Chapter 12

Floodplain applications

The strategy for controlling erosion on floodplains is to ensure that floods are encouraged to spread out as much as possible thus reducing their velocity. In areas where both winter and summer crops can be grown reliably, strip cropping (Figure 12.1) is a successful solution. Crops are grown in alternating strips that are perpendicular, or close to perpendicular, to the direction of flow of water. Strip cropping should be combined with conservation cropping and crop rotation techniques to ensure that there is always a crop or standing stubble in every strip to help spread water and reduce flow velocity. Stubble needs to be anchored to avoid its floating and subsequent deposition where it may cause problems such as the blocking of road cross-drainage structures.

Incorporating opportunity cropping into a strip cropping system provides greater protection from erosive flooding. Opportunity cropping is the practice of planting a crop whenever soil moisture reserves are considered sufficient, rather than according to a rigid rotational pattern. This leads to an increase in cropping frequency (eg. two crops in three years) and greater levels of surface cover.

Figure 12.1 Strip cropping on the Darling Downs floodplain

As well as controlling soil erosion, strip cropping improves water quality by assisting in filtering out sediment, nutrients and pesticides.

For more detailed information about strip cropping, the following publication is recommended: *Better Management Practices – Floodplain Management on the Darling Downs*, published in 1999 by what was then the Queensland Department of Natural Resources.

The use of strip cropping in Queensland has been pioneered on the floodplains of the Darling Downs. While flooding is most common in summer, winter floods also occur in this area. The geomorphology of a number of creeks flowing out of the upland areas of the Eastern Darling Downs is a well-defined watercourse in the upland area, spreading onto ill-defined flow paths on the Condamine River floodplain. Flow velocities, and consequent erosion risk, depend on the land slope, cover levels and proximity to channels where flows are deeper than the adjacent areas. Overland flow velocities generally decrease, as the flows get closer to the Condamine River. This is because slopes are lower and the floods have had an opportunity to spread over a vast area. Many parts of the Darling Downs floodplain are regularly inundated but are not at risk of erosive flooding. There are also large areas with soils and topography that are characteristic of the floodplain but are rarely flooded.

The risk of erosive flooding in the Brigalow floodplains between Dalby, Jandowae and Chinchilla is lower than that for the creek outlets on the eastern Darling Downs. However, the levelling of melonholes to make the land more suitable for cropping has reduced the amount of rainfall that is retained on the surface and increased the rates and volumes of flood flows (McLatchey and Watts 1985).

Strip cropping layouts need to be designed and implemented in a co-ordinated manner. The adoption of strip cropping practices on a single property will have limited overall benefit. All affected landholders, including farmers, local and state governments must work together to ensure that floodwater is spread over the entire floodplain. Co-ordinated planning of the whole floodplain is required to minimise the effects of structures such as roads, railway lines, irrigation infrastructure and levee banks that may divert and concentrate flood flows.

Strip cropping is generally not suited to narrow floodplains associated with creeks and rivers. In these situations the strip length is too short, leading to inefficiencies in crop production. Narrow floodplains subject to regular erosive flooding (eg. less than once in five years) should have permanent cover such as that provided by a pasture.

12.1 Design of strip cropping systems

12.11 Strip width

A number of formulae have been developed to determine recommended strip widths based on criteria such as land slope, flow rates, soil erodibility, crop rotations and management. Most of these formulae were developed from practical experience. However Smith, Hancock and Ruffini (1988) developed more technically rigorous design procedures from experimental work.

Many of these formulae were developed when bare fallows were normal practice. The widespread adoption of zero tillage has meant that entire properties may be protected by crop or standing stubble at the one time. If such a cropping system could be guaranteed, irrespective of seasonal conditions, then strip cropping would not be necessary, provided the crop rows were at right angles to flood flows. However the following factors create a need for strip cropping:

- The use of erosion inducing row crops such as sunflower and cotton that give inadequate protection
- In periods of drought it is likely that parts of a property will not be protected from erosive flooding by adequate levels of cover.

Table 12.1 is a guide to strip cropping widths based on the topographic situation and the level of protective cover provided by the crop rotation and management system. The determination of the level of protective cover is somewhat subjective but some guidance can be obtained from Tables 12.2 and 12.3.

It is necessary to refine the width of the strip to achieve compatibility with the various widths of the commonly used machinery on the property.

