extend at least 300mm each side of the path width
- headwall dimensions will depend on the pipe size, but the outer edge should extend in front of the pipe by at least 150mm, to hide the pipe; and the top and side stones should retain the trench backfill and path edge, and fully enclose the pipe extending outside the path width
- there should be at least 100mm of backfill or bedding material between the inside faces of headwall stones and the pipe
- splash plates, preferably stones of some depth, should be wedged under the pipe extending by at least 150mm at the inflow side of the pipe and by approximately 300mm at the outflow
- the top stone surface should be lower than the finished path surface, and allow turfing over to match adjoining path edge landscaping

Materials

Polypropylene pipe is most commonly used for culverts because it can be easily cut to the length required and transported. Alternatives such as concrete and clay are available but will be heavy to transport to remote sites.

300 or 450 mm twin walled rigid polypropylene pipes should be used because they better support the weight of fill, lessening crush and UV damage. Black pipe should always be used as it has less visual impact.

Local, weathered stone for the headwall should be found within reach of the path. Points to note when selecting stone:

- the side stones should be large and deep enough to support the top stone above the pipe
- the top stone should be wide enough to span the side stones; and not extend above the path surface level
- top and side stone should be long or deep enough to hide the exposed pipe and retain the trench and path edge

Bedding material should be gravel, or small aggregate, won from borrow pits or stream beds within close reach of the path.

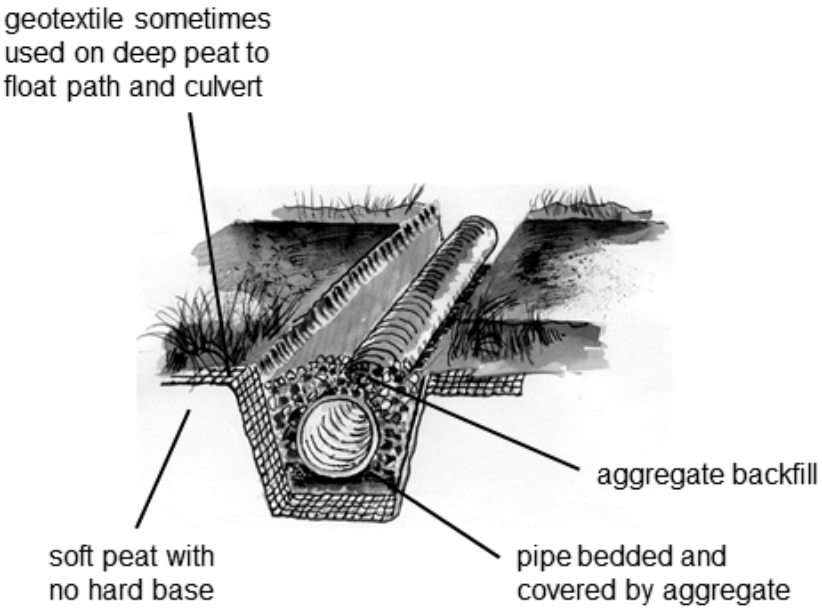
Backfill material must compact well; trench excavated material should be suitable, unless it is peat when material should be won from borrow pits or stream deposits.

Method of Construction

Step 1

Excavate a trench.

- dig the trench long and wide enough for the required pipe length, diameter and bedding surround; and deep enough for bedding material, pipe diameter and compacted backfill below the path surface
- the angle, and base of the trench must provide the required fall for the pipe
- if the path is on deep peat, and floated on geotextile, the matting and geogrid are taken into the trench to line it; for fitting, and ease of laying, the geotextile should be cut and overlapped across the full trench width



Step 2

Position the pipe

- cut or trim the pipe to the exact length required
- compact and level the bedding material in the trench base working up from the outflow end to maintain the required draining fall
- position the pipe and align correctly, adjusting the drain fall, if necessary
- construct the headwalls using block stone, setting the side stones firmly against both ends of the pipe
- pack the sides of the pipe using bedding material topped with compacted backfill
- taking care not to move or damage the pipe with any large or sharp stone, backfill the trench across the path width, compacting in at least two layers, to the required level
- construct the headwalls prior to final compaction

Step 3

Construct the headwalls

- set the splash plates to extend under the pipe bedding and the required length out from the pipe, making sure they are level if used to support the side stone
- consider the path line. If the path changes direction the pipe may be more difficult to conceal and additional stone may be required to hide the pipe
- set the side stones firmly against both ends to retain the trench and enclose the pipe, leaving the required margin around it, either for providing level top surfaces for the top stone, or protruding higher to retain layered turf

- set additional side stones, if needed to achieve the required height, and to provide solid and stable side walls
- position the top stone to span the side stones, set back to retain the trench or path edge and enclose the pipe, leaving the required margin above it, and the top surface to the required level.
- wedge, pin and pack all stonework firmly before completing the backfill, with gaps packed tightly with smaller stone, to prevent any movement
- set splash plate stones wedged firmly between the side stones, with the surface level below the outflow lip of the pipe and above the inflow lip

Step 4

Complete the aggregate path over the backfill base to tie in with the adjoining surface.

Step 5

Complete the inflow and outflow ditching, connecting to drainage ditches as required. Ensure the required draining fall is maintained to collect and disperse the waterflow.

Step 6

Restore all areas damaged during construction. The path edges and the area above the headwall should be carefully landscaped using turf and spoil, won from ditching and excavations. Turfing over the top stone must be stable and form a containing edge to the path. Lay turf up to the side stones to minimise the impact of the pipe and stonework, ensuring the feature is as natural and unobtrusive as possible.

Troubleshooting

Key points to watch out for:

- use the correct diameter of pipe for the volume of water - one wide bore pipe should be used in preference to two parallel narrow pipes where possible, because it is less prone to blocking or washout
- maintain the pipe and ditch run - ensure that water will flow through the pipe
- set in splash plates firmly - prevent undermining by waterflow pressure
- make sure the headwall protects the trench and path edge - prevent path edge collapse over the pipe
- set the pipe at least 300mm below the path surface - if not it will become exposed with use

Variations

Larger piped culverts are needed when there is no suitable material for stone culverts, and covered drains are essential for the nature of path use. They are also required to channel streams with high flows. Where large pipes are used, substantially wider and higher revetted headwalls, with several courses of stone, will be necessary.

Another variation for high volumes of water is to use two pipes side by side with a wider headwall. As well as blocking more easily, twin pipes are hard to disguise and site against each other, but can be used where it is not possible to have one wide pipe, such as over bedrock.

Where no block stone is available on site to construct a stone-faced culvert headwall, an alternative is to use large turfs to construct a turf bank. This is built using layers of strong turf to build up around the mouth of the culvert pipe. Build the bank so that it shapes back,

with a batter of 30°- 45°, and use large turfs to prevent movement. This solution will not be as solid as a stone headwall, but is preferable to an unsupported and uncovered culvert end. There is also a method of layering turf between the side stones which forms around the shape of the pipe and knits into the surface material. This requires the height of the two side stones to protrude about 100 - 150mm higher than the top of the pipe.

Base stones are sometimes used to raise the culvert. These should be at least 200mm deep; wide and level enough to support the side stones and if possible long enough to serve as the splash plates.

Maintenance Tasks

Piped culverts are very prone to becoming blocked and may not cope with extreme weather events as well as an open system such as cross drains or stone fords. Routine clearing after long or high periods of rain or after snow melt is essential:

- carefully clear out debris and silt from the pipe; drain rods or long handled tools will be required for this
- clear out debris and silt from out and inflowing ditches
- check stability of headwalls; re-pack stonework where there is any movement or gaps
- check landscaping around the headwall and path edge, stabilise and re-instate as required
- re-pack surfacing over the culvert, and backfill over pipe if there is any settling, compaction or erosion
- cleared silt or gravel can be re-used in packing and re-surfacing; any spare material should be carefully hidden on site

ENVIRONMENTAL SENSITIVITIES

- The appropriateness of piped culverts in the landscape must be considered - it is difficult to hide the pipe completely - use an alternative technique, such as cross-drains or stone culverts when possible on sensitive sites
- Surplus spoil from excavations should be used for landscaping, in-filling borrow pits or discretely hidden on site.
- Any off-cuts or excess pipe must be removed from the site and disposed of properly.

HEALTH AND SAFETY HAZARDS

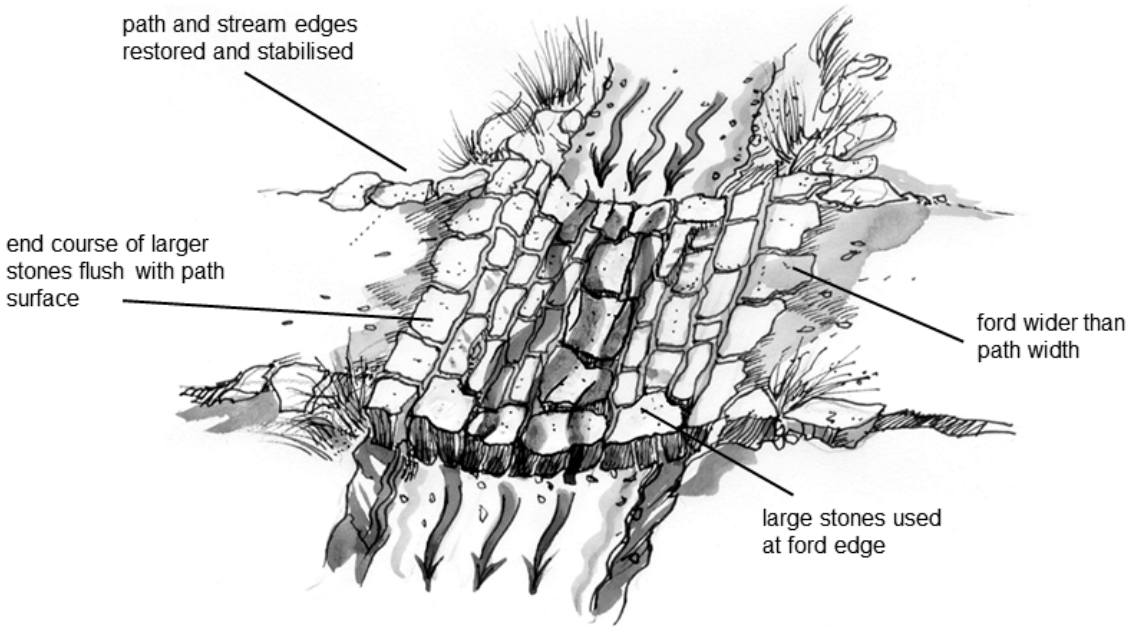
- Be careful when cutting pipe, use sharp tools - blunt ones may lead to excessive force being used and an accident.
- Take care when working in the trench of a culvert - it may become wet and slippery under foot.

TAKE CARE

- Make sure the pipe is well hidden and the path edge and headwall are stable.
- Do not under estimate the amount of water that culverts will channel in the wettest conditions. If the pipe is too small the path will quickly get ripped out, but a smaller capacity pipe will be easier to conceal.

2.8 Stone Ford

Fords have been traditionally used on all access routes, from roads to hill tracks and stalkers paths, where wheeled vehicles or stalkers' ponies require access. They work particularly well in areas subject to large fluctuations in run-off or water levels, but walkers may get wet feet! On upland paths this common feature has a stone pitched or cobbled surface, with variations in style from place to place.



Function

The ford provides a solid, hard-wearing stone surface through rivers, large streams or burns, where bridges or stone culverts are not appropriate or feasible. It also serves to dissipate the waterflow by increasing the width of the watercourse, and possibly reducing the depth. A regular surface enables ponies and wheeled traffic to cross easily, and walkers to have a safer crossing, though probably a wet one. The whole structure should withstand fast flowing water, and also help prevent erosion of the river bank where it meets the path.

Bill of Quantities (example)

Using local weathered stone construct a stone ford, with a pitched surface lining the full length and width. Extend at least 300mm wider than the path on each edge, and to the top of each bank. Re-grade the path surface at least 2 metres either side of the ford.

Positioning of the ford

This will obviously be where the path crosses the watercourse, which may limit the option of choosing the best place. The ideal position for a ford is on a wide, level stretch of slower flowing water, where its force is reduced. This may mean re-aligning the path, or the burn. The ford should not be placed where walkers will by-pass it on dryer days.

Construction

Components

The pitched surface comprises the number of courses of stone required to run from the path on each bank down to the centre of the stream. The courses normally run parallel with the bank. These form the ford:

- Channel - the lowest, centre course of the pitched surface; largest stones form a firm base for the upper courses of the ford, and a shallow channel where the water flow is fastest
- Edges - where it joins with the stream's natural bed; large stone used for the end stones in each course forms strong edges; the largest on the uphill edge which takes the force of the waterflow
- Ends - at the bank edge; large stones also required for the end courses to solidly join the ford with the path surface

Dimension Guidelines

Dimensions of the ford vary according to the width of the watercourse and the width of the path.

- the width should be at least 300mm wider than the path width at each edge
- the length should extend to at least one course of stones past the top of the stream bank, or to the width of the waterflow when in spate, whichever is the greater
- the edge or end stones, of the centre courses, should provide a surface level with the stream bed at the upper end or edge, so as not to impede water flow, and no more than 150mm above the bed at the lower end
- all lower edge stones should be pitched in to at least 2/3 of their depth, for stability of the structure
- the surface of the bank edge courses should be flush with the path surface
- all other stones should form as level a surface as possible for the ford, sloping gradually down to the base of the stream, providing a good surface for path users, and water to flow over

Materials

Local block stone should be found within the area that the path passes through, and from the stream bed where this does not have an adverse impact on the flow of water.

The size and shape of all stone should be such that the depth can be pitched into the bed of the stream with a level tread surface on the top side. Other faces should be as even as possible, to form a tight match with adjacent stones.

The 'key' stones of the ford, edges and ends should have a minimum depth of 300mm, dug into the stream bed.

Method of Construction

Having assessed the dimensions required for the ford during high waterflow, the construction should preferably be undertaken during the period of lowest flow.

Step 1

Prepare the stream bed.

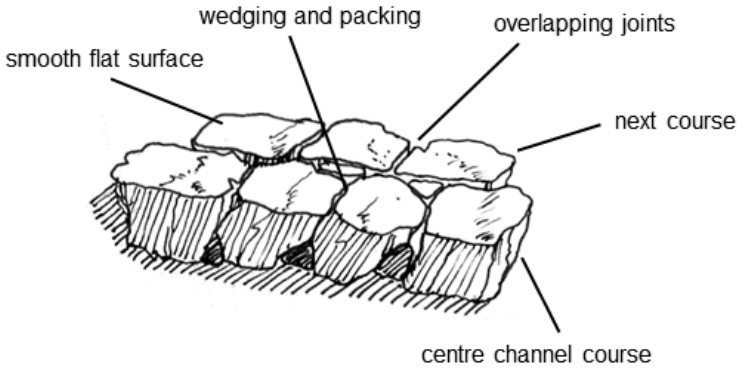
- divert or block the waterflow taking care that damage is not caused to the adjoining path
- where the stream is wide, half or part of the bed may be blocked for work to take place
- the force of the water may be reduced by placing large boulders upstream
- remove any stone or material from the stream bed that may cause obstruction, over the area to be constructed, saving suitable stone for construction.

Step 2

Pitch the ford centre channel.

To provide a firm base, and achieve the required levels, start with the centre course of stones, at the lowest point of the stream bed. If the drop from each bank is minimal and the stream narrow, construction may start at the path edge.

- work upstream from the lower edge, and parallel with the stream bank
- set the depth of the stones into the stream bed to achieve the required ford surface level
- fit adjoining stones together tightly, with top surfaces flush with the adjacent stone
- tightly wedge and pack all gaps with smaller stones and gravel



Step 3

Pitch the remaining courses.

Starting each adjoining course at the lower ford edge, pitch parallel courses, until the ford ends are reached, at the bank

- make sure top surfaces are flush with the adjoining course to achieve a gradual slope down to the centre channel
- fit all adjoining stones, and courses together tightly
- overlap all joins with the previous course of stone
- tightly wedge and pack all gaps with smaller stones and gravel, to form an immovable structure that won't be undermined by the force of water

Step 4

Re-grade and compact the path surface, over approximately 2m length, down to the level of the ford end stones on the stream bank, in order to achieve a draining fall towards the stream.

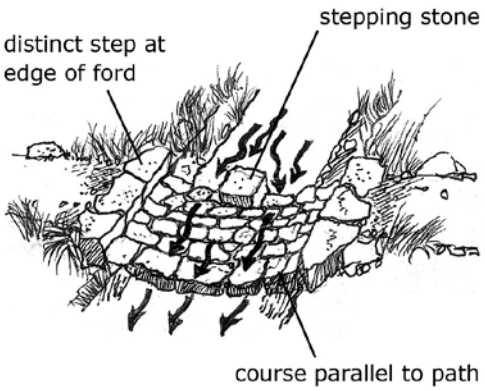
Step 5

Restore any damaged areas, particularly the path and stream bank edges above and below the ford, to ensure there is no risk of water flowing around the ford causing damage to the path.

Troubleshooting

Key points to watch out for:

- make sure that all adjacent stones are tightly butted, with overlapping joins, and gaps wedged or filled to allow no movement of the stone
- ensure that no stones are protruding above others
- make sure that the ford is adequate for the waterflow of the stream at its fullest: wide, long and deep enough, to prevent water washing out behind the ford onto the path



Where no wheeled traffic is expected the design can be varied by incorporating a defined step, at each end forming an edge to the path where it joins the ford. This would use large block stones butted tightly together. The ford becomes like a very large cross drain, with a wide stone liner - with large edge stones and water flowing below walking level.

This, or other designs, may also incorporate stepping stones to give walkers good footholds when the waterflow is particularly high. These may be the edge stones on a wide river, or a single large stone in the centre of a narrower stream.

If the ford is constructed where there is a steeper fall, such as where the path is traversing a steep cross-slope, it may be preferable to construct courses of stone running parallel to the path. The course on the downstream edge will require the largest stones, as the base of the structure.

Maintenance Tasks

Fords should require minimal maintenance. They are self-cleansing, and if constructed properly and soundly, should only require minor repairs. Maintenance should take place during dry weather.

- re-pack stonework where there is movement or any visible gaps
- re-pack path surfacing above the ford end stones, where it may have been washed out or settled
- re-build path or stream banks where water is flowing around the ford ends and damaging the path - minor extension to the ford width and length may be required

ENVIRONMENTAL SENSITIVITIES

- Build a ford that will blend in with the surrounding landscape, using stone from the stream bed or surrounding ground
- Check that changes in waterflow will not affect the ecology down stream

HEALTH AND SAFETY HAZARDS

- Do not work on the ford when the waterflow is strong
- Be aware of slippery surfaces on boulders and stone underfoot

TAKE CARE

- Build a ford that is large and solid enough to prevent washout with the highest and fastest flows of water; in particular after sudden snow melt and long periods of rain.

3. Upland Path Surfaces

3.0 Introduction to Surface Techniques

An upland path has to withstand the pressures of people and the elements. If these are great, erosion will inevitably occur, and a hard wearing path surface becomes necessary in order to reduce the environmental impact and provide a durable and pleasant route.

A well surfaced path should be attractive to use, so that people will not take alternative routes, causing further erosion scars, but not be so smooth and regular that it detracts from the experience of visiting an upland landscape. Path edge work and landscaping will help to reduce the impact of a hard surface in the surrounding landscape (see Restoring Vegetation).

The traditional surface techniques used on upland paths in Scotland are:

- aggregate, with on-site material
- stone pitching

The choice of techniques will depend on an assessment of the characteristics of the path, its use, and the site through which it passes.

