CONTOUR BANK CONSTRUCTION USING A BULLDOZER

by
J. P. Marshall and P. Rowland

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This publication was prepared in 1987 by the Soil Conservation Services Branch of the former Queensland Department of Primary Industries (QDPI). The state agency now responsible for soil conservation matters is the Department of Environment and Resource Management (DERM).

Some construction methods may have been modified since the publication was written.

People using the information in this publication do so at their own risk.

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INTRODUCTION

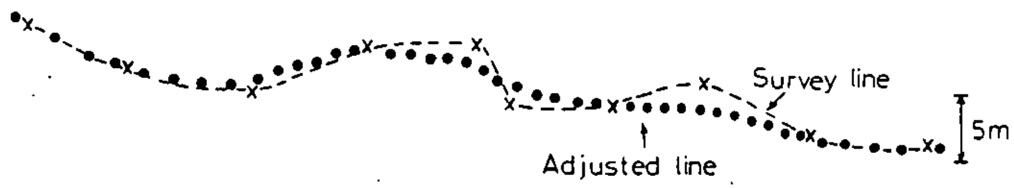
This publication is designed to give a step by step guide to the building of contour and diversion banks. It covers construction techniques for landholders using a bulldozer. Other publications have been prepared for construction using a farm tractor blade, and using a grader.

1. FIELD PREPARATION

1.1 Improving the shape of the survey line

The survey line should be checked for awkward, unnecessary bends and smoothed to improve the workability of the eventual contour bay.

Figure 1. Adjusting the survey line prior to construction.

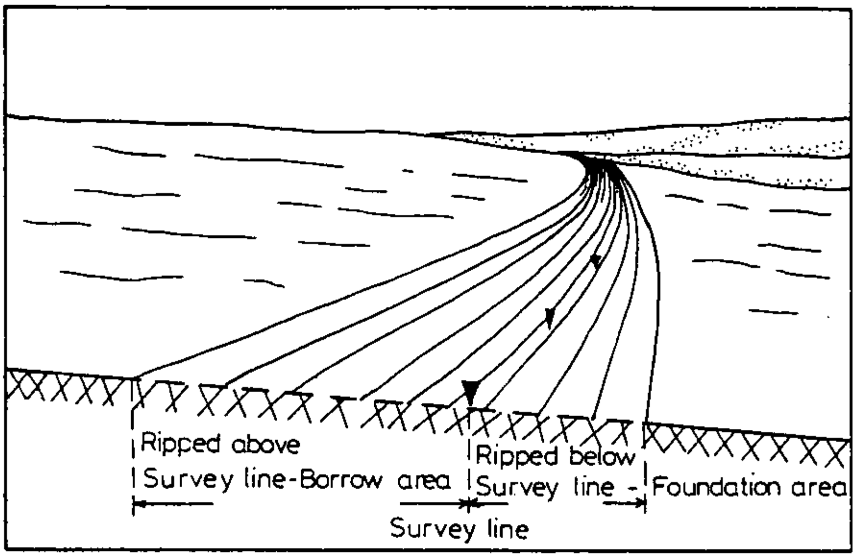


The survey line should not be moved more than 5 m on flatter country (less than 2%), nor more than 3 m on steeper areas. Where the survey line goes around a ridge, uphill movement should be minimal. Pondage in the channel will occur unless the channel is cut deeper. Where the survey line follows sharp gullies or depressions, it can be moved downhill. The height of the bank should be increased accordingly.

1.2 Ripping

The aim of the ripping phase is to prepare sufficient quantity of well ripped material to construct the required bank. A well ripped borrow improves the efficiency of all construction machines. The ripping operation is also important in achieving a desirable channel shape, that is,broad and relatively flat. This is important for channel performance, and workability. A sharp dropover into the channel is to be avoided.

Figure 2. Ripping above and below the adjusted survey line



Care must always be exercised when ripping around bends, the tendency being for the turning of the tractor to narrow the borrow width. In fact, extra borrow is required in these situations, to account for the proportionally greater length of bank that has to be constructed.

The bank material must bind with its 'foundations' for strength, and for prevention of seepage. Therefore, it is necessary to rip below the surveyed line as well, unless the ground has been recently cultivated. It is wise to leave a 30 to 45 cm width of unripped ground immediately below the survey line as a guide in placement of the first and subsequent pushes.

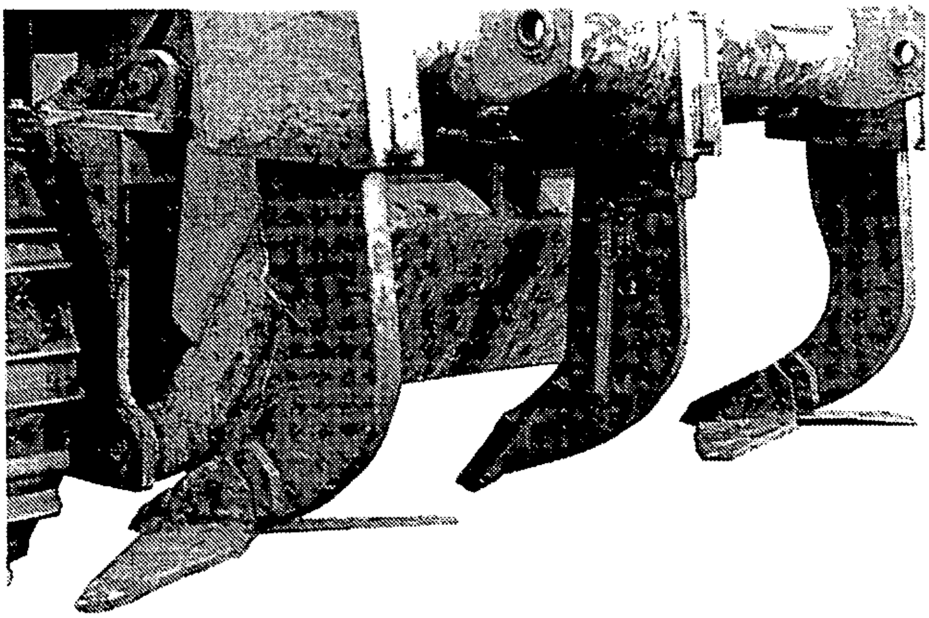
If a heavy bulk of pasture or crop stubble is present, this should be removed from the 'foundation' area, to prevent problems when this material decays.

Heavy pasture or stubble will interfere with ripping operations in the borrow area. Spraying and/or burning of vegetative material will improve efficiency (well prior to construction however!!!)

1.3 Equipment for ripping

Inefficient ripping can result in a construction job becoming excessively costly. Using a single tine ripper is very inefficient because of the excessive amount of 'straddle' ripping that has to be carried out. Straddle ripping is time consuming, and inefficient because of slippage by the tracks. Even a three tine ripper may not achieve a completely satisfactory 'breakout' in difficult soil conditions. Looping a cable through the back of the tines is one way of improving the job. Using 'knock-on' sweeps, which can be rapidly exchanged with the ripper points, will produce a well cut borrow.

Plate 1. Sweeps attached to rippers for improved performance



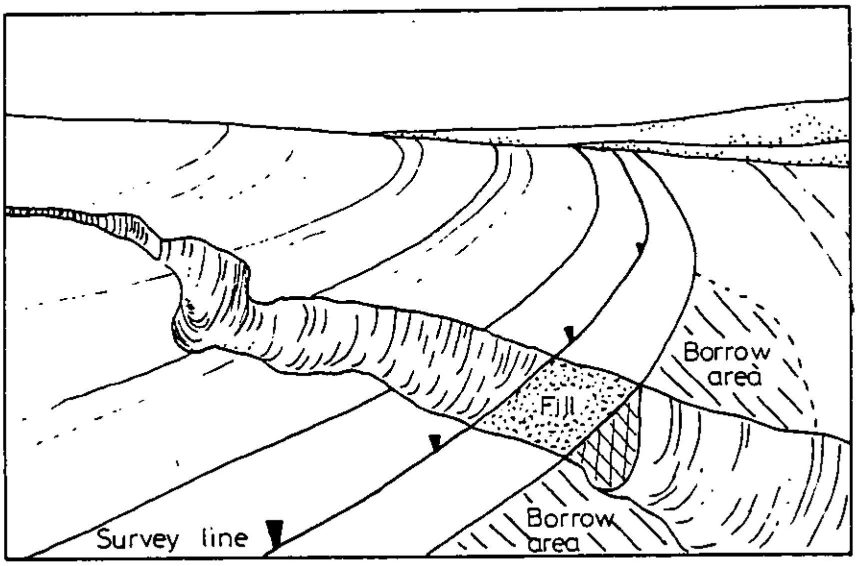
The tendency to rip to the full depth of the rippers should be avoided. There is no requirement to rip to more than 35 cm depth for a push, provided the material is well cut.

A trailed chisel plough with sweeps attached can be very efficient in preparing the borrow area in cultivation, if soil conditions are not too tough. A blade plough, with a new blade for good penetration, does a good job of 'cutting' the borrow. Only the centre section of a 3 blade machine is used.

1.4 Filling gullies along the line

It is important that gullies be filled along the foundation line, prior to commencement of actual construction. For this task, most material should be taken from below the future bank location. Use subsoil material as fill, preserving topsoil for dressing the source area.

Figure 3. Gully fill prior to construction



1.5 Channel preparation prior to pushing

Not only does a sharp dropover into the channel predispose to future erosion problems but also it can interfere with the efficiency of the dozer during the reversing phase of the operation cycle. This problem can be lessened by a quick run along the top of the ripped area with an angled-tilted blade on a grader or dozer prior to the normal pushing, producing a wedge shape approach.

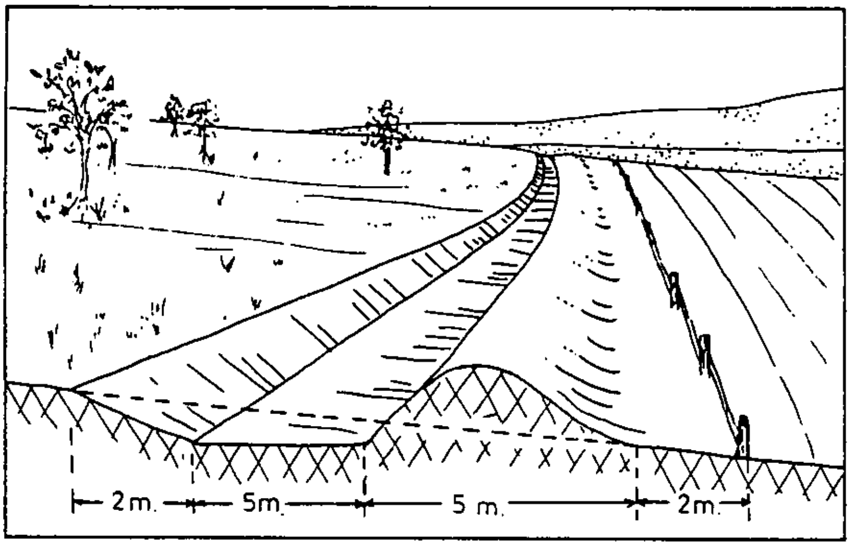
Plate 2. Using an angle-tilt blade to lessen channel dropover

2. TYPES OF CONTOUR BANKS

2.1 Diversion banks

This is a large contour bank, generally located between upslope timber-pasture country and lower cultivation areas. It can be used on all soil types suitable for bank construction. It serves to direct runoff water from grazing areas into natural drainage lines or constructed waterways. The cultivation or pasture area below the diversion bank is protected from this run-on water. The channel and bank itself are grassed.

Figure 4. Diversion bank



Typical dimensions:	constructed bank height	1.0 m
	borrow width	8.0 m
	bank width	5.0 m

2.2 Contour banks

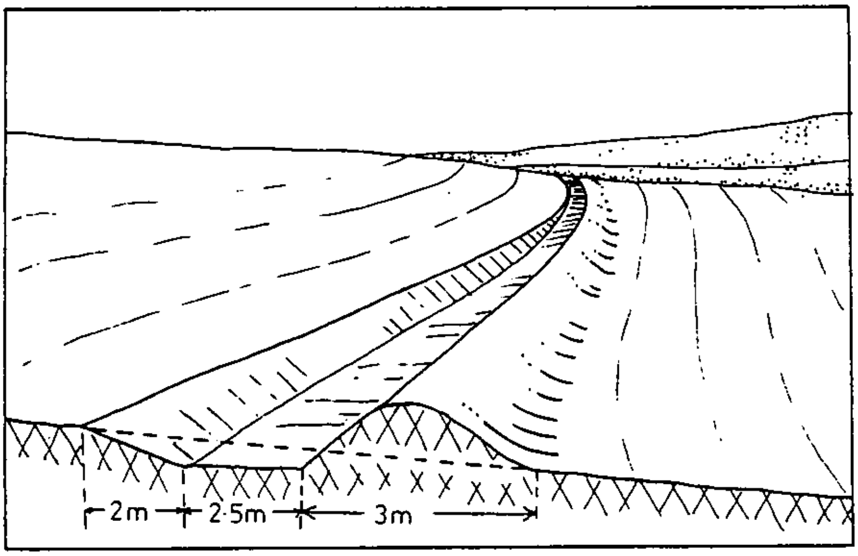
In cultivation a number of different bank types are used. The choice of bank type is determined by the slope, soil type, soil erodibility and the farming method. The local soil conservation adviser will indicate which bank type is necessary in each situation.

2.2.1 Narrow based bank

This bank type is suitable for shallow, non cracking soils. After construction, the bank is allowed to grass but the channel can be cultivated. They are relatively cheap to construct. However, they have a number of disadvantages when compared with most other bank types:

(i) site for weed growth.
(ii) subject to damage from burrowing animals
(iii) most prone to damage by animal pads.
(iv) result in some loss in cultivated area.
(v) likely to fail in cracking soils.

Figure 5. Narrow based bank

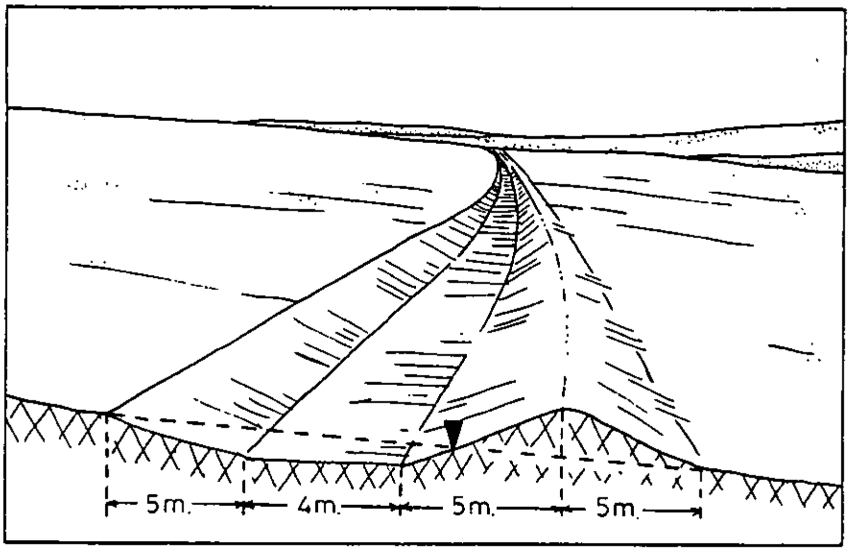


Typical dimensions:	constructed bank height	0.75 m
	borrow width	5.0 m
	bank width	3.0 m

2.2.2 Broad based banks

These banks are particularly suitable for deeper cracking soils. The bank can be either allowed to grass or be cultivated. A bank base width of 5 to 8 metres is normal with the grassed version. Usually 8 to 12 metres base width is necessary for the cultivated bank. Broad based banks are relatively expensive to construct. Maintenance costs are greater for the cultivated bank but no area of cultivation is lost when the bank is formed.

Figure 6. Broad based bank



Typical dimensions:	constructed bank height	0.8 m	
	borrow width	10.0 m	(cultivated)
		8.0 m	(grassed)
	bank base width	11.0 m	(cultivated)
		6.0 m	(grassed)

2.2.3 Broad based top side, broad based bottom side banks

These banks are particularly suitable to deeper, cracking soils where cultivation of the channel and one side of the bank reduces cracking problems. These banks are relatively expensive to construct, but maintenance costs are less than for fully cultivated banks. On steeper slopes (greater then 5%), the broad based top side is recommended.

Figure 7. Broad based top side bank

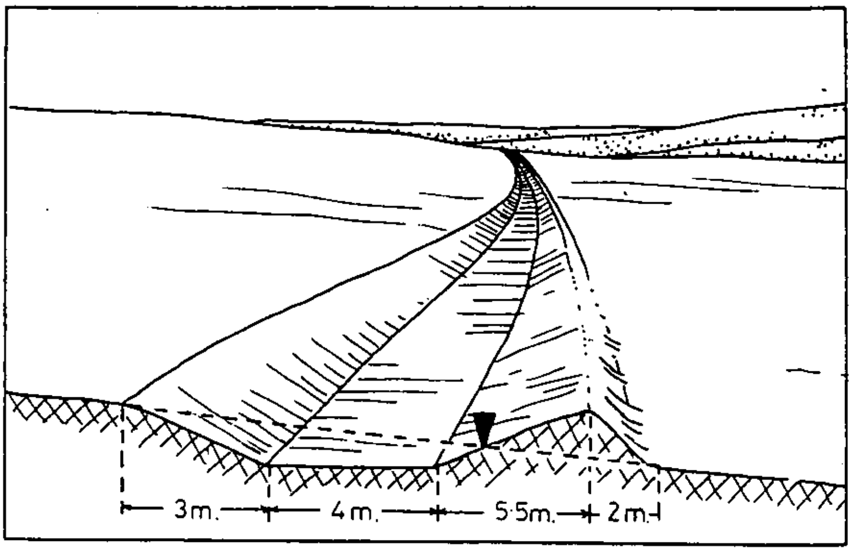
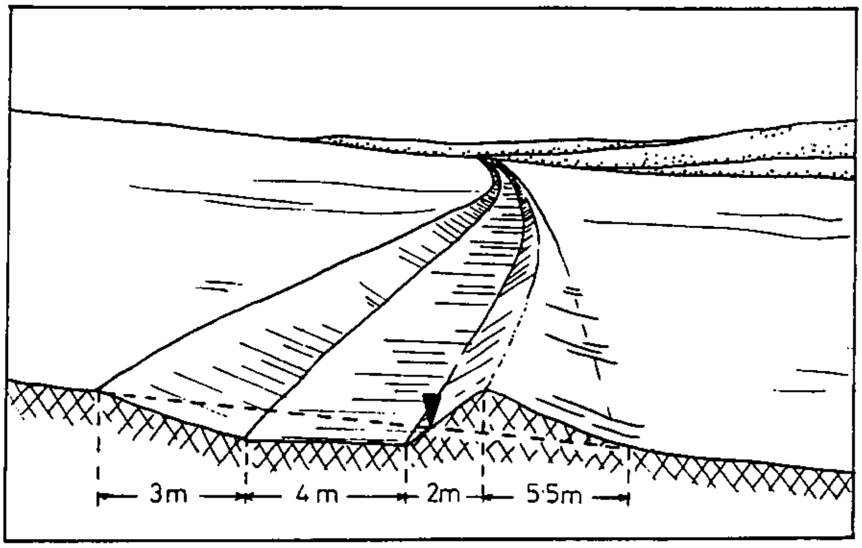


Figure 8. Broad based bottom side bank



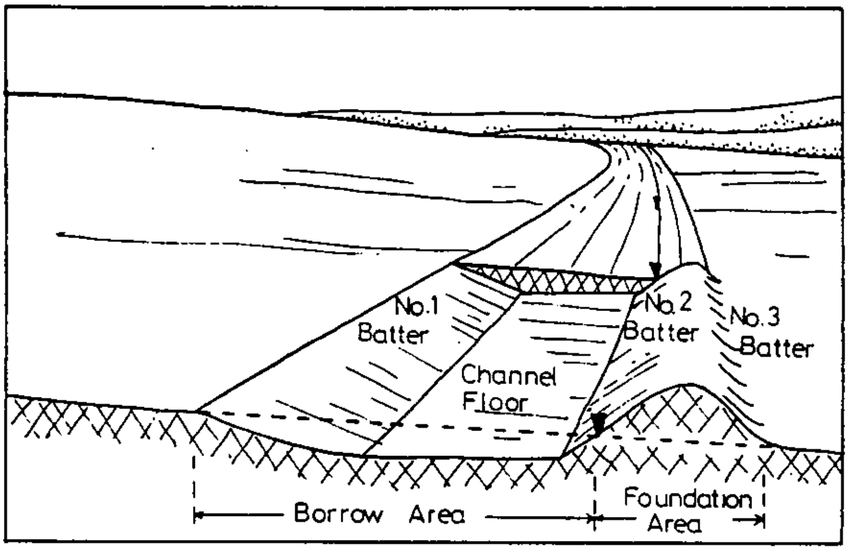
Typical dimensions:	constructed bank height	0.8 m
	borrow width	8.0 m
	bank base width	7.5 m

3. VARIATIONS IN THE BASIC COMPONENTS OF CONTOUR BANKS

3.1 Terminology

The following diagram illustrates some of the terms used in describing contour banks and the techniques of bank construction.

Figure 9. Contour bank terminology



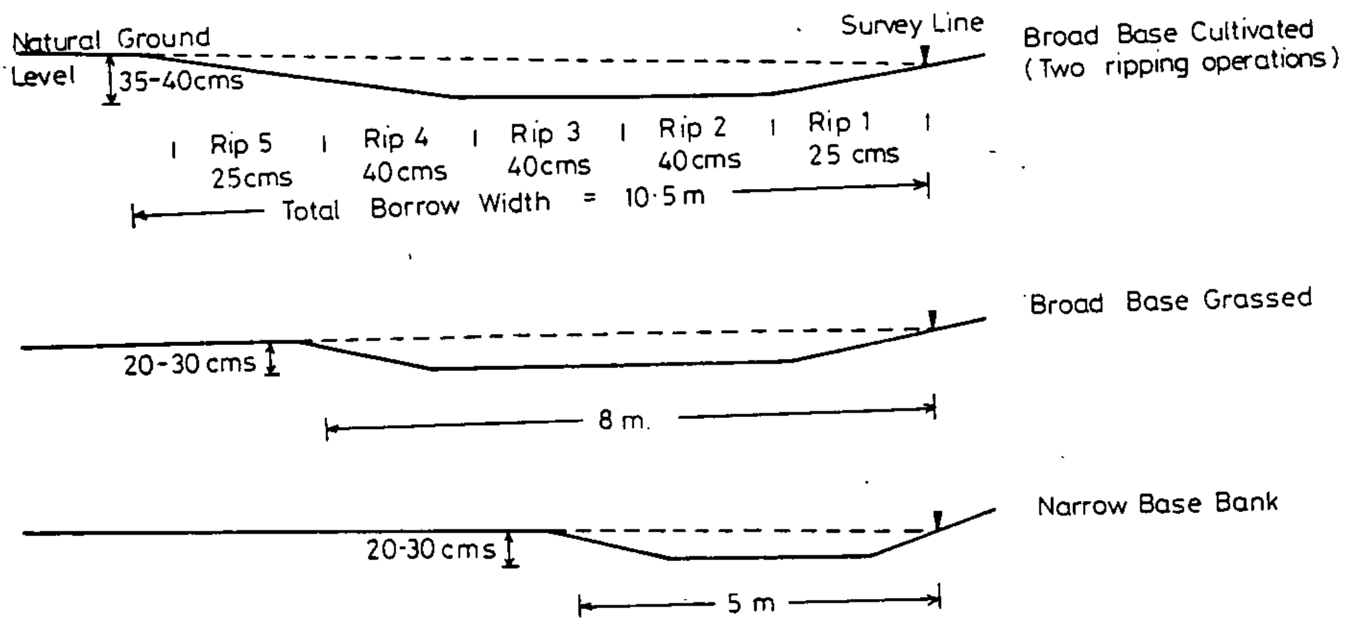
3.2 Borrow area

The amount of material required from the borrow area is influenced by the type of bank being built. A typical broad based cultivated bank may require 3.0 m^3 material per 1.0 m of bank length, while a narrow based bank may require 1.0 m^3/m. This difference in requirement is met by varying the width of the borrow area, and the depth of borrow (number of rips, depth of each rip).

There is a temptation to have a deep, narrow borrow area to reduce the amount of back and forward travel by the dozer. Such a channel can produce a number of problems. Effective cultivation is difficult. The steep dropover into the channel can aggravate rill erosion. Exposure of deeper subsoil, and the narrow flow section can lead to channel erosion.

Ideally, every attempt should be made to have the water flow carried in a broad, relatively flat channel, away from the base of the bank. This can be achieved by varying the depth of ripping, with maximum depth in the centre of the ripped area.

Figure 10. Variation in borrow area dimensions for different bank types



3.3 Typical changes in cultivated bank with 'ageing'

All bank types change in the first couple of years after construction. The alteration is most noticeable on cultivated banks on swelling clay soils. Some of the reasons for change include silt deposition in the channel, settlement of the bank and movement of material from the bank crown during cultivation operations.

These changes have important implications, because of the necessity of maintaining an adequate flow cross-section area and the desirability of matching planting equipment with the bank shape.

Figure 11. Changes in cultivated bank dimensions with 'ageing'

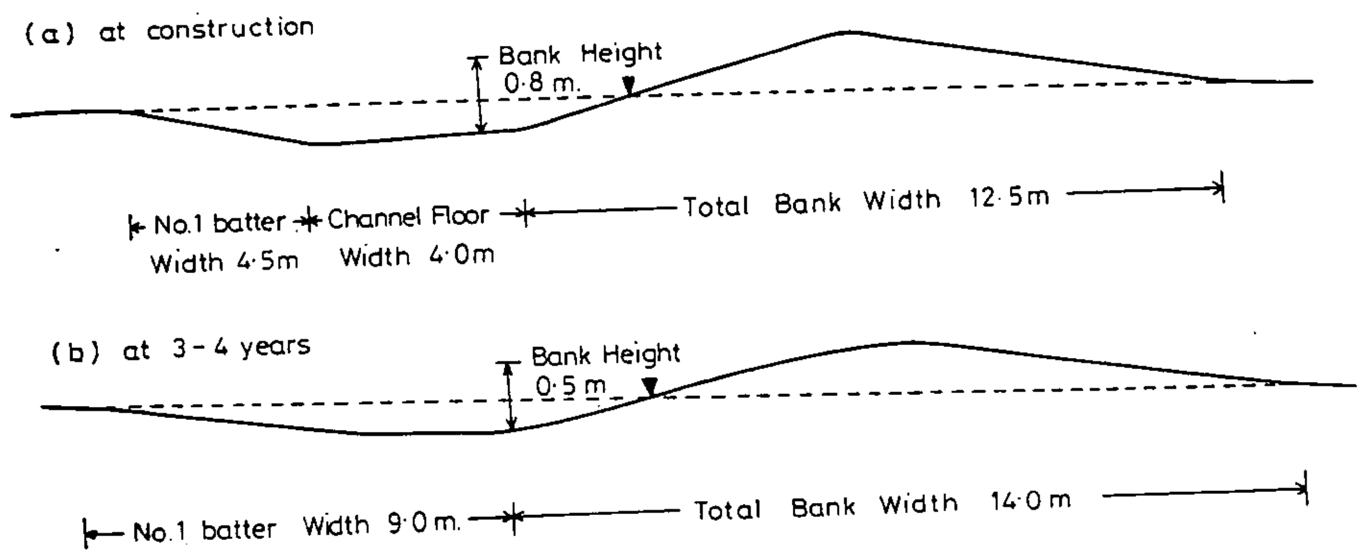


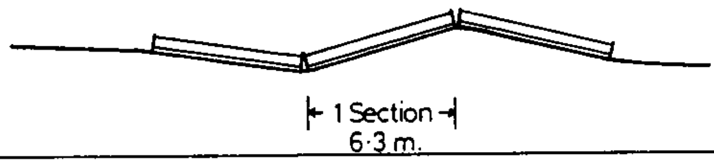
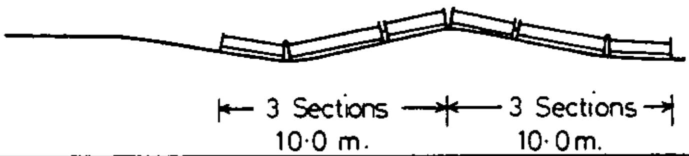
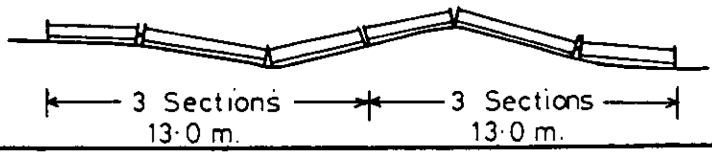
Table 1. Dimensions for typical broad base cultivated contour banks (4% land slope)

Bank Dimension	(a) At construction	(b) At 3 to 4 years
Width of borrow	10.5 m	-
Total bank width	12.5 m	14.0 m
Bank height	0.8 m	0.5 m
Flow section shape	Trapezoidal	Triangular
Flow area	6.2 m^2	3.6 m^2
Width No. 1 batter	4.5 m	9.0 m(combined)
Width channel floor	4.0 m	
Width No. 2 batter	5.5 m	7.0 m
Slope No. 2 batter	1:8	1:16
Width No. 3 batter	7.0 m	7.0 m
Volume of excavated material	3.0 m^3/m	-
Volume of deposited material	4.2 m^3/m	-

3.4 Catering for variation in width of planting machinery in cultivated bank construction

The advent of planting machinery with folding sections has made construction of cultivated banks a more feasible proposition in most situations. The channel and bank can be more readily shaped to accommodate such equipment. Alternatively, when buying new planting machinery, it can be purchased with a sectional arrangement which will readily fit existing banks. It is important to realise that the shape of a cultivated bank does alter after construction. A poor fit immediately after construction will usually improve with time.

Table 2. Accommodating planting machinery of varying width on banks

Planting machine type	Suggested technique for fitting planting machine on bank
Rigid frame 6.3 m wide	
Folding wings 10 m wide (3.0m,4.0m,3.0m)	
Folding wings 13 m wide (4.0m,5.0m,4.0m)	

3.5 Topsoiling

In some instances (where a grader or scraper is available), consideration should be given to removing the top 5 cm of soil from the borrow and the foundation area prior to ripping, and stockpiling this material. It can be used to topdress the channel and bank batters. Although adding to the initial cost, this practice decreases the loss of productivity in borrow areas due to removal of the topsoil. Topsoiling also speeds up vegetation of banks and the channel where they are to be grassed.

4. BANK CONSTRUCTION TECHNIQUES

The following section deals with actual construction techniques. A number of different techniques are employed by contractors in moving material from the borrow area, depositing it on the foundation area. Landholders are recommended to try all and decide which is most efficient for their soil type and machine. The techniques outlined are based on use of a medium sized dozer (for example D5). Obviously the number of ripping operations and pushes will vary with the size of the machine.

4.1 Construction technique A

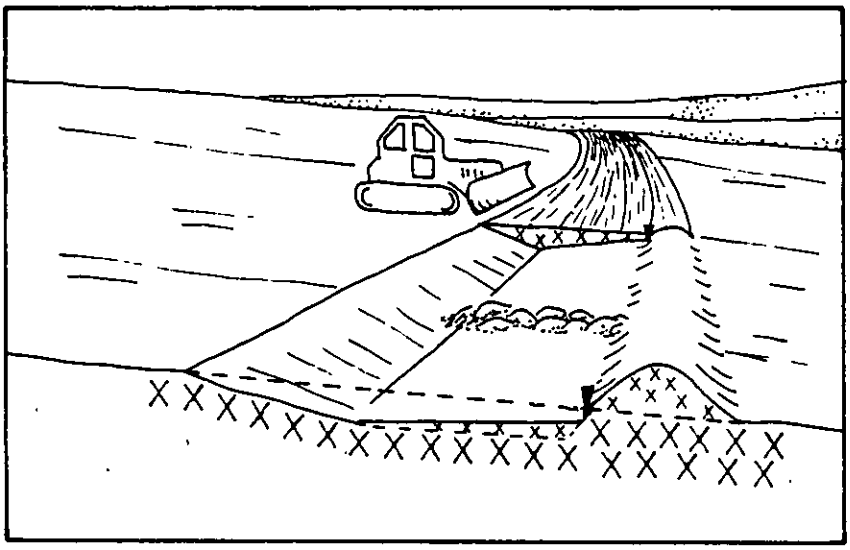
4.1.1 For grassed and cultivated banks

Step 1. Rip or plough an 8 m wide strip above the survey line, a 5 m wide strip below. (These widths vary with bank type).

Step 2. The first push commences from the top edge of the ripped area, at the outlet end of the bank. The blade will fill with material from the No. 1 batter and will skim the top off the remainder of the ripped material. The material is dumped on the bottom side of the survey line so that it falls back to the survey line as the dozer reverses.

While in reverse, the machine is manoeuvered to be a full blade width from the initial push, the blade is lowered gradually into the ripped material. Having the blade on the ground before forward movement creates a very uneven batter.

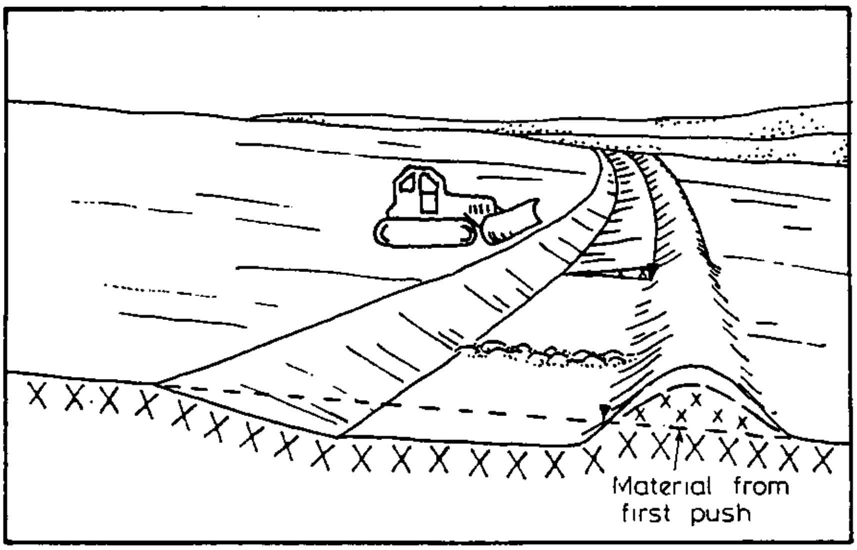
Figure 12. Bank appearance after 1st push



Step 3. The material in the second push will consist of the remainder of the ripped material, plus windrows resulting from the first push. This push will start 2 to 3 metres closer to the survey line. The No. 1 batter and channel are shaped with this push. The material is pushed into the earth dumped by the first push. Care has to be taken that the survey line is not lost, otherwise the bank toe creeps back into the channel.

The type of bank being constructed influences the blade travel at the end of this push. If the bank is going to be cultivated, the blade is gradually raised after crossing the survey line position, shaping the No. 2 batter as it travels forward. To reduce construction time the blade should not be allowed to pass the extremity of this batter. For grassed/ uncultivated banks, the blade is quickly raised after passing the survey line position, piling the second push material on top of the first. The machine is then manoeuvred back ready for the adjacent push.

Figure 13. Bank appearance after second push

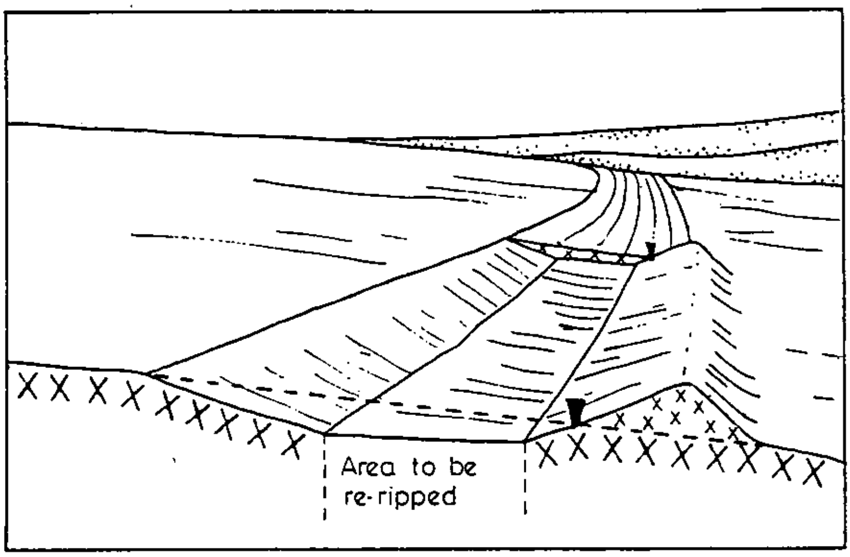


Step 4. If a contour bank is to be fully cultivated, a third push may be necessary. A second ripping in the borrow area will be necessary to provide material.

Usually a much narrower area is ripped, across the channel floor, not extending up the No. 1 batter.

Any windrows left behind after the second push will cause no problem if the blade is lowered during the ripping operation.

Figure 14. Preparing for second ripping



Step 5. The third push completes the channel, the No. 2 batter, establishes specified bank height, and spills remaining material over the back, for later formation into the back (No. 3) batter. Since less material is required on lower slopes to form the No. 3 batter, pushes can be spaced slightly wider apart.

During this push, the dozer itself travels up the No. 2 batter, but must not drop over the bank crest. The No. 3 batter is generally shaped by the dozer after completion of the third push, by working along the batter.

4.2 Construction technique B

4.2.1 For grassed banks

Step 1. As for construction technique A.

Step 2. Part of the blade collects ripped material; this material flows along the blade so that the blade fills as the machine crosses the channel.

As the full blade approaches the ripped ledge on the survey line, it is eased up slightly and then brought back down again. The dozer travels through until the tracks reach the survey line. As the machine reverses, soil will fall back to the survey line.

While in reverse, the machine is manoeuvred to be 1/3 to 1/2 a blade width along from the previous push. Material from subsequent pushes is 'pushed' beside and into that from the previous.

4.2.2 For cultivated banks (Average dozer)

Step 1. As for 'Technique B - grassed bank'.

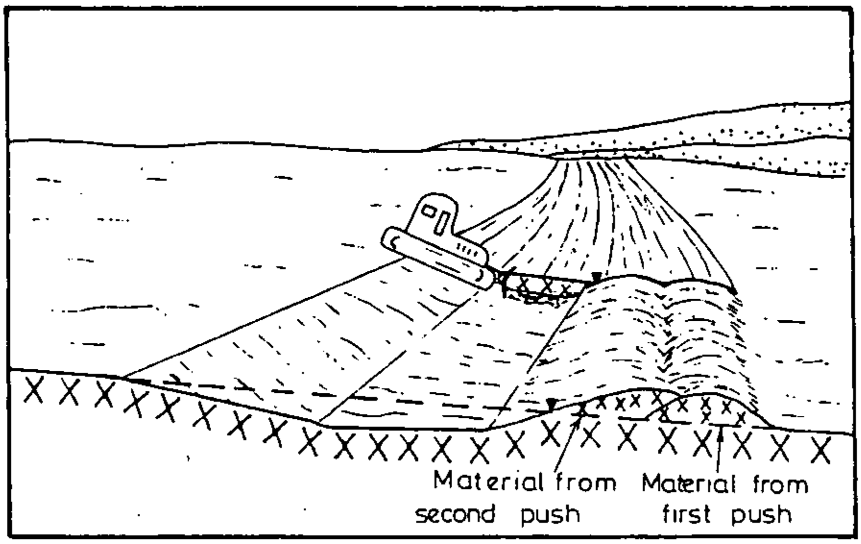
Step 2. As for 'Technique B - grassed bank'.

The only difference is that the dozer travels on further past the survey line, depositing the material so that, as the machine reverses, it falls back to be 2 to 3 m below the survey line.

Step 3. After a first push down the entire channel length the channel is re-ripped. Usually a much narrowered area is ripped, across the channel floor, not extending up the No. 1 batter. Since this is a shorter push and there is less ripped material, a greater width of blade is used to collect the material.

Step 4. As the full blade passes the survey line, the blade is lifted gradually, allowing controlled escape of material to form the No. 2 batter. Most material from this push sits in against the first push material. No. 3 batter is shaped up subsequently by the dozer working along the batter.

Figure 15. Bank appearance after second push



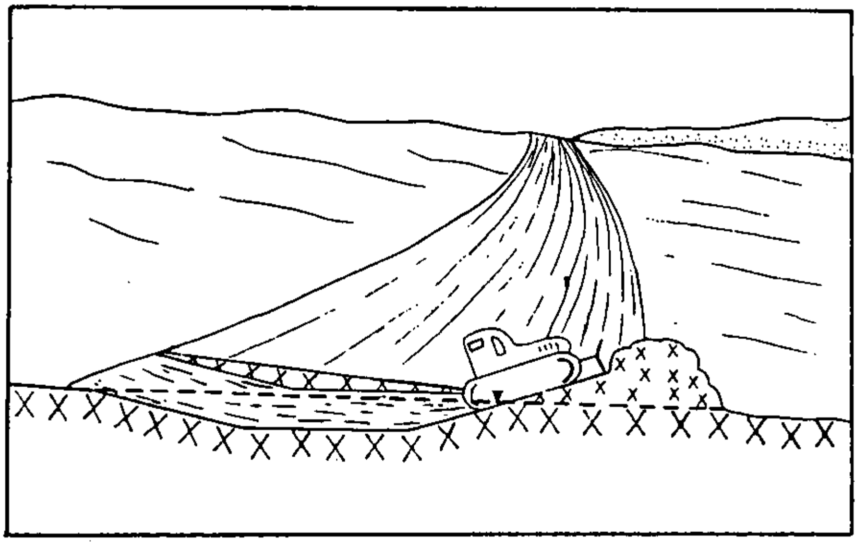
4.2.3 For cultivated banks (large dozer)

Step 1. Using this technique, large dozers (D7, D8 and equivalent) have the blade capacity and power to move sufficient material to construct a cultivated bank with one pass. A much greater width of borrow is ripped (up to 12 m).

Step 2. Part of the blade collects ripped material from the top extremity of the ripped area. As the full blade approaches the ripped ledge on the survey line, it is eased up slightly. As it passes the survey line, the blade is kept up off the ground, allowing material to escape to form the No. 2 batter. The dozer continues through until the driver's seat is in line with the survey line. The No. 3 batter is shaped up subsequently from the pile of material left as the machine reverses; the dozer works along the batter to do this.

While in reverse, the machine is manoeuvred to be 1/3 to 1/2 a blade width along from the previous push. Material from subsequent pushes is 'pushed' beside and into that from the previous.

Figure 16. Approaching end of first push



4.3 Construction technique C

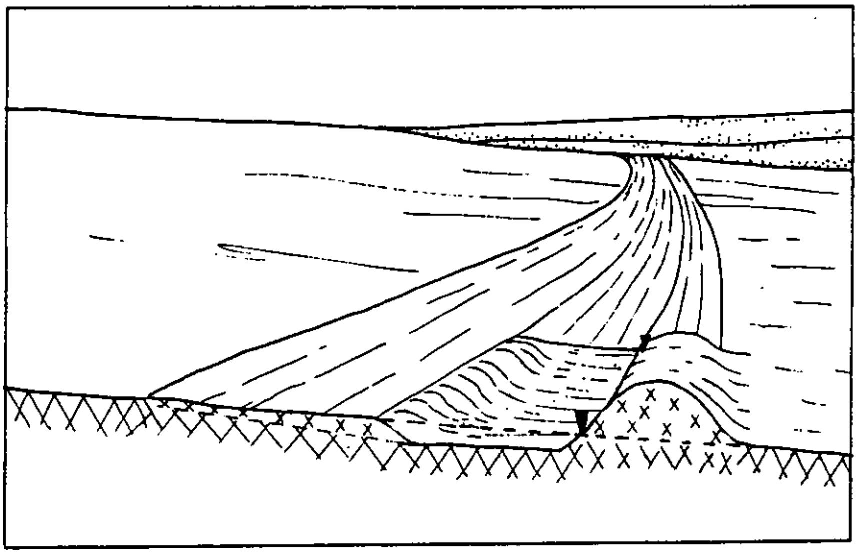
This technique varies from technique A principally in that the ripped material nearest the bank is moved first. Two variations of this technique are used depending on the type of bank to be constructed.

4.3.1 For grassed banks

Step 1. As for technique A.

Step 2. The first push commences approximately half way across the ripped material above the survey line. A full blade of material is dumped below the survey line.

Figure 17. Bank appearance after first push

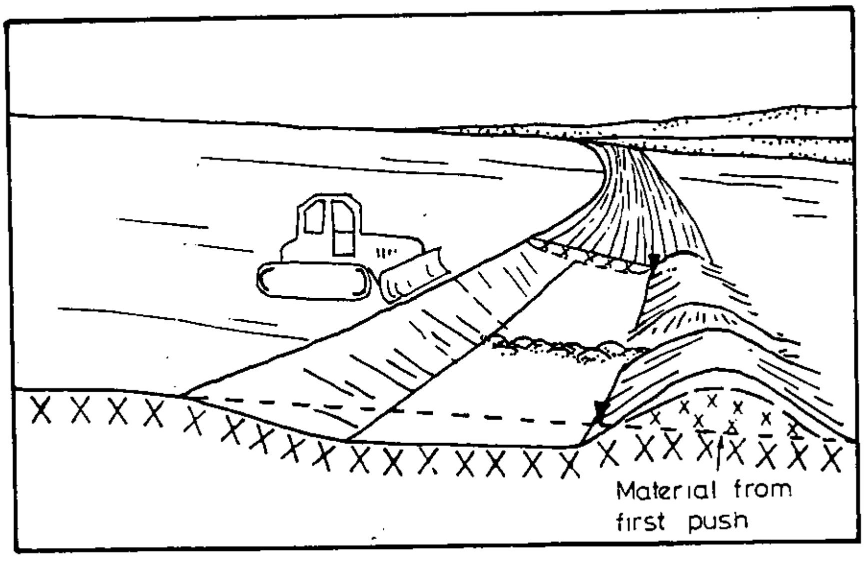


Step 3. For the second push the tractor reverses back to the edge of the ripped material. This ripped material is pushed forward and is placed on top of the first push.

Step 4. Repeat step 2 and 3 for the adjacent blade width of the bank.

Step 5. A 'clean-up' push overlapping the previous ones picks up the rill material and places it in the gap between the previous pushes.

Figure 18. Bank appearance after second push



The bank is completed as the dozer works along it.

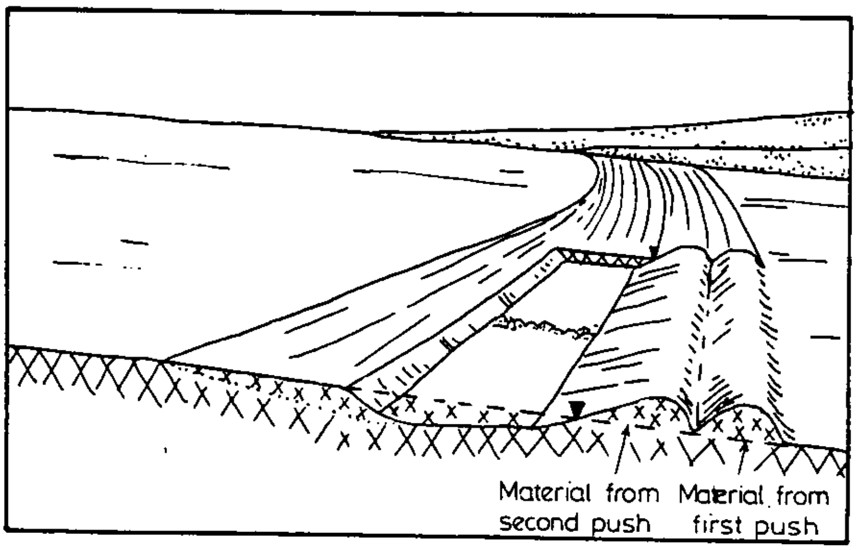
4.3.2 For cultivated banks

Step 1. Rip or plough a broader area (up to 12 m wide) above the survey line and 8 m below.

Step 2. The first push is taken from about 1/3 of the way into the ripped material above the survey line. This is deposited about 3 m below the survey line. Obviously, this distance is influenced by the width of the batters desired.

Step 3. The second push is taken from about 2/3 to 3/4 of the way into the ripped material and is deposited in front of the mound left by the first push.

Figure 19. Bank appearance after second push



Step 4. The third push starts from the upper edge of the ripped material. The material is taken up and over, fills in the hollow between the previous mounds. During this push the shape of No. 1 and No. 2 batter is formed.

Step 5. Repeat steps 2, 3 and 4 for the adjacent blade width of the bank.

Step 6. A 'clean-up' push overlapping the previous ones picks up the rill material and places it in the gap between the previous pushes.

Table 3. Summary of different bank construction techniques

Bank construction technique	Bank type	Movement of material from borrow area	Deposition of material on foundation area
Technique A	Grassed bank	First push from rear of channel, full blade width. Second push closer to survey line, full blade width.	Material from second push 'pushed' into first push material sitting on bottom side of survey.
	Cultivated	First push as above. Second push as above. Third push, reripped material closer to survey line,full blade width.	As above. Second push used to shape No. 2 batter. Third push material spilt over back for No.3 batter.
Technique B	Grassed bank	1/3 to 1/2 blade taken into ripped material for each push, across full channel width.	Material from each push 'pushed' beside and into that from previous one.
	Cultivated bank	As above. Area reripped across.	Material from first taken 2 to 3 m below survey line. Second push material pushed up against first push material
	Cultivated bank (large dozer)	Single ripping only, but greater width than for previous.	Material from each push carried through to shape No. 2 batter, leave deposit for No.3
Technique C	Grassed bank	First push from half-way across channel,full width. Second push from rear of channel,full blade width. 'Clean-up' push from halfway across channel.	Material from second push 'pushed' into first push material sitting on bottom side of survey line. Clean-up push placed in gap between adjacent 'pairs'.
	Cultivated bank	First push from front 1/3 of channel, full blade width. Second push from 1/2 to 3/4 back into channel, full blade width. Third push from rear, full blade width. 'Clean-up' push from halfway across channel.	Material from first push taken 3 m below survey line.Second push material sits between it and survey line. Third push up and over, filling in the hollow.Clean-up push placed in gap between adjacent 'pairs'.

NOTE: Any combination of movement and deposition techniques outlined here is possible. The combinations listed are ones used by a few representative contractors.

4.4 Finishing the job

* Loose material left in the channel should be worked in by ploughing. This should be done soon after the dozer is finished as the exposed subsoil material can set very hard. If topsoil has been stockpiled prior to construction, this is spread across borrow area and batters.

* The dropover into the channel (No. 1 batter) should be gradual. If it is left too steep after construction, it is best smoothed out by ploughing along it, using a disc plough.

* Bank outlets into waterways should be made wide to allow efficient outflow, prevent blockage with stubble, hail etc.

* If new fencing is to be carried out in conjunction with the banks, a gateway is needed at the outlet end to allow maintenance. Two strainers are needed, one above the borrow area, the other below the bank, with a short section of fencing in-between. Netting fencing needs a float system in the channel section.

* Cultivated banks should be left for several months to settle before working them. A lot of slipping and sliding on the bank is likely if they are not allowed to settle.

5. SOME CONSIDERATIONS IN DOZER SELECTION FOR SOIL CONSERVATION WORK

If considering purchasing a dozer for construction of soil conservation works, certain aspects should be considered.

5.1 Transmission

Because of the large number of forward and reverse movements, ways of speeding up this cycle are important. Machines with power shift and torque convertors, obviously have an advantage over machines with a clutch and gear shift. The former may be capable of completing a normal full working cycle in approximately 20 seconds, the latter would take 30 to 40 seconds for the same cycle.

5.2 Location of controls

The layout of the major controls can influence operator efficiency. The important ones are the steering clutches and steering brakes, and the blade controls. The ideal arrangement has these controls hand operated, leaving the feet free for operation of the decelerator.

5.3 Blades

There is a big variation between blades, both in type and size. The table below lists the major types and their normal size.

Table 4. Types of bulldozer blades

Blade type	Normal width	Normal height	Blade shape
Bull blade	3.0 m	0.9-1.2 m	Very slight curve in the vertical, straight in the horizontal; no end abutments.
U blade	3.0 m	0.9-1.2 m	Blade has two shoulders, 30 to 45 cms forward of centre section
Semi U	3.0 m	0.9-1.2 m	Very slight curve in the vertical plane; has end abutments.
Angle and tilt	3.0-4.0 m	0.6-0.9 m	C shaped in the vertical plane, straight in the horizontal; no end abutments

A range of blade adjustments are possible. Some machines have a very basic 'blade up and down' function only, while others have the full range. What is important in soil conservation work?

5.3.1 'Blade up and down'

Variation can occur between different machines in even this very basic function. The speed of the response will obviously have a bearing on the length of the normal operation cycle. The system also needs to be sensitive to minor adjustments by the operator during the forward or pushing phase.

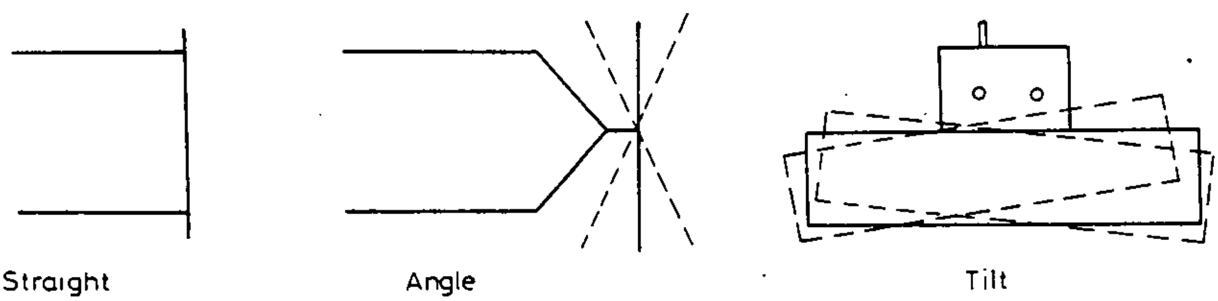
The limits of the 'up' and 'down' movements cause occasional problems. Achieving a constructed bank height in excess of 0.75 m with narrow based ('peaky') banks is difficult with some machines because of 'up' travel limitations. Conversely, some machines have difficulty making bank crossovers, and whoaboys because of 'down' travel limitations.

5.3.2 Blade pitch

The degree of pitch on the blade can be altered on most machines. The adjustment is manual on most, although a few have it hydraulically controlled. The pitch or 'bite' of the blade is seldom altered during normal operations. Ideally, a blade is capable of getting loose soil to roll along in front of it. This minimises the load on the dozer. Too much bite can interfere with this rolling action. Very tight soils or gravelly conditions may require some re-adjustment.

5.3.3 Blade approach

Figure 20. Blade approach



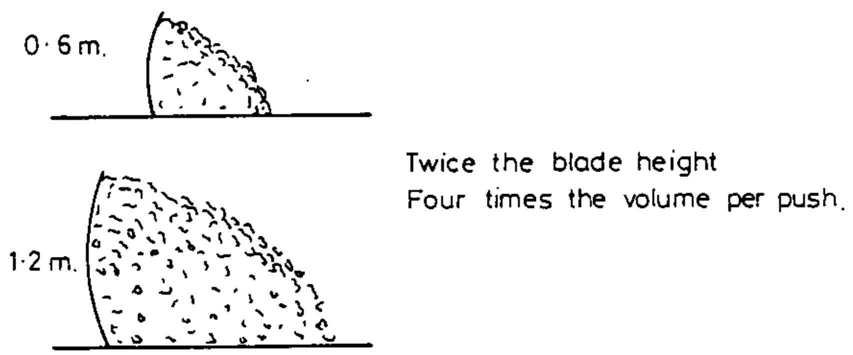
A range of options are available in this function, depending on the machine chosen. The most basic is the straight blade, with no adjustment for angle or for tilt. A number of machines have an angle and tilt blade with either manual or hydraulic tilt, and manual angle adjustment. Some machines have hydraulic (power) angle and tilt PAT as standard. A machine with basic angle and tilt blade with manual adjustments can be modified for power for either or both these characteristics.

5.4 Which combination?

Bull, semi U and U blades tend to be narrower than an angle and tilt blade. This is because the latter, when on full angle, must still 'cover' the tracks and blade carrier behind. This extra width with more blade to ground contact creates control problems in some machines when pushing straight, resulting in sideswing. This is aggravated by the angle and tilt blade-carrier arrangement, which results in the blade being positioned 1.0 to 1.2 m out in front of the machine. Other blade types are positioned closer to the front. Wider blades tend to dig in the corners more often.

Angle and tilt blades are normally not as high as the other blade types. This leads to more dirt boiling over the blade top as the operator strives to keep the machine capacity up.

Figure 21. Influence of blade height on volume moved.



Semi U blades have some advantages over bull blades in soil conservation work: less dirt is lost round the end of the blade; as well, it is easier to get the corner of a semi-U blade under obstructions if encountered. Some machines are now available with semi-U blades with hydraulic tilt. This is a good combination for soil conservation work. U-blades have some limitations for soil conservation work. They are ineffective in grading and trimming operations. They do not produce as even a bank due to different dirt distribution in fron of the blade.

The value of angle and tilt adjustment on a blