Appendix 1

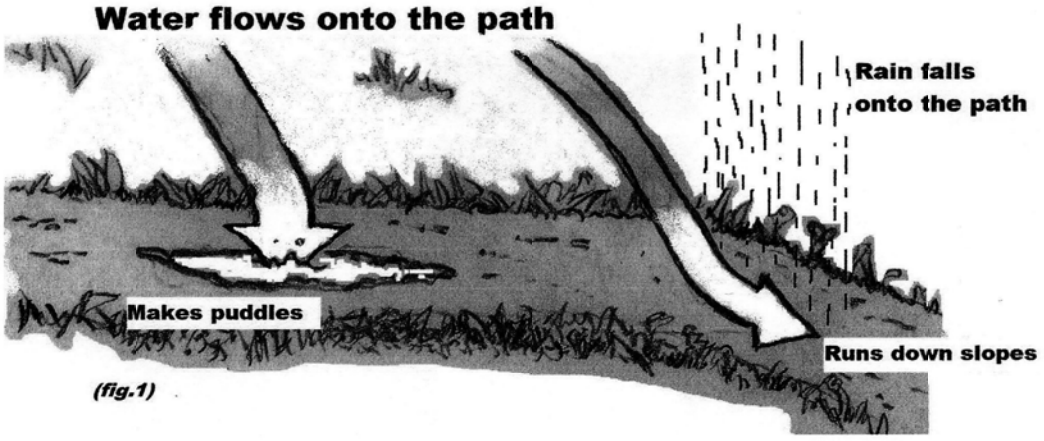
DRAINAGE

Appendix 1: Drainage

1.1: Overview

Water Damage

When water runs down a hillside onto a path, or when rain falls on it, puddles form. When the path goes downhill, it provides an easy channel for the water to flow along. As it goes it pulls material out of the path's surface, causing erosion.



(fig.1)

We need to get water off the path or, better, keep water away from it.

Getting water off the path – stone waterbar:

A **waterbar** intercepts water which is flowing down the path and turns it away to the side before it can erode the surface.

The **bar stones** turn the water to the side (A).

Paving stones provide a smooth surface to help it to run away fast (B).

When the ground at the side is flat, a channel is needed to take the water to a slope where it can run away (C).

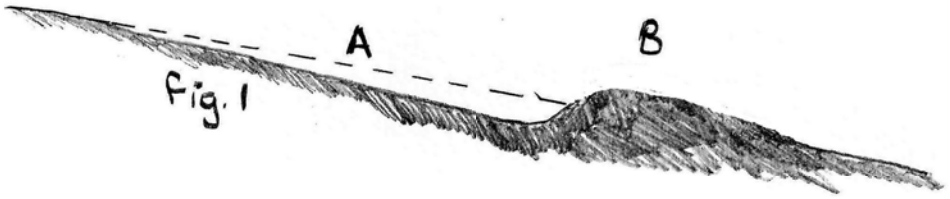
Roger Whysall

1.1: Overview

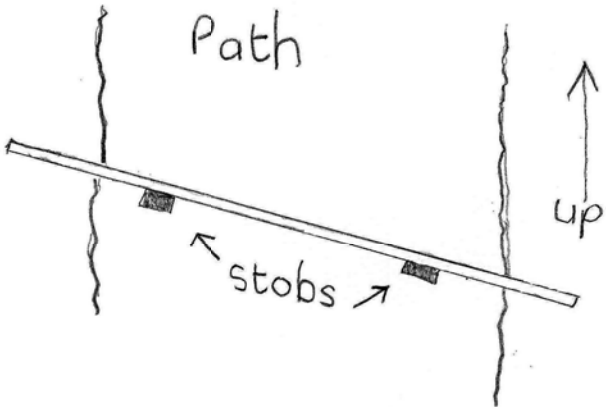
Getting water off the path - alternatives to stone waterbars:

Most often, waterbars are built of stone. In rare cases, due to shortage of material, these alternatives may be considered.

Earth bars: These can be surprisingly effective and they blend well into the landscape. However they require frequent inspection and maintenance. It is only possible to make them where there is good, sticky, material in the path which will consolidate well.

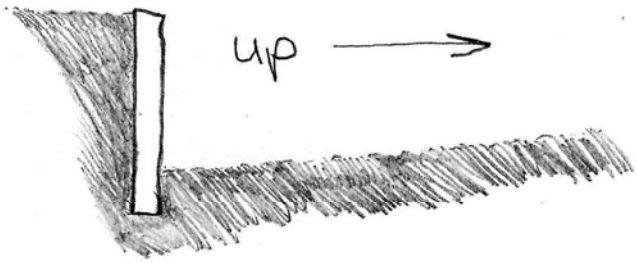


The path is graded down to where the bar stones would be in a stone waterbar (A). The spoil from this is used to raise a hump (B) which serves the same purpose as bar stones.



Wooden bars: These are not often used, and are less robust than stone, but can be appropriate in some situations, for example in woodland. The stonework is replaced with construction timber which is held in place by stobs. They can suffer from undermining, so require frequent maintenance.

Wooden bar, side view ----->

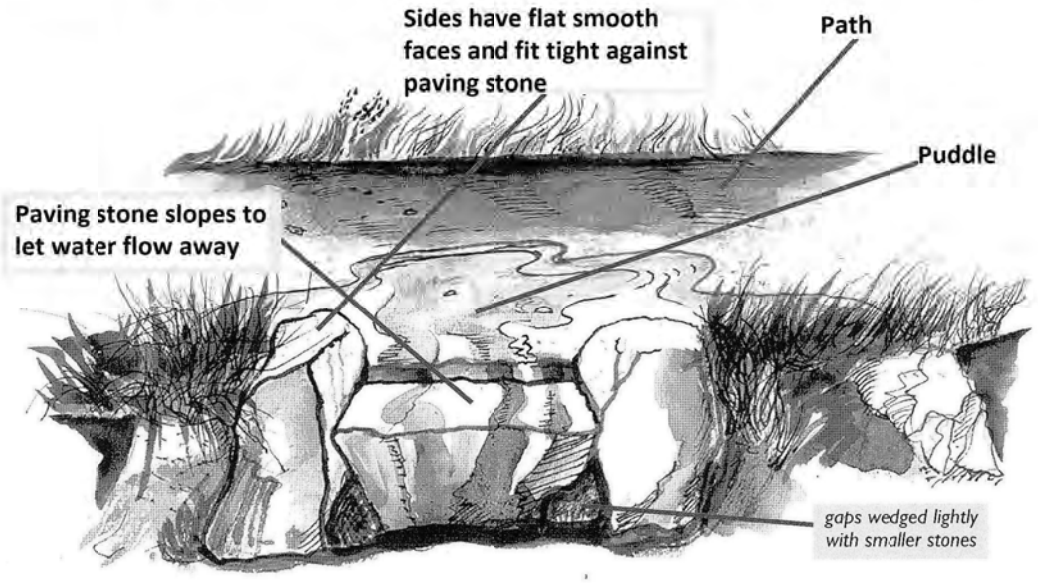


Appendix 1: Drainage

1.1: Overview

Getting water off the path - Letts:

A lett is a simple drainage channel cut through the edge of a path at a place where puddles form. Stone sides and paving help the water to flow away quickly and help to prevent the channel from becoming overgrown.