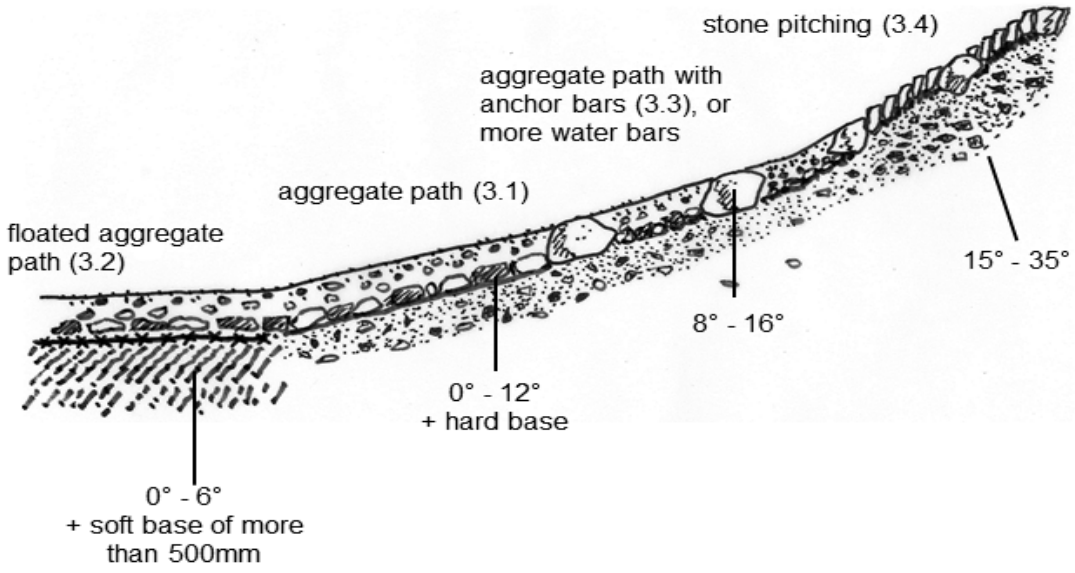
Assessing the Site

The key factors that determine which technique to use are the extent of existing damage, topography of the land and the nature of path use (see also the Environmental Impact and Path assessment sections).

Erosion problems

A path survey is used to identify the extent and type of erosion. Typical erosion problems include:

- loss of surface vegetation and soil - from pressure of use and water flow
- path braiding to either side with further erosion of vegetation - from people avoiding pitched, rough or wet areas
- further eroded paths, and short-cuts across corners or straight down slopes - from people avoiding the path completely
- deep eroded gullies - from people continuing to use a path after water damage to a mobile surface
- wash out – surface materials are lost after failure of drainage or extreme weather events



Topography

The surface technique is largely influenced by gradient and associated ground conditions.

- Over wet and peaty areas the aggregate path may need to be 'floated', either on geotextiles or a natural foundation such as sheep fleece.
- Aggregate paths are generally used on gradients up to 12°/20%. Higher gradients should be avoided as the aggregate will be more susceptible to migration down the path, from the pressure of feet and water flow, as well as gravity. This will depend on the quality of the surface binding material, which depends on the geology and can be mobile on gradients greater than 5°/10%. For instance granite derived aggregate does not bind easily, but can benefit from the addition of organic material.
- On steeper slopes (up to 16°/30%) aggregate maybe used with anchor or additional waterbars incorporated in the construction. More closely spaced water bars can also help to improve the stability of the surface by preventing scouring. Particularly on these steeper slopes extra care and resources are required to ensure that new path surfaces are well bound and compacted. Time needs to be taken to secure, use and batter down an appropriate surface

- Stone pitching is generally used on slopes exceeding 15°/30%, where there is no viable alternative and an aggregate path will not provide a stable and durable surface due to the mobility of aggregate on the slope.

The path alignment is influenced by the land that the path crosses, as well as the eventual destination. In most cases, the general line will already be established and it may not be necessary, or appropriate, to change the line of an established route. Alternatively, slight alterations such as reducing the gradient by adding zigzags in small sections can make the difference between the surface technique succeeding or failing. The alignment should always fit in with the character of the surrounding landscape. There are some circumstances where major realignments are possible and desirable, but they require intensive work away from the realigned section to prevent people using the old line.

- Gradual curving lines, making use of natural features will enhance the aesthetic and natural appearance. Incorporating variations in width will avoid a formal appearance. This may be determined by physical factors or restrictions.
- Obstructions such as large boulders and bedrock may affect the alignment, and width. They can be used to define the path line, where the path turns, or as markers to aim for on long stretches of open ground.
- Steep gradients should be avoided, as the path will tend to erode quickly, particularly with high levels of use. Where they are inevitable an angled, or zigzag, line should be chosen to reduce the gradient.
- Particularly wet and peaty areas of ground should be avoided by keeping the path above the water table. An alternative alignment on drier or easily drained ground should be chosen wherever possible.
- Mountain bike speeds can be reduced by incorporating boulders and large cobbles in the surface (to make it uneven, but not uncomfortable to walk on) and avoiding large cross drains or water bars that force skids or diversions off-path.

Path use

To help determine the alignment, and achieve the balance between an aesthetically pleasing path, its ease of use, and durability, consideration must be given to the characteristics of the path use. For instance if the path is:

- regularly used in winter or wet conditions - more serious path damage occurs from pressure of use in wet conditions
- used more often in descent or ascent - downhill use causes quicker erosion, and more short cutting
- a traditional route or a newly created desire line - changing the alignment may make the path unattractive to use
- at the end of a long route - tired walkers are more prone to cut corners or go off a rough path surface
- frequently used by mountain bikes – drainage features and surfacing need to be constructed to avoid bikes going off path or causing unnecessary damage

An alignment designed to reduce the gradient on steep slopes should keep zigzags as short as possible, to discourage descending walkers from taking short-cuts straight down the slope. The choice between an aggregate and pitched surface on a slope may also be influenced by the characteristics and number of people using the path.

The popularity of paths in an area will also help to determine an appropriate width. This will generally be between 900mm for single track and up to 1500mm for walking two abreast. The path may need to be as wide as 2000mm to cope with heavy use and high numbers, or on corners or open slopes.

Development of a sustainable route

Great care must be taken to develop a sustainable route taking into account the impacts of the weather, particularly the increasing effect of mild, wet winters on path surfaces. This includes:

- cambering the path surface to shed water laterally
- raising the path surface above the surrounding ground
- ensuring that the path surfacing contains enough fine material to help bind it
- ensuring the surfacing is laid to sufficient thickness
- constructing sufficient anchor bars, cross drains and water bars
- adhering to maintenance requirements

Availability of materials

The materials for aggregate and pitched paths are normally sourced from the surrounding area. The large quantities required for pitching and long sections of aggregate path may therefore influence the choice of technique, width, and alignment. If the source is limited, it may be possible to realign the path to be closer to an available source, or to import material. Some designated sites may have restrictions on the import or transport of on-site materials and this may affect the techniques used.

It is important to match imported materials to the existing geology of the site, both for aesthetic and geochemical reasons (for example, schist should not be used on a path across a granite area).

Previous pathwork

Wherever previous work, to a good standard, has proved successful in achieving the objective of the pathwork, a similar style should be used to maintain continuity. In locations where traditional stalkers' paths are present the same style of construction is usually most appropriate.

Examples

The following gives some typical examples of problems experienced on upland paths, and the potential solutions:

Drainage Problem	Solution
Eroded surface vegetation with path starting to widen and deepen 	Aggregate path, at a suitable width to cope with expected use 
Path widening through a deep, wet peat bog 	Aggregate path floated on geotextiles 
Gullying and braiding on a steeper path gradient 	Aggregate path with anchor bars 
Deep eroded path on steep path gradient 	Stone pitching 

Main Problems to Avoid

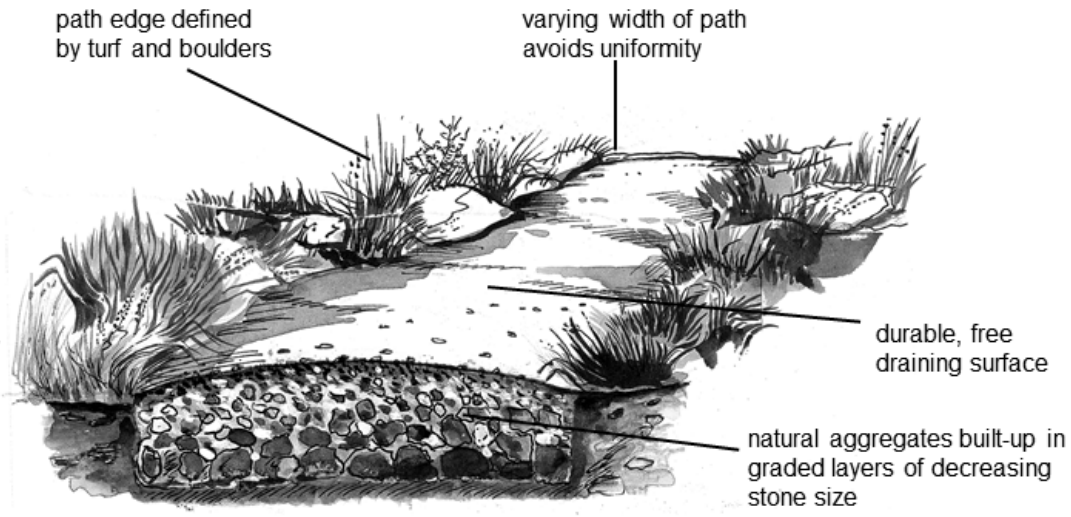
Upland path surfaces should be carefully chosen and used in appropriate situations. These should be identified during the path assessment. The most common problems that arise are:

- Wrong Position - people do not stick to the path line and take shortcuts.
- Wrong Style - the path is visually obtrusive, not fitting in with the surrounding landscape.
- Poor Construction - cannot cope with the pressure of use and water; people choose to go off the path.

The following technical sheets give guidance on some of the surfacing techniques used on upland paths. Each sheet has a section on materials as well as the technical detail required for construction.

3.1 Aggregate Path

The traditional hill path uses natural aggregate material found at, or near to, the path site. The resulting path is one that is not out of place in an upland environment, blending with the surrounding landscape without appearing too formal.



Function

The aggregate path provides a hard wearing, durable surface to withstand the expected pressure of use. It should be comfortable to use so that people will keep to it and not use the surrounding vegetation or take alternative routes. Path edge definition with turfs and boulders, and site restoration, will help to control this. The path should be free draining, with drainage features incorporated, to withstand the expected weather and water flow. Where mountain bikes can be reasonably expected to use the path it should avoid long smooth sections that allow riders to build up speed, and drainage features should not be built with the aim of blocking wheeled progress.

Bill of Quantities (example)

Using locally won aggregate re-construct existing path to a width varying between 600 -1000mm, and a minimum depth of 250mm. Grade base material and allow 50mm of graded surface material, with a binding of fine material. Compact to form draining cambers or cross-falls. Use excavated material with turfs and boulders to define and contain the path edge.

Construction

Components

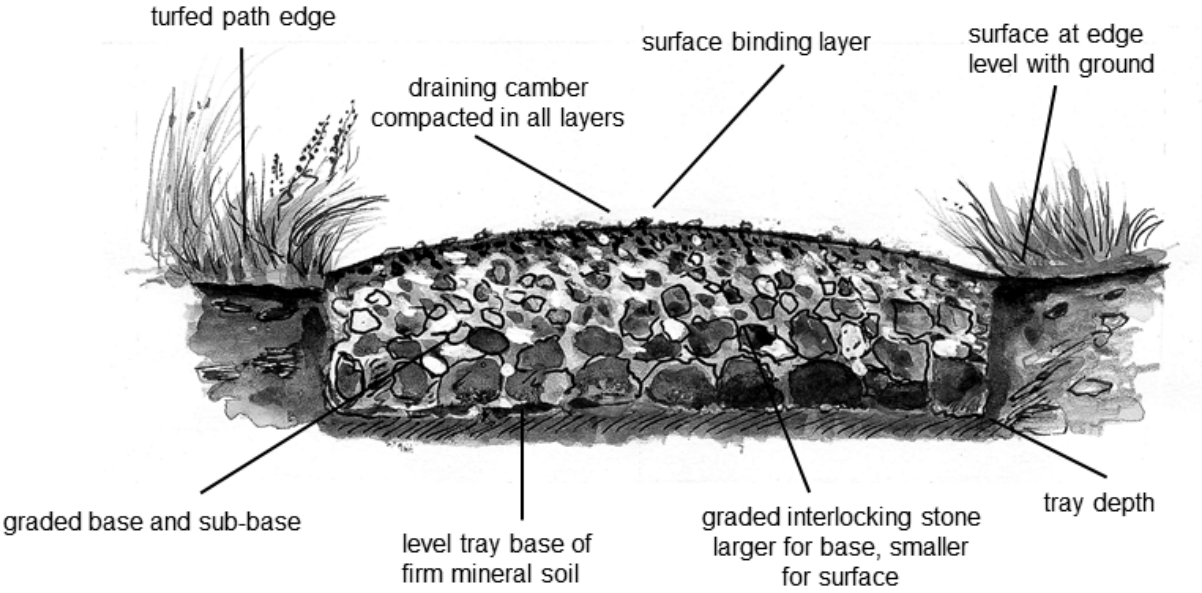
The aggregate path comprises layers, or grades, of angular, interlocking stone laid in a path tray.

- sub-base - the load bearing path foundation, required for deep construction over wet or rough ground
- base - provides strength to the construction and a solid base for the path walking surface
- surfacing - forms a durable, and firm surface over the path base
- binding - protects and prevents movement of loose surface material; provides a good walking surface

Each construction layer should contain a range of stone sizes graded on site. The cobble needs to be angular to ensure that the aggregate interlocks when compacted and forms a strong and solid layer without any gaps which may weaken the construction. Building a path in several layers of differing grades of aggregate will significantly increase the path durability, compared to using ungraded 'as dug' material in one, single layer.

The construction layers are compacted to form a free draining camber, or cross-fall, for surface water to run off either one or both path sides, depending on the site. Generally a traversing path built into the hillside will have a cross-fall, and a path on more open ground will have a camber.

Drainage features are incorporated in the path, as identified during the path survey, and the path edges defined, or contained, with turf and boulders.



Dimension Guidelines

- the width should be naturally varied along the length of construction; the average width will be determined by the path assessment - this may be as little as 600mm, or up to 2000mm
- the average tray depth should be no less than 250mm; the path tray base should be a solid, natural mineral soil foundation; where path tray excavation reaches 400mm and the ground is still soft, or wet, 'floating' the path could be considered

- the depth of construction, or path tray, will depend on the nature of the ground and depth of erosion; softer ground, and heavier use will require a deeper tray and a sub base
- the depth of surface, base and sub-base will depend on the tray depth, and material available; minimum depths should be:
    - 50mm of compacted surface material
    - 100mm of compacted base material
    - 150mm of sub-base material
- the surface layer should always be at least 50mm to prevent exposure of the rougher base course through pressure of use; combined base and sub-base depths can be varied, depending on material source and stone size available (see below)
- the surface camber or crossfall should be between 2° to 5° (5-10%), to effectively shed surface water
- the finished path surface should be slightly higher than the ground at the path edge to avoid water collecting here, especially once the path has settled.

Materials

On-site aggregate is won from the surrounding area and should be sourced during the path assessment (see also Path Survey). Material should not be used 'as dug' but graded for each path layer. Where feasible this may be done using purpose built screens with different size wire mesh.

The source available may dictate the grading but, as a rough guide, the largest size stone for each layer should be at least 50% of the layer depth. For minimum depths:

- sub-base stone would be between 75 - 150mm, graded down to approximately 10mm
- base stone would be between 50 - 100mm, graded down to 5mm, with some fine particles
- surface stone would be 25 - 50mm, graded down to fine particles
- binding stone should always be no more than 5mm graded down to very fine particles

Stone should be angular for good interlocking. Binding material should have a high mineral content and be free draining, i.e. with not too much peat or soil. In some places the binding layer may be clay.

Material sources include:

- borrow pits
- streams or rivers
- scree slopes or embankments
- stone from around the path, broken up to make smaller aggregate

Borrow Pits

Borrow pits are small quarries or excavations dug in the vicinity of the path to win materials. They are normally a good source for all grades of stone, but a trial dig will be needed to ascertain the suitability of the material.

Careful assessment of the surrounding landscape will give clues to borrow pit locations:

- mounds of glacial deposits, or moraines; normally vegetation covered but there could be suitable material in the mound
- evidence of exposed material, alongside streams, on steep banking or ridges

Borrow pits can be dug into the top or side of a mound. Avoid areas of deep peat, particularly in the bottom of dips or gullies. Peat layers are thinner on the side of mounds or embankments. Once the borrow pit is finished with, it should be filled in with excess stone and spoil, and carefully landscaped with turfs (see Introduction to Restoration Techniques).

Borrow pits are a potential health and safety hazard and excavation should be subject to risk assessment and control measures. For deep borrow pits, precautions should be taken to shore up the sides to avoid the danger of collapse.

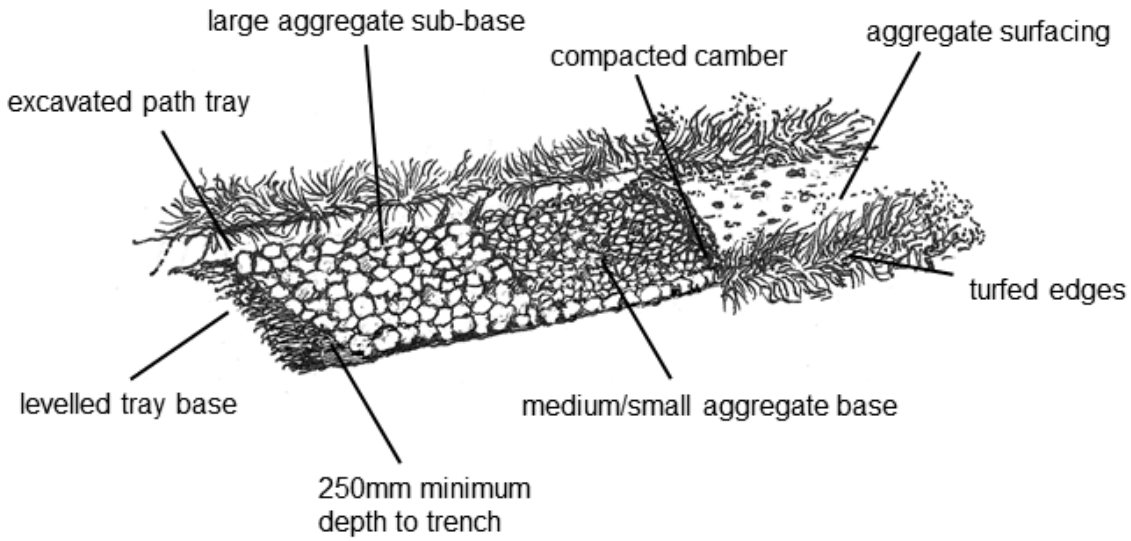
Rivers and streams can be a good source of material, particularly for surfacing, providing that the particles have not been strongly rounded. Turbulent water grades the stone naturally, depositing it as gravel under banks and on the outside of bends. Larger, angular stone from stream beds is suitable for base and sub-base material, but water smoothed and rounded stone will not interlock, so may need to be broken on site. Care must be taken mot to change the nature of the watercourse by removing large amounts of material from one place.

Method of Construction

Step 1

Form the path tray.

- excavate the tray to the variable width required, and the depth required or down to a solid base; infill eroded sections to form a level base
- if the path is badly eroded into a wide, deep gully, use excavated material to infill the gullied width and form the tray base and sides; the tray edges may need to be formed with good size turfs
- form the tray sides so they are capable of containing the aggregate layers; if the aggregate spreads out, with the pressure of use, the thinner surface will erode and expose the path base
- allow for incorporation of drainage features within the path construction
- set aside excavated material for path edges or site restoration



Step 2

Incorporate drainage features

- construct the selected drainage features at the positions required
- depending on the feature these may be constructed at any stage of laying the sub-base and base, but to achieve the required draining levels they should be completed before final compaction

Step 3

Lay the sub-base and base

- place the graded stone into the tray to the depth required for each layer; using larger graded stone for the bottom layer, and smaller graded stone for the top layer, below the surfacing
- ideally, for good compaction, the graded material should be in layers that are no more than twice the depth of the maximum stone size
- incorporate shaping for the camber or crossfall required in each layer; with the material slightly thicker in the centre of the path to form the camber, or on the uphill side to form the cross-fall
- compact each layer with a tamper or, if site access allows, a vibrating plate, maintaining the camber or crossfall
- if barrows are used along the path during the construction process a camber may be difficult to achieve; compacting the camber level throughout the sub-base and base construction will help. The surface and camber may need to be topped up after barrow use along the path
- the level of the top layer should allow for the surfacing and binding layer to be flush with path edge vegetation after some settling of the sub-base. If there is any doubt about the compaction, add more surfacing, as it will settle with use
- where mountain bike use can be reasonably expected, occasional boulders set almost flush with the finished surface can be incorporated into the sub-base and base to leave an irregular surface.

