Country Fords Embankments and Underpasses

Scope

This guide provides an introduction o the construction and maintenance of fords embankments and related structures. It is not intended that this guide replaces competent advice as each water course and its landscape introduce their own conditions.

Larger vehicle embankments will normally be subject to Highways Agency approval and probable construction. The description given is for information only.

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1 Fords

Fords are impassable by electrically operated mobility vehicles and unless the surface is regularly smoothed forms a hazard for people with mobility and visual impairments. A guard-rail to assist movement should be provided on the up and downstream sides of the ford. There should be a level waiting area at each end of the ford where people can wait while others are assisted across the ford.

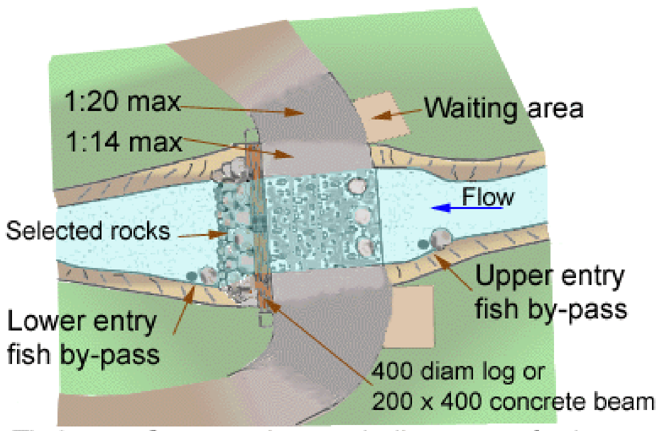
Stepping stone crossings are unusable by most older and disabled people.

Provision of a suitable footbridge as an alternative should be considered. Alternatively signage should be provided at the junction before the ford warning of the obstruction.

Generally, fords (or drive-through/unimproved crossings) are not acceptable permanent stream crossing due to sedimentation of the stream and damage to the banks. The idea behind a shallow stream ford is to provide solid footing, at a consistent depth from one bank to the other. Most fords are not designed to be used during high runoff, but are intended to be used when flows are moderate to low.

Fords are sometimes used for low-water crossings where transportation requirements are seasonal and stream channel and slope configurations are suitable. Fords with concrete sills or grade-control structures can be barriers during low-flow conditions, but they can usually be mitigated in the design. Fords are preferable to culverts for fish passage because high-flow migration is unimpaired and low-water migration is easy to accommodate.

Properly designed submersible crossings can be an economical solution to river crossings with low levels of traffic. They are only viable where normal daily flow over the structure is less than 150 mm deep and where flooding occurs for no more than about two weeks per year.

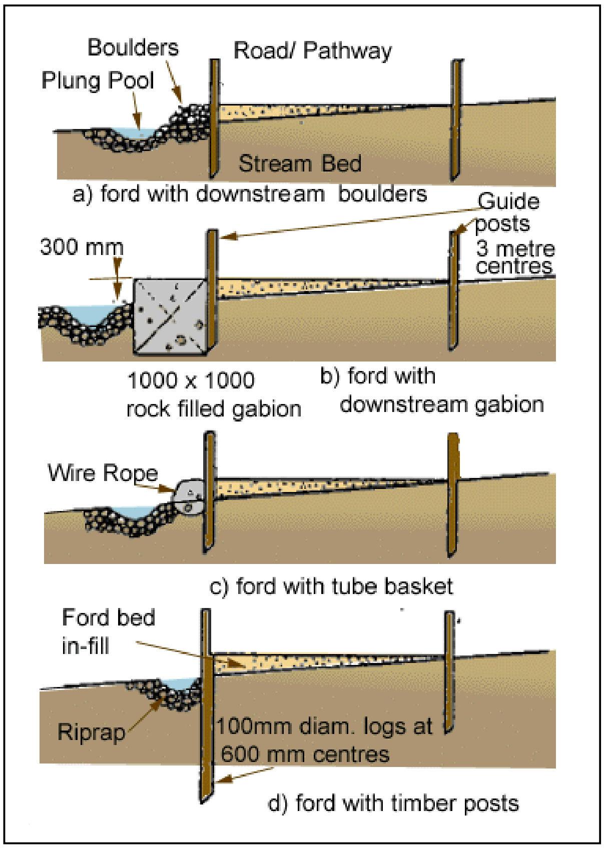


Timber or Concrete beam shallow water ford

Hydraulic design is of primary importance because most damage to the structures results directly from scour. For this reason it is also recommended that the design includes provision for ease of maintenance.

A ford is an alternative but non-accessible way to cross a water course:

- **The streambed has a firm rock or coarse gravel bottom, and the approaches are low and stable enough to support traffic.**
- **The streambed does not contain over 150 mm of soft sediment.**
- **Traffic is limited to low volumes of light vehicles.**
- **Water depth is less than 600 mm (1 metre max.).**
- **If corduroy, coarse gravel, or gabion is used to create a driving surface, it should be installed flush with the streambed to minimise erosion and to allow fish passage.**
- **Large stones placed across the river bed at the downstream side of the crossing are reputed to filter the flow of water and retain gravel and sand, which eventually form a more level and even surface for users. However, if the stones are too large or form too high a wall, scour will result. If they are not heavy enough, they will be washed away at the first flood. See Ford Types below**
- **Crossings should be at right angles to the stream.**
- **Stabilise the approaches by using non-erodible material. The material should extend at least 15 metres on both sides of the crossing. Ramp inclines should be no greater than 1:15 for pedestrians traffic, 1:12 for horses and 1:5 for vehicle only use.**
- **Approaches should have water barriers to prevent road water run off entering the stream where the runoff may be highly contaminated by traffic.**



- **A waiting area should be available on single track crossings suitable for vehicles and horses.**

- A depth measurement gauge should be placed where users from either side of the ford can read off the current depth of water over the bed. Readings should have large clear markings and text so that it can be read at a distance, e.g. when water levels rise and force readers to stand back.