This illustration is reproduced from Upland Path Advisory Group, *Upland Pathwork* (2004), 2.2

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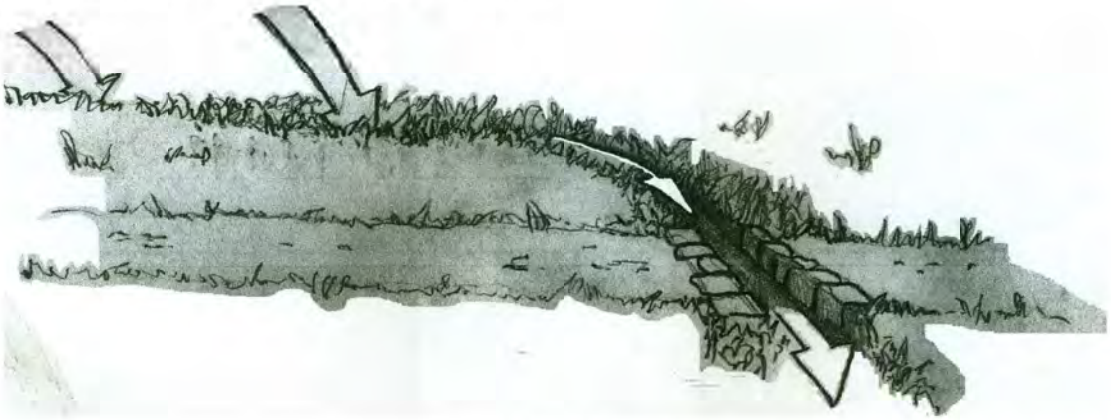
Appendix 1: Drainage

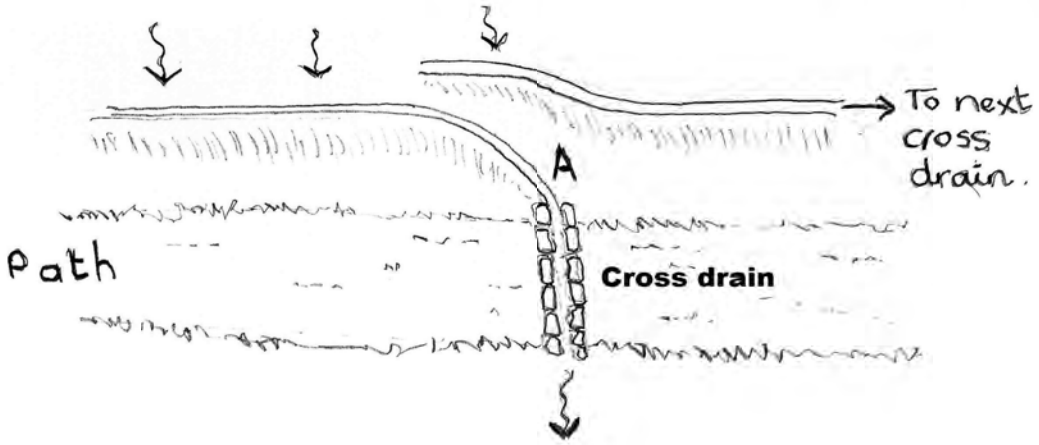
1.1: Overview

Keeping water away from the path - Side Drains and Cross Drains:

Water is intercepted by the *side drain..*

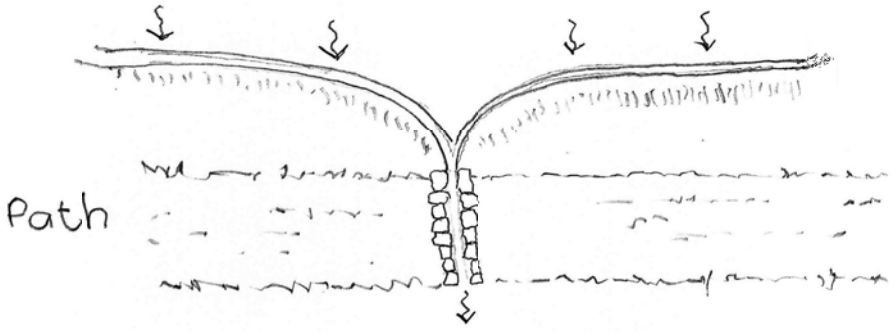


...and taken across the path by the *cross drain*.



When **a second side drain** is constructed it overlaps the first drain so that no water can run between them – see above. The turn made by the side drain into the cross drain is very gradual (A above). A sharp turn, 90 degrees for example, would concentrate the force of the water onto one small place which would soon erode away.

Sometimes, two side drains can be run into one cross drain.



