



## Gully erosion

Gully erosion is a highly visible form of soil erosion that affects soil productivity, restricts land use and can threaten roads, fences and buildings. Gullies are relatively steep-sided watercourses which experience ephemeral flows during heavy or extended rainfall.

Soil eroded from the gullied area can cause siltation of fencelines, waterways, road culverts, dams and reservoirs. Suspended sediments, which may have attached nutrients and pesticides, can adversely affect water quality. These fine, colloidal clay particles remain in suspension and may clog groundwater aquifers, pollute water courses and affect aquatic life.

Controlling gully erosion can be difficult and costly. It may be justified on better quality soils where there is a reasonable chance of success or where a road or building is threatened by an advancing gully. However, controlling gullies over large areas of poor soils may be impracticable. For this reason prevention is far better than control.

### How gullies develop

Gully erosion is caused when run-off concentrates and flows at a velocity sufficient to detach and transport soil particles. A waterfall may form, with run-off picking up energy as it plunges over the gully head. Splashback at the base of the gully head erodes the subsoil and the gully eats its way up the slope.

Gullies may develop in watercourses or other places where run-off concentrates. In cultivation or pastures, advanced rill erosion can develop into gully erosion if no protective measures are taken. Cattle pads can be a starting point for a small rill that can develop into a large gully.

A watercourse is ordinarily in a state of balance where its size, shape and gradient are suitable for the flows it carries. If the balance is disturbed, for example by larger than normal flows, gully formation may begin. Gullies generally create far more capacity than they need to accommodate the run-off they are likely to carry.



A four metre deep gully advancing into grazing land

Widening of the gully sides may occur by slumping and mass movement especially on the outside curve of meanders. Scouring of the toe slope can lead to mass failure of the side of the gully under gravity. This soil is then washed away by subsequent flows.

Active gully sides are usually vertical but may adopt an oblique shape once they start to stabilise. This process may occur naturally but can be hastened by the adoption of various gully treatment measures.

Run-off may enter a gully from the sides, causing secondary gullies or branching resulting in a 'badlands' effect. The gully floor may be subject to further down-cutting as secondary gullies advance up the channel. Sediment deposition below gully heads results in a "steps and stairs" pattern.

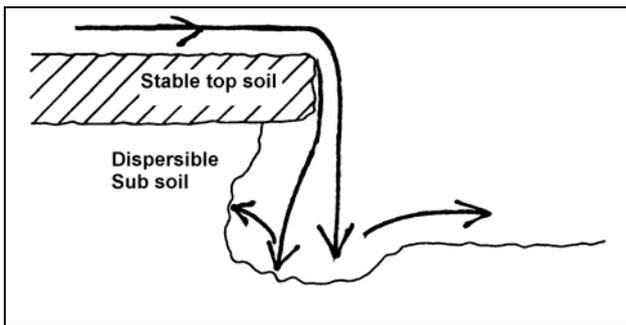
While peak flows from intense rainfall causes considerable gully erosion, the prolonged low flows resulting from an extended wet period can also create problems. Constant trickle flows through a drainage line can saturate the soil in the trickle zone making it structurally weak and very susceptible to erosion. The constant wet conditions may also weaken the vegetation which then provides less resistance to erosion.

Gully depth is often limited by the depth to the underlying rock which means that gullies are normally less than 2 m deep. However on deep

alluvial and colluvial soils gullies may reach depths of 10 to 15 m.

### Dispersible sub-soils

Soils with dispersible subsoils are very common throughout Queensland and are especially vulnerable to gully erosion when the top soil is disturbed. They may have a relatively stable, but shallow, light textured topsoil with an abrupt change to a highly erodible, clay subsoil with a high exchangeable sodium percentage. When saturated by seepage flows or subject to splash back, these subsoils will slump, leaving the topsoil unsupported. The topsoil then collapses and the process is repeated.



Gully formation in a dispersible sub soil

Sub surface flow in dispersible soils can cause the saturation of gully sides leading to slumping of gully walls and the expansion of the gully. Under these circumstances gully head advancement can occur with little or no surface flow. The slumping process is comparable to the way a hole dug to the depth of the watertable in the sand at the beach expands as the sides slump away.

### Tunnelling

Tunnelling is an important mechanism for headward and lateral gully expansion in dispersible soils. When dispersible subsoils become exposed, the gradient for water flow through cracks in the soil is increased causing more rapid seepage water flow and crack enlargement by tunnel erosion. The enlarged cracks develop into tunnels which carry a suspension of soil and water. The tunnels soon collapse causing rapid progression of the gully head

A simple way to test for soil dispersibility is to place a small clod of dry subsoil in a jar of water. The soil is dispersible if the clod disintegrates and the water becomes cloudy. For more information on dispersibility refer to *NRW Facts W15 (Water series) Dispersive soils – Guide for use in farm dam construction*.

### Cracking clay soils

Cracking clay soils, such as those found on the Darling Downs and the Central Highlands have more resistance to erosion than the dispersible clay

soils. Gully heads in these soils may sometimes be oblique rather than vertical.

In very dry weather, cracks of up to 2 m deep and 100 mm wide may develop in these soils. Large slabs of soil may fall into the gully leaving vertical sides. The cracks are interconnected laterally and when storm rainfall occurs, water penetrates the cracks and moves downslope through the soil. The soil swells and closes up eventually, but not quickly enough to prevent large volumes of water from filling cracks in the subsoil. If an outlet is found, the hydraulic head may cause a subsurface flow and tunnelling will develop.

### Saline areas

Saline areas have depleted vegetation and become very susceptible to erosion. On the positive side, the eroding gully may help to provide drainage to the area that could assist in alleviating the salinity problem by lowering the water table. Control options in this situation should aim to stabilise the drain but not to fill it in.

## Triggers for gully development

Gully development may be triggered by:

- cultivation or grazing on soils susceptible to gully erosion
- increased run-off from land use changes such as tree clearing in a catchment or construction of new residential areas
- run-off concentration caused by furrows, contour banks, waterways, dam bywashes, stock pads, fences, tracks or roads
- improper design, construction or maintenance of waterways in cropping areas
- poor vegetative cover e.g. from overgrazing, fires or salinity problems
- low flows or seepage flows over a long period.
- 'down-cutting' in a creek (causes gullies to advance up the drainage lines flowing into it)
- diversion of a drainage line to an area of high risk to erosion eg a steep creek bank or highly erodible soils.

## Prevention measures

Regular monitoring is essential to detect early stages of gully formation. A range of measures to prevent the development of gullies is described below.

### Property development

- Manage catchments to ensure run-off is not increased

- Assess the land's capability to ensure it is suitable for the proposed use
- Locate and construct roads, fences and laneways so that they cause minimal concentration and diversion of run-off.

### Grazing management

- Maintain adequate pasture cover by better stock management
- Be prepared to fence off and exclude stock from land vulnerable to gully erosion
- Locate watering points, stockyards, shade areas and gates away from gully-prone areas
- Contour banks are normally not necessary on well managed pasture land. Poorly maintained banks in such situations may lead to rilling and gullying. An option is to level them or create gaps in the banks to safely disperse the run-off.

### Cropping management

- Control erosion on sloping, cultivated land by stubble retention and the construction and maintenance of contour banks and waterways
- Construct waterways to appropriate specifications and stabilise and maintain them
- Ensure that contour banks discharge into waterways at safe locations
- Spread flood flows on cultivated floodplains and avoid practices that concentrate flood flows.

### Urban development and management

- Avoid the development of bare, compacted areas that may occur in school grounds or other heavily trafficked areas
- Avoid developing steep sites and drainage lines
- Minimise soil disturbance, stockpile and respread topsoil and revegetate affected areas
- Construct flood detention systems below high run-off areas.

## Controlling gully erosion

Vegetation is the primary, long term weapon in controlling gully erosion but structures may be needed to stabilise a gully head or to promote siltation and vegetative growth in the gully floor. While structures may be subject to decay and become less effective over time, vegetation can multiply and thrive and improve over the years.

Structures may be made of concrete, masonry, wood or other building material. They need various skills for their design and construction and may be expensive to implement. Structures have an inherent risk of failure and may be undermined or bypassed.

Factors to consider when controlling gully erosion are:

**The cause** – Refer to the previous section to see what action can be taken.

**The effect** – What will happen if no action is taken to control the gully?

**Catchment size** – The larger the catchment the more complex the problem.

**Soil type** – Gullies in fertile soils are easier to control than those in poor soils that are highly erodible.

**Gully components** – Which parts of the gully are most actively eroding? Is it the gully head, the floor or the sides? Does the gully have branches? What is the height of the gully head?

**Potential for diversion** – Is there an option to divert run-off flowing into the eroding gully to a safe disposal area?

The key to most gully stabilisation work is choosing the right time to do it. Autumn is generally a suitable time for most of Queensland as there is less chance of high volumes of run-off, yet there is sufficient soil moisture and warmth to promote the growth of vegetation.

### Using vegetation

Vegetation provides protection against scouring and minimises the erosion risk by reducing flow velocity. As velocity falls, sediment is deposited forming an ideal environment for new vegetative growth.

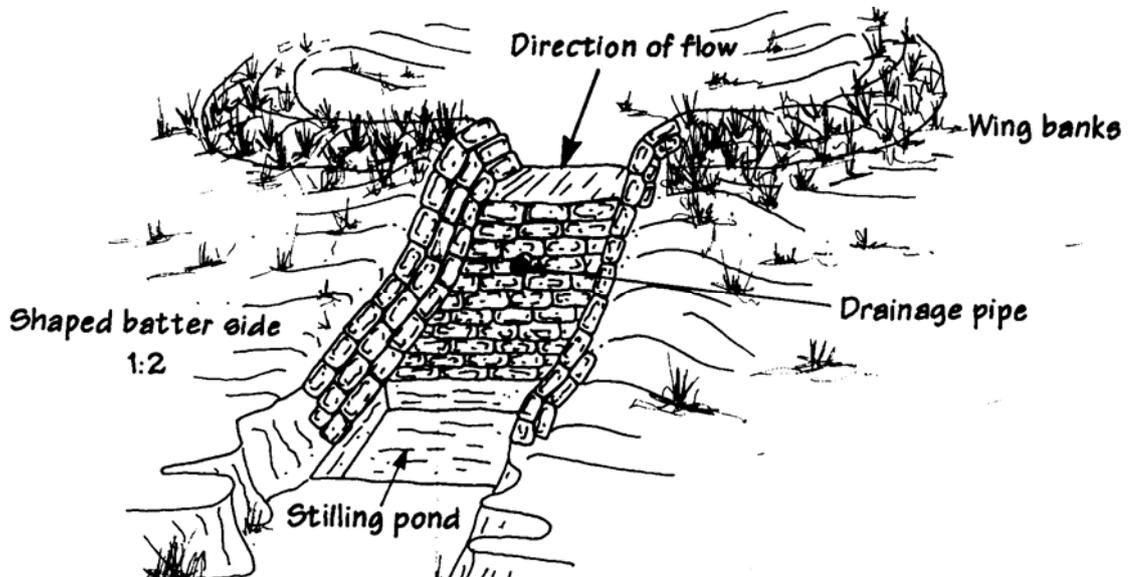
However, gullies can be a harsh environment in which to establish vegetation. They dry out very rapidly and usually have infertile subsoils.

Indigenous species should be considered, especially in an area where it is not desirable to introduce exotic species. However, a number of exotic grasses and other species are well established in our agricultural lands and have been used with great success for controlling erosion. Vegetation that grows vigorously with a spreading, creeping habit is preferred. Obtain local advice to see if a proposed plant has a weed potential in a particular area.

Fencing the gullied area is highly desirable. Stock are attracted to gullied areas, especially if they include shade trees. These areas are then subject to heavy grazing and compaction.

If it is available, some form of irrigation is desirable to assist in the establishment of vegetation. An initial application of a mixed fertiliser aids in rapid establishment of an effective cover.

Trees are desirable in the areas surrounding gullies but are not likely to be successful in stabilising an actively eroding gully head. Trees growing in gullies should not be too dense and should have an open canopy to allow protective vegetation to grow on the soil surface. Where subsurface flows are contributing to gully erosion, trees in the area above the gully head should assist by helping to dry out the soil profile and provide structural support to subsoils prone to slumping.



Chute for controlling an eroding gully head

## Gully reshaping and filling

The practicability of shaping a gully depends on its size and the amount of fill needed to restore the gully to its desired shape. Steep gully sides can be reshaped. Topsoil should be stockpiled and re-spread over exposed areas to ensure the rapid establishment of vegetation. Annual crops such as millet (summer), oats or barley (winter) can be used to provide a quick cover. It may be possible to temporarily divert water from the battered gully while grass is establishing.

Gullies in cultivation can be filled when constructing contour banks. The banks must have sufficient capacity where they cross old gully lines as this is a common site for contour bank failure.

## Controlling gully heads

Options for controlling gully head erosion include:

**Diversion** – Diversion banks divert run-off from the gully head to a stable outlet. Unfortunately, such outlets are difficult to find and often the instability may simply be transferred from one area to another.

**Chutes** – Chutes are formed by battering gully heads to an acceptable slope depending on the method used to stabilise it. Their role is to convey run-off safely to a lower level. Chutes are lined with erosion-resistant materials such as stoloniferous grasses, reinforced turf, erosion control mats, rock, rock mattresses, concrete, rubber or PVC sheeting.

**Drop structures** – Drop structures allow run-off to drop vertically to a lower level, where the energy is dissipated before flowing down the watercourse. They can be made of formed concrete, concrete blocks, gabions, timber or steel plate. Gabions and rock mattresses have an advantage of being flexible and permeable.

**Dams** – Gully control dams are situated so that they 'drown' the gully head when the spillway is

operating. Run-off is returned to the watercourse at a safer location or allowed to spread into a grassed area via a diversion bank. The success of these dams depends on a stable bywash and outlet which can be difficult to obtain in erosion prone soils.

## Gully floor stabilisation

The long-term success of gully stabilisation work depends on establishing a good vegetative cover on the gully floor which prevents further gullying and allows the gully floor to gradually silt up reducing the fall over the gully head.

A series of small weirs made from wire netting, logs or concrete can trap sediment which encourages vegetative growth. Vegetative weirs can be established using species with erect growth forms such as vetiver grass and lomandra.

Branches of dead shrubs or trees can play a useful role in stabilising a gully floor by restricting access by grazing animals. They also retard run-off flows which encourages further sedimentation.

Old car bodies are not recommended for gully stabilisation. They divert flows against the sides of the gully which leads to further erosion.

## Further information

Other Department of Natural Resources and Water fact sheets related to soil erosion include:

- L13 Erosion control in grazing lands
- L34 Monto vetiver grass for soil and water conservation
- L91 Erosion control in grazing lands. ■