Table 12.1 Recommended strip cropping widths for floodplains subject to erosive flooding

Level of protective cover provided by the crop management system	Recommended strip cropping width (metres)		
	Slopes of 0.4% to 0.5%	Slopes of 0.2% to 0.3%	Slopes of 0.1% and less
	Creek outlets and narrow valley floors	Plains – upland flow	Plains in lower areas subject to widespread inundation
High	50	80	100
Moderate	25	40	50
Low	Not recommended	Not recommended	30

Table 12.2 Guide to determining the level of protective cover provided by a crop management system

Level of protective cover provided by the crop management system	Stubble management	Cropping system
High	Zero tillage	High proportion of crops providing high cover levels. Opportunity cropping whenever possible.
Moderate	Reduced tillage	A moderate proportion of crops providing high cover levels. Low levels of opportunity cropping.
Low	Bare fallow	One crop per year with a high proportion of crops providing low levels of cover.

Table 12.3 Level of protective cover provided by crop type.

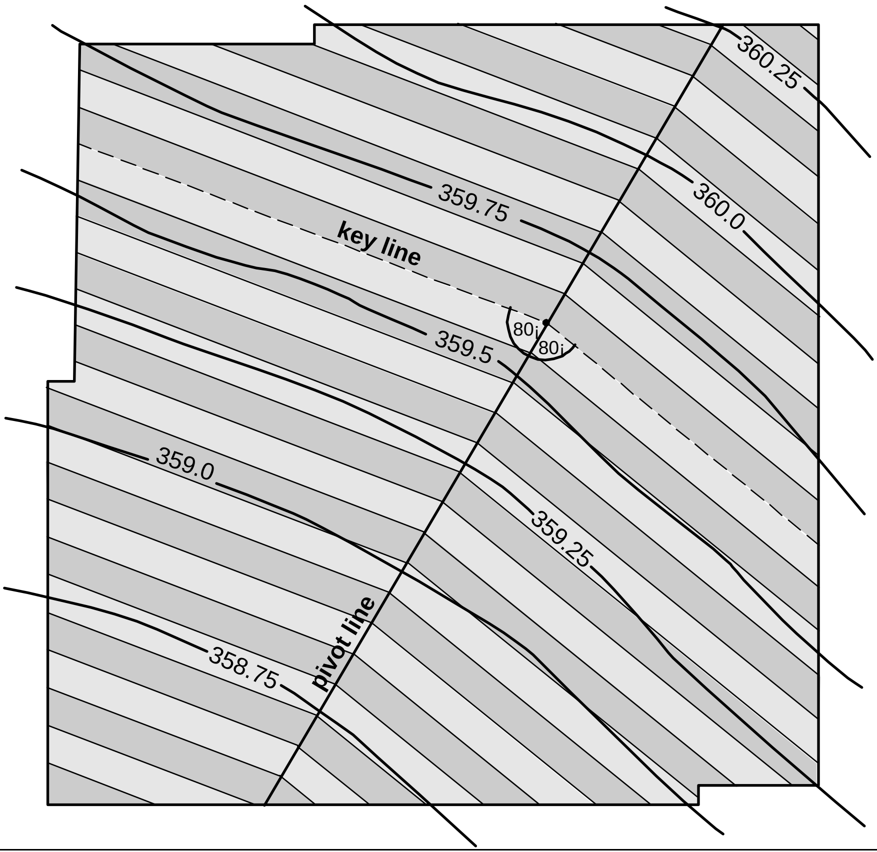
Level of protective cover	Crops	Comment
High	wheat, barley, sorghum, maize	Crops grown in wide rows provide less protection
Low	sunflowers, chick peas, cotton, mung beans	Legume crops leave little or no stubble after harvest. Cotton is an effective crop at slowing floodwaters during active growth but the stubble provides little protection after harvest.

12.12 Strip direction

Detailed topographic and flood flow path information is necessary in order to determine the most appropriate direction for strips on floodplains. Ideally, topographic information should have an interval of 0.25 m or less for slopes of less than 0.5%.