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Appendix 1: Drainage

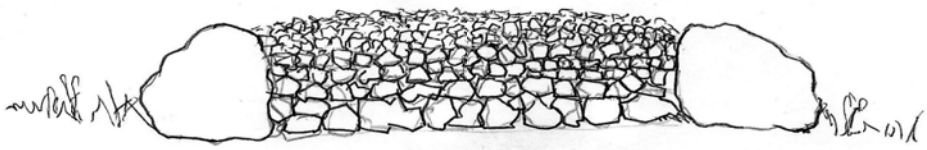
1.1: Overview

Keeping water away from the path - Hidden Drains:

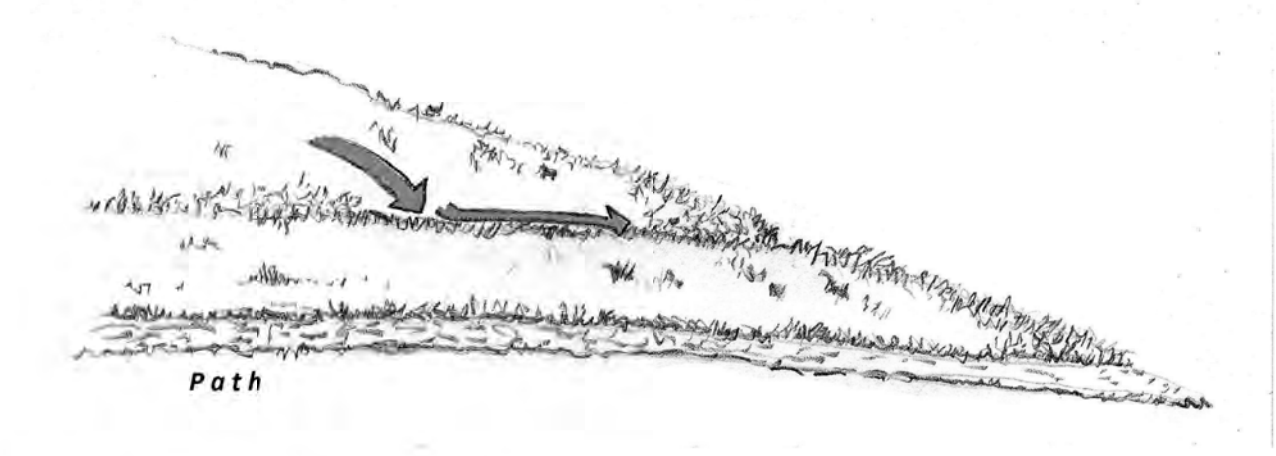
Sometimes water seeps through the ground, like water in a sponge. When it meets a path it runs out of the ground and onto the surface, creating puddles and erosion. A side drain will be of limited use in such a situation.

It may be possible to use 'hidden' drainage in addition to a side drain or instead of it. This allows water to pass through the path without collecting on the surface.

If wished, the path can be laid between retaining stones or revetments in order to raise it above standing water:



Keeping water away from the path – Grass-lined Gulley



If there is a slope nearby, a grass-lined lined gulley can be created to collect water and redirect it there, away from the path.

Appendix 1: Drainage - Guide Sheets

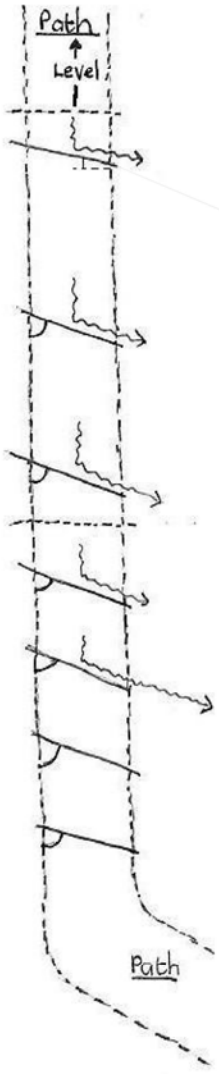
Contents:

Guide sheets will be found at the numbered locations.

(continued)

Contents (continued)

1.2a: Waterbars - Where to put them



---Downhill slope starts here---

Put the first waterbar near the top of the slope.

Make an angle of **30-40 degrees** to turn the water in the direction you want it to go.

<---**Repeat** at intervals,* to take water away before it gets faster and more destructive.

---Slope gets steeper---

<---So, put waterbars closer together*

<---- If the ground at the side is flat, a channel should be made to take the water to a slope where it can run away.

Protect a corner with a waterbar as it is vulnerable to erosion.

***How Far Should The Bars Be Apart?**

On a **Steep** slope of >10 degrees: <10m apart.

On a **Medium** Slope of 5-10 degrees: 10m-25m.

On a **Slight** slope of < 5 degrees: >25m.

These figures are taken from: Upland Path Advisory Group, *Upland Pathwork,* 2:3. Please think of them as advisory only and feel free to make your own decision based on conditions you see on site.

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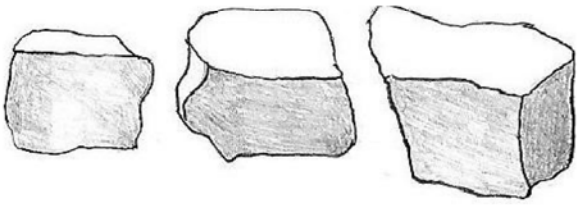
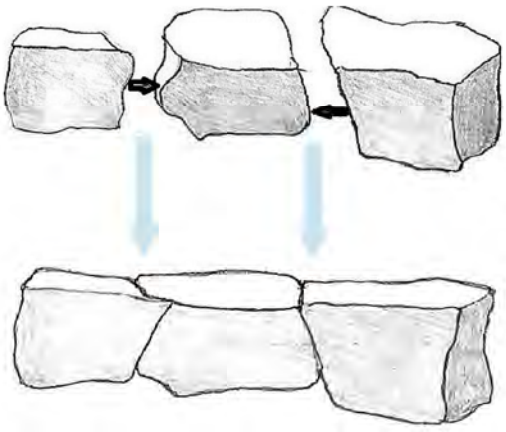
1.2b: Waterbars – selecting the stones

Bring together a selection of stones



Big and heavy. If you can lift a stone and carry it on your own it is probably too small.

Try to find stones which will have a fairly **flat** face and top.

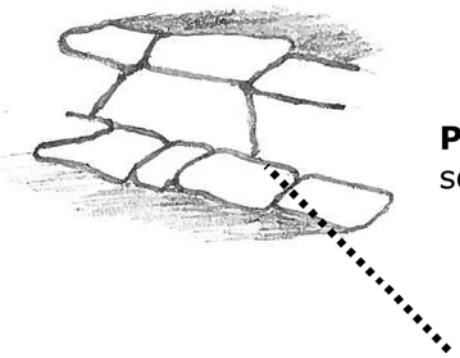


Stones need to fit tightly together or water will get through the spaces between.

Tops should be level to make them safe to walk on.

Try them out on the surface before you start building.

They need to be big enough for half to be buried below the tops of the paving stones.

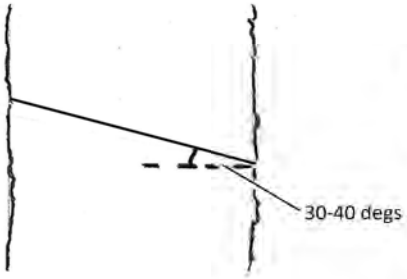


Paving stones should have flat tops, and be thick so water cannot get under them.