Step 4

Lay the surface and finish with binding material

- lay and compact the surface material to the depth required over the full path width; this should be at least 50mm, but more may be required depending how well compacted, and interlocking, the base is
- allow for some settling and loss of material into the base during compaction, and over time
- allow adequate depth at the path edges. If surfacing is too thin the material will protrude and lead to breaking up of the path, with use
- spread and carefully compact the binding material over the top of the surface, with the path edge surface flush with the ground level

Step 5

Edge finishing

- turf and landscape the path edges to ensure the path construction is contained, the line defined and the appearance "softened", using turf, boulders and spoil from path tray excavation

- use excess turf and spoil to re-instate any eroded or damaged ground, and for infilling any borrow pits (see Restoration Techniques)

Troubleshooting

Key points to watch out for:

- long, straight, even lengths - break up with curves, undulations, and variations in width
- surface layer too thin - quickly erodes exposing the path base, which is uncomfortable to use forcing people off the path
- single size large stone in the base - unstable path structure; surface layer disappears into gaps
- small stone used for the sub-base and base - needs more stone and more handling to reach the level required for surfacing
- use drainage features within the path construction to protect it from water erosion
- avoid long straight smooth stretches that encourage mountain bikes to gather speed – minor variations in path direction will reduce the sight-line of the surface and random boulder set flush with the surface will help to slow riders without making the surface uncomfortable for walkers.

Variations

Over wet, but firm ground the path construction can be raised above the water table as a causeway. The aggregate is laid directly onto the ground, using large boulders and turfs to contain it and reinforce the path edges (see Bank and Slope Stabilisation). Over very wet peat the causeway path can be floated.

Long stretches of newly constructed path require a large amount of aggregate and imported aggregate may be the only option if on-site material is not available or suitable. Approximately one tonne of aggregate will be required to cover three metres of 1000mm wide path, at 200mm depth. Wherever possible a local quarry of the same, or similar geology as the path site should be used. The aggregate should be graded, as required for the base and surface material, and have suitable binding properties.

Aggregate paths can be built using tracked excavators, where access allows. Path drains are constructed as part of this process. The technique requires sensitive machine work and hand finishing to produce a path that fits in with the upland environment. Machine work should only be carried out by a trained and competent operator with close supervision during the works.

Maintenance Tasks

With drainage features protecting it from water erosion, a well-constructed path should withstand the pressure of use. Depending on the path dynamics it will need some maintenance, but generally not as frequently as the drainage features.

- top up surfacing where it has settled, compacted or eroded, incorporating a camber or cross-fall as required
- repair path edges with turf where they have collapsed and aggregate has spread out of the path tray

ENVIRONMENTAL SENSITIVITIES

- obtain permissions prior to any material excavation on sites with environmental restrictions relating to habitat or historical designations
- when extracting material from streams or rivers take care not to change the natural water flow or impact on the ecology of the watercourse
- excess excavated spoil and turfs should be used to in-fill and landscape over borrow pits or any other areas that require restoration

HEALTH AND SAFETY HAZARDS

- during material excavation in borrow pits, wear a hard hat if the excavation is above chest height; shore up the sides if excavating any deeper than 1.5 metres, or if the pit is unstable
- if using plant such as power barrow or vibrating plate, make sure the operator is trained and the correct PPE is worn, i.e. steel toe capped boots and ear defenders

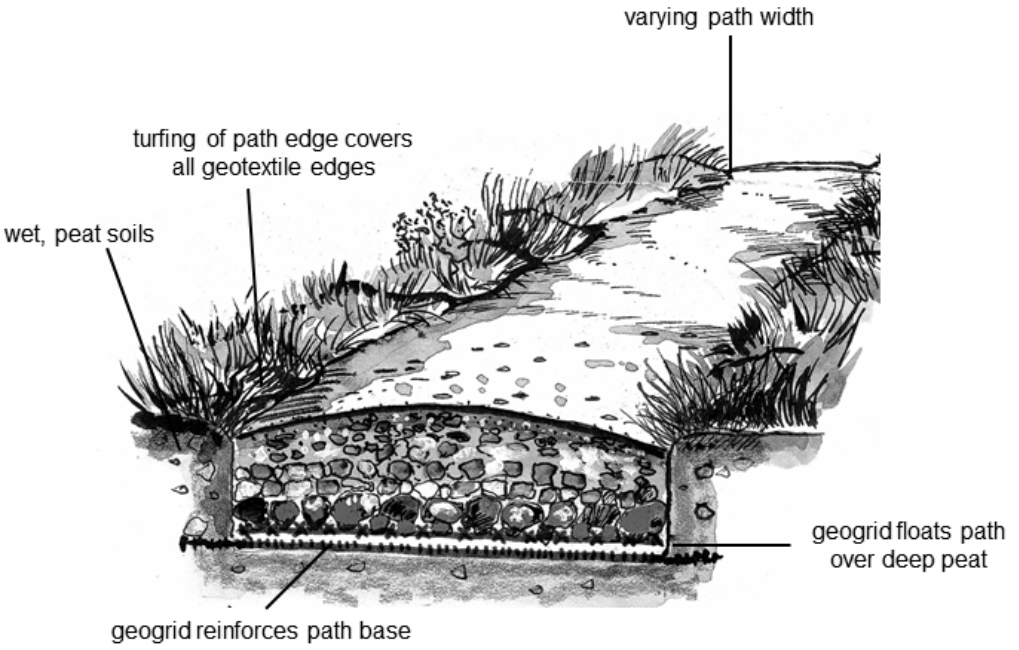
TAKE CARE

- do not under estimate the amount of material and labour required to build new sections of aggregate path
- ensure that the path gradient is not excessive, resulting in loss of surface material and erosion of path base

3.2 Reinforced surfacing: Aggregate Path on Peat

Path construction through peat can require deep excavation to reach a solid base. Where the peat depth exceeds 400mm this may be impractical. Either large quantities of material are required, or, without a firm base, the path structure will be unstable. If it is not possible to excavate to reach a solid base, it may be possible to re-route the path, or the path can be floated, either by using geotextiles or natural material such as sheep fleece.

The use of synthetic geotextiles to provide the foundation, and 'float' the path over deep peat has developed from road engineering and construction methods. Whilst geotextiles can create a path through deep peat path managers are increasingly considering other alternatives, including excavating deeper to find a suitable base, or using a natural material because geotextile does not tend to bind well with the aggregate, increasing the amount of aggregate washing off. This can relatively quickly result in the geotextiles being exposed, particularly on slopes and heavily used paths, with subsequent failure of that section of path. The choice of what to use is dependent on the location and logistics. Geotextile can be easier to get onto site, but the path is likely to need more maintenance.



Cross section of a path through deep peat using geo-textiles

Function

A semi-permeable membrane laid under the path separates the path material from the peat; it prevents aggregate loss and the path subsequently disappearing. Selection of appropriate material will provide a strong path base and if laid well results in a stable path. This technique reduces the amount of excavation and aggregate required compared to excavating to a hard base and infilling with stone, but needs to be checked frequently particularly if using geotextile, to ensure that it is not exposed, which as well as looking unsightly quickly decreases the effectiveness of the path.

Bill of Quantities (example)

Construct aggregate path on geotextile to a variable width, between 800 -1200mm. 'Terram' 2000 to be used on full length; 'Tensar' TS20 to be used on sections where the gradient exceeds 6°, on very soft ground and on benched crossfalls. Aggregate base and surface must be a minimum depth of 300mm. No geotextile to be left exposed above the path surface.

Construction

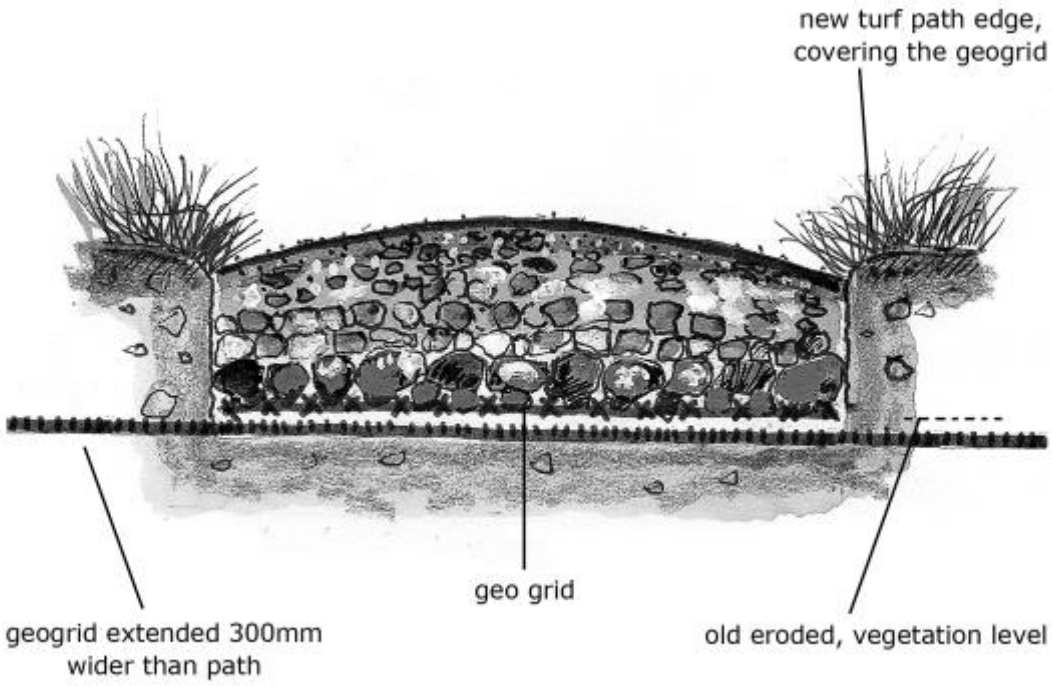
Two examples are given here, for geotextile and for sheep fleece.

Geotextile components

The components are as for an aggregate path, with one important addition - the path tray is lined with geotextile. Turf edging may be required to prevent geotextile exposure at the path edge.

Dimension guidelines

These are the same as an aggregate path with the exception of the path tray depth. This should be 300 - 400mm. The location and pressure of use will determine the need for a stronger path base to the maximum depth - for example, if the path will be used by ponies, or on softer ground the greater depth helps stop the path bouncing, leading to it cracking and letting the water in.



Cross section of a path through very soft ground

A deep path tray should not be excavated where the peat is wet and has minimal vegetation cover. Either a shallow tray can be carefully dug, or, preferably, the tray depth formed with good size turfs, to provide a stable path edge, and the path built up over the eroded vegetation surface, rather than dug down into it.

If the peat has no structure or is very wet the formed tray should be increased to 300mm wider than the required path width, on each side. This allows for a greater geotextile width, which will give added strength to the path base, and allow better water drainage from the path base. Good size turfs will be required to place over the excess width of geotextile, and to create the tray edges.

Materials

The aggregate material is the same as for an aggregate path.

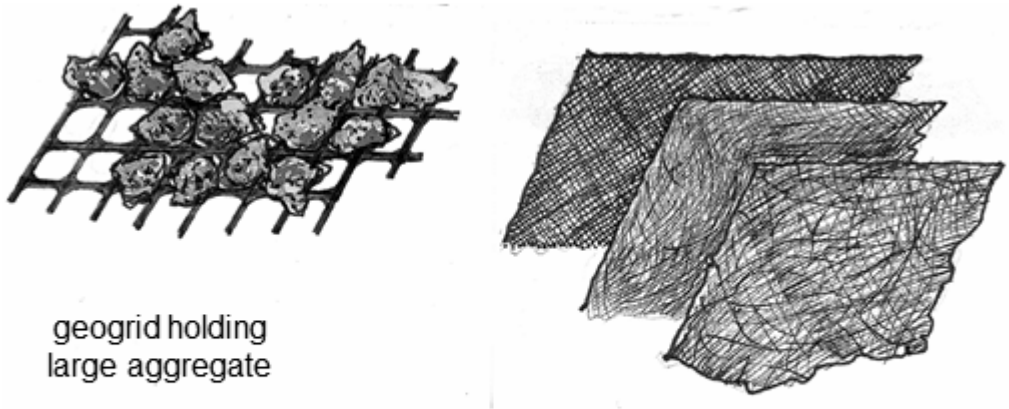
There is a variety of geotextiles on the market, mainly geared towards road building or engineered landscaping. Two geotextiles are commonly used under aggregate paths - mattings and geogrids.

Matting

The matting, of tightly woven synthetic fibres, is the separation material used to 'float' the path. The main properties are:

- separates the path material from underlying peat, or wet clay
- semi-permeable allowing water to seep through and drain away from the path structure
- spreads the load across the path width and length and prevents subsidence or sinking into the peat.

Mattings come in several grades, the highest provide greater load bearing strength, which will be required over very deep or wet peat. Lower grades are suitable where the peat layer is thin or has a higher mineral content. The one most widely used in Scotland is "Terram" 2000.



geogrid holding large aggregate

geotextile matting of different grades

Geogrid

The geogrid is a thick plastic mesh, which is used in addition to matting where extra support is required, particularly on very soft ground. It also helps to hold the aggregate in position.

The main properties are:

- provides a strong path foundation
- spreads the weight of path use over the full path length and width
- grid structure prevents path material from moving along, or across the matting and migrating from the path sides into the peat

Geogrids may be used with lower grade matting for additional strength over deep, wet peat.

They are particularly useful to prevent movement of the base aggregate where there is a cross-slope or a downhill gradient. The one predominantly used in Scotland is 'Tensar' TS20.

Geotextiles can be obtained from most industrial suppliers. They are normally supplied in rolls, of variable width and length. Whole rolls of matting may be cut, off-site, to a suitable width using a chain saw or hack saw. The lengths required can be cut on-site using a sharp knife or heavy duty scissors.

Method of Construction

Step 1

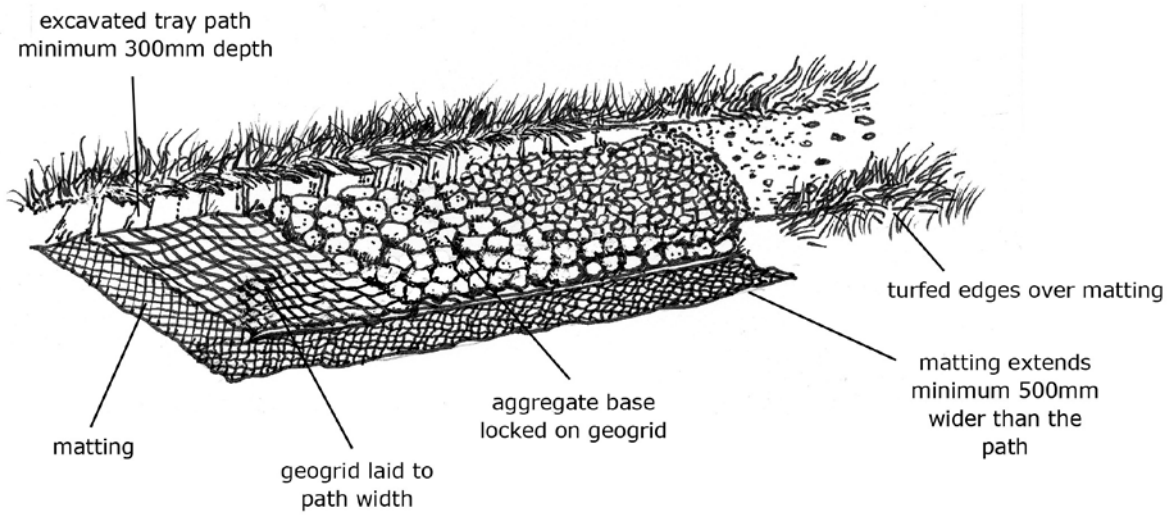
Form the path tray

- excavate the tray as for an aggregate path, with the exception that the depth does not need to reach a solid base
- form a base that is level and even for laying the geotextile
- remove any protruding bog wood, stone or boulders to prevent distortion or puncturing of the matting
- if the peat is very wet, or has no vegetative content, form the tray depth and sides with good size turfs, after laying matting

Step 2

Lay the geotextile matting

- line the path tray with the geotextile matting, cutting it to the required width allowing for up to one metre on either side of the path line
- to take up curves and bends in the path either fold the matting or cut it to suitable lengths, allowing an overlap of at least 300mm
- secure folds or overlaps with larger aggregate stone to prevent them protruding up through the path material
- if a tray is not being dug, a raised tray should be formed with large turfs or boulders along the edges with the matting laid within the tray
- to prevent aggregate migration into the peat, or peat into the path structure, the matting should be folded up the tray sides and the edges secured below the path surface with turfs or boulders. Alternatively the matting can be carefully pushed back down into the peat at a 45° angle to the surface with a spade.



Step 3

Lay the geogrid

- where required, lay the geogrid over the matting, cut to the required path width, and for bends in the path alignment; as with the matting joins should overlap by 300mm
- where there is an excess on either side, due to the variable path width, it should be dug into the tray edges, or, if the matting is folded up, cut to the exact size
- the geogrid should not curve up the tray sides; it is important that no geogrid edges are left exposed after the surface has been laid and compacted

Step 4

Incorporate drainage features

- construct drainage features as for an aggregate path, with the exception that geotextile should be laid to continue into construction trenches
- for ease of laying, and to provide additional strength, cut the geotextile to allow a full overlap across the drainage trench width

Step 5

Construct the aggregate path.

- take care to prevent any puncturing of the matting when laying and compacting the lower layer of base, or sub-base material
- care is also required if moving aggregate along the prepared path tray with a power barrow; minimise the number of movements as far as possible

Step 6

Edge finishing

- make sure that any turfs already laid are effective in covering the geotextile and containing the aggregate
- the path edges may require further turfing and landscaping, to define the line and ‘soften’ the appearance

- use excess turf and spoil from the tray excavation to re-instate any eroded or damaged ground, and for in-filling any borrow pits (see Introduction to Restoration Techniques)

Alternative Construction Using Sheep Fleece

The use of sheep fleeces to provide the foundation and 'float' a path over deep peat is an environmental alternative to geotextiles.

To minimise levels of contaminants present, the wool should be sourced as locally as possible and is used in its raw state with no treatments, cleaning or further processing, from sheep managed in accordance with British Wool Board standards and complying with licensed animal health product usage requirements. It is expected that the use of wool will have a performance and longevity at least that of geotextile membrane, and wool is considered an appropriate and sustainable alternative when used in this way.

Construction

Components

The components are as for an aggregate path, except the path tray is lined with wool. Turf edging may be required to prevent wool exposure at the path edge.

Dimension guidelines

Dimensions are as for an aggregate path with the exception that the path tray should be 450mm deep (or about the size of the rolled up fleeces in the path tray).

If the peat has no structure or is very wet the formed tray should be increased to 300mm wider than the required path width, on each side. This allows for a greater width of fleece, which will give added strength to the path base, and allow better water drainage from the path base. Good size turfs will be required to place over the excess width of fleece, and to create the tray edges.

Materials

Any type of fleece can be used but those without a ready market and preferably of a coarse variety produced locally are the most sustainable. These can be provided rolled or as they come off the sheep and do not need any form of treatment or further manufacture.