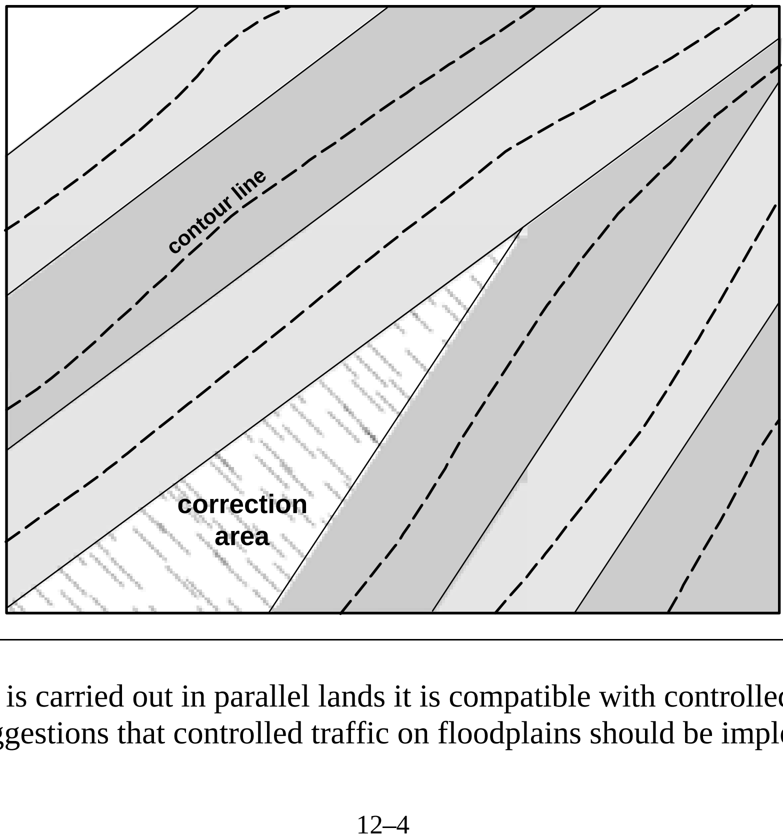
If it is necessary to locate strips in different directions due to a change in the direction of flow/slope, then a pivot line is required at the change in direction (Figure 12.2) For the width of strips on either side of the pivot line to be equal, the angles at which the strips deviate from the pivot line must also be equal. If the pivot angles are unequal it will be necessary to manage the strips on either side of the pivot line as separate blocks. The minimum angle for a pivot is generally about 70° as sharper angles will leave unplanted headlands especially when multiple-hitch machinery is used.

Figure 12.2 Strip cropping layout showing a pivot to provide for change in strip direction. (Eacott 1979)



In order to improve workability and ensure that strips are located on the contour, it may be necessary to insert a correction strip as shown in Figure 12.3

Figure 12.3 Correction area in a strip cropping layout (Macnish 1980)



Since strip cropping is carried out in parallel lands it is compatible with controlled traffic farming. There have been suggestions that controlled traffic on floodplains should be implemented with strips running up and down the slope. While this practice may be acceptable in a section of a floodplain where erosive flooding is not an issue or where drainage is necessary, it is considered to be most inappropriate on floodplains at risk of erosive flooding. Such a system may divert flood flows down the strips that had the least retardance to flows. High velocities and associated gullying would be a likely result with deep wheel tracks being especially vulnerable.