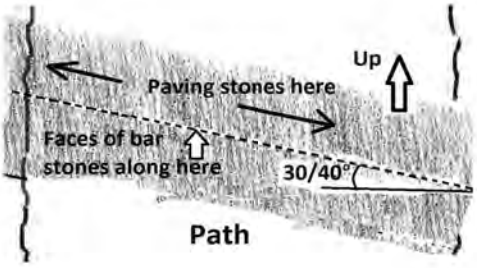
They should fit tight against the bar stones and should fit closely together. Joints between paving stones should not be next to joints between bar stones.

1.2c: Waterbars – Building the bar stones and paving stones part (i)

Building the bar stones:

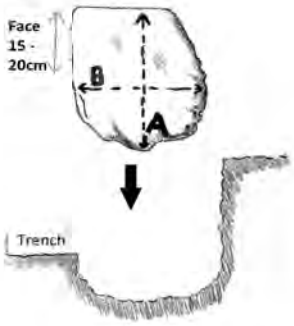


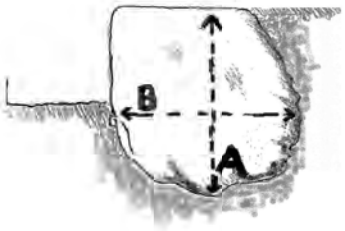
Mark a line across the path where the waterbar will be. Make an angle of 30-40 degrees to turn the water to the side.



Dig a trench along the line, approximately deep enough and wide enough for the stones. It should extend beyond the sides of the path by about 30cm.

Measure the first stone and mark the approximate shape of the hole it will need. Make adjustments to the trench so that it will fit.



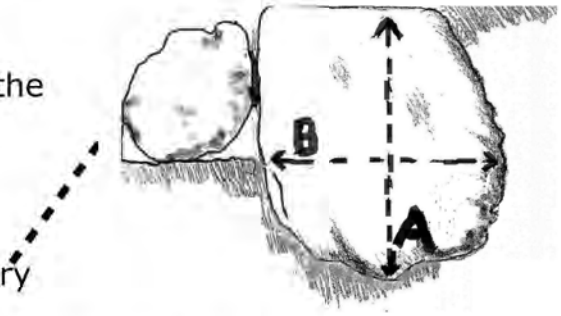


Measure the stone where it is deepest (A) and widest (B).

Keep the sides of the hole vertical – or the stone will get stuck and will not drop to the bottom.

Pack earth around it and make it secure.

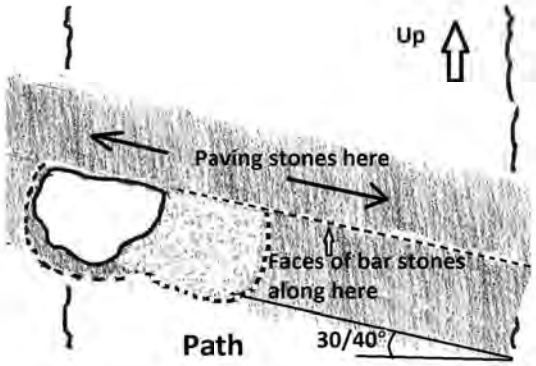
If necessary, use another stone for temporary support while you work around it.



Check: is the face vertical? Is the top level with the path behind it?

(Continued, *1.2d: Waterbars – Building the bar stones and paving stones part (ii); finishing*)

1.2d: Waterbars – Building the bar stones and paving stones part (ii); finishing



Prepare the hole for the second stone.

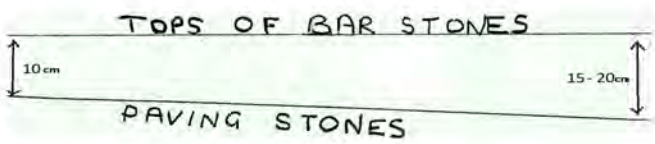
Put the second stone in and check as before. Make adjustments until the tops and faces are in line, and the stones fit tight together.

Repeat until all the bar stones are in.

Paving Stones:

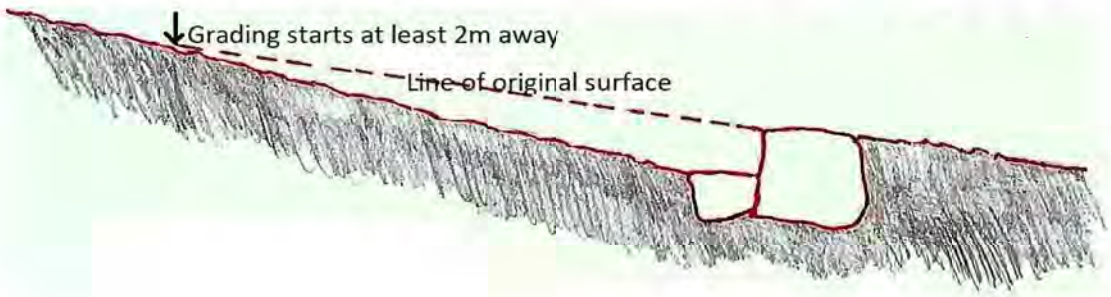
If possible, choose stones which fit together without leaving gaps. It's OK to use a small stone to fill a gap between paving stones if an exact fit isn't available.

The paving stones should slope gently down to the place where the water leaves the waterbar. Start building at the low end and work towards the high end.



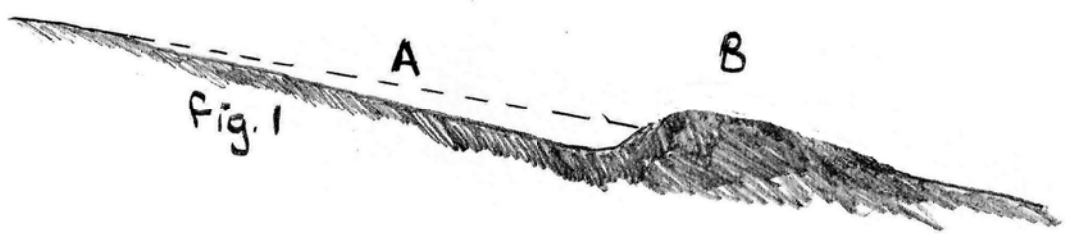
Adjust the depth of the trench to get the top of each paving stone to the right height. This will be around 15 - 20cm below the top of the bar stones at the lower end rising to 10cm at the upper end.