Method of Construction

Step 1

Form the path tray

- excavate the tray as for an aggregate path, with the exception that the depth does not need to reach a solid base
- form a base that is level and even for laying the fleeces
- if the peat is very wet, or has no vegetative content, form the tray depth and sides with good size turfs, after laying fleeces on top of the current surface

Step 2

Lay the fleeces

- pack the path tray with the balls of rolled up fleece into the tray butting each ball as tightly as possible against the next. This will fill the tray, but they will compact under the weight of the aggregate

Step 3

Incorporate drainage features

- construct drainage features as for an aggregate path, with the exception that the fleeces should be laid to continue into drainage trenches under the stones used in forming the drain

Step 4

Construct the aggregate path

- take care to prevent any puncturing of the fleece mat when laying and compacting the lower layer of base, or sub-base material
- care is also required if moving aggregate along the prepared path tray with a power barrow; minimise the number of movements as far as possible

Step 5

Edge finishing

- make sure that any turfs already laid are effective in covering the wool and containing the aggregate
- the path edges may require further turfing and landscaping, to define the line and ‘soften’ the appearance
- use excess turf and spoil from the tray excavation to re-instate any eroded or damaged ground, and for in-filling any borrow pits if used

Troubleshooting

Key points to watch out for:

- avoid the possibility of material becoming exposed - keep path construction deep enough to cover it and to avoid erosion
- ensure matting, or geogrid, is not sticking up after surface compaction - use good size turf effectively at path edges
- incorporate drainage features into the path
- avoid long straight smooth stretches that allow or encourage mountain bikes to gather speed – minor variations in path direction will reduce the sight-line of the surface and random boulders set flush with the surface will help to slow riders without making the surface uncomfortable for walkers.

Variations

Other methods have traditionally been used to float paths over deep peat, particularly heather, tree brashings, or wooden stakes. These rely on the preservative nature of the peat and, depending on its acidic balance, may break down quickly.

Where it is not feasible to excavate a path tray a 'causeway' may be constructed with a geotextile base. The path sides are contained by large boulders with spoil and turfs, which must be placed to provide a solid edge. If the path is traversing a slope the uphill slope may provide an edge. A double course of boulders or very large turfs will be required to take a causeway path through a particularly wet area.

Maintenance Tasks

With appropriate and sensitive design, a well-constructed path should withstand the pressure of use, and drainage features protect it from erosion. It will need some maintenance over the years, as well as regular monitoring to ensure that geotextile, or alternative, is not exposed:

- if geotextile is exposed, dig it securely back under the path surface, or path edges, and re-surface over the top
- top up surfacing where it has settled, compacted or eroded, incorporating a camber or cross-fall as required
- repair path edges with turf where they have collapsed or been trampled and eroded

ENVIRONMENTAL SENSITIVITIES

- make sure all laid geotextile is well covered and will not be exposed by path surface or edge erosion
- clean up and remove any off-cuts of geotextile that may be left on site

HEALTH AND SAFETY HAZARDS

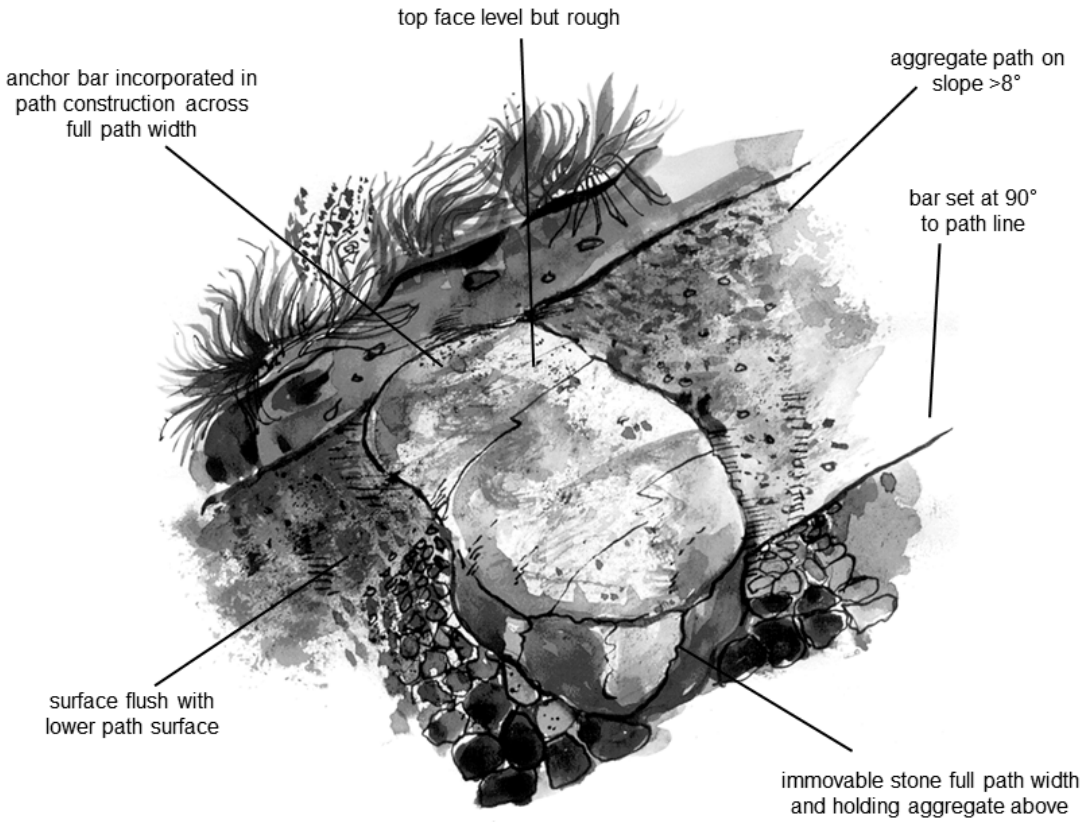
- take care when cutting geotextiles, use sharp tools - blunt ones lead to excessive force being used and potential accidents
- if using chain saws, or similar, to cut rolls of matting, make sure the correct PPE is worn and the operator is trained

TAKE CARE

- do not under estimate the amount, and type of geotextile required
- ensure that the path gradient, or crossfall is not too steep, usually under 15°, to minimise the risk of erosion and exposure of geotextile

3.3 Anchor Bars: Aggregate Paths on Slopes

Where an aggregate path is constructed on a slope greater than 8° (15%), there is the risk of the material migrating down the slope, particularly if the binding properties are not good, or there is a high level of path use. To help prevent this occurring stone anchor bars can be incorporated into the path structure. However, not all paths on gradients require anchor bars. They may not be necessary if the surface and base material binds well, or if the path is well protected by drainage features, and the level of use is low. A range of options should be considered for paths on gradients including ensuring that there are plenty of waterbars and using short sections of pitching. The selection of techniques needs to be based on a judgement of how the path will be used and maintained bearing in mind that long flights of pitching at relatively low gradients do not get used and that aggregate is not stable on steeper slopes. There is also a need to consider the potential for mountain bikes bouncing on the aggregate off the anchor step and actually speeding up deterioration.



Function

Anchor bars form solid, immovable structures within the path construction and, depending on their spacing, hold the aggregate on the slope above. The anchor bar may be used with water bar construction, as the stabilising stone below the shedding bar stones. Anchor bars can be added to existing paths that are showing signs of movement.

Bill of Quantities (example)

Re-construct existing path with aggregate to a variable width, between 600-1000mm. Use large block stone to construct anchor bars every 10m, across the full path width, and flush with the path surface on the upper edge.

Positioning of Anchor Bars

Anchor bars will generally be used on paths with a gradient between 8° to 16° (15-30%), but if the surface material does not bind well anchor bars can be useful on slopes as low as 5° (10%). On mobile slopes extra effort should be made to improve the binding properties of surfacing and to compact firmly, as well as carefully, considering the spacing of anchor bars. Depending on the gradient and surface material anchor bars should be positioned at intervals of between 3 and 20 metres.

The following table gives a general guide to spacing.

Gradient of Path			
Gradient	low 8-10°	medium 10-12°	high 12-16°
Spacing	10-15m	5-10m	3-5m

Construction

Components

The anchor bar is an informal structure, comprising one or two large block stones, set across the path line. The block stone is sunk into the path with the top face just visible as a part of the path surface and should not normally stick up like a step. Depending on the gradient and the size of stone available it may be necessary to have a double row, or two courses, of stone.

Dimension Guidelines

- the bar should span the full width of the path line; this may require the use of more than one stone
- the bar should be positioned at approximately 90° to the path line
- stone should be set in approximately 200mm deeper than the path construction depth, so that the bar is an immovable, "independent" structure, which will withstand the weight of aggregate and the pressure of use
- the top surface, or tread, of the stone should be flush with the path surface; the lower edge should not normally form a step up from the surface below
- on steeper paths it may be necessary to have a slight step, to avoid the tread being at an uncomfortable angle to walk on
- a double course of stone may be used to provide the height gain required without creating too high and unnatural a step

Materials

The local stone selected should be in its natural form, preferably weathered.

- the stone should be large enough to hold the compacted aggregate above and the pressure of path use - if it can be moved and lifted easily it will be too small

- the stone should be at least the width of the constructed path, if two stones are used each should be at least half the path width; it is better for stone to extend outside the path edges than be too narrow
- the stone should be deep enough to bury into the ground by approximately 200mm below the path base
- it should have a level, but rough top face for the tread; it should have no large protrusions, but not be so smooth that people will slip with gravel on the surface

Method of Construction

Anchor bars are built into the excavated path tray before the aggregate is laid.

Step 1

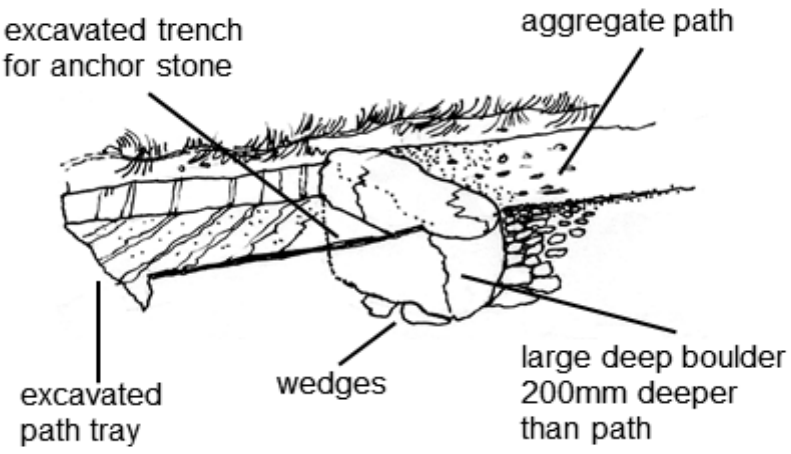
Excavate a trench

- dig a trench approximately 200mm deep across the full width of the path tray
- the trench should be wide enough to allow for the width of the bar stone and the depth required for bar stone tread to be flush with the path surface

Step 2

Position the anchor bar stone or stones

- set the anchor bar stone so that the surface will be flush with the compacted path surface, and not create a step, unless the path is steep
- if a second stone is necessary they should be tightly butted together to form a solid bar across the path and provide an even tread surface
- wedge and pack any gaps with smaller stone, and backfill the trench firmly, to form an immovable structure



Step 3

Construct the aggregate path.

- take care not to dislodge the anchor bar when compacting the path material above and below the bar
- make sure that the surface layer is compacted to be flush with the top and bottom edges of the bar stone or stones

Troubleshooting

Key points to watch out for:

- use large stone, if possible one to span the full path width - too small a stone will become loose with the weight and pressure of the path
- keep the bar flush with the uphill path surface - avoid steps up from the downhill surface
- avoid using anchor bars on too steep and mobile a gradient – short sections of pitching and aggregate may be a better solution

Variations

If large block stone is not available the anchor bar may be formed by constructing short sections of pitching. This will also be suitable on steeper gradients where double rows of large block stone, or longer sections of pitching, may be required to "take up" the gradient without creating high and formal steps.

An anchor bar can be built 2 or 3m down a path from a water feature, such as a waterbar. The anchor bar will hold the surfacing on the ramp below the waterbar, creating a more durable walking surface and preventing erosion behind the face stones.

A further variation on steeper slopes is to build anchor bars with a step. This reduces the gradient of the aggregate between the anchor bars, but will require more maintenance and is likely to be less successful on very mobile slopes.

Maintenance Tasks

Anchor bars require maintenance on a regular basis:

- check the stability of the stonework - re-pack where there is movement or any visible gaps
- re-pack aggregate surfacing above and below the bar where compaction or erosion may have taken place
- if anchor bars are not preventing downhill movement of aggregate, some re-alignment of the path may be required using short sections of pitching and aggregate

Often anchor bars are added to an existing aggregate path on a slope, at time of maintenance, to solve problems of surface movement.

ENVIRONMENTAL SENSITIVITIES

- use natural looking weathered stone, that will blend in with the surrounding landscape
- turf over the edges of the anchor bar where they extend outside the path edge

HEALTH AND SAFETY HAZARDS

- use safe lifting techniques when moving or positioning stone for the anchor bar

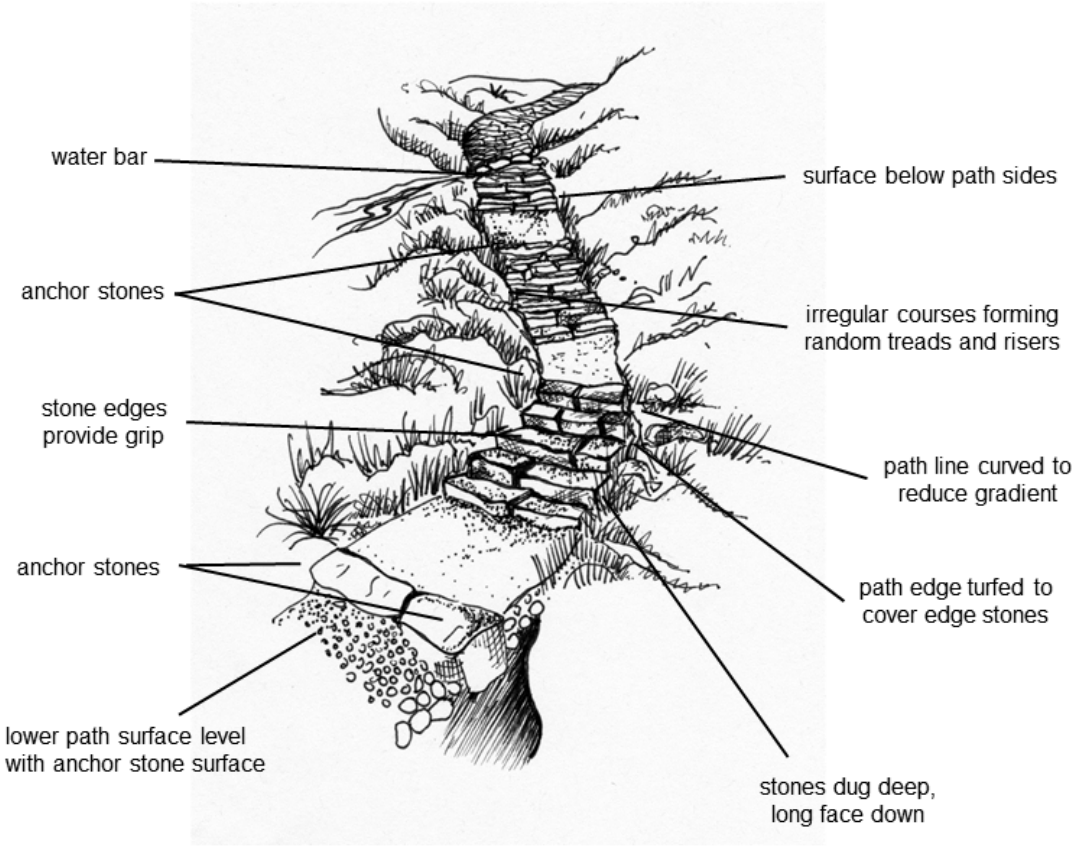
TAKE CARE

- the path's dynamics must be carefully considered before deciding to use anchor bars to stabilise it, in particular consider the gradient of the path, the mobility of path material, and the levels of use
- particularly on well used steeper paths where the surfacing does not bind well, migration of material is likely to create 'steps' below anchor bars as the surfacing migrates downhill. This encourages people to leave the path to avoid the step, creating braids and can increase the chances of erosion by bikes dropping off the step
- help avoid braiding by ensuring that anchor bars extend past the edges of the path or use blockers/vegetation mounds

3.4 Stone Pitching

Introduction

Stone pitching evolved from the smooth cobbled surface of ancient tracks and roads, into the traditional rougher cobbling of stalkers paths, suitable in the upland environment. Further adaptation developed the technique for recreational use, and to merge with the landscape. It has gone through many years of experimentation, such as using larger boulders placed with a horizontal surface rather than angled down the slope, and this is ongoing. Stone pitching should only be used where there is no viable alternative because it is uncomfortable to walk on, particularly in descent. On steep slopes efforts should be made to align the path so that only small sections of pitching are required interspersed with an aggregate path.



Function

Stone pitching provides a hard-wearing surface for steeper paths. It is used where aggregate is impractical or has failed due to the gradient and erosive pressure of feet and water. The pitched surface can withstand these pressures, and, with sensitive construction can blend aesthetically with the surrounding landscape.

The best sites for pitched paths are where they merge naturally with the rocky appearance of the landscape and provide an easier route than the surrounding ground. To enhance the aesthetic appearance they should avoid steep straight lines, and incorporate curves and variations in width, making use of natural features wherever possible.

A pitched path is not always easy to use. It does not absorb impact, and may be steep and rough. If the surrounding ground is easier, or more comfortable to walk or ride on users will cause further erosion by short-cutting or walking on landscaped edges. An alternative of short vegetation will invariably be used if it is available. A comfortable walking surface is therefore essential for both ascent and descent, in all conditions, which means that treads need to be at a low angle to avoid becoming slippery when wet or icy. It is also very important to ensure that site restoration and landscaping encourages people to stay on the path. To encourage success of the work path lines should minimise the amount of pitching required. This may require altering the path line and managing zigzags to reduce the gradient.

Pitching may act as a hazard to bikes or be treated as a 'thrill feature' if poorly executed or badly placed – low gradient pitching should therefore be avoided.

Bill of Quantities (example)

Use local, weathered stone to construct a pitched path, average 1.2m wide. Irregular, random treads must be comfortable to use, with risers of no more than 150mm. The construction must be solid with stones fitting tightly, well packed, with overlapping joins. Use excavated turfs, spoil and boulders to define and contain the path edge.

Construction

After choosing an alignment that fits the landscape and requires the minimum amount of pitching, the main considerations are:

- provide a good surface for users, particularly on descent; allowing walkers to place a whole foot on a single tread wherever possible
- reduce the gradient with angled lines across the slope and intersperse with aggregate path wherever possible
- produce a structure that is solid and immovable, and will withstand the most extreme pressures of use and water flow
- incorporate drainage features for a path surface that will not be under-mined, will be long-lasting and require the minimum amount of maintenance
- avoid having an excessively large drop-off which can cause bikes to 'ground' the chain ring on the descent
- ensure that the bottom step is flush with the path as this stone will become higher than the aggregate below due to the compaction and migration of the aggregate
- pitching changes the rhythm of walkers' strides and a few lower steps to lead into it helps to encourage use, rather than an abrupt big first step
- landscape carefully to further encourage walkers to stay on the path

Components

Stone pitching comprises various stone shapes and sizes, used in rough courses across the slope, to provide a series of irregular and random low steps and footholds, with a cobbled or bouldery appearance.