Factors to consider in choosing a ford crossing of a stream are:

- Fish and water life needs;
- number of crossings planned, with what type of vehicles;
- permanence of the crossing site.;
- stability and natural rock armouring of stream bed and banks;
- time of year crossing planned;
- whether this is an existing, historic ford crossing;
- accessibility to people with movement impairments and their needs.

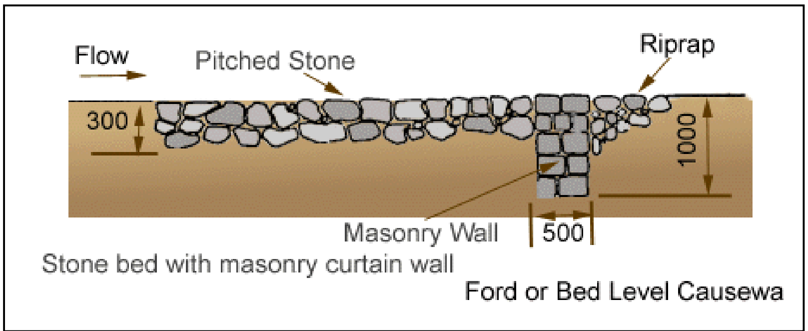
Armouring the streambed and banks with rock, or concrete planks fastened together can provide an improved ford crossing.

The simplest solution to the inadequate water depth problem at fords is to install a pipe or culvert to carry low flows beneath the roadway, allowing the high flows to pass over the roadway. The culvert can be much smaller than would be required if flood flows had to be conveyed, but (for example) it should not be below 300 mm diameter for trout passage or 450 mm diameter for salmon passage. Such small diameter pipes are vulnerable to blockage by debris so regular inspection and maintenance may be required. Pipes installed beneath natural bed level will also be subject to blockage through silting. This alternate route also helps provide slower moving water more suited to sedentary fish which are generally less strong swimmers than migratory fish. The entry should be protected by a bay or large rock to provide a back water and the upper entry should not face into the current to help calm water flow in the culvert. The culvert should not be a potential trap for children and dogs when sited on pathways.

Note: With natural bed fords the bed is subject to washout and may have changed location following a flood.

1.1 Common Trouble Points

- Inadequate flow capacity and/or lack of overflow area around structure; this results in washout



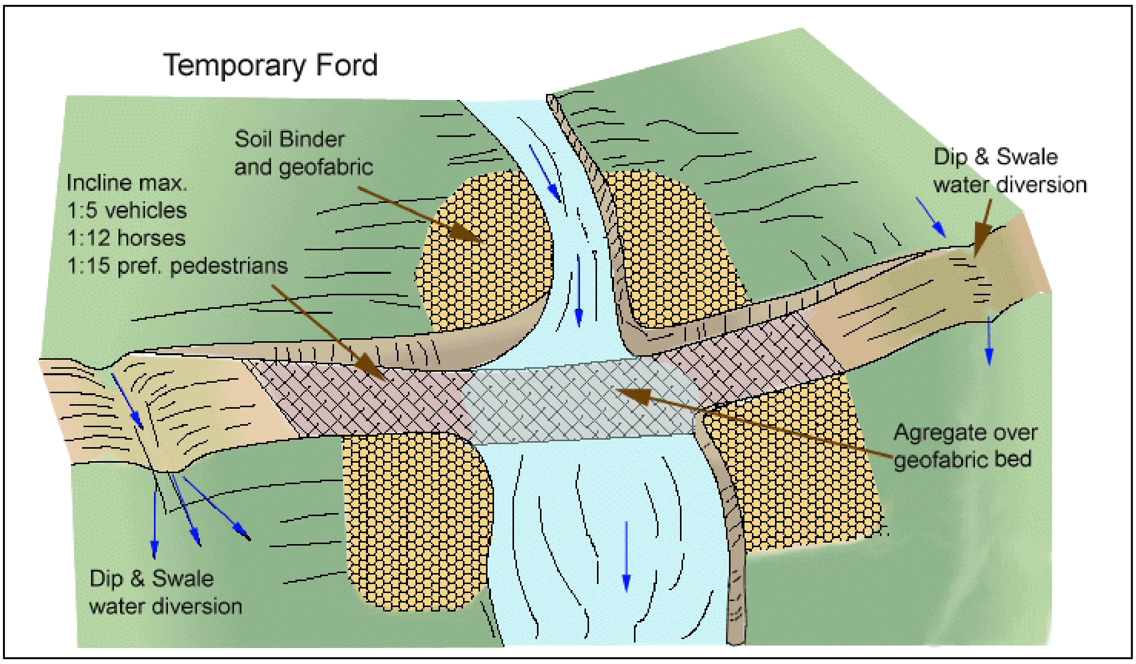
of culverts or bridge abutments.

- Inadequate stabilisation of overflow area; this results in severe erosion around bridges and culverts.
- Exit velocity from culvert or bridges too high; high exit velocity causes stream channel erosion and may eventually cause erosion of bridge abutments/piers or culvert fill.
- Debris not removed after a storm; debris clogging may cause washout of culverts or bridges.
- Inadequate compaction under or around culvert pipe; culverts wash out due to seepage and piping.
- Stone size too small; a ford can wash out.
- Culvert pipes too short; use of too short pipes results in a crossing supported by steep, unstable fill slopes.

1.2 Temporary Fords

Temporary stream crossings are used as access points to construction sites when other detour routes may be too long or burdensome for the construction equipment.

Often heavy construction equipment must cross streams or brooks, and detour routes may impose too many constraints such as being too narrow or poor soil strength for the equipment loading. Additionally, the contractor may find a temporary stream crossing more economical for light– duty vehicles to use for frequent crossings, and may have less environmental impact than construction of a temporary access road.



Temporary fords should only be used in low rainfall periods, if work must be carried out during high rainfall seasons a temporary bridge and culvert should be used.

For temporary or short term use crossings, fords should only be used where the stream has an applied or existing firm base. Riprap stone, brush, poles, or other materials stabilise the road or path approach to a ford and the streambed to protect the stream channel. The ford base materials should not reduce the depth of water through the ford otherwise it will act as a weir or may be washed away.

A temporary ford provides little sediment and erosion control and is ineffective in controlling erosion in the stream channel. A temporary ford is the least expensive stream crossing and allows for maximum load limits. It also offers very low maintenance.

Stone is usually not removed after path/road use ceases, but poles, brush, and other materials are removed.

This is not an 'accessible' route and is unsuitable for cycles.

Inspect temporary stream crossings after runoff-producing rains to check for blockage in channel, erosion of abutments, channel scour, riprap displacement, or piping. Make all repairs immediately to prevent further damage to the installation.

2 Ford Construction

Design and installation requires knowledge of stream flows and soil strength. Designs should be prepared under direction of, and approved by, a competent civil engineer and for bridges, a competent structural engineer. Both hydraulic and construction loading requirements should be considered with the following: (not listed in order of importance)

- **know what fish, water life uses the location and their particular needs, including those of juveniles,**
- **adequate depth of water for fish at the time of passage,**
- **appropriate water velocity for fish,**
- **adequate fish resting places above and below the structure,**
- **no physical obstructions to fish passage,**
- **Ensure that bypass channels necessary to de-water the crossing site are stable before diverting the stream. Upon completion of the crossing, fill, compact, and stabilise the bypass channel appropriately.**
- **Comply with any special requirements for culvert and bridge crossings, particularly if the temporary stream crossing will remain through the rainy season.**
- **Provide stability in the crossing and adjacent areas to withstand the design flow. The design flow and safety factor should be**

selected based on careful evaluation of the risks due to over topping, flow backups, or washout.

- Install sediment traps immediately downstream of crossings to capture sediments. These should not restrict fish passage, where necessary install a fish stairs.
- Avoid using oil or other potentially hazardous materials for surface treatment. Divert all surface water from the construction site onto undisturbed areas adjoining the stream.
- Culverts are relatively easy to construct and able to support heavy equipment loads.
- Fords are the least expensive of the crossings, with maximum load limits.
- Material excavated from the streambed or banks should not be placed in any surface water body or wetland and must not be placed in a floodplain where it will obstruct flood flows.
- Ensure that design flow velocity at the outlet of the crossing structure is non-erosive for the receiving stream channel.
- Consider overflow for storms larger than the design storm and provide a protected overflow area.
- Design erosion practices associated with the stream crossing to control erosion from surface runoff at the crossing and during a 10-year peak storm runoff.

Crossing structures can consist of clean, washed gravel over geofabric or gravel and cellular confinement system blocks. Either angular or naturally occurring rounded gravel, because the cells provide the necessary structure and stability. Natural gravel is optimal for this technique, because of the habitat improvement it will provide.

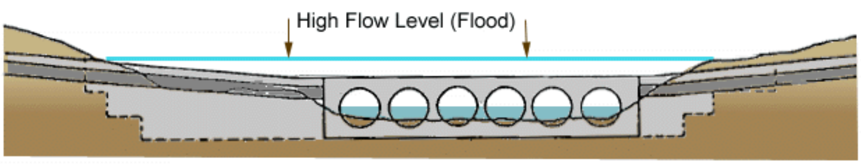
A gravel depth of 150 to 300 mm for a ford base structure is sufficient to support most construction equipment.

These are appropriate for streams that would benefit from an influx of gravel; for example, salmon streams, streams or rivers below reservoirs, and urban, channelled streams. Many urban stream systems are gravel-deprived due to human influences, such as dams, gravel mines, and concrete channels.

2.1 Construction and Use

- Stabilise construction roadways, adjacent work area, and stream bottom up and down stream against erosion.
- Construct during dry periods to minimise stream disturbance and reduce costs.
- Construct at or near the natural elevation of the streambed to prevent potential flooding upstream of the crossing.

- **Install temporary erosion control to minimise erosion of embankment into flow lines.**
- **Any temporary artificial obstruction placed within flowing water should only be built from material, such as clean gravel or sandbags, that will not introduce sediment or silt into the watercourse.**
- **Temporary water body crossings and encroachments should be constructed to minimise scour. Cobbles used for temporary water body crossings or encroachments should be clean, rounded river cobble.**
- **Vehicles and equipment should not be driven, operated, fuelled, cleaned, maintained, or stored in the wet or dry portions of a water body where wetland vegetation, riparian vegetation, or aquatic organisms may be destroyed.**
- **The exterior of vehicles and equipment that will encroach on the water body within the project should be maintained free of grease, oil, fuel, and residues.**
- **Drip pans should be placed under all vehicles and equipment placed on docks, barges, or other structures over water bodies when the vehicle or equipment is planned to be idle for more than one hour.**
- **Disturbance or removal of vegetation should not exceed the minimum necessary to complete operations. Precautions should be taken to avoid damage to vegetation by people or equipment. Disturbed vegetation should be replaced with the appropriate soil stabilisation measures.**
- **Riparian vegetation, when removed pursuant to the provisions of the work, should be cut off no lower than ground level to promote rapid re-growth. Access roads and work areas built over riparian vegetation should be covered by a sufficient layer of clean river run cobble to prevent damage to the underlying soil and root structure. The cobble must be removed upon completion of project activities.**
- **As an alternative to conventional gabions, tube baskets can be made from a roll of fencing mesh filled with stone or shingle.**