This means the slope is quite gradual. So **don't make it too steep** at the beginning or your stones will get too high too soon. Finally, **grade the path**, i.e. make a gentle slope from the original level of the path to the bar.



(See also *1:6a - Extra information for building stone waterbars and drains)*

1.2e: Waterbars– Building an earth bar



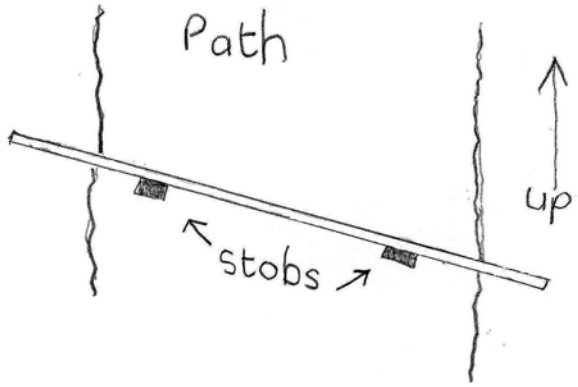
Grade the path surface as you would for a stone waterbar (A). Use the material you have removed to make a *low, wide,* mound across the path in the place where the bar stones would normally be (B). The face of the earth bar should slope to reduce erosion. On the downhill side, the slope down to path level should be as gradual as you can make it – if available, extra earth can be added for this. Stamp the earth down to make it firm.

Avoid making the kind of hump shown in fig.2. This is unstable and will soon break down. The bar should be low and broad to withstand being walked on.

Good earth bars are a subtle and attractive re-landscaping of the path. They require time and patience to get right. They should not be a hasty 'quick fix'.

1.2f: Waterbars – Building a wooden bar

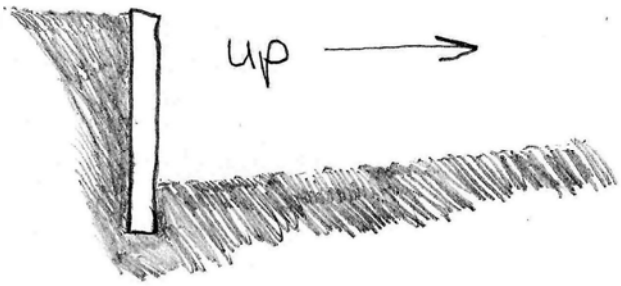
These are not often used now but they have been used in the past and sometimes we have to rebuild them. We should avoid building new ones. They are unstable and are much less robust than stone. Construction timber is used instead of bar stones and is held in place by stobs. They can suffer from undermining, so require frequent maintenance.



The timber should, if possible, be well dug into banks at the side of the path as this helps stability.

Stobs are fixed behind the bar timber. This is not as strong as putting them in front but they would impede the flow of water if they were there.

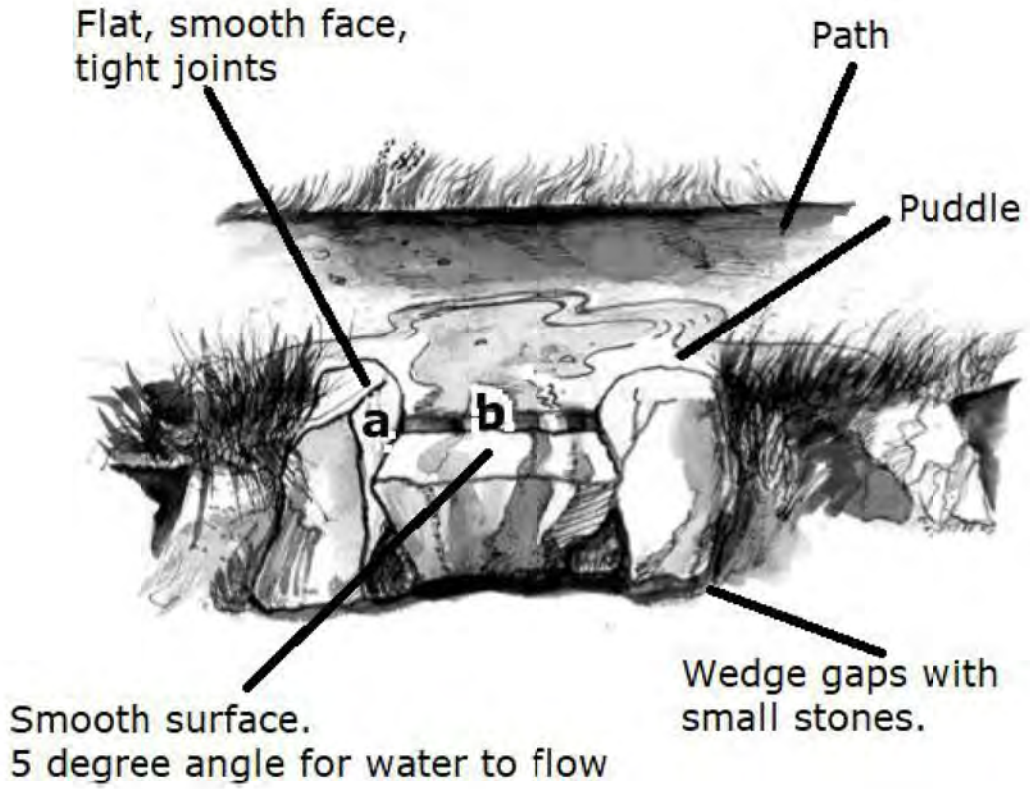
Wooden bar, side view ----->



Grading the path and landscaping are the same as for stone water bars. (See *1.2d Waterbars – Building the bar stones and paving stones part (ii); finishing.*)

1.3a: Building a lett

A lett is a simple drainage channel cut through the edge of a path at a place where puddles form. Stone sides and paving help the water to flow away quickly and help to prevent the channel from becoming overgrown.



This illustration is reproduced from Upland Path Advisory Group, *Upland Pathwork* (2004), 2.2

- Build the lett where a puddle forms, causing erosion or forcing walkers to step off the path, but where there is not enough water to make a water bar necessary.
- The instructions here are for a stone lett, but if you have no stone it is OK to just dig a small channel out through the side of the path. This can also be done when the need for drainage is only temporary.

(*Continued, 1.3b Building a lett (continued)*)

1.3b: Building a lett (continued)

The lett should be at least as wide as a spade, for easy cleaning.