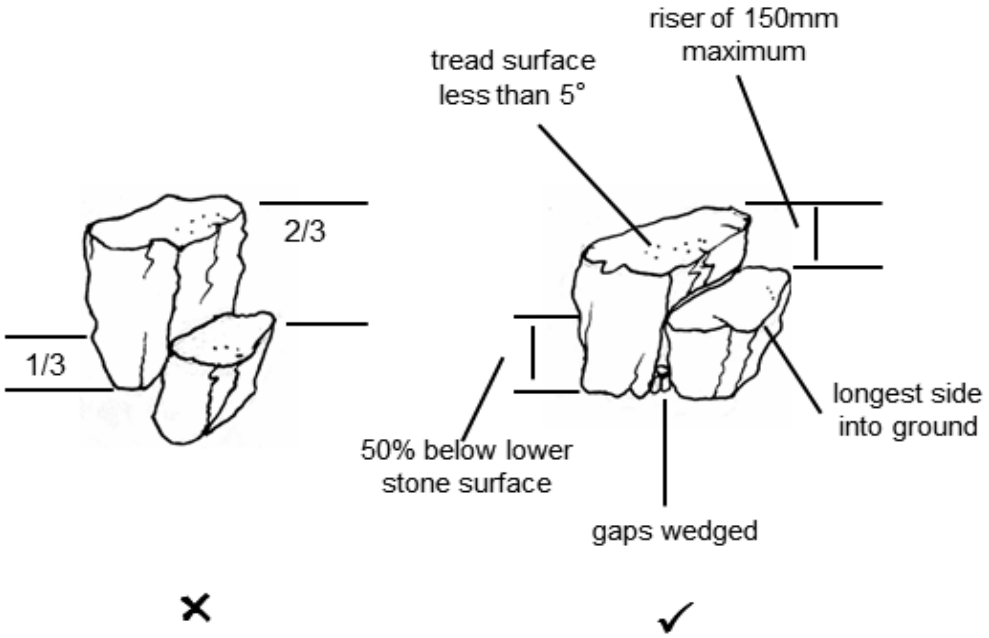
The largest block stones are used as anchor stones at the bottom of pitched lengths, and at regular intervals throughout the length to support the stonework above. Large stones are also used at the path edge for structural stability.

Drainage features are incorporated at regular intervals. For path surface water these will be water bars, although cross drains can also be used. It is good practice to protect the path surface below the pitching with a drain close to the bottom. The top of the pitched length should be similarly protected, but this does not need to be directly at the top of the 'flight'. The path edges are contained, defined, and softened with turf, spoil and boulders (see Restoration Techniques).

Dimension guidelines

There are varying styles of pitching, attributed predominantly to the stone type available. The basic principles for construction remain the same.

- the overall path gradient should be kept as constant as possible by incorporating curves on short steep sections, and adjusting the pitched depth and surface level
- the path surface should be flush with the adjacent ground, with the vegetation or turf higher than the pitching. It may be necessary to raise the path edge by turfing and landscaping. Higher turf edges help the path to blend in fit better in the landscape as well as encouraging users to stay on the path.
- anchor stones at the start of pitched lengths should have the tread flush with the lower path surface; if a step down is created, the surface below will erode, the step will become too high, and the anchor stones will be under-mined; this will cause the pitching above to fail
- pitching must not start anywhere other than at a change of gradient. If the path below the bottom anchor bar is too steep, then it will quickly erode away creating a step
- path stone should be pitched with at least half the stone depth below the surface of the lower stone, and the longest side into the ground; the deeper the pitched depth the more solid the construction
- the resulting upstand, or riser should ideally be no more than 150mm; if it exceeds 200mm it can be difficult to use



- adjoining stones should form a rough course across the path with variable upstands to avoid a formal step appearance
- stone should be pitched vertically, with the tread surface more or less horizontal; downhill tread angles should not exceed 5°
- it is important that the overall surface is not a sloping ramp without good footholds

Materials

The local stone selected should be in its natural form, and preferably weathered (see Environmental Impact). The quantity of stone required for pitching is high - approximately 1 tonne for $2m^2$, depending on the density and depth. If not enough is available in the vicinity of the path it may be necessary to import material to site by helicopter.

To avoid uniform steps a variety of irregular and random stone size should be selected. Stone varies considerably from thin slatey schists, and large rounded granite, to chunky sandstone blocks. Depending on what is available the following points should be noted:

- each stone should be deep enough to provide the pitched depth required - a general guide is no less than 300mm; anchor and edge stones will be deeper
- tread faces should provide a "grippy" surface; not so rough that protrusions may be tripped over, nor smooth and slippery

The best sources for stone are glacial surface deposits, scree slopes or rock falls on the surrounding open hill. Stream beds are another source but tend to provide rounded smooth stone which has to be used with skill.

Method of Construction

Step 1

Form a path tray

- excavate a path tray along the selected path alignment, to the required variable width
- the depth of the tray should allow for the depth of the stone available, and for a finished path level below the surrounding vegetation
- where the path line is severely eroded, to a variable width and depth, it may require realignment, infilling or narrowing, without any excavation; this can be achieved with careful use of spoil, turf and boulders

Step 2

Set the pitched stone

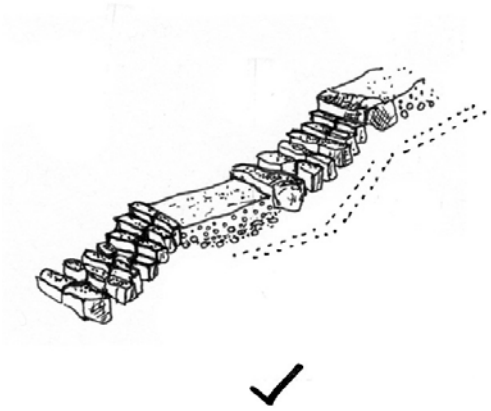
Depending on the number of workers and the length of the path, pitching may be split into sections. If these are pitched simultaneously pay close attention to the overall gradient. To ensure that the path climbs at a steady rate, and avoid joining either too low or high, the next set of anchor stones should be visible to judge the height gain required.

Always start at the bottom of a section and work uphill.

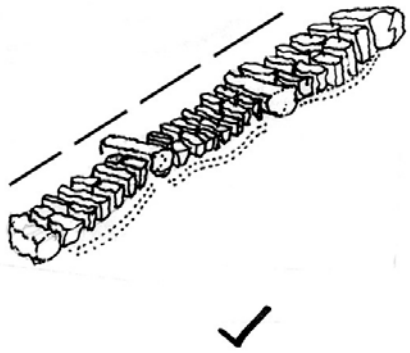
- the first line of stone will be large anchor stones set flush with the lower path surface; it is essential that they are dug in deep and are immovable; they may also form the lower side wall for a cross drain at the base of the pitched length
- progressing up the slope pitch the stone into the tray in rough courses across the slope, to achieve the required random footholds and risers

- use large, deep stone at the path edges to form a strong edge
- butt adjoining stones tightly together, on all side faces, maintaining good footholds
- wedge all gaps firmly, before subsequent courses are pitched, so that all path stones are solid and immovable
- overlap joins on adjoining courses for a sound structure
- pack remaining gaps with smaller stone and gravel; this is essential to prevent the ingress of water under the pitching, which may cause loosening and wash out, or break up with water freeze and expansion in winter
- incorporate waterbars or cross drains at intervals required, with the bar, or side wall, stones tied in with path stone to maintain footholds

Uneven gradient



Even gradient over changing terrain



Step 3

Edge finishing

- use turf, boulders and spoil from path tray excavation to landscape path edges, ensuring that edge stone side faces are covered, the line is defined, and the appearance "softened"
- where necessary the edge finishing should raise the path sides to contain path use, particularly to avoid short cutting at corners
- use excess turf and spoil to re-instate eroded or damaged ground (see Introduction to Restoration Techniques).

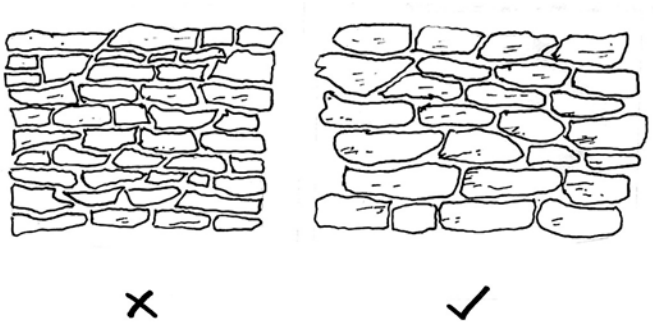
Troubleshooting

Key points to watch:

- firmly pack all stonework - this is time consuming but if neglected or not done thoroughly it will result in water damage and stonework collapse
- make sure joins overlap for a solid, stable structure
- provide secure footing - a rough uncomfortable surface will not be used
- avoid regular courses of stone that create a formal step
- match the pitching gradient to the path alignment - avoid steep sections by re-aligning and incorporating curves
- ensure that the bottom step is flush, or nearly flush with the path leading up to it, ideally the first stone should have a big, deep tread to lead walkers on to the pitching

Edges too straight and too many small stones

Better edge - bigger stone



Variations

Stone pitched paths throughout Scotland reflect regional variations, the main influence being the geology.

The type and size of stone results in styles such as:

- Granite (boulder pitching)- large rounded stone - pitching with treads bigger than the average foot size and larger rises
- Schist - thin slate like stone - pitching with small treads of several stones, but dug in deep
- Sandstone - smaller blocky stone - pitching using several stone courses to form a "grippy" foothold

The incorporation of grass seed or small strips of turf, in the packing between stones is suitable on some sites. The vegetation softens the visual impact of the hard pitched path. It can also help to stabilise pitching that may be susceptible to loosening.

Maintenance Tasks

Stone-pitching should require minimal maintenance, other than drainage features and edge work. The main tasks are:

- pack and re-set stonework where there is any movement or visible gaps
- turf the edges where trampling and erosion has occurred
- block any shortcuts that develop

ENVIRONMENTAL SENSITIVITIES

- take care to avoid creating trample lines when collecting large quantities of stone from within reach of the path - vary the route to spread the pressure
- carefully turf over scars left from removed stone, particularly if within sight of the path
- dispose of excess stone sensitively, or use to create landscaped mounds or to in-fill borrow pits

HEALTH AND SAFETY HAZARDS

- take care to prevent stone falling onto path users or anyone working below when off-loading collected stone, or moving it from a stockpile
- the work site is often steep, rough and restricted for space - provide alternative routes for the public whenever possible

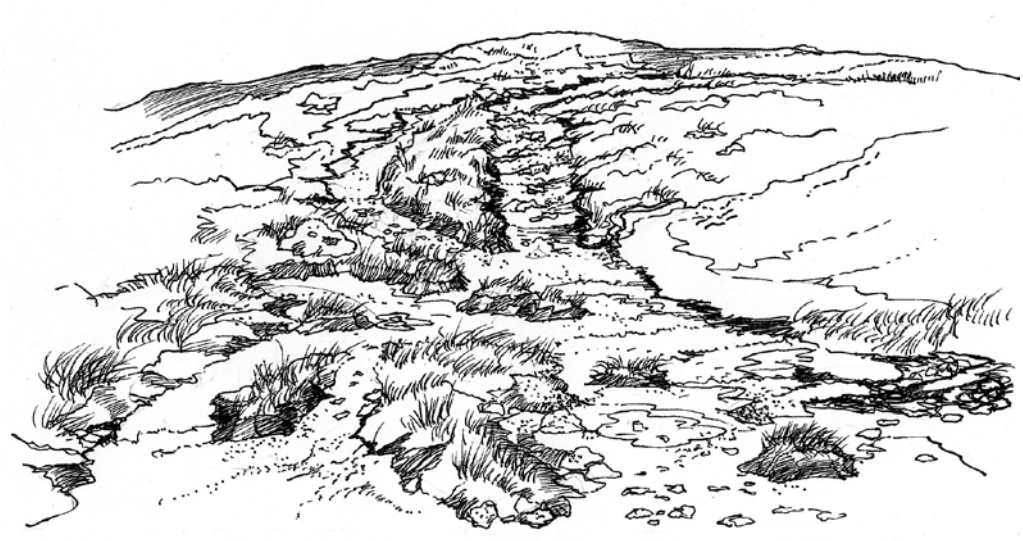
TAKE CARE

- stone pitching should only be used where there is no alternative available - it is notoriously uncomfortable to walk on for descending walkers
- incorporate path drainage - surface water, or ice, can make the surface very slippery, assess the site for alternative routes or better alignment
- if the pitching is lower than the surrounding vegetation, water and snow, will collect on the path. Conversely, pitching which is high and proud does not blend in so well and is more likely to be avoided by walkers

4. Upland Path Site Restoration

4.0 Introduction to Restoration Techniques

The overall aim of upland pathwork is to reduce and reverse the environmental impact of erosion. Site restoration is a key element, with the objective to improve and safeguard the aesthetic appeal of the upland landscape. Effective revegetation and natural landscaping should make the ground look as if it has never been touched.



Before - wide erosion, bad braiding, eroding slope, edge collapse and breakup.

After - alignment defined, use contained, slope stabilised, vegetation restored.

Restoration is required on:

- Path edges
- Alternative paths, or desire lines
- Unstable slopes
- Eroded areas

Undertaking this work early, as the first signs of erosion appear is usually both cost effective and results in a more subtle and natural path line. Often if surface water can be shed with water bars and braids blocked then the path can be maintained in its current condition as the processes of erosion have been slowed down.

It is important that the revegetation and landscaping of the area around a new path line uses appropriate techniques. These should define the path and channel use onto it. The highest quality pathwork, on a good alignment, is worthless if an eroding or easier line is seen as a preferable route that encourages users to veer off the managed path. This can result in numerous lines and shortcuts developing into visual scars and detract from the experience of walking in the upland landscape.

The function of the techniques used is to:

- Define and stabilise a new path alignment
- Channel and contain use onto restored or newly defined paths
- Stabilise eroded gullies, embankments and slopes
- Encourage re-vegetation of eroded areas, including where path materials have been taken from

Materials

Site restoration improves the chances of natural revegetation, providing the basis of a better growing environment to encourage re-colonisation by native species. This is achieved by using naturally occurring byproducts of the pathwork including stone, turf and spoil gathered from the surrounding area. It is important that permission is obtained prior to moving, or using these materials.

On some sites there will be little natural material available, whether due to site designation or altitude, climate or erosion. Nutrient poor soils and dramatically shortened growing seasons will also slow down and reduce the rate of recovery. In these cases it may be necessary to import fertilisers, seed, mulches or geotextiles to artificially improve the process.

Whilst various techniques are used for this type of work, there are no definitive solutions. There is considerable scope for development of new and better techniques over the coming years.

Assessing the Site

Site restoration requires careful consideration of the landscape where the work is taking place, to ensure that the correct approach is taken. Things to consider:

- the natural habitat of the area - vegetation, soil, hydrology
- the altitude and exposure - and its effect on revegetation
- designations - with possible restrictions on collection and use of materials
- the availability of materials - and implications of importing unnatural material
- land and path use - and their effect on success of restoration techniques

There are broadly two types of situations to consider:

- areas where path use and water damage has already caused erosion
- areas which may erode, or deteriorate, if users do not keep to the managed path line

For either situation, both the immediate environs of the path and the overall area through which the path runs need to be assessed.

Existing problem areas should be obvious, and identified during the path survey. They include:

- rough, wide path surfaces
- path edges, where walkers have trampled the vegetation on either sides of the path
- narrow braids caused by walkers leaving the main path and forming a number of path lines along the edges or close to the path
- wide braids merging to form areas of eroded ground, often with islands of turf remaining
- short-cuts, or alternative desire lines, where users cut a corner or avoid a badly eroded section of path
- scarred channels and gullies, where turf has completely broken down and sub-soil is eroded by water flow
- steep eroded slopes adjacent to the path line
- unstable slopes above or below the path line

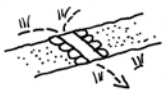
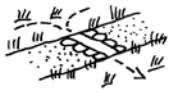
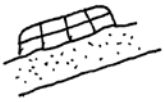
The potential for damage by off-path use should be assessed by walking both directions of the new path alignment. This should identify the areas where it will be easy, or tempting for users to take alternative routes or use the softer path edges. Remember that more erosion will be caused by the predominance of downhill off-path use, particularly as walkers get tired.

Methods Used

There are a range of techniques and intensity of site restoration - from minimal clearance of debris and subtle path definition, to the reconstruction of larger slopes. Methods include:

- De-roughening - movement of rough loose stone off a path.
- Placement of blocking or edging boulders and stone.
- Turfing and in-filling of erosion scars, gullies, path edges and embankments.
- Slope, embankment and path edge stabilisation with revetments.
- Seeding and fertilising areas with no remaining vegetation cover.
- Occasional use of fertiliser to encourage quick growth on areas of bare ground with a limited seed source.

The following technical sheets give guidance on materials and the method of use, as well as the techniques used for the varying objectives of site restoration.

SITE PROBLEM	PATHWORK	RESTORATION
Flat, boggy path. Several braids on either side of the path, deep wet hollows forming. 	New geotextile path slightly raised over the bog, with cross-drains. 	Turf edges of path. Turf to revegetate and deter use of braids beside the path. 
Steep, rough zig-zagging path. Braids on both sides, short-cuts across corners. 	Re-align and pitch the path with waterbars, and gradual curves to reduce gradient. 	Turf edges of path, create side banks to contain path use. Use blocking boulders and turf binds to discourage short-cutting. 
Very wide erosion on a moderate slope. Numerous braids merging with no defined path. 	Construct a new aggregate path, with waterbars, on a curved line. 	Turf path edges to define path. Spot turf, re-seed and fertilise remaining areas of erosion adjacent to new path. 
Unstable eroding slope above established path line. 	Stone revetment to contain bank and stabilise slope. 	Turf over the top of the revetment and any gaps in the wall. 

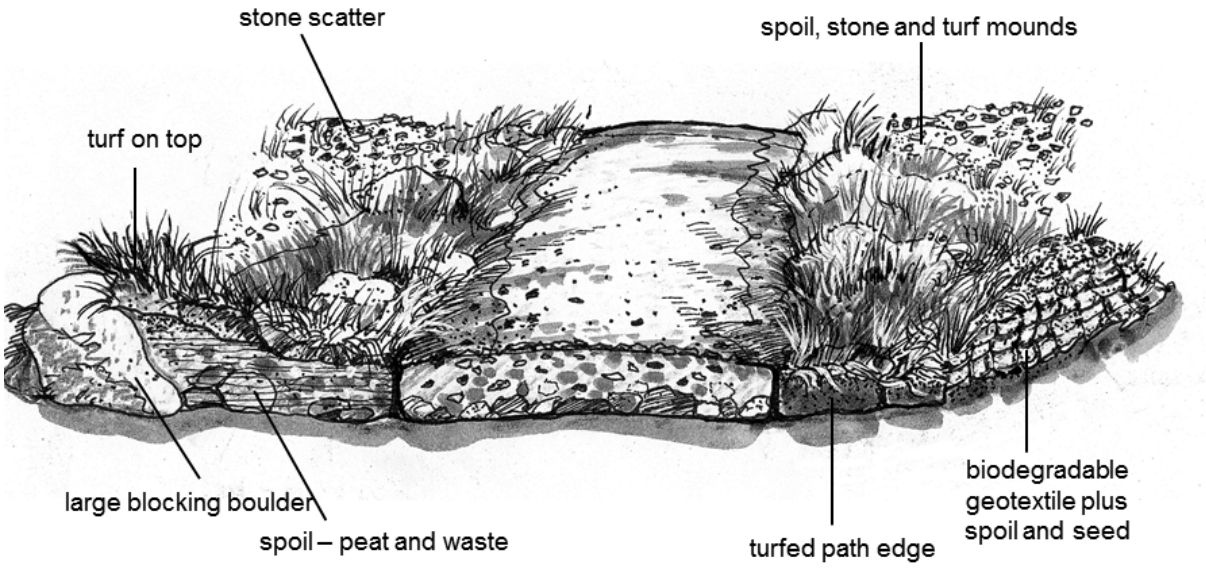
Main problems to Avoid

Site restoration should promote the natural revegetation of damaged areas; stabilise and help the pathwork to merge with the landscape; and deter movement off the path. Failure to achieve these objectives can be attributed to:

- Wrong Position - features to contain path use or stabilise banks do not control the problem and damage continues
- Wrong Style - use of materials in a way that does not blend with the surrounding ground or landscape; unnatural landforms and formal lines created
- Poor Methods - cannot cope with the pressure of off-path use, or extremes of weather; features are trampled, or vegetation dies through bad timing of work

4.1 Materials and Use

The most important factor when choosing materials for site restoration is to achieve a natural finished appearance. Sensitive use of materials appropriate to the site, and to the purpose of the restoration, is essential.



Careful attention must be paid to:

- matching vegetation type
- following topographical and geological characteristics
- sensitive collection of materials

The natural, on-site, materials used are:

- Stone
- Turf
- Spoil

Supplemented as necessary by:

- Seed
- Fertiliser
- Biodegradable geotextile
- Seed aide (a biodegradable mulch that helps stabilisation and encourages seed

Stone

Stone that will remain visible should be in its natural form and weathered, preferably lichen or moss covered, to blend with the surroundings. Stone for site restoration can be sourced from:

- surface stone and boulders, within proximity of the path

- excavation, or movement, during path and drainage work
- borrow pits, excavated for path surface material

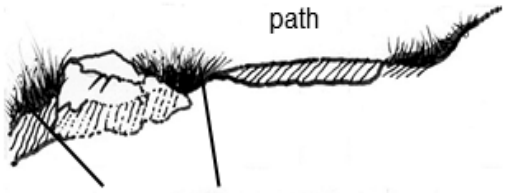
Take care to avoid further ground damage when moving stone to the restoration area with winches or power barrows

General Principles of Use

The main use for stone is to stabilise slopes and prevent off-path movement. Specific use depends on size:

- large boulder stone - to stabilise and stop use of path edges; to block use of alternative path lines
- medium size stone - to create blocking mounds, with spoil and turf, at path sides and corners to encourage users to stay on the path; to revet banks and steep slopes
- smaller stone - scattered, with spoil and seed, to help revegetate and prevent use of eroded ground

Boulders for blocking should be large enough to dig partially into the ground whilst leaving the majority exposed as an obstacle. For stability, dig in to at least one third of the depth. It may be necessary to use stone wedges to ensure that no movement occurs.



turf behind edge boulder on unweathered sides and lower slope

turf around protruding boulder for natural appearance

Blocking stone should appear as natural as possible, with weathered and lichen covered surfaces exposed. Transplanted turf can be used to cover unweathered sides, or to landscape around, particularly on slopes or the path edge.

Unweathered or broken stone can be used to create blocking or blocking mounds, if it will be turf covered. Stone exposed at the surface should be weathered and placed to look natural. Small stone spread over eroded areas should be scattered to achieve a naturally appearing, random cover. The stone scatter should deter use and break up the visual impact of large bare areas.

Turf

Turf used for restoration should closely match the vegetation of the site, wherever possible making use of turf cut during ditching or path excavation. Turfs may also be gathered randomly from the surrounding ground, but out of sight of the path. Consider the impact on the donor site, particularly on exposed or higher sites where vegetation will take much longer to recolonise.

Grass turfs are usually best for blanket coverage; taller vegetation, such as bushy heather or rushes, is better for blocking off-path use. Leggy and woody heather should not be used as it will not survive transplanting.

General Principles of Use

Unless in short supply, turf is used in all site restoration, including:

- defining and establishing a path edge
- blocking use, with boulders
- revegetating eroded ground, braids and short-cuts
- covering stone and spoil mounds and banks
- landscaping backfilled borrow pits

Transplanting

To improve the chance of success turf should be dug large and deep with a good, soil covered, root system. Soil around a turf will normally hold a seed source, and when transplanted the turf will provide shelter for the germination of this, or introduced seed. Turfs should be carefully handled and transplanted into prepared holes, or onto loosened ground or spoil.

Turf should not be transplanted during periods of dry weather as success is dependent on rain to help root systems establish. Periods when frost is expected should also be avoided as it can damage establishing roots.

Turf should be left for as short a time as possible before transplanting. When not used immediately cover the root system with soil, to protect it from drying out. Stack turfs excavated during path construction, with root systems facing inward, until it is required. To help retain moisture lay the turf on, and cover with, synthetic material or matting.

Spot turfing

Turfing, with one or two large turfs, is appropriate at path edges, around large boulders, or to block path braids. Over larger, eroded areas spot turfing can create "islands" of vegetation, when not enough turf is available for total coverage.

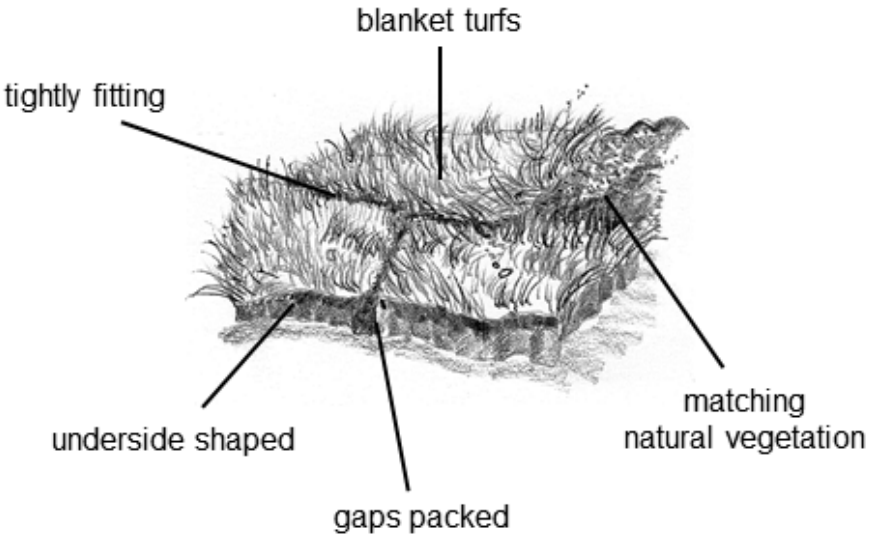
To appear natural turfs should be randomly positioned. Spacing will depend on availability, but over large areas aim for at least 30% cover. If spare small stone is available this can be scattered to further discourage users from leaving the path and may help to minimise the visual impact of the landscaping.

On exposed sites with a scarcity of available turf, such as on or near plateaux, much smaller turfs can be used in association with matting to help stabilise the site and provide shelter for the transplanted turf.

Blanket turfing

In this method turfs are laid for total cover over bare ground, or mounds. Grass turf can be cut to the shape required to achieve good coverage. This may include shaping the under-side to the ground being turfed over. Adjoining turf edges and surfaces should be flush, but with undulations incorporated for a natural appearance.

Turfs will shrink slightly, especially during periods of dry weather. To prevent the root system drying out, and vegetation dying, turfs should fit tightly together, with overlapping joins. Fill gaps between or beneath with spare spoil or turf off-cuts.



The join with existing vegetation should match in type, form and surface contours. When turfing over mounds, surface matching is achieved by shaping either the underside of the turf edge or excavating a small tray and slotting the turf in. Alternatively carefully lift existing vegetation and fill underneath with spoil to raise the level. Finally match the surfaces by tamping down firmly.

Spoil

Depending on the geology of the site, spoil will have a mineral or organic content, and be acid or alkaline - usually acidic. Some sites may allow a choice of spoil for specific use. The more organic the spoil, the better it is for establishing vegetation. Mineral spoil, with a higher content of stone particles, is more suitable for stabilising slopes, forming mounds and backfilling borrow pits.

Spoil is generally won from path tray and ditch excavations, or from borrow pits if alternative material is available for backfilling. To prevent damage to vegetation, store spoil on bare ground, or on a tarpaulin or geotextile.

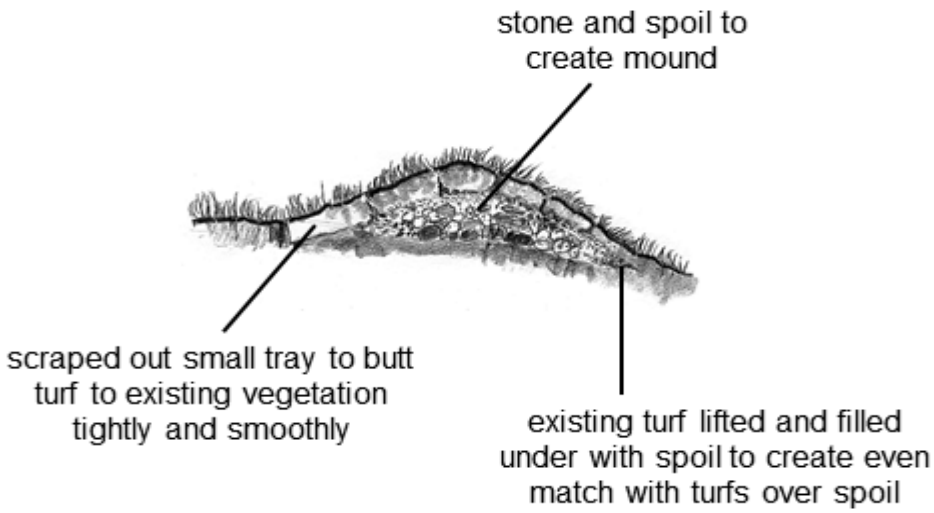
General Principles of Use

Spoil is the bulk material used to:

- create mounds and banks, with stone and turf, to channel use onto the path
- spread over eroded areas, as the base for revegetation with turf and seed, backfill revetments to stabilise slopes and banks
- backfill redundant borrow pits

When used for mounds and banks the spoil should be shaped to imitate natural landforms. Any larger, unweathered or broken stone in the spoil can be used to create the bulk of the mound. Smaller stone and spoil content is then compacted over and around to form the shape, ensuring that it is contoured to naturally match and join the surrounding ground level and slope.

It is always preferable that shaped mounds are blanket turfed, incorporating weathered stone, if appropriate to the surrounding area. If turf is limited, careful spot turfing can be used, with stone; if no turf or seed source is available the mound can be seeded, and occasionally fertilised to help stabilise the surface.



Where mounds or banks are created on wide areas of erosion it is important to use similar turf and stone around them to help avoid an unnatural appearance

Seed

Imported seed must be specifically selected for the site, and the nature of the restoration required. Specially prepared seed mixes will depend on:

- soil and natural vegetation
- altitude and climate
- whether a nurse crop for natural vegetation is required
- whether the seeded area will be walked on
- type of use - for instance, whether deep rooting for slope stabilising or fast growing cover for path sides

Consult a seed specialist on the suitability of particular cultivars in the seed mix. On designated sites advice should be sought from the local SNH office for suppliers of special mixes, or local sources where it is necessary to use native seed.

General Principles of Use

Depending on site designation, and ground conditions, seeding may be used in all types of restoration work:

- revegetating mounds or banks and eroded ground
- recovering braids and short-cuts
- slope stabilisation
- landscaping borrowpits

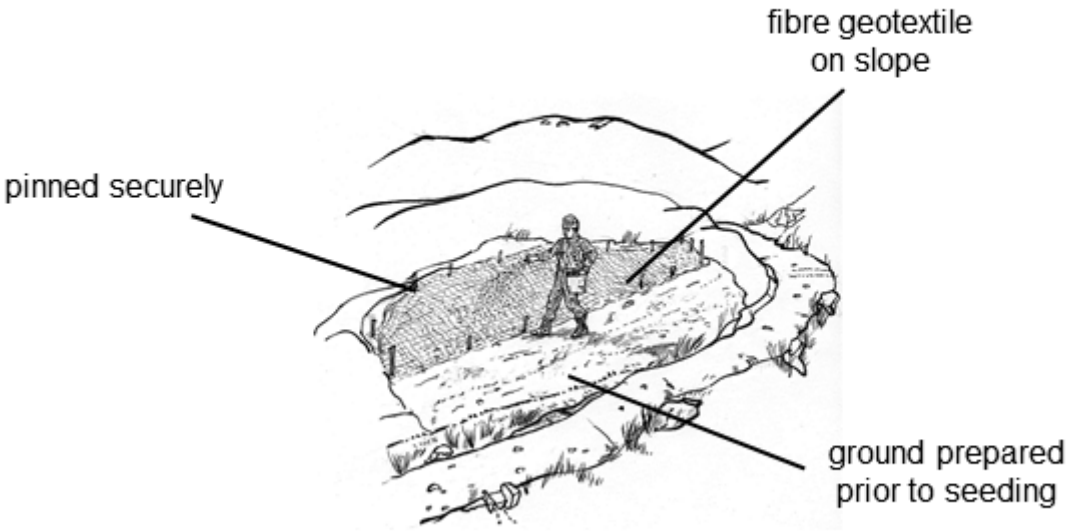
It is particularly useful where turf is in short supply, but is not necessary where turf is available for blanket cover. The best time of year for seeding is either late spring or early autumn. With the climatic variability of upland sites, sowing between these times can be successful, particularly if temperature and moisture levels are suitable.

Ground preparation

Damaged ground requires preparation before seeding. This involves either spreading spoil, or scarifying the ground to break up the surface layer. A texture that will hold and protect the seed from blowing away is required. Scarifying also encourages water to soak into the ground, which aids germination, and reduces the risk of rapid water run-off, taking seed with it.

Site conditions will dictate the extent to which ground preparation is feasible. On exposed sites, particles of loosened soil will blow or wash away, particularly on sloping ground.

If fertiliser is to be used it can be applied during ground preparation, preferably a couple of weeks prior to seeding.



The best method on upland sites, is broadcasting by hand, avoiding windy days. Even with prepared ground wind will inevitably reduce the revegetation success on the required area. Long periods of dry weather should also be avoided.

The rate of seeding depends on the seed mix, the vegetation cover required, the ground conditions and the expected success of germination. Advice on this can be provided by the seed specialist. A rough guide is approximately 25gm, or one handful, per square metre of ground.

Fertiliser

Fertilisers add essential mineral elements to nutrient poor, eroded ground or spoil. Different compositions and forms release nutrients over varying periods of time, some as slow as two

years. This can be beneficial where the soil condition is particularly poor, or germination and vegetation recovery will be slow due to extremes of climate. For sites requiring rapid recovery, appropriate fertiliser use will encourage root and shoot development.

However, depending on the mineral balance, fertiliser can affect the natural balance of surrounding vegetation, particularly in wet areas, where it may leach out. Therefore fertiliser should only be considered where turf is not available and there is bare ground with limited seed source. Specialist advice should be sought, on the appropriate type and quantity for the soil, natural vegetation, and revegetation required.

Some sites have restrictions which prevent the introduction of nutrients, and the local SNH office should be consulted. Fertilisers are generally obtained from agricultural or seed suppliers.

General Principles of Use

As with seeding, fertiliser can be used as part of site restoration work. It can be mixed with the soil prior to seeding to promote quick and strong germination and growth; or applied to encourage natural re-vegetation. On an upland site, fertiliser is best broadcast by hand, and gloves should always be worn. The rate of spread will depend on the nature of the site and the vegetation cover required. Specialist advice should be sought for individual sites, and specific fertilisers.

Following seeding, especially if the required vegetation recovery is slow, a follow up application may be necessary, at the start of the growing season.

Geotextiles

An extensive range of geotextiles has been developed for formal, or engineered landscaping work. Most are synthetic mats and meshes which stabilise the soil structure. These are only covered as vegetation grows through. In an upland environment they will potentially remain exposed, and are therefore not suitable.

For upland site restoration mattings of coir, jute or straw, are preferable, as the natural fibres retain moisture, and biodegrade over time, leaving no sign of use. If required, special seed mixes can be incorporated within the matting.

Geotextiles are obtained from specialist suppliers.

General Principles of Use

Geotextiles are useful where soil, seed or fertiliser cannot be retained on eroded slopes and banks. With their woven mesh they provide a "bound" structure to the surface, and encourage quick vegetation establishment over exposed slopes. Natural fibre mattings also provide a water retaining medium for seeding of large eroded areas where there is no organic soil and provide some protection from the wind.

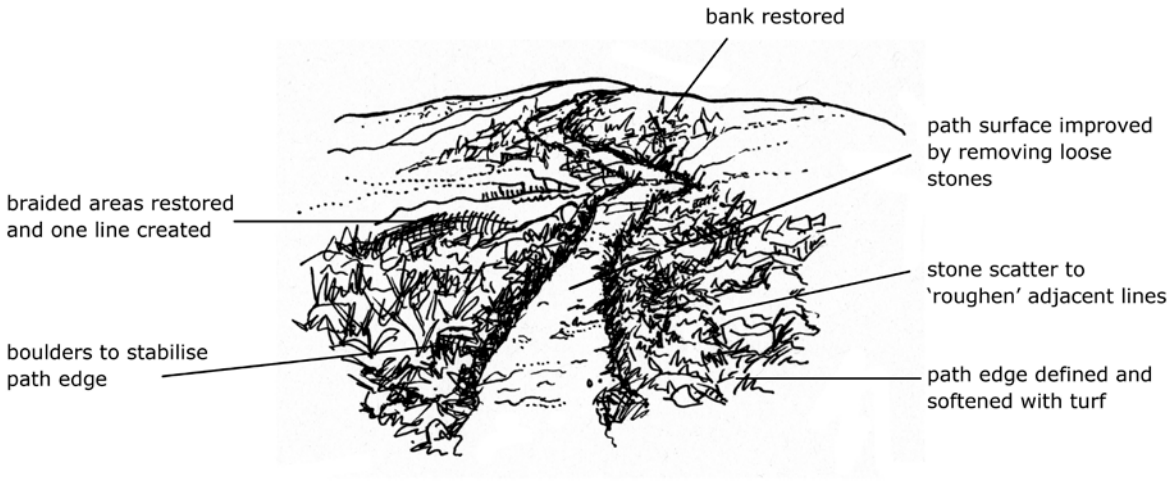
Natural fibre mattings are normally supplied in rolls, with instructions for laying. They can be cut for the area and shape required, or to go around large boulders. Holes can also be cut for spot turfing.

Fibre geotextiles need to maintain contact with the ground to be effective. Make sure that the mat can lie flat on the ground, hugging contours, removing large loose or awkward stones. Apply approximately 50% of the seed and fertiliser under the matting and 50% over the top.

It is essential that the matting is firmly attached to the ground, to prevent movement Slot the cut edges into the ground, or tuck under, to prevent fraying. Secure all edges firmly, at regular intervals, with long metal pins, pegs, or secured with boulders. The matting should also be secured across its width.

4.2 Defining Path Alignment

A path line may not be immediately obvious to the user if the path material merges well with the surrounding ground, or the path passes through a rough or eroded area. To prevent inadvertent movement off the managed path, further definition will be required in the form of sensitive path edge restoration and landscaping.



Function

Good path management entails encouraging walkers to stay on the managed path. Defining the path line and containing path use are vital parts of this.

The purpose of path definition is to:

- reduce use to a single line and prevent it spreading across a wider area
- minimise the impact of the path in the upland landscape
- revegetate and stabilise weak or poorly vegetated path edges

As well as being an essential element of pathwork, it can be a minimal impact technique to define a path line without the use of surfacing materials. This is suitable on stable stony or eroded ground, where path use has spread over a wide area. The aim is to provide a more comfortable walking surface, within a clearly defined width.

Bill of Quantities (example)

Define one path line. Remove any loose large stone and obstructive boulders or turf islands to the path margins. Set in boulders and transplant turfs as informal path edges to define the path line and width.

Methods

Path definition requires great care. An aim of upland pathwork is to minimise its impact in the landscape and path definition will conflict with this if it is not sensitively undertaken. Defined path sides should merge naturally into adjoining ground. The methods used must be appropriate to the character of the path, its surface and the surrounding landscape.

Methods include:

- turfing the path edges
- shaping or restoring banking at path edges
- placement of stabilising stone
- movement of loose stones, boulders and turf islands

Materials

The types of materials available are usually quite limited, and include:

- Boulders and stone
- Turfs

These materials and the general principles for their use are detailed in materials and use.

Procedure

Natural Surfaces

A single path line should be defined wherever problems are encountered with walkers following a variety of lines across a wide area of rough ground. This involves the careful "sorting" of the natural, or eroded, surface material.

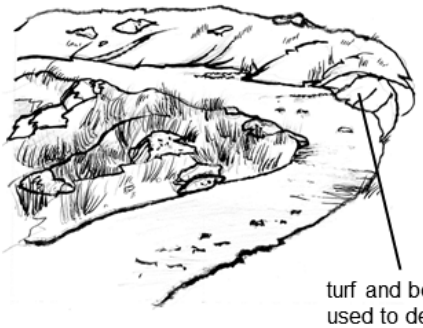
All rough loose stones and boulders are removed from the preferred path alignment, unless they provide good and solid footholds. Small stone is scattered in the alternative lines. Larger stone and boulders are then set into the ground to define an informal path edge. Any islands of turf remaining are carefully transplanted either at the path edge or in the alternative lines to provide a natural appearance, appropriate to the surrounding area.

The alternative path lines may need additional blocking (see containing path use).

Aggregate Paths

Turfing of the aggregate path edge may have been undertaken as part of the construction, particularly where the path tray sides were unstable, or geotextile used. Additional definition, with turfs and boulders if appropriate, may be needed at changes in alignment, and to help vary the path width. Turfing may also be required to slightly raise the path edges and prevent the aggregate surface from spreading or eroding with use. The use of turfs will soften the edges and encourage vegetation to grow into the aggregate.

Turfs should be laid right up to the path edge, maintaining a variable path width. Care should be taken to avoid creating straight lines. Incorporating small boulders or large stones can help to give a natural look to regular turfing, as long as they are randomly placed, and not in a uniform line along the path edge.



turf and boulders used to define change in path alignment

Pitched Paths

Pitched paths are often constructed through wide rough and eroded areas. The placement of boulders and turf, particularly at changes in width and alignment will help to define the edges.

The path surface should not be higher than the adjoining ground and the turfing angled to form a bank that is not suitable for walking on. The turf should be butted tightly into the pitched stone, to encourage it to grow over and soften the edges.

Under-cutting

Where a traversing path is benched into the slope the uphill bank may become under-cut by path use, weathering, or sheep sheltering. This can lead to overhanging turf that is liable to collapse onto the path. A path that has eroded to form a stable mineral surface can also leave over-hangs, on both sides.

In these cases it is necessary to reshape and stabilise the path sides. This can be done by rebuilding the eroded bank with boulders, and turfs. Alternatively, if no material is available, the turf may be carefully lifted, the soil underneath reshaped down to the path edge, with the overhanging turf transplanted over it. In both methods the banking should be angled back, so that undermining is less likely to re-occur.

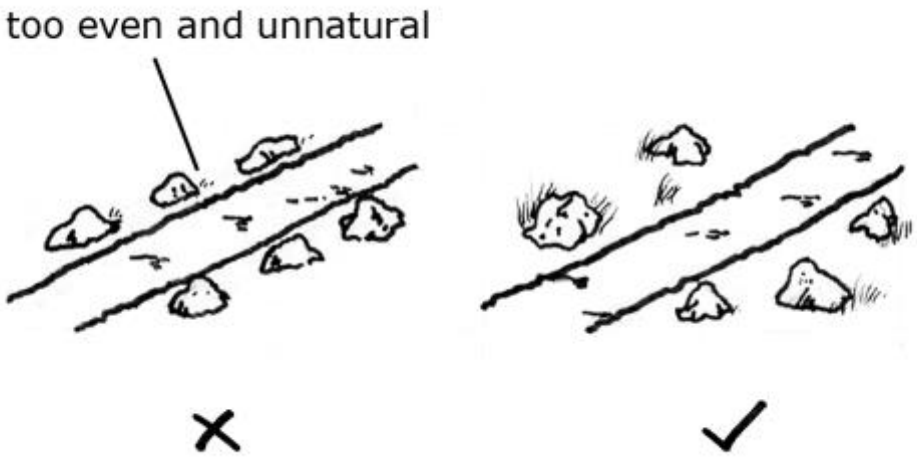
Drainage Features

Wherever drains extend outside the path width the path edge should be defined with large turfs or stone. This helps to soften the appearance of a stone drain and stabilise the path edge where it joins the drain construction. Care is needed in placing the turf to avoid channelling path use into the drain rather than onto the path.

Troubleshooting

Key points to watch:

- make sure that boulders or stones are secure and will not move onto the path line
- ensure that edge definition channels walkers onto and not off the path
- avoid regular and even placement of turf and boulders - position randomly



Maintenance Tasks

The following maintenance may be required:

- replace any dead, worn or displaced turfs
- re-set, or replace any loose or dislodged boulders

ENVIRONMENTAL SENSITIVITIES

- create natural path edges - merge them with adjoining ground
- use a mix of turf, stone and boulders appropriate to the surrounding landscape

HEALTH AND SAFETY HAZARDS

- be aware of any steep drops or slopes when working on path edges

TAKE CARE

- stand back before completing alignment definition - make sure the path line is appropriate and other measures are in place to keep users on the path

4.3 Containing Path Use

People moving off the path line can cause damage and erosion of fragile revegetating areas. It is essential to prevent this with careful landscaping and placement of ‘natural’ obstructions, as part of the site restoration.

Function

Incorporating "blocking" features, or obstacles, in the site restoration serves to channel and contain use on the path and discourage walkers from leaving it. Before considering preventative work it is necessary to identify why and where users will be tempted to move off the path line. This may include:

- poorly constructed or rough path surface
- steep or difficult sections of path
- easier walking ground adjacent to a hardened path
- short zigzags on a slope where walkers can descend an easy fall line
- old path lines appearing as alternative or more direct routes
- poorly positioned drainage features channelling use off the path
- steep path crossfalls "pushing" use off the path edge
- short-cuts or desire lines to a particular destination

Bill of Quantities (example)

Use large boulders and turfs with landscaped mounds to prevent use of path sides, alternative paths or desire lines. Obstacles and mounds must be large enough to contain path use but appear natural and blend with the surrounding area.

Methods

The following methods developed to channel and contain path use can be used together or individually, depending on the nature of the site and the problem.

- strategic positioning of large blocking boulders
- turf and spoil bunds, mounds and bankings
- turf and stone placement over alternative paths
- ground roughening of open path sides

The appropriate choice will depend to a large extent on the materials available.

Materials

Any of the following can be used to contain path use:

- Boulders
- Turfs
- Spoil
- Mixed size stones

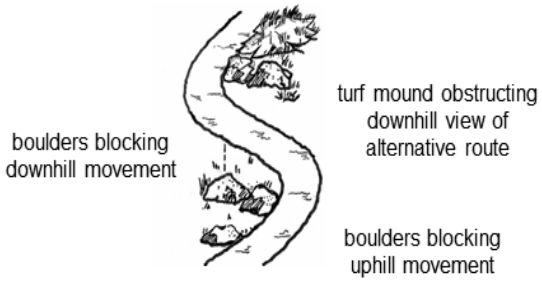
These materials and the general principles for using them are detailed in Materials and Use.

Positioning

Whichever method is used to prevent movement off the path, it should not be perceived by users as a deliberately placed obstacle. Rather than being a physical barrier the obstacles should create an impression of difficult ground. To be effective these need to be carefully positioned where problems may occur. The most common places are at:

- changes in the type or condition of path surface
- points of access off the path onto easier ground
- path corners or changes in alignment
- changes in gradient, particularly the top of steep downhill sections
- points where braids or old paths leave, or are obvious from, the path line
- drainage features on corners or bends, particularly waterbars
- lower path sides on traversing paths
- the point where destinations become obvious or visible e.g. car parks, viewpoints, landscape features

For strategic positioning it should be remembered that the path user's visual assessment of a better or alternative route will be different when ascending and descending.



When blocking ascending off-path use, the obstacle needs to be at the path edge, as the walker's view will be limited to the slope immediately above.

A descending walker will be looking further ahead, and over a wider area. More than one feature will be required, positioned randomly, but to obstruct the view of an alternative line and to give the appearance of rough ground.

On zigzag paths the best position is immediately below the lower path edge particularly at the bends.

Procedure

Blocking Boulders

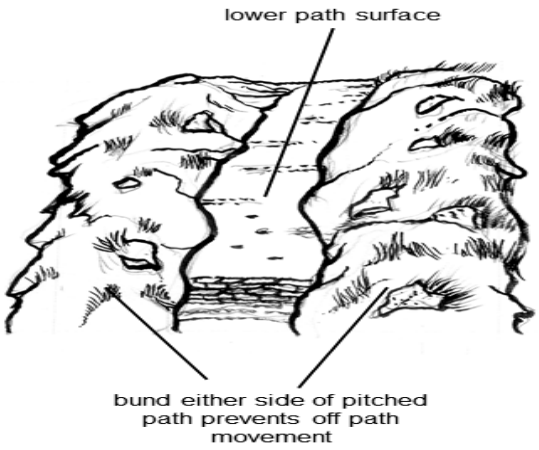
Large boulders should be used, at the point where walkers may be tempted off the path by an apparently better route. The best positioned blocking boulders will not be obvious to path users. Turfs transplanted around them will help to achieve this.

On alternative paths or wide path sides more than one boulder may be required, and care with positioning is needed. Blocking boulders, and their placement, must mimic and look as natural as any others in the surrounding landscape.

Bunds, Mounds and Bankings

Along with occasional boulders, these are the ideal method of containing path use, so long as their appearance blends with surrounding area. They may be the only option available in situations where boulders are in short supply or do not fit the surrounding area. Using spoil and turfs they can create longer obstacles, either along the path edge or at an angle to the path, and, as low mounds, across alternative paths or braids. As well as blocking off-path use they encourage or divert use onto a particular alignment, particularly on zigzag paths.

Carefully positioned raised bunds or banks along the path edge, are helpful in preventing movement off the path onto revegetating sides, but great care needs to be taken to create banks that fit within the landscape. They also serve to reduce the visual impact of a hard path edge or the path alignment.



Where there is no spoil or turf available, mounds and hollows can be carefully created. Turf is removed over an area, and a hollow dug; the spoil is used to create a mound; and both the hollow and mound re-turfed. This is particularly useful to prevent use of easier, softer ground adjacent to a hard path.

Mounds used as obstacles must be substantial enough for the purpose, and rough enough to deter use over them. However, care is needed to avoid creating unnaturally high features.

As with boulders, the emphasis is on their natural appearance, avoiding uniform shapes or positioning. Where used for banking alongside the path edge, care is needed to avoid long unnatural looking mounds of regular width.

Turfing

Large turfs can be used, with boulders if appropriate, at the path edges to prevent movement off the path, and to disguise and block the line of braids and desire lines. The aim is to 'roughen' the appearance and care should be taken not to create a better walking option than the path.

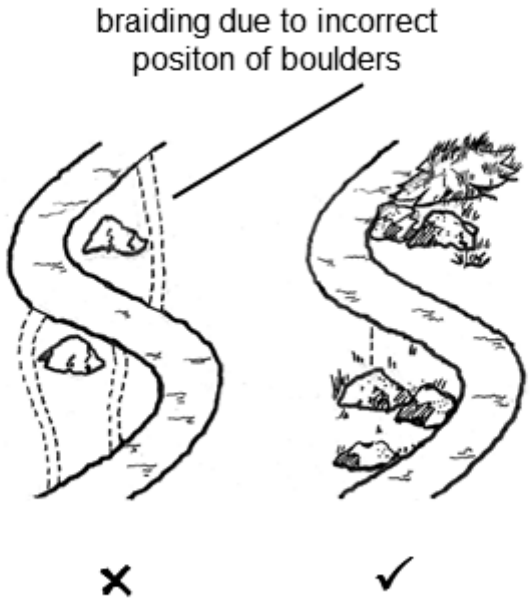
Ground roughening

This method is suitable on wide open areas adjacent to the path, where large boulders or turfed mounds would not be appropriate. The aim is to roughen the ground enough for it to appear unattractive to walk on. On eroded ground this can be achieved with mixed size, weathered stone scatter over the surface. Small, low mounds and hollows may also be appropriate. These can also be used effectively to create an uneven grassed area. Mixed height turfing, combined with weathered medium size stone can also achieve the desired effect. Particular care is needed with this method to avoid a contrived unnatural patchwork of material.

Troubleshooting

Key points to watch:

- correct positioning of the feature - further erosion will occur if walkers continue to deviate from the path



- avoid periods of dry weather when turfing

Maintenance Tasks

The following maintenance may be required:

- replace worn or dead turfs
- reset loose boulders or stone
- move, or extend features to effective positions

ENVIRONMENTAL SENSITIVITIES

- the features used must fit in with the surrounding landscape; a natural look is essential

HEALTH AND SAFETY HAZARDS

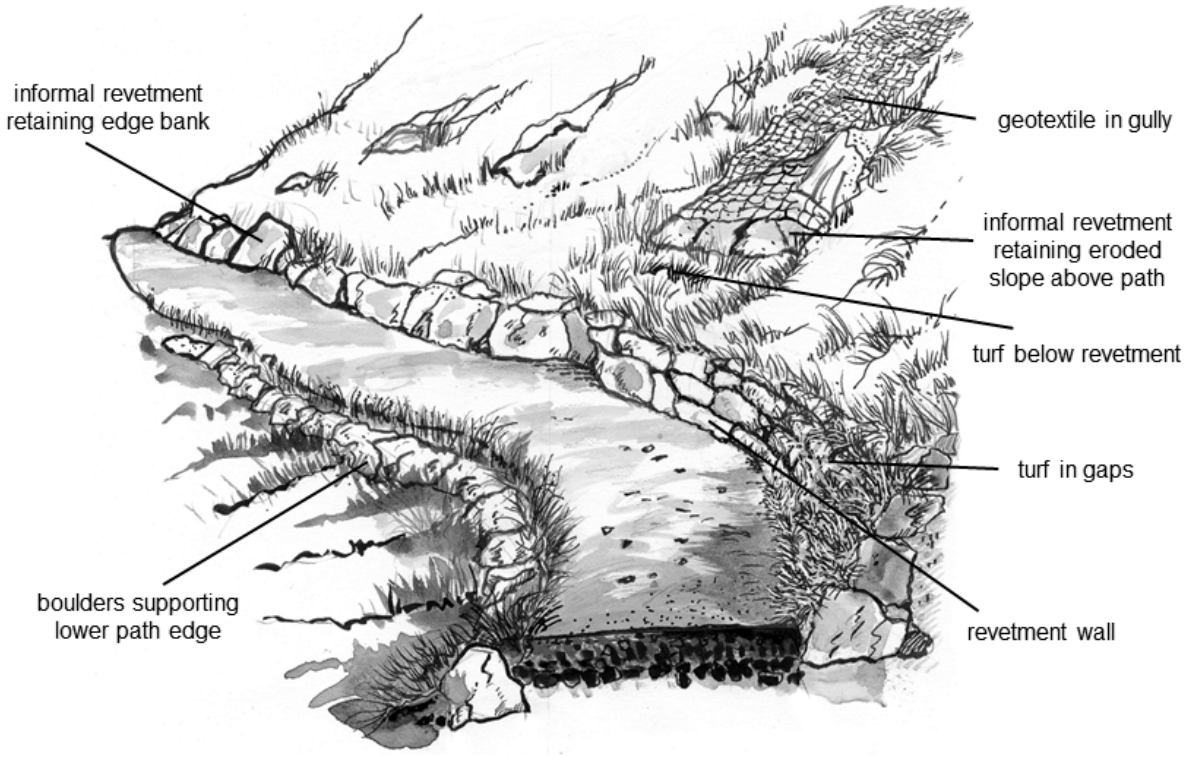
- use safe lifting techniques when manoeuvring large boulders
- when moving large boulders divert the public and warn other workers on the path below

TAKE CARE

- step back from the work as you are doing it - view it from the path and at a distance to check for the correct position and merging with surroundings

4.4 Bank and Slope Stabilisation

Upland slopes are prone to slippage, particularly when vegetation has been lost. Initial loss and erosion may be caused by pressure of use, but fragile vegetation, thin friable and mobile soils, high rainfall, and frequent freeze thaw action all contribute. Slopes will need stabilising if a path solution is to be effective.



Function

The revetment wall is solidly built to retain loose or unstable ground on steep slopes. The stabilised slope will then provide a better base for revegetation. Revetments are also used to support and consolidate banks along path edges. The most typical situations for its use are:

- on open eroded slopes, or gullies associated with the old path alignment
- where the path traverses a slope, either on one line or zigzagging
- to support a lower path edge from collapsing down the slope
- to retain the bank or slope above from collapsing onto the path, either at the path edge or on the slope above

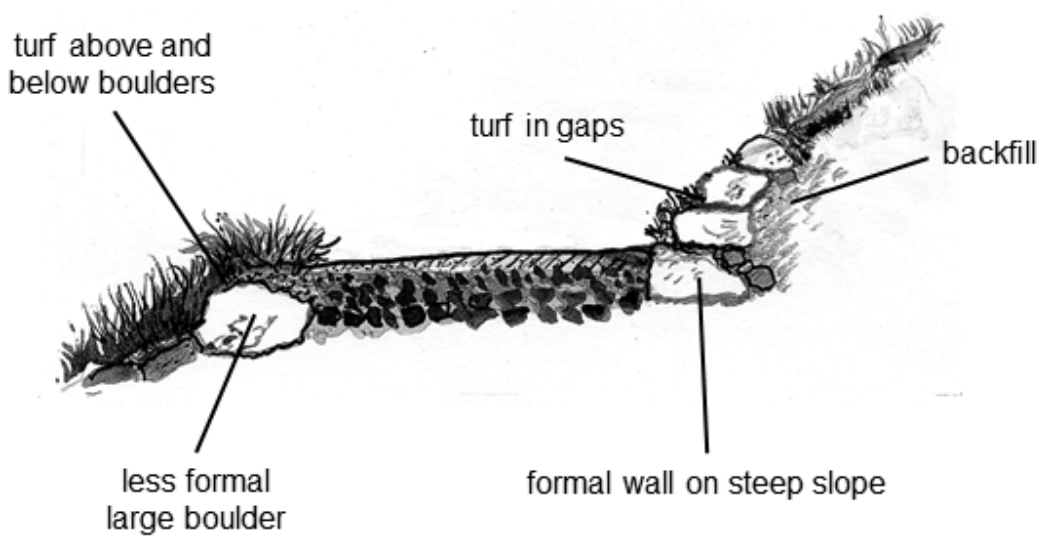
Bill of Quantities (example)

Using natural weathered stone construct an informal revetment wall to retain the slope above the path. The construction must be solid and stable, with large foundation stones, off-set joins, pinned and backfilled firmly. Pack gaps between the courses with turf, and turf over the top to blend with the upper slope.

Where revegetation over an eroded slope is necessary the revetment may be combined with turf banks and transplants, or geotextile with seed (see Restoring Vegetation).

Construction

The revetment is a rough-faced, random coursed, drystone wall. On steep slopes the structure may need to be a formal retaining wall, of approximately 500mm height, or more. Preferably, a less formal approach should be used, with large boulders butted together along the path edge to support the banking. Both should be made to look as natural as possible by incorporating turfs into and over the structure.



Materials

Revetments are built from the following:

- large boulders for informal revetments
- variable sized, block stone for formal revetment walls
- spoil for back-filling
- turf for landscaping the revetment

These are described in detail in Materials and Use. Stone for revetments should be in its natural form with the outer faces weathered, preferably lichen or moss covered, to blend with the surroundings.

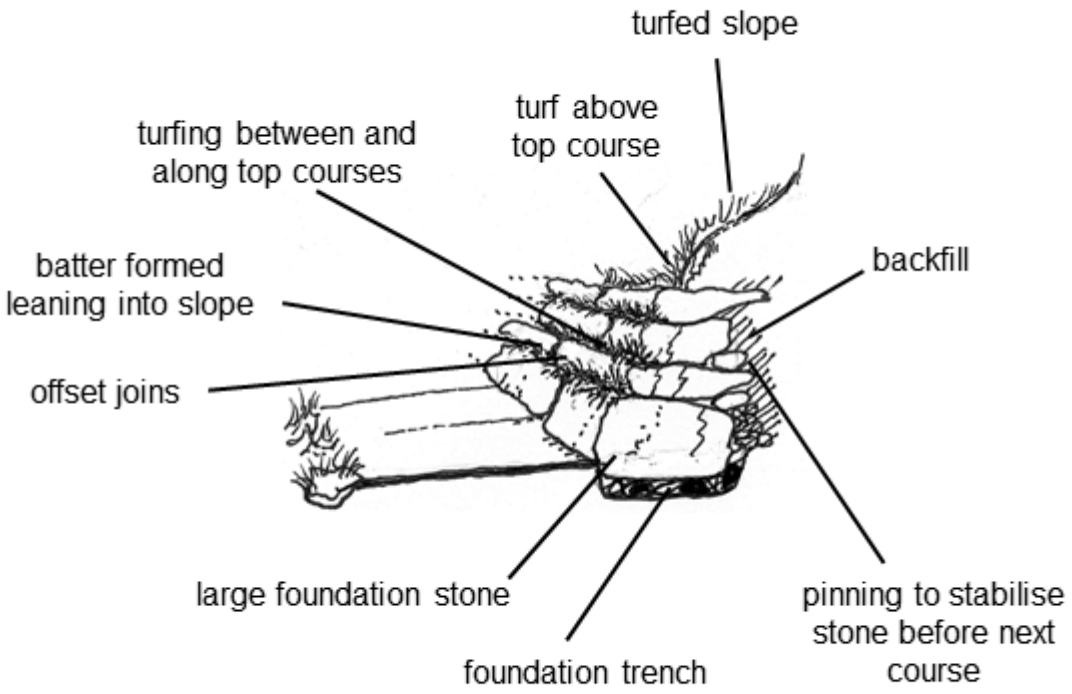
Method of construction

Foundation

The key to a solid revetment is the foundation. Whether it is the more formally constructed wall or the random boulder edge, a solid base should be excavated and levelled to build on. This should be to at least one third of the depth of the base stone.