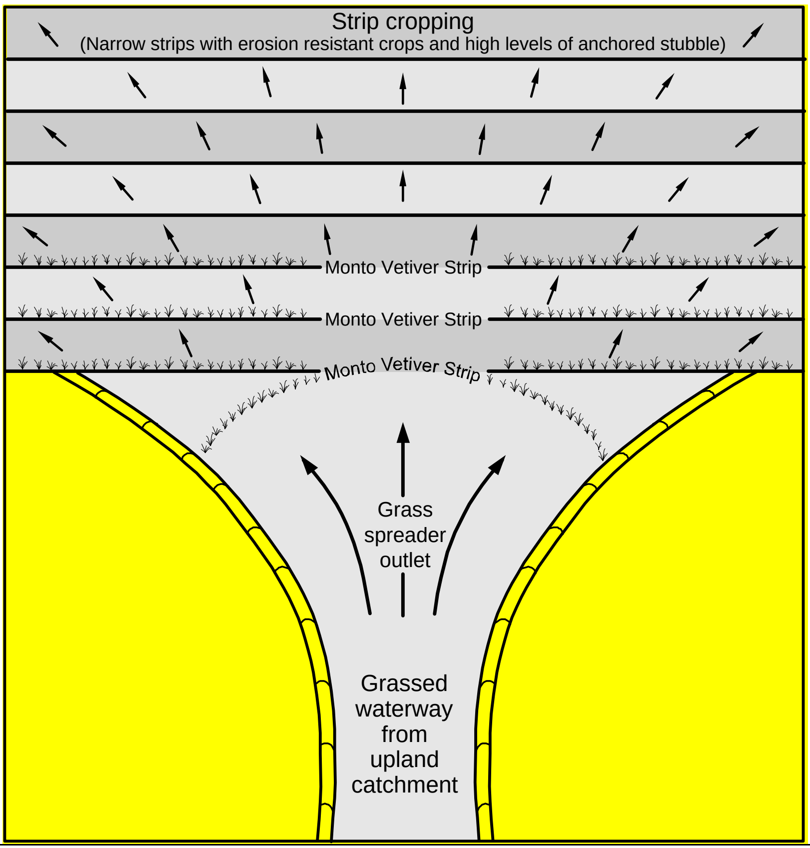
In Queensland, it is generally not practical to use strip cropping directions that would provide protection from erosive winds. The heavy texture of most cropping soils in Queensland means that they are not susceptible to wind erosion. Such layouts would need to be at right angles to erosive winds (generally from the south-west) and would not be compatible with any strips or runoff control measures that may be required for control of erosion by water. The adoption of conservation cropping measures should be sufficient to provide protection against wind erosion in the Queensland environment where wind erosion is not considered to be a serious problem in cropping lands

12.13 Dealing with concentrated runoff flowing onto floodplains

There are a number of options for dealing with the situation where concentrated flows spill onto floodplains. A grass spreader outlet (Figure 12.4) may be used at the point where a waterway meets a strip cropping area. Another option is to design and build a dam with provision for bywashes on either side discharging into a subsurface channel or sill. Maintenance of these outlet areas is critical. They are subject to high rates of sedimentation, which may direct flows away from the grassed area and onto adjacent areas that will be vulnerable to erosion.

Relatively narrow strip widths are required immediately below any spreading devices to accommodate the high velocity flows. The waterway delivering the runoff to the grass spreader requires regular maintenance including slashing, strategic grazing and desilting.

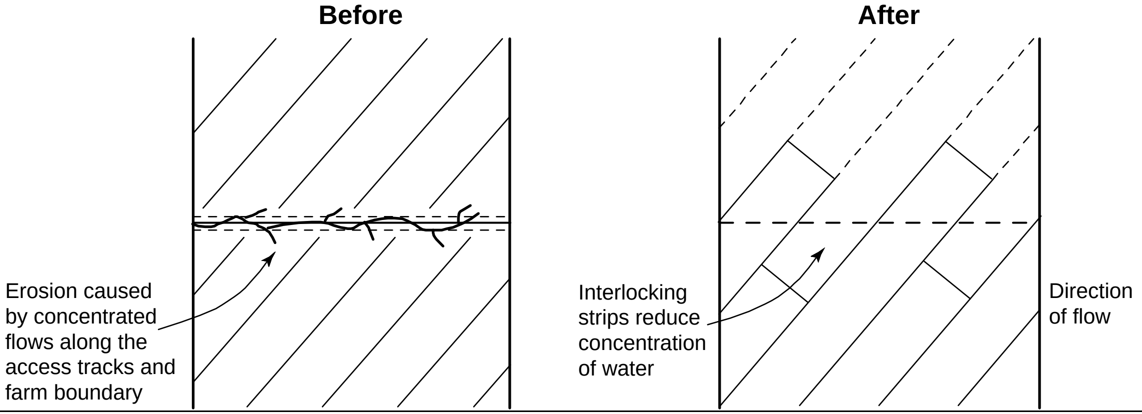
Figure 12.4 Grass spreader at a waterway outlet



12.14 Give-and-take

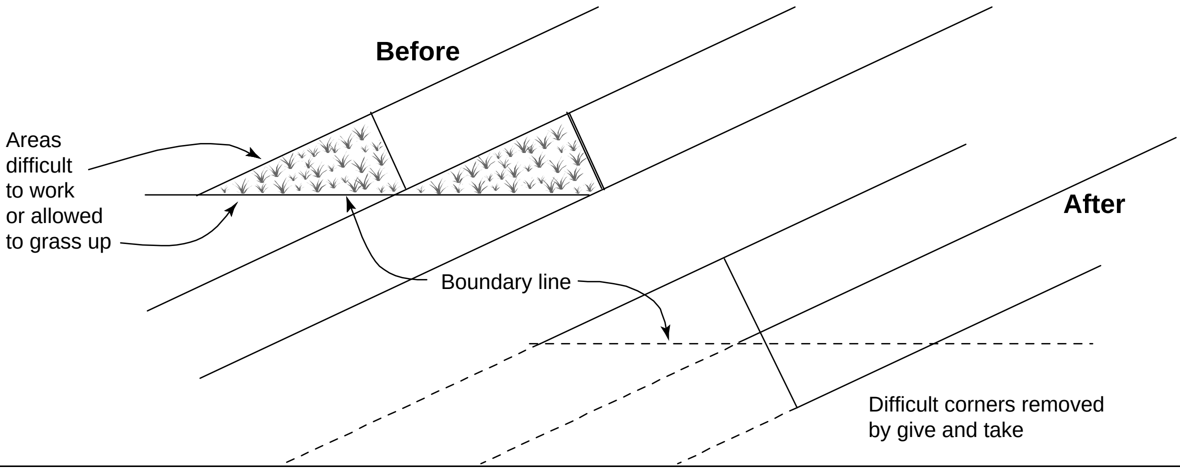
'Give-and-take' refers to an exchange of land between neighbours to help keep floodwaters spread. Problems often arise where two strip cropping layouts meet at a boundary line. There is usually an access track on both sides of the boundary where water tends to concentrate, causing washouts. This can be overcome by neighbours interlocking their strip cropping layouts and each landholder farming some of their neighbour's land as shown in Figure 12.5. Alternative means of access in strip cropping layouts is described in a later section.

Figure 12.5 'Give and take' to overcome concentrated flows along fencelines



In some strip cropping layouts, the strip will meet the fence line at very sharp angles creating corners that are difficult to work. These corners are often left to grass up, creating potential weed problems. By the use of 'give-and-take' with a neighbour, these problems are overcome (Figure 12.6)

Figure 12.6 'Give and take' to avoid difficult corners



12.15 Land levelling

The presence of rills and gullies in a paddock can make it difficult to achieve an effective spread of flood flows and make crop management more difficult. They are also susceptible to further erosion during a flooding event. Runoff flowing in such depressions may result in poor crop establishment or even the need to replant a crop.

Land levelling combined with strip cropping can assist in achieving a more effective spread of floodwaters. It may be carried out with the use of a land plane drawn behind a tractor, scraper or tractor drawn bucket. The use of laser equipment assists the process.

To have minimal impact on natural flow paths, all land levelling should be carried out in such a way that the down-field and cross-field slopes align with the natural slope of the land. Land levelling should be designed to blend with natural surface profiles both within and surrounding the block. This will avoid significant differences in finished heights on the block boundaries, which can promote erosion and consequent concentration of flows.

12.16 Use of Monto Vetiver Grass on floodplains

The Monto strain of Vetiver grass (*Vetiveria zizanioides* L) is being evaluated on the Darling Downs floodplain to stabilise and silt up active gullies. The grass is established in rows across gully floors. The rows act as barriers to flood flows and silt is deposited against and in front of the rows. Unlike earth structures, which often fail due to cracking or undermining, Vetiver weirs will not easily wash away. At the same time as water flows over the top of the grass 'weirs', water also flows through them, minimising turbulence and undermining. Vetiver grass has a very dense, deep root system (another reason why it is not easily undermined and washed out). The Vetiver rows should extend out onto the shoulders of the gully to prevent water from cutting around the ends.

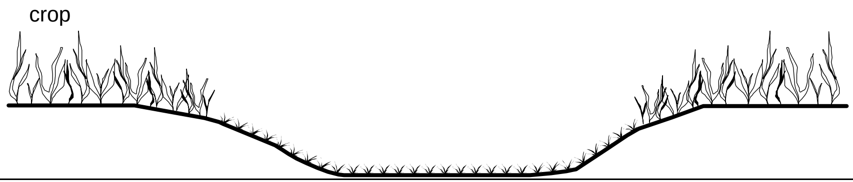
In a field trial on a floodplain at Jondaryan, Monto Vetiver hedges have also been used between crop strips to provide additional protection (Truong and Loch 2004). Such a system would be advantageous when some strips remain in fallow because of drought conditions.