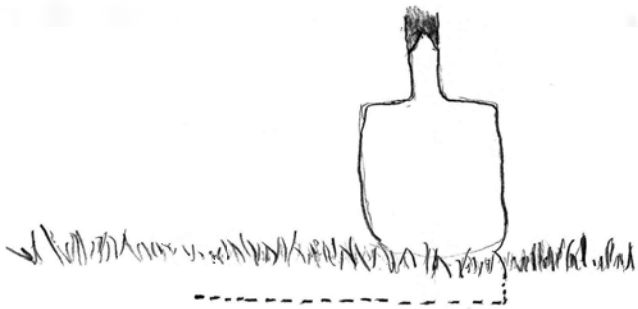
Build the lett

- at the side of the path,
- at the deepest part of the puddle,
- with the paving stone level with the surface of the path (b),
- with side stones vertical or leaning away slightly, and at least 10cm higher than the path surface.
- side stones should be at least 30cm deep, with at least half buried below the surface of the paving stone.
- The paving stone should be at least 20cm thick: if it is too thin water can get under it.
- The paving stone should slope slightly to help water to get away (5°).
- If the ground at the side of the path is flat the water may not move away quickly enough. If so, add an extra paving stone at the end of the first one, a few centimetres lower. It may also help to dig a channel to a nearby slope.
- When the stone work is finished, restore the turf and plants.

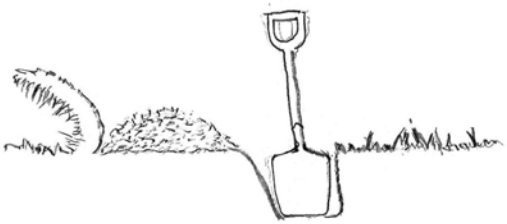
1.4a: Building a side drain

(fig.1)

The profile above shows (A) A bank to prevent water overflowing onto the path. (B) Sloping sides which help against erosion, and which receive some sunlight to encourage growth of grass etc. which helps to strengthen the sides. Turf, when available, is laid to also help with this and to improve the appearance (C).

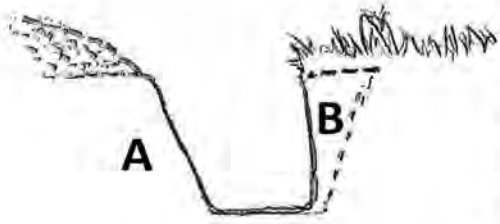


Mark out the line you wish the drain to follow, then cut the turf and roll it back or remove and store it. Take up enough turf to make space for the drain and the bank.



The drain should be about as wide and as deep as a spade end.

The bank is made from the earth which is taken from the drain.



Create the sloping side at A as you dig the drain. Then, under-cut the turf on the other side at **B** and take out earth to make the sloping side. When this is done, bend the under-cut turf down the side as far as it will go (fig.1 above).

It is not always possible to do this because the turf is weak or non-existent. If there is some weak turf, cut it away, cut the side of the drain, then pin the turf in place using sharpened sticks.

The side drain should slope gently down to the cross drain to aid water flow. Check it as you dig and level out any humps. If possible start to make the side drain at the cross drain and work away from it to ensure a good fit.

Roger Whysall

1.5a: Cross drain – positioning, placing the first side stone.

Side Stones:

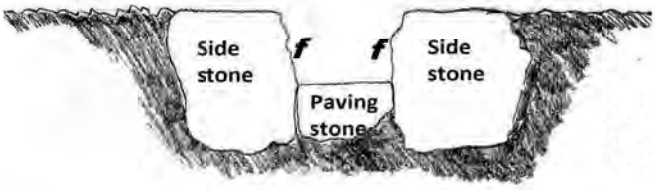
Dig a trench where you want the cross drain to be. (Unlike a waterbar, this can go straight across without being angled.)

The stones will fit in the trench as shown here:

Faces of side stones along here - - - -

Paving stones here - - - - - - - - - - -

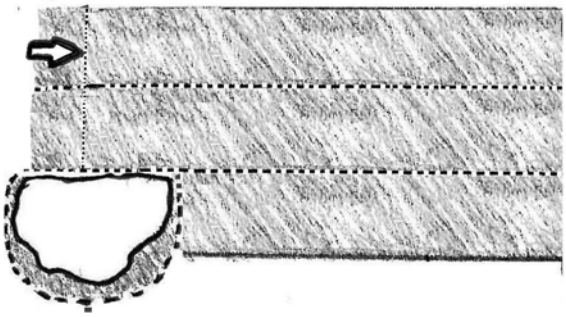
Faces of side stones along here - - - -

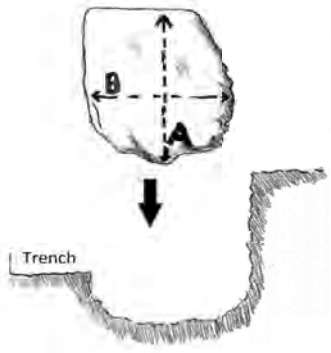


The faces of the side stones (*f*) are vertical, or sloping back slightly. They should not lean forward as they would get pushed over. The drain should be wide enough to be cleaned out with a spade. Width can be varied according to expected water flow but must not be too wide to step over easily. Side stones are buried at least 1/3 below the top of the paving stones.

The drain extends beyond the edge of the path by about 30cm.

Measure the first stone and mark the approximate shape of the hole it will need. Make adjustments to the trench so that the stone will fit.



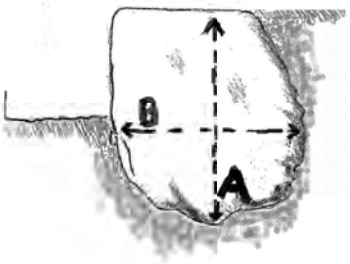


Measure the stone where it is deepest (A) and widest (B).

keep the sides of the hole vertical – or the stone will get stuck and will not drop to the bottom.

(Continued, *1:5b Cross drain – side stones (continued)*)

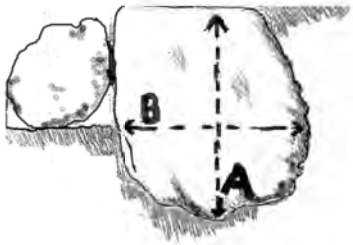
1.5b: Cross drain – side stones (continued)

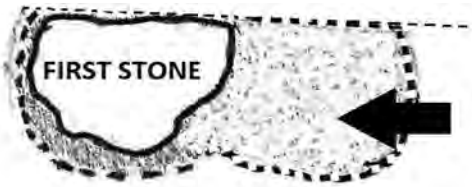


Pack earth around the stone and make it secure.