Courses

- use the largest stones for the wall base stones, progressing with courses reducing in size towards the top; the final course should use stone that is large enough to form a solid top to the wall
- the courses should form a batter, leaning into the slope, to provide more resistance to any slumping of the slope behind
- outer stone faces should not protrude, as these may be used as steps, by people or animals, to climb over the wall, which will ultimately result in weakening of the structure



- lay the stone a course at a time, butting adjoining stones tightly, and with off-set joints, to provide a solid structure
- pin each course from behind with smaller stone wedges, to ensure that no movement occurs, before the next stone is laid
- backfill any space behind the revetment as each course is laid; it is essential that this is packed tightly to minimise movement and settling of the soil which inevitably happens after construction is complete

Finishing

- fill gaps between courses on the face of the wall with turf off-cuts to help create a natural appearance

- revetments above the path should be topped off with turf, and landscaped into the upper slope
- to keep walkers off the top of revetments below the path edge, spoil and turf should also be used on the path edge
- revetments supporting the lower path edge should have spoil and turf in front of the foundation stones, to help stabilise and blend them with the lower slope
- revetments on open slopes should have turf and spoil above and below to blend into the slope and aid stabilisation

Troubleshooting

Key points to watch:

- always build on top of securely wedged stone - if the course below is loose then all those above will be unstable
- extend the revetment by one metre past the end of the bank that requires stabilising, to prevent banks collapsing around the ends

Maintenance Tasks

The following maintenance task should be carried out regularly:

- re-packing of loose stone work with turf or stone wedges
- re-turfing of any areas where turf has died or been damaged

ENVIRONMENTAL SENSITIVITIES

- revetment walls can be very visible on steep slopes - avoid high formal structures
- use turf with care to help walls blend into the slope
- source turf and stone away from eroded slopes to prevent further erosion

HEALTH AND SAFETY HAZARDS

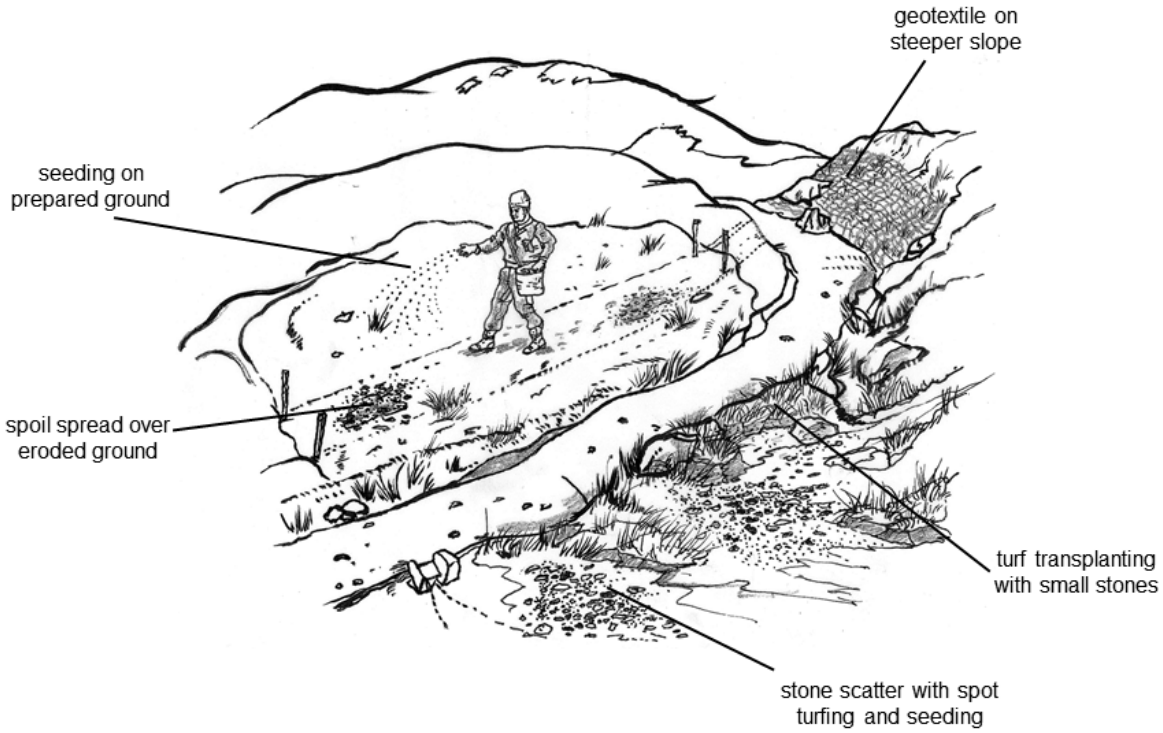
- if working on a revetment over one metre high, take precautions to ensure the safety of the worker; wear PPE, and take particular care when working on the top courses of the wall

TAKE CARE

- minimal impact is the over-riding aim of pathwork - a certain amount of erosion on slopes is acceptable in an upland landscape

4.5 Restoring Vegetation

Where the natural landscape and fragile habitats have been damaged by upland path use the eroded areas are restored by encouraging natural re-vegetation.



Function

The objective is to return the vegetation as closely as possible to its natural state prior to erosion. This includes minimising the visual impact of the path on the surrounding landscape. Vegetation may need restoring on:

- eroded ground at the side of newly surfaced or defined paths
- alternative path lines
- eroding, or unstable slopes above or below a traversing path
- trampled path edges or braids alongside an established path

Bill of Quantities (example)

Turf eroded areas to blend in with surrounding undamaged ground. All turf edges and joins should look natural. Turf cover of bare ground should be at least 75%. Apply seed with stone scatter to areas with less than 50% turf cover.

Methods

Revegetation of damaged areas can be achieved by using the following methods:

- turf transplants
- seeding and fertilising
- adding spoil and stone scatter
- stabilising and improving the soil structure with fibre matting, or mulches

The methods used are dependent on the size of the area to be restored and the availability of materials.

Materials

The following materials are used to restore and encourage revegetation:

- Turfs
- Seed, and fertiliser
- Spoil
- Small stones
- Geotextile

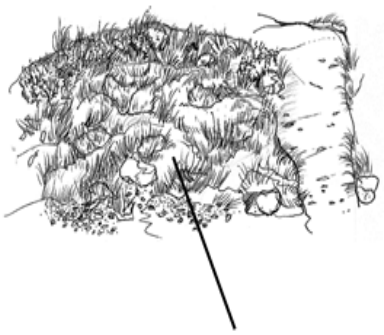
These materials and the general principles for using them are detailed in Materials and Use.

Procedure

Turfing

Blanket turfing is labour intensive but it provides an instant effect of full revegetation, and the success rate is high. The availability of turf is a key consideration. Restrictions will be placed on some sites due to conservation designations and fragile habitats.

Spot turfing can be used to give partial coverage. The turfs will also act as a nurse crop either for the natural seed source, or in conjunction with seeding. By providing shelter and better conditions turfs encourage seed germination and growth. Total revegetation cover will be slower than blanket turfing, particularly if growing conditions are poor.



spot turfing with small stone scatter

Seeding

Seeding is a slower and less reliable way of restoring vegetation. If the site has a favourable climate and soil conditions, recovery can be successful. Most upland sites have low fertility soils, and a colder climate which slows down the growth and recovery rate of a seeded site. Applications of fertiliser will help to address this. Over-grazing of new shoots by sheep or deer can dramatically hinder the success of seeding. Temporary fencing to exclude stock and deer may be needed - this will also prevent physical damage from trampling by both animals and people.

Stone Scatter

Problems can also arise from walkers trampling over seeded areas, if they stray from the path line. Random stone scatter will deter this and will also aid germination and growth by providing small moisture retaining pockets.

Spoil

Spoil from excavations can be used to spread over areas where the soil has been totally eroded. If the spoil is organic and nutrient rich, it will provide more fertile and stable growing conditions. If not, fertilisers can be added. Only the top 100mm or so of soil is "active" and will immediately boost plant growth. Soil from below this level, particularly dark wet peat, will not on its own support successful plant re-establishment.

Geotextile

Where no turf is available or slopes are too steep, natural fibre matting can be used in conjunction with spoil, for soil and water retention. This will provide a more stable base for seeding, or for turf transplants.

Troubleshooting

Key points to watch:

- avoid creating unnaturally smooth turfed areas - incorporate undulations, mix plant species and stone, if appropriate to the site
- make sure that seed and fertiliser is suitable for the site - consult a specialist
- always follow the guidelines given with the product

Maintenance Tasks

The following maintenance may be required:

- re-turfing or re-seeding any areas that are not recovering
- further applications of fertiliser to areas that have not achieved full vegetation density
- checking for trampling or grazing, and taking appropriate action to stop disturbance, if necessary

ENVIRONMENTAL SENSITIVITIES

- do not use seed mixes that will introduce "alien" species to the area
- be cautious in the use of fertilisers - over-green vegetation is unnatural in an upland landscape
- don't use fertilisers where water run-off or leaching may affect natural or fragile vegetation
- geotextiles can be intrusive on steep slopes - use only where they can be effectively hidden

HEALTH AND SAFETY HAZARDS

- wear gloves if handling seed or fertilisers
- remove excess fertiliser from the site, on completion of work

TAKE CARE

- not all areas will require revegetation - a certain amount of erosion can be acceptable in an upland landscape. Consider whether the pathwork fits in with the surrounding area, there may be areas of bare ground due to wind and poor soils, or vegetation may recover quickly once a new route has been created
- developments in site restoration are happening all the time - consult other pathworkers or managers, to find out latest developments and the success of other techniques

Glossary of Symbols

Survey Features

bedrock 

knoll or bank 

marker boulders 

photograph 

fence 

borrow pit 

Drainage Problems

burn or other watercourse 

seepage or water flow 

wet path surface 

Drainage Techniques

open ditch 

turf lined ditch 

lett 

waterbar 

cross drain 

stone culvert 

piped culvert 

ford 

Path Problems

rough path surface 

gully 

Path Techniques

aggregate surface 

reinforced surfacing such as aggregate with geotextile 

aggregate with anchobars 

pitching 

steps 

causeway 

Restoration Problems

braided paths 

turf islands or hags 

Restoration Techniques

blocking 

seeding 

turfing 

revetment 

Glossary of Terms

Abutment
Supporting ends for a bridge deck; built as revetment walls either side of the watercourse.

Aggregate
Graded stone used to form the sub-base, base and surface of a path. Imported material is available in a variety of grades.

Anchor bar
Stone structure built across the path to stabilise aggregate surfaces on slopes; deters down-hill slippage.

Back-fill
Mixed spoil - stone, minerals and soil, used to infill gap or space behind, or between stone work after pinning; also use to infill a borrow pit prior to turfing over.

Bare width
Survey term to describe the width of ground, including the main path line, that has no vegetation cover; usually where it has been trampled or eroded away.

Batter
The backward leaning slope on the face of a retaining wall, or sides of an open ditch; prevents wall from falling forward, ditch edges from collapsing.

Benching (in)
Excavation to build a path traversing a steep slope; maintains a flat surface (bench) by digging into the slope or building up lower edge.

Blockers
Boulders, turf or mounds positioned around the path to discourage users from taking short-cuts or leaving the path.

Block stone
Large stone used to construct drainage features, anchor bars etc.

Borrow pit
Small scale excavation (mini quarry) for winning aggregate and surfacing materials for path construction.

Braiding
Narrow path lines worn parallel to main path; caused by users deviating from an eroded, or damaged surface; can be numerous depending on severity of erosion, vegetation type etc.; join up to form wide erosion scars.

Bunds
Landscaped embankments at path edge, made of spoil and turf; used to channel walkers onto the restored path line.

Camber
Path surfaced with middle slightly higher than the sides; allows surface water to flow off to both sides.

Catchment
Area of ground around path where water collects in the form of bogs, surface water, springs, streams; affects path drainage.

Catch pit/Soakaway
Excavated to collect path drainage water where there is no natural outflow; also slows down water flow and collects debris.

CDM
Construction (Design and Management) Regulations 2015; safety management from design stage to construction completion; covers all path construction work and applies in full for projects lasting more than thirty days, or 500 man days.

Chamfer
Cut back or bevel the sides of ditching and embankments, to give sloping surface (batter) and avoid unstable vertical sides.

Clinometer
Small instrument for measuring gradients (calibrated spirit level).

Course, of stone
Single row or line of construction stones on a revetment wall, pitched path etc.

Cross-drain
Open top drainage channel, typically lined with stone; used to direct water from one side of the path to the other.

Cross-fall
Path surfaced with one edge higher than the other; allows surface water to flow off to the naturally draining slope or ditch.

Cross-slope
Slope across which the path traverses; land slopes up on one side of the path, and down on the other side.

Culvert
Covered drainage channel taking water from one side of the path to the other; stone and piped culverts are the most common types used in upland pathwork.

De-roughening
Removal of loose stone to informally define the path line.

Desire line
The preferred or easiest line taken by walkers; which is often to a landscape feature and not necessarily following the main path line.

Ditch/drain
Open channel used to catch, direct and disperse water flow.

Dynamism
Rate of change in path condition; depends on motive force of gradient, user numbers, water flow etc. A highly dynamic path will erode quickly; a path with low dynamism will be relatively stable.

Face stone
Upstand or side stone of drain channel: waterbar, cross-drain or box culvert; the face is the side of the stone which channels the water flow.

Fall-line
Most direct line from the top of a slope downwards.

Fines
Smallest size of stone in graded aggregate; helps in compaction and used alone for binding the top surface of path.

Flag stone
Large slabs of stone, normally sandstone; used for top of boxed culverts.

Ford
A solid, hard-wearing stone surface through rivers, large streams or burns; spreads the water flow by increasing the width of the watercourse, and enables an easier and safer crossing, though probably a wet one.

Friable
Refers to stone that breaks up easily; often exposed and weathered stone with visible fractures.

Frost heave
Freeze thaw effect of water under and through the path surface; lifts and breaks up the surface or drainage features.

Geotextiles
Synthetic, or man-made materials used in road construction and landscaping; meshes and matting adapted to float paths over areas of deep peat; biodegradable meshes used in site restoration.

Gradient
Angle or slope of the ground or path; long gradient refers to the slope along the path line.

Gullying
Eroded channels formed on or alongside the path; loss of vegetation and soil by force of feet and water.

Humps and hollows
Landscaping technique to keep walkers on restored path line; banks and dips created from spoil and turf; tested on Ben Lomond.

In-fill
See back-fill.

In-flow/out-flow
Water channelled into and out of a path drainage feature by ditching.

Keystone
Final, or first stone, that is used to lock together a section of stonework, or provide a firm base stone e.g. in pitching or revetments.

Lett
Small open channel at path edge; dug, or stone constructed, to allow small amounts of surface water or puddles to drain from the path surface.

Liner
Base stones of drain feature providing the water channel; stops the front or base of the drain eroding away and sheds water and debris away.

Maintenance
Routine inspection and minor repair of paths on a regular basis; includes clearing out drains, surface repair, site restoration.

Mineral
Material (aggregate) composed of small stone particles exposed once peat or soils have been eroded, or excavated; used for path surfacing, or infilling gaps in stone work.

Peat hags/Hags
Small islands or banks of peat; formed by the surrounding ground eroding away by water, feet or grazing.

People counters
Electronic instruments installed to count path users; various types available - pressure mechanisms used under path surface; sensory mechanisms at path sides; counts carried out manually using recording sheets.

Pigeon-holing
Early sign of sheet erosion and gullying on steep slopes; walkers use same foot placements, causing concentrated vegetation and soil loss, appearing as series of “pigeon-holes” down the slope.

Pitching
Random sized and placed stone forming a hard wearing, rough cobbled, mini step like surface; used on steep gradients where erosion is severe.

Pinning
Small stone wedges used to prevent movement of structural stone used in pitching, drains, revetments, etc.

Piped culvert
Drain channelling water across and under the path by means of a pipe; comes in a variety of materials, plastic most commonly used.

Remedial works
Repair work carried out under the contract; normally 9 to 12 months after completion of initial pathwork.

Revetment/ retaining wall
Formal or informal wall built to hold up unstable banks and steeply sloping ground; may be single or multiple course and above or below the path edge.

Re-vegetation
Restoring vegetation to eroded areas of ground; predominantly achieved by turfing over erosion scars, and by seeding.

Scour
Water erosion of the path surface; forms small channels which may lead to severe gullying.

Splash plate
Stone placed at the outflow end of a culvert, waterbar or cross-drain; prevents water eroding the path edge at the end of the drain.

Tensar
Proprietary product - plastic mesh or grid; used to strengthen, stabilise and prevent lateral movement of aggregate path.

Terram
Proprietary product - woven matting used to “float” aggregate paths over peat or soft clay; strengthens construction and separates aggregate from underlying soil.

Trample width
Survey term to describe the width of ground, including the main path line, that shows signs of having been walked on.

Traverse
A path line which crosses a side slope; avoiding the straight down route.

Tray
Excavated path line; prior to filling with aggregate or pitching.

Tread
Top surface of a pitched path or drain stone which is used by walkers as a foothold to “tread” on.

Upstand
Height of a drain face stone above the liner, or the pitched path stone above the lower stone tread; forms the “depth” of the drain and deflects the water, or forms the height of the pitched “step”.

Variation
Used on a path contract to vary the specification or bill of quantities; agreed in advance of the work being undertaken.

Waterbar
Drainage feature, usually stone, built across the path; diverts path surface water to the lower side slope.

Water-table
The water-table is the natural water level of saturated ground; often underground.

Weathered/ lichened stone
Stone with a natural appearance caused by exposure to the elements for many years; may have lichens growing on its surface.

Zigzag
A path line descending a steep slope by using a snaking line of alternate, angled traverses, rather than straight down the fall-line.

Further Reference

British Upland Footpath Trust (now the Upland Path Trust) (1998)
Mending our Ways; the quality approach to managing upland paths
Mending Our Ways outlines the principles for a quality approach to upland path work, providing good and bad examples.

Fieldfare Trust
Countryside for All Good Practice Guide (2005)
The standards for full accessibility in a rural and working landscape can be viewed here.

Health and Safety Executive
Comprehensive information on Managing Health and Safety in Construction are available from the HSE site.

Paths for All
Lowland Path Construction - A guide to good practice

Paths for All
Multi-use and accessibility factsheet

Paths for All (2010)
The Path Bridges - Planning, Design, Construction and Maintenance can be downloaded from here.

Scottish Access and Technical Information Network
SATIN shares technical information and promotes good practice.

Scottish Natural Heritage (2002)
Countryside Access Design Guide

Scottish Natural Heritage (2011)
Paths and Climate change

Scottish Natural Heritage
Outdoor Access Website
Information about statutory access rights, responsibilities, and management of access in Scotland.

Scottish Natural Heritage (2013)
Constructed Tracks in the Uplands

Upland Path Advisory Group (2003
Upland Path Management – Standards for delivering path projects in Scotland's mountains
Scottish Natural Heritage

Upland Path Trust (formerly the British Upland Footpath Trust)
Information about the Trust including the *Upland paths facing the future conference* report (2005) and a monitoring survey of the BUFT award scheme projects (2005) can be found here.