12.2 Residual flow drains

On the floodplains of the Darling Downs, a residual flow may persist for several weeks after a major flooding event or prolonged wet period. Residual flows within cultivated lands have the potential to interrupt farming operations and cause waterlogging.

Residual flow drains (Figure 12.7) may be used to remove residual flows from cultivation allowing for more timely access after floods and to even out moisture conditions over the cultivated area (Begbie 1977, Cummins and Bass 1978). The restriction of saline trickle flows to a residual flow drain will protect agricultural land from contamination.

Figure 12.7 Residual flow drain



12.21 Planning

Residual flow drains should be co-ordinated from property to property and should be subsurface so that they do not interfere with flood flows. Historically, they have been located along the length of the main flowpaths of some of the floodplain catchments. Their location and effectiveness has been totally reliant on the goodwill and co-operation between the floodplain stakeholders across whose land the residual flow drain has been constructed.

In general, residual flow drains should be located so as to run parallel to the natural flow path as closely as possible. This minimises earthworks and decreases the potential for diversion of flows. Changes of direction should be accomplished with gentle curves rather than sharp bends to avoid erosion-inducing turbulence. The risk of erosion in a residual flow drain can be minimised if the drain is not located in the deepest section of the flood flow where high velocities may occur during floods. With approval and co-operation from Local Government, residual flow drains may be constructed along roadsides. However, they should remain separate from road table-drains to avoid destabilising the road as a result of long-term saturation of foundations associated with residual flows.

Residual flow drains may be subject to Local Authority by-laws pertaining to levee banks. In catchments where Water Resource Plans have been approved under the provisions of the Water Resources Act 2000, there may be controls on new works requiring approval as assessable development if such works are likely to increase the 'take' of overland flow wate12.2

12.22 Design

Residual flow drains should be subsurface without any banks above normal ground level that would divert flood flows. They are at risk of erosion during flood events especially when they flow between well advanced crops which have a high retardance to flood flows.

There are no hard and fast rules for determining the capacity of a residual flow drain. If possible, observations of the trickle flow should be made to determine the required capacity. Bass and Cummins (1978) based designs for drains in the Pittsworth Plains on 0.21 m^3/1000ha for upland catchments plus 0.07 m^3/1000 ha for plains catchments.

Residual flow drains can be stabilised using species such as kikuyu and African star grass. In wetter areas, water couch and salt tolerant couch grasses could be considered (Bass 1984). Where spring flows persist, it may not be possible to maintain a permanent vegetation cover and designing the drain for bare soil conditions may be the only option.

Residual flow drains with a bare channel are vulnerable to erosion especially considering the saturated soil conditions that would exist during flooding. Because they are located on flood plains where slopes would normally be less than 0.3%, it is possible to ensure that shallower flows can be kept below a velocity of 0.3 to 0.4 m/s. Additional protection could be provided with drop structures or sod chutes with energy dissipaters.

Outfalls are one of the most important sections of a drain. They allow water to free-flow from the drain into a disposal area. Outfall into deeper drains, pump sumps, etc, need to be rock protected to prevent erosion or other suitable stabilisation measurers. Structures similar to that used on drain entries can be used.

12.23 Construction

Drains should be constructed with very broad-sided batters that can be cropped part way down the channel sides to avoid scours developing from the channel sides back into the cultivation.

Drains generally produce significant amounts of spoil because they are constructed below normal ground level. This spoil should be placed so as not to interfere with overland flow paths. It should be spread as shallow fill on adjacent cultivation, placed as spoil banks aligned with the direction of flow, or removed totally from the area. It is inadvisable to construct a raised road parallel to the drain as this can interrupt or divert flow, or induce erosive flow velocities as a consequence of increased depth of flow.

Crossings over residual drains should be constructed so as not to affect flows in the drain. Ideally, crossings should be constructed as gravel inverts either at or slightly above (max. 100 mm) bed level of the drain. The thickness of gravel required will depend on the weight and frequency of traffic; a minimum of 200 mm depth of gravel is necessary, but for heavy traffic loading, a thickness of up to 300 mm over a suitable geofabric would be required. Culverts require sufficient cross-sectional area to pass flow with minimal surcharge level upstream of the structure. Box-shaped culverts are preferable. Professional design will often be necessary.

12.24 Maintenance

Drains need to be well maintained to retain their function. Vegetation should be managed by slashing, spraying, or occasional grazing. Silt deposits should be removed. In many cases, it will be necessary to virtually reform the drain at regular intervals. Ancillary structures such as inlet works, outfalls and drop structures also require ongoing maintenance. Access for maintenance is not possible until the drain has dried out.

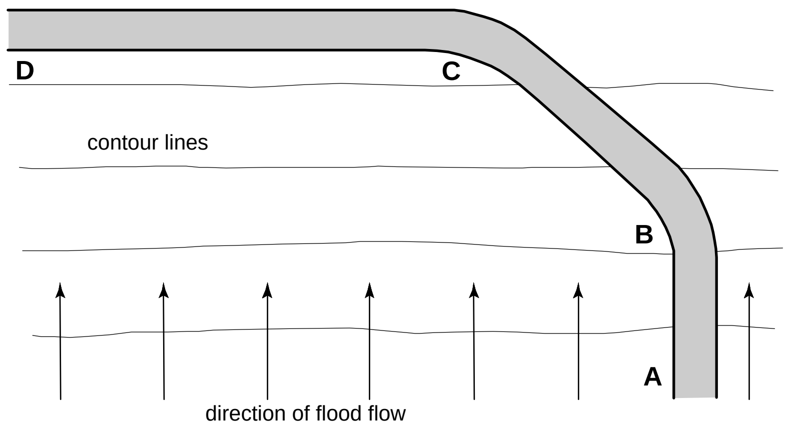
12.3 Infrastructure effects

On floodplains, roads, railway lines, fences, levee banks and irrigation structures can significantly interfere with the natural spread of floodwaters. They can concentrate flows that would normally spread and greatly increase the risk of erosive flooding in affected parts of the landscape.

12.31 Public roads

Conventional roads are generally raised 300 mm to 600 mm above natural ground level, however this is not recommended for most situations on the floodplains. The impact that formed roads have on flood flows depends on their orientation towards the natural flow direction. Figure 12.8 shows how the direction of a road may be orientated within a floodplain landscape. The section of the road A—B is running directly up and down slope and would cause no diversion of floods no matter how elevated it was. The section B—C is running diagonal to the slope and may cause significant diversion. The section C—D is on the contour and can act like a weir. High flow velocities could be experienced downstream from any floodways or culverts located on roadways that are perpendicular to the natural flowpath.

Figure 12.8 The orientation of a road to the contour affects its impact on flood flows (Marshall (1988)



Where a road runs across the flowpath of floods, lowering the formation to no more than 100—200 mm above natural ground level will overcome most erosion problems on surrounding land. Such a road acts as a long floodway and creates much less backup of water than a raised road. Floodwaters flow over its full length in a shallow controlled flow. As the overfall below such a road is small, turbulence is minimal and little damage will be experienced on the cultivated land below.

Low roads are generally considered unacceptable by constructing authorities for major highways because they will flood too frequently. People unfamiliar with the area and unaware of driving requirements during flood times frequently use highways, so for safety reasons, raised formations are preferred. However, safety problems are less likely on low secondary roads. Provided low sections are well marked with depth indicators and built with adequate cross fall to prevent water lying on the road, they will create few problems for local residents and will contribute substantially towards reducing erosion problems.

In cases where drainage is provided under roads, it is preferable to use box culverts rather than pipes in order to achieve a better spread of flood flows, and to help in keeping the road formation to a low profile.

12.32 Farm roads

The same issues that apply to shire roads also apply to farm roads and access tracks. Where such roads cross-flood flow areas they should be constructed no more than 100 mm above natural ground level. A formed road may be prone to damage because of high moisture content after flooding, so it should be built at least 5 m wide with a solid foundation.

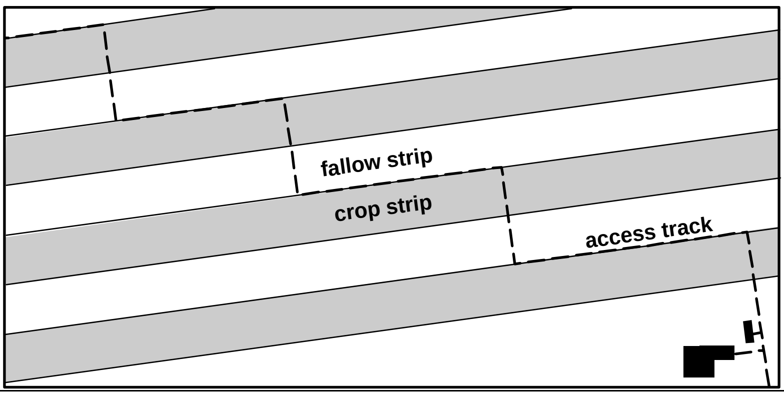
Where a road already exists across a flood-flow area, floodway sections should be installed at intervals to reduce flow diversion and concentration. The width and frequency of these floodway sections is dependant on the intensity of the flooding. Where a road is causing major erosion or pondage problems, serious consideration should be given to relocating the road so that it does not affect flood flows.

On unformed roads and access tracks, water can run along and damage the road surface. Low banks, or ‘whoa-boys’, placed at intervals across such roads and extending into adjoining cultivation will minimise this problem. ‘Whoa-boys’ should be no more than 200 m apart so that runoff is released in small quantities onto adjoining land.

12.33 Access tracks

Access tracks through cultivated paddocks should be relocated regularly as they are very prone to erosion damage. Crops should be planted across tracks and right up to paddock boundaries so that the whole paddock is protected from erosion by a growing crop. Tracks through a strip cropped area can be zigzagged to reduce the possibility of flow concentrating along the track and causing erosion (Figure 12.9)

Figure 12.9 Zigzagged track through a strip cropping layout



12.34 Railway lines

Railway embankments are typically raised at least 500 mm above normal ground level and hence have potential to cause considerable impediment and diversion of flood flows. The loose stone ballast supporting railway sleepers is easily removed by floods leaving the rails and sleepers unsupported. For this reason, railway lines are always constructed on embankments to raise the railway above expected flood levels.

Railway lines on the Darling Downs were constructed in the late 1800s or early 1900s when there was little cultivation on the floodplain. Since then there has been considerable change in the patterns of overland flow resulting in inadequate railway cross-drainage at many locations. Subject to budget restraints, Queensland Rail is willing to consider suggestions for improving cross-rail drainage.

12.35 Fencelines

Floodwater is often diverted and concentrated along fencelines, not necessarily because of the fence itself but because of the vegetation growing along the fenceline or a build-up of soil or silt deposits along the fence.

In many parts of the Darling Downs floodplain where there are no stock on farms and no stock routes, fences have been removed. Removal of fences must be accompanied by levelling of soil build-up and erosion scours along them. Where fences have been removed, corner posts should be retained along portion boundaries to prevent the need for a re-survey on the sale of the property and avoid encroachment of cultivation onto road reserves.

Where occasional fencing is required for stock control, electric fencing is ideal. If this is impractical, suspension fencing will cause fewer problems than conventional fencing because of the lower number of posts to collect debris and interfere with under-fence maintenance.

12.36 Levee banks

Levee banks are often constructed in an attempt to control flooding on floodplains. In attempting to achieve this, they may concentrate flows, which can lead to higher velocities, more erosion and may have adverse effects on downstream properties.

Levee banks counter the basic principle of spreading flood flows. Levees along a watercourse can increase the discharge downstream and thus increase flooding problems for lower landholders. Serious scouring and gully erosion can also result if a levee bank is breached and water rushes through in a confined flow.

Levee banks constructed to protect residential areas from flooding may cause major problems for surrounding cultivated land. However, a levee bank surrounding isolated homes and buildings in the middle of a floodplain should have minimal impact on flood flows.

Some Local Authorities with floodplains have established Local Laws under the *Local Government Act 1993* to give them control over levee bank constructions. Construction of levee banks may also be controlled under the provisions of a Water Resource Plan approved under the Water Act 2000, relating to control of overland flows.

12.37 Irrigation structures

Any above–ground structures associated with irrigation such as ring tanks, diversion banks and head ditches may interfere with flood flows. Most infrastructure for irrigation on the Darling Downs floodplain has been constructed on sections of the floodplain that are less vulnerable to erosive flooding. However in recent years there has been an expansion of the irrigated area in areas subject to erosive flooding.

Irrigation infrastructure may also be subject to development controls by Local Government Levee Bank Local Laws, or Water Resource Plans. ■