Check: is the face vertical? Is the top level with the path behind it?

If necessary, use another stone to provide temporary support while you work around it.





Prepare a hole for the second stone.

Put the second stone in and make adjustments until the tops and faces are in line, and the stones fit tight together.
Repeat until all the side stones are in.

Next: line the channel with paving stones: see *1.5c: Guide to Construction – Cross Drain, Paving Stones.*

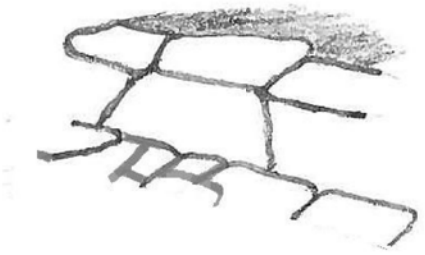
1.5c: Cross drain - paving stones.

When the two sides are built, **lay a 'floor' of paving stones** between them. Try to choose stones which fit together without gaps.

It's OK to use a small stone to fill a gap between paving stones if an exact fit isn't available. This should be **built in, not pushed in** at the end as it would soon wash out.

The paving stone 'floor' should slope down from the end where the water comes in from the side drain to the end where it leaves the cross drain. **The slope should fall about 9cm for every 1m of length.** but can vary depending on how much water is expected. (Upland Path Advisory Group, *Upland Pathwork,* 2-4)*. Start building at the low end and work towards the high end.

Adjust the depth of the trench to get the top of each paving stone to the right height.



Paving stones should fit tight against the **side stones** and should fit closely together. Joints between paving stones should not be next to joints between bar stones.

* *Upland Pathwork* gives the recommended slope in degrees: 5 – 10 degrees for a cross drain. The formula to convert from degrees to a ratio is:

degrees x 1.75 x metres = fall in cm.

So for a drain which is sloping at 5 degrees and 3m long:

5 x 1.75 x 3 = 24.75cm

This approximates to 8 or 9 cm fall per 1 metre length.

This is quite steep compared to a waterbar, so it is OK to vary it according to the expected volume of water, but bear in mind that a strong flow of water helps to clear debris from the drain.

See also: *1.6*a - *Extra information for building stone waterbars and drains*

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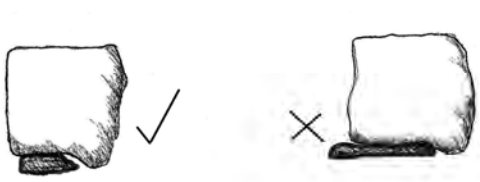
1.6a: Extra Information for Building Stone Waterbars and Drains



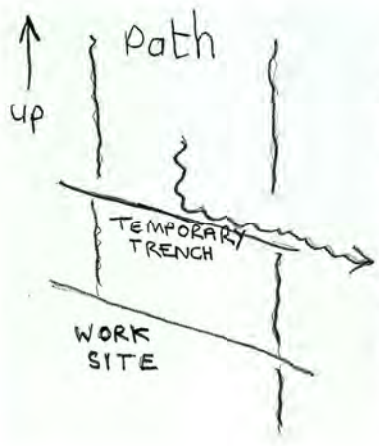
It's OK to place smaller stones under side and paving stones to adjust the level. They must not stick out beyond the stone's 'footprint', as they would get in the way of adjacent stones.

If it is impossible to find an exact fit between two stones, a small projection is acceptable, but only in the way shown here (viewed from above).

A is acceptable because the water is thrown out beyond the joint: flow is not interrupted. **B** is unacceptable because the projection catches the water and drives some of it into the joint.

It's OK to use a smaller stone to fill a gap between side stones or paving stones when a tight joint is impossible – but this must be firmly built in; it must not be pushed in at the end of the job, as it would soon wash out.

The perfect stone does not exist in nature. We have to do the best job we can with the best stones we can find. It is OK to use imperfect ones when they are the only ones available. Tops which are not exactly flat and faces which are a bit lumpy often have to be used. **But-** never use stones which are too small (will soon be frost lifted), and avoid spaces between stones (water will get through and erode the path).

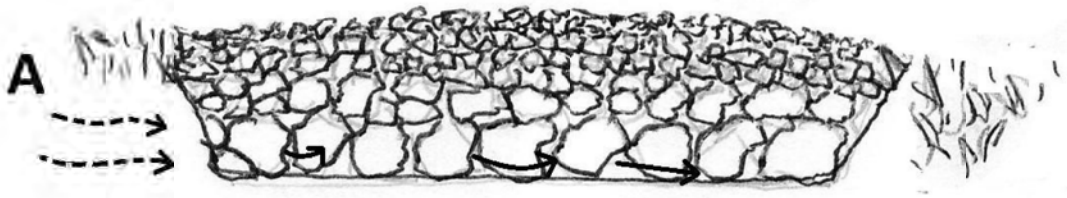


If you are working on **a path which has water flowing down it**, it can be helpful to dig a temporary trench to take the water away from where you are working.

And remember, **frost lifting**, i.e. moisture freezing under a stone, expanding and ratcheting the stone out of its hole, is a problem in Iceland. Use big heavy stones to prevent this.

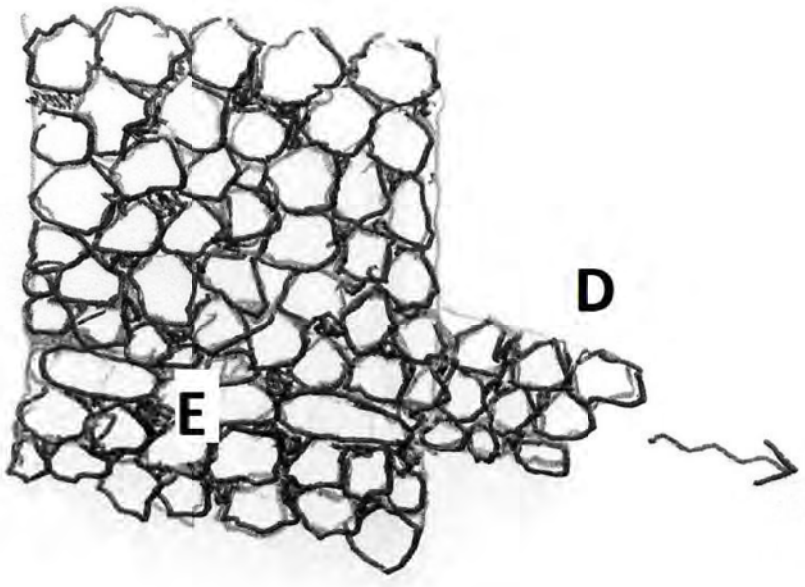
Roger Whysall

1.7a: Hidden drain, basic



Cut a tray for the path. In the bottom of the tray, place a layer of large stones – about the size of an apple and irregular in shape. Spaces between the stones will allow incoming water to flow through (A). Place a layer of smaller ones – about the size of an egg – on top of these. Then add a layer of smaller ones than these and finish off with a surface of gravel.

At intervals dig a side channel to take water out of the path (D). If possible take it to a lower point where the water can flow away. Line this with stones. If the path is sloping, a row of larger stones can be used to turn the water into the channel (E). These need not be as precise as in a water bar, and will be hidden by the upper layer of stones.



(*Continued, 1:7b - Hidden drain continued; hidden drain with raised surface*)

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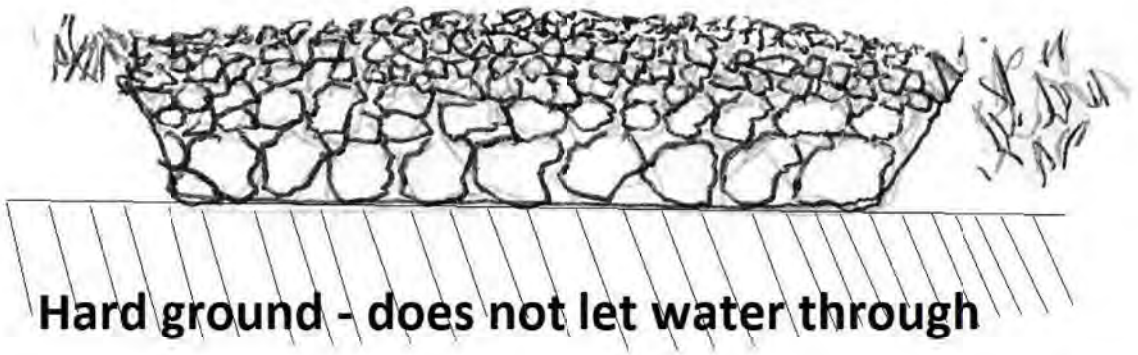
1.7b: Hidden drain continued; hidden drain with raised surface

Sometimes there is a layer of impervious ground below the waterlogged ground. If it is close enough to the surface it can be used as the bottom of the path tray. This will improve the stability and effectiveness of the path. It is worthwhile to investigate for this possibility before work starts.



On ground which has standing water or which is intermittently flooded, a similar technique can be used to make a raised path supported at the sides by large rocks or wooden revetments (below).

Caution: the collection and sorting of the right stone makes this work very labour intensive. Unless stone is sourced from an off-site supplier, projects should be only attempted which are small in extent, and trail teams should only do the work for a maximum of 2-3 days at a time.

1.8a: Building a grass lined gulley

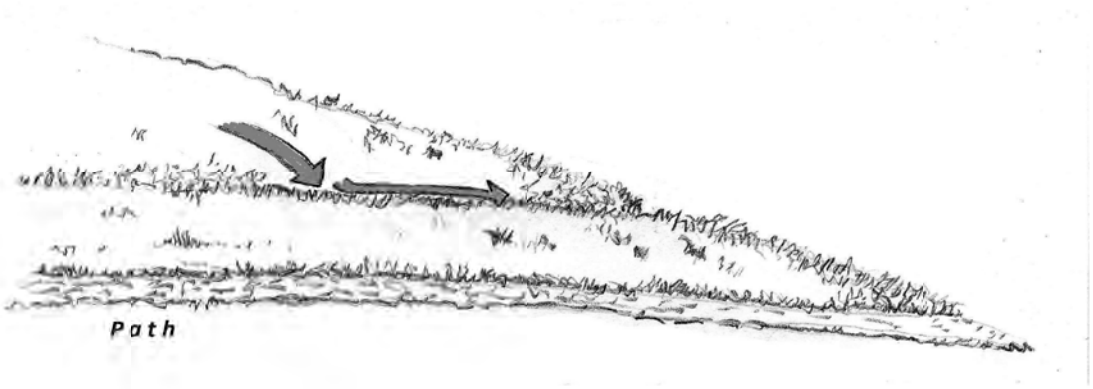


fig.1

If there is a slope nearby, a grass lined lined gulley can be created to collect water and redirect it there, and away from the path.

To make the gulley: cut and roll back, or remove and store, the turf. Then remove and dispose of earth to make a gulley with gently sloping sides (*fig.2).*

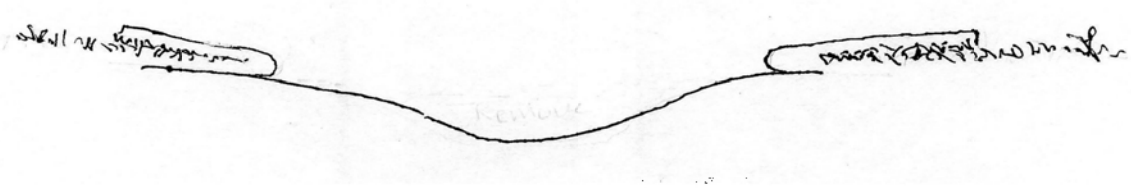


Fig.2

Roll back, or replace, the turf. If there is spare turf available, use it to patch any spaces between the sides (fig.3, (A)).

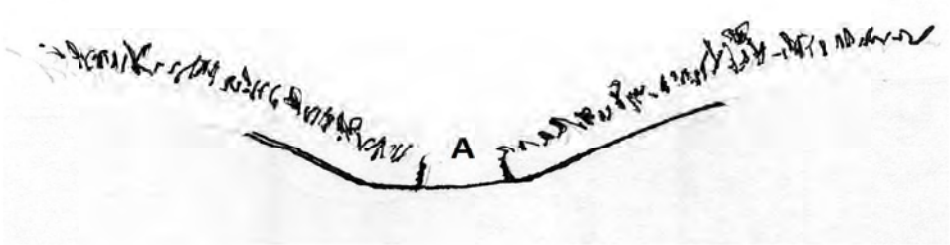


Fig.3