Vented Causeway

During filling, the edges are raised and then bent over at the top

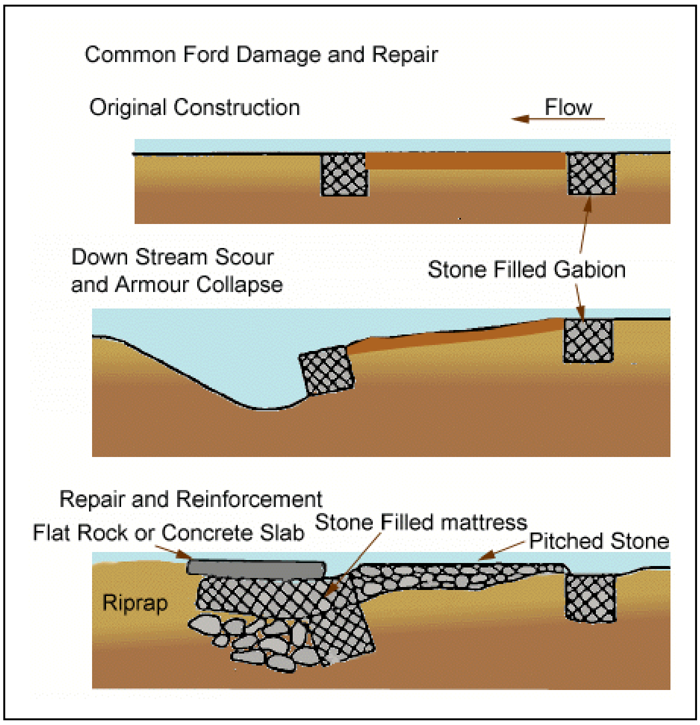
to form a tube and tied; finally a wire rope is attached and securely anchored at each end. As with gabions, tube baskets need to be installed in a previously excavated trench approximately half the depth of the basket, i.e. 0.2 to 0.3m.

- a vented causeway or submersible bridge may be used in some locations where for short periods the bridge becomes overtopped by flood waters. The causeway remains usable by vehicles but is dangerous for pedestrian use. Suitable signage should be provided to warn of the hazard in time for pedestrians etc. to take an alternate route.

2.2 Inspection and Maintenance

Submersible crossings of all types require more frequent maintenance than most conventional bridges. Therefore the structural design should allow for easy repair of anticipated damage, which is usually caused by scour. On very erodible beds it is often more successful to build gabion curtain walls and use reno-mattress aprons rather than a rigid concrete structure, and to accept that some rebuilding will be required each year.

- Inspect and verify that activity-based protections are in place prior to the commencement of associated activities. While activities associated with the protection systems are under way, inspect weekly during the rainy season and at two week intervals in the non-rainy season to verify continued protection effectiveness.
- Check for blockage in the channel, sediment build up or trapped debris in culverts, blockage behind fords or under bridges
- Check for erosion of abutments, channel scour, riprap displacement, or piping in the soil
- Check for structural weakening of the temporary crossings, such as cracks, and undermining of foundations and abutments



- Remove sediment that collects behind fords, in culverts, and under bridges periodically
- Replace lost or displaced aggregate from inlets and outlets of culverts and cellular confinement systems
- Remove temporary crossing promptly when it is no longer needed

3 Temporary Stream Diversion

Temporary stream diversions are used to divert or reduce stream flow from a critically erodible area disturbed by construction within the normal stream path until such areas can be stabilised.

Temporary stream diversions are used:

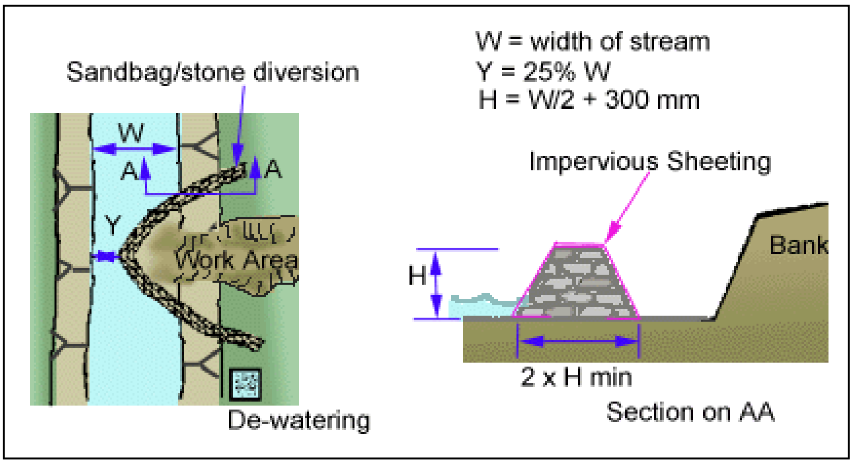
1. When construction within a full flowing stream could create severe environmental impacts due to potential erosion and the resulting sedimentation;
2. When any construction activity is necessary within a stream, such as piers, abutments and/or bank stabilisation;
3. When high waters due to heavy rains could cause damage to construction areas in or beside the stream.

Erosion control devices must be in place prior to commencement of construction works. All materials should be on site before work begins. All excavated material should be disposed of in an approved disposal area outside the 100-year floodplain or as otherwise specified by the engineer.

When de-watering the construction area, sediment-laden water should be pumped to a de-watering basin prior to stream re-entry. Sediment removal in the basin must be sufficient so that released water is as clear as or clearer than the receiving stream.

3.1 Partial Stream Diversion

Materials used in a partial stream diversion should consist of sandbags, stone, sheeting (such as polyethylene) and/or other suitable material that is capable of diverting a segment within the stream.



Material used, when applicable, should be resistant to ultraviolet radiation, tearing, and puncture and should be woven tightly enough to prevent leakage of fill material. Materials should be installed from upstream to downstream

The diverted stream's height should not exceed the stream's 2-year/24-hour frequency storm depth, nor should the stream be allowed to overflow the bank of the channel

If the stream needs to be diverted more than 75% of its width, then Temporary Bypass Channel criteria should be followed.

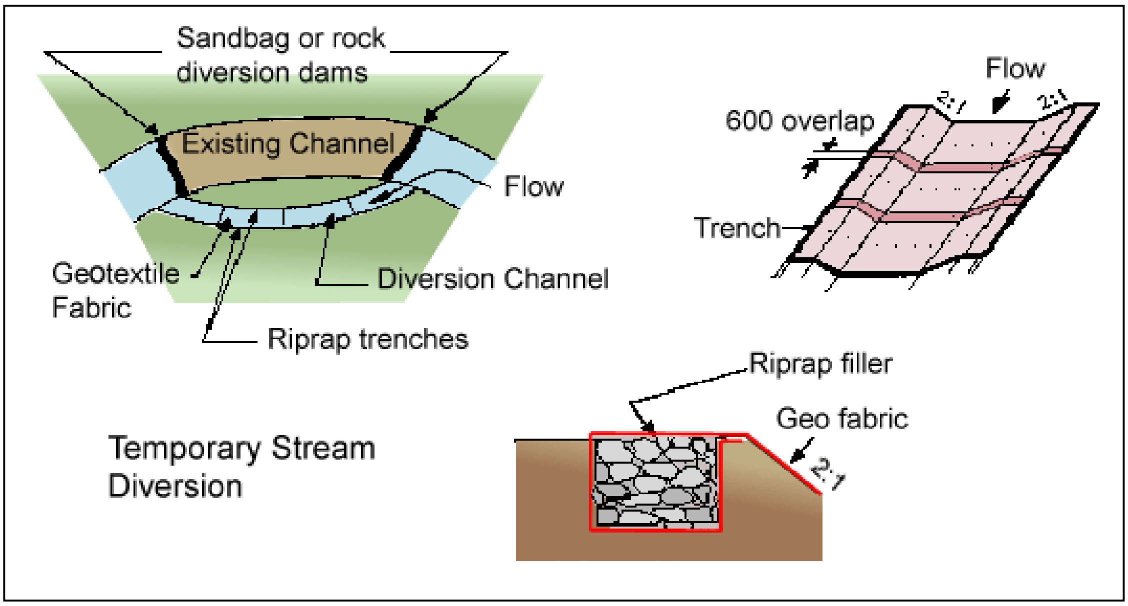
In small channels the height of the diversion may be 300 mm higher than the lowest bank elevation if a stable overflow area is provided, otherwise the height should not exceed one-half the distance from streambed to the stream bank plus 300 mm.

3.1.1 Temporary Bypass Channel (Full Diversion)

A temporary bypass channel should be stable for flows up to and including that expected in a 10-year/24-hour frequency storm. The stream should be diverted with minimum excavation, clearing, grubbing, and embankment fills.

Temporary slope drains are sometimes substituted to convey water in low flow streams within drainage areas of 5 acres or less provided they pose no threat to aquatic life.

Excavation of the bypass channel should start at the downstream end and proceed upstream. All excavated material should be stockpiled outside the 100-year floodplain and stabilised to prevent entry into the stream. Side slopes should not exceed 2:1. The process of excavation and stabilisation (with fabric and/or riprap) should be a continuous process.



When fabric is used, it should have a continuous width wide enough to allow it to lie flush with the canal at all points, and the fabric should be keyed (anchored) at the top of the stream bank. Upstream sections should overlap downstream sections a minimum of 600 mm. Additionally, the fabric should be keyed with riprap in approximately 600 x 600 mm trenches that extend the channel's width at the upstream entrance and at 15 metre intervals. Overlaps should be pinned with minimum 450 mm long staples and spaced a minimum of 1 metre apart. Pins may not be necessary when riprap lining is used.

The downstream and upstream connection to the natural channel should be performed under dry conditions and may be so accomplished by use of sandbag diversions.

3.2 Removal

Leave in-stream sediment traps in place during removal of the temporary stream diversion. Remove stream diversions as soon as they are no longer needed. Restore stream channel and stabilise all disturbed areas. Temporary bypass channels should be back-filled and properly stabilised to prevent the stream from re-establishing the diversion path.

3.2.1 Common Trouble Points

- Stream velocity exceeds that allowable for the temporary channel; stabilise the channel with appropriate sized riprap.
- Washout of partial stream diversion; the diversion is not properly stabilised or installed. Re-evaluate the design.
- Fabric not wide enough to be continuous over the width of the channel; some fabrics may be sewn together and will work equally well.
- Re-establishment of stream in bypass after the bypass was back-filled; the backfill and stabilisation was not done properly. Points of tie-in with the natural channel may require additional stabilisation.

4 Embankments & Drops

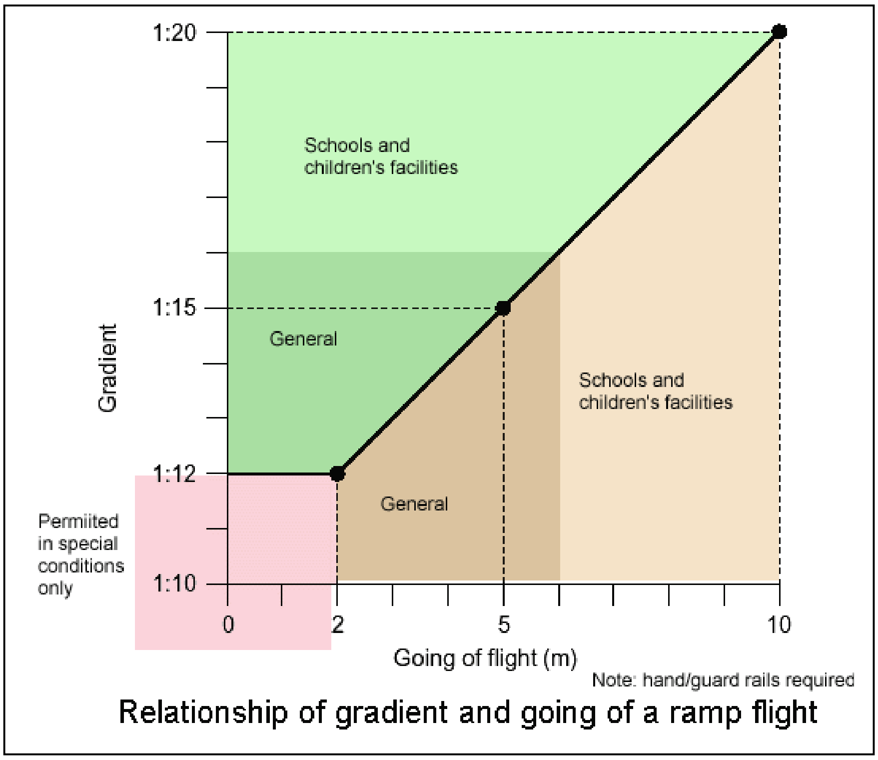
All walkways along embankments and other drops should have adequate guard-rails whenever possible. Alternatively a level 600 mm wide grassed border giving a texture change warning of the drop should be provided.

Where a footpath, bridle path or cycle way need to cross an embankment a ramped route should be provided. This should be as wide as the path type (see Country Pathways and Surfaces) and provide handrails at 600 and 950 mm heights continuous along the ramp and rest platforms.

Tapping rails/plates 150 mm high, with the lower gap no greater than 75 mm, or raised kerbs at 150 height, and guard rails on footways at 1100 mm height, for cycle ways at 1500 and bridle ways at 1750.

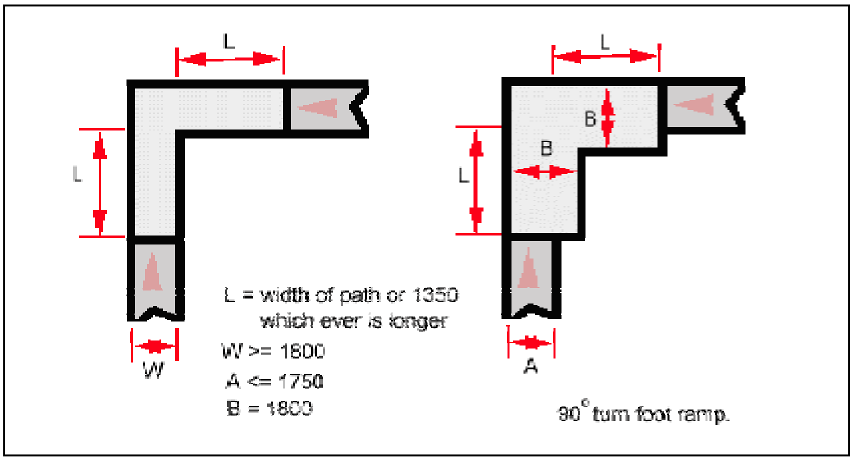
The ramp surfaces should be skid resistant, well drained.

On footways rest platforms should be provided at the intervals shown in the chart.

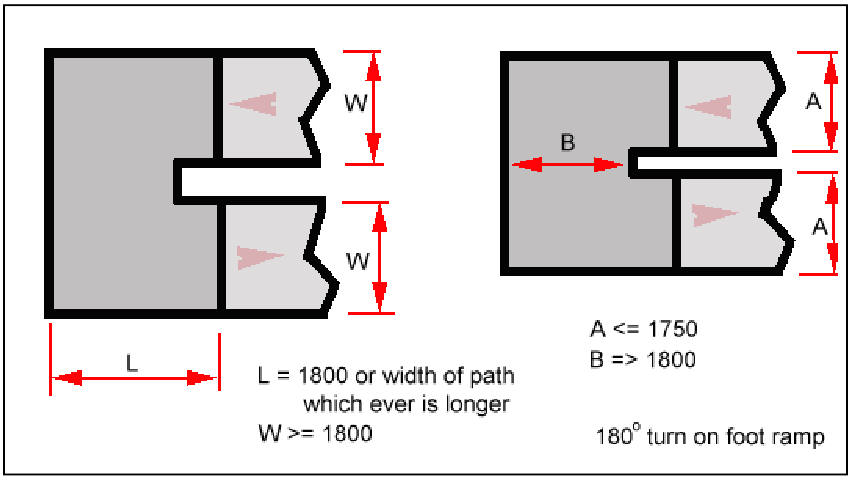


Relationship of gradient and going of a ramp flight

All turns should be made on the level for foot and cycle paths a 1:50 cross fall, the turn should be as wide as the pathway. If the path is narrow the turn should also be a passing place. Footpath ramps should not be less than 1200 mm wide.



Any curved/radius turns must be made on the level.



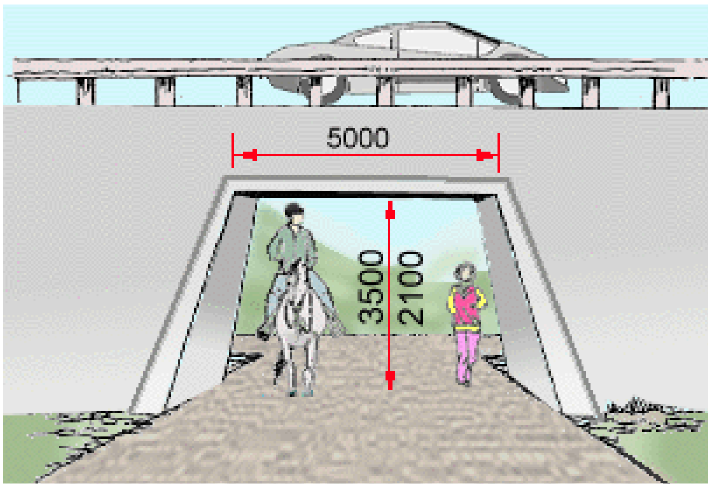
All ramp surfaces above 1:20 should be macadam or concrete to avoid erosion and tripping hazards.

It is preferred that the ramp and platform surfaces are different colours/shades or textures.

Gutters and drainage ditches close alongside country roads should be indicated by use of a continuous stippled white line. This is done in some places as an aid to motor vehicles; however, it is just as important to pedestrians and cyclists who have low vision or hearing.

4.1 Underpasses

Some underpass crossings are very steep and are difficult for people with mobility impairments to negotiate. In addition, underpasses are extremely costly to construct and are often not considered pedestrian-friendly because pedestrians are forced to travel out of their way to use the underpass or overpass. The effectiveness of an underpass depends on whether or not pedestrians perceive that it is easier to use than a street crossing. Perception of danger is use detractor for older and disabled people. Good lighting is essential.



Where underpasses are provided the approach to them should be as wide as possible to give an open aspect and sense of security. It is recommended that the width of the underpass itself should be at least 4800 mm wide and have a clear headroom of 2100 mm for pedestrians, 2500 mm for cyclists and 3200-3500 mm for equestrian use. Within the underpass, handrails set at 1000 mm above the walking surface should be provided on both sides. Experience has shown that underpasses with less than 3000 mm head clearance are avoided by pedestrians.

There should be a clear view from one end to the other and a good level of lighting, at least 50 Lux (150 pref.) Some LA's recommend CCTV surveillance, however, recent research has shown that good lighting levels provide a much greater crime deterrent than do cameras.

Entry to the underpass if not level should be provided by use of a ramp and alternate staircase.

4.2 Construction Larger Embankments

These are more substantial constructions than causeways and intended to raise the right of way well above the surrounding area.

An embankment refers to a volume of earthen material that is placed and compacted for the purpose of raising the level of a path, track,

roadway or railway above the level of the existing surrounding ground surface.

A fill refers to a volume of earthen material that is placed and compacted for the purpose of filling in a hole or depression.

Embankments or fills are constructed of materials that usually consist of soil, but may also include aggregate, rock, or crushed paving material.

Normally, the coarser fill materials are placed at or near the bottom or base of the embankment in order to provide a firm foundation for the embankment and also to facilitate drainage and prevent saturation. The top portion of an embankment usually is constructed of relatively high-quality, well-compacted sub-base material that is capable of supporting the overlying paved surface layers and imposed loading without deflection or undesirable movement. The fill material used throughout the remainder of the embankment must be capable of meeting applicable specification quality requirements and be capable of being placed and compacted at or close to its maximum achievable density. The material is spread in relatively thin layers of 150 mm to 200 mm and each layer is compacted by rolling over it with heavy compaction equipment.

Fill materials should not disrupt the layer thickness. Some oversize materials (over 100 mm in size), such as rocks, large stones, reclaimed paving materials, or air-cooled slags, can be used for the construction of embankment bases. Although the use of oversize materials can result in a stable embankment base, the oversize materials should have strong particles that do not readily break down under the action of construction machinery, but which have a range of sizes so that void spaces are at least partially filled.

Many different types of soils may be suitable for use in the construction of an embankment or fill, ranging from granular soils (sand and gravel), which are highly desirable, to the more finely sized soils (silt and clay), which are usually somewhat less desirable. Certain types of soils (such as saturated clays and highly organic soils) are considered unsuitable for use as materials in embankment or fill construction.

Well-graded fill materials that consist of two or more soil types, usually a mixture of granular and fine-grained soils, are the most suitable for embankment construction. Because of the wide variety of soils that may be encountered, there is no universally recommended range of gradation for fill materials, although the maximum particle size should be less than 100 mm.

The permeability or hydraulic conductivity of the Soil is important consideration. This refers to the ability of a soil (or an oversize material) to transmit water through the pore structure of the fill material at a given rate. This property varies with the make-up of the

fill and specialist advice should be sought as this is indicative of the ability of a compacted fill material to provide drainage for excessive moisture and therefore of the stability of the finished structure.

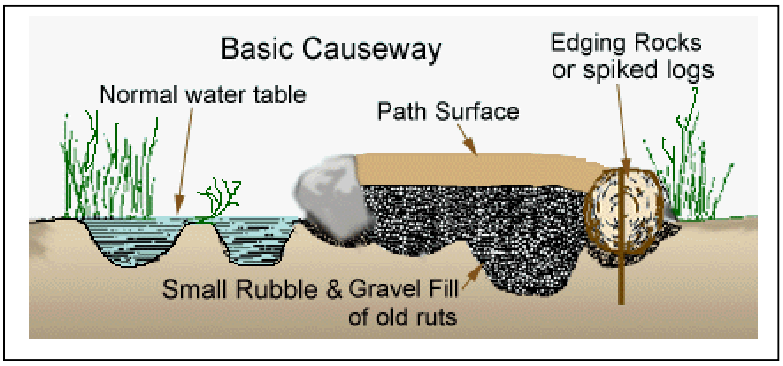
The embankment structure is built up in layers and results in a structure similar to that described for a causeway.

Where an embankment is constructed along flowing water, erosion and scour protection may be required the construction method is quite different as the materials for the embankment are supported by the existing bank or are built above an existing bank.

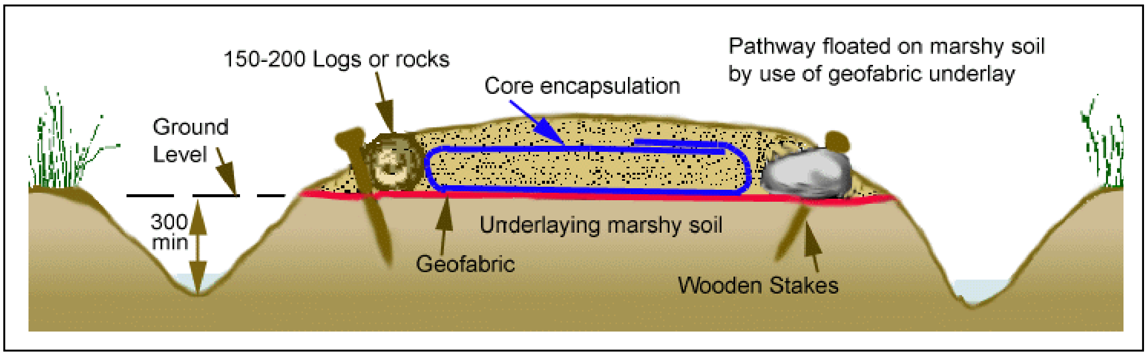
Embankments suitable for vehicle traffic are heavy structures, therefore, before deciding to construct an embankment the sub-surface soil structure should be studied by a competent person.

5 Causeways

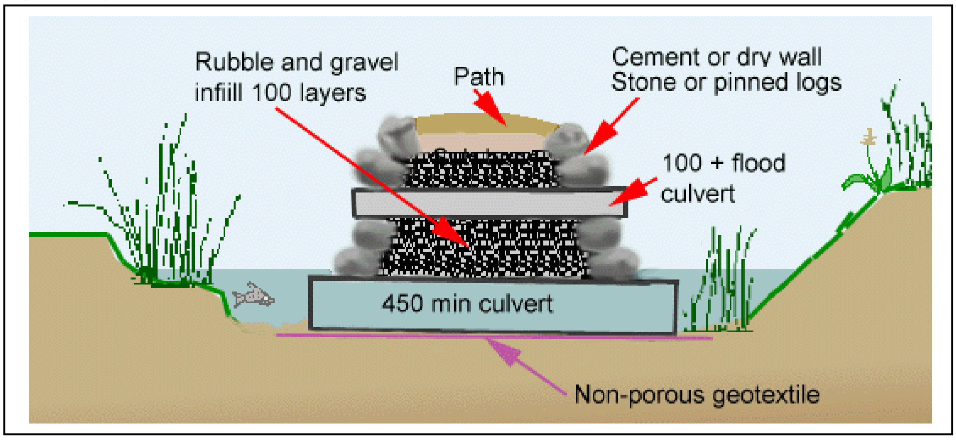
Causeways can be used to provide dry footpaths across boggy ground in an environmentally friendly way. They are better than ditched paths as they do less damage to the hydraulic flows of the area.



One causeway can replace a number of paths which are damaging the wetland. Causeways are also used to take paths across easily damaged areas such as alpine meadows where path users need to be encouraged to remain on the path.



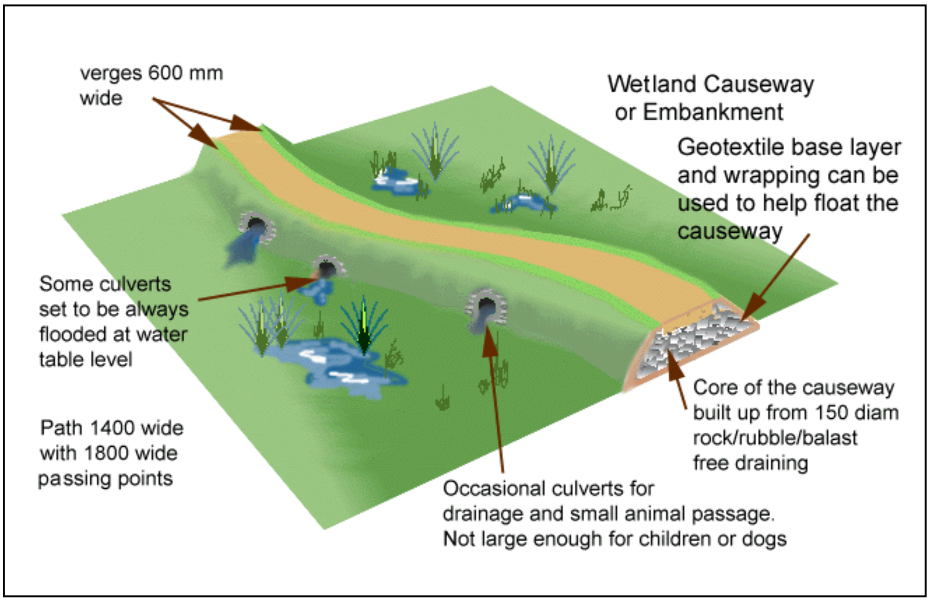
Where the path is to be used by older and people with disabilities the path should not be less than 1400 mm wide, with passing places 1800 mm wide and 2500 mm long every 10-30 metres but each successive passing place always in view of the preceding space. Edging as guidance for people with low vision is not required as the



edging stones provide a tactile and colour clue.

In some cases where wetland exists on both sides of the path a culvert should be placed below the normal water table height to equalise water levels on both sides. These should be at no more than 6 metre intervals.

An alternative method is to float the path surface and sub-base on a layer of geofabric (red line) this spreads the weight and helps to



prevent the path sinking into the soft soil. These paths can be further protected by use of drain itches which help lower the water level from he supporting soil. Where space is available extending a shoulder either side of the path will increase stability and resistance to collapse. Another related method is to encapsulate the sub-base core

in a wrapping of geotextile (blue line), this method keeps the filler drier than the supporting soil which improves it's buoyancy.

In areas prone to flooding during periods when visitors are likely to use the path the causeway may need to be higher and more robustly constructed.

These can be built from dry stone walls, cemented rock, or logs spiked together for stability. Taller causeways may require a foundation layer under the walls or, a timber bed may be needed to float the construction. These type causeways must be designed by a a civil engineer with wetland experience. Springs, quick sand, peat etc. can be a problem. In these locations consider a boardwalk as these are less disruptive of the ecology and are easier to construct.

Culverts should be sited where some are always submerged at the normal water table level, to allow fish and amphibians to pass unobstructed. Other culverts should be placed higher in the structure to carry flood water levels. These should be 100 – 300 mm diameter or 600 + mm diameter for child safety. These higher normally dry culverts will serve to help flood water flows and in drier periods form passageways for small animals

Tall causeways should have guardrails on both sides. Alternatively all causeways and embankments with more than 200 mm drops or water more than 300 mm deep from a path which may be used by people with disabilities should have a 600 mm wide verge on each side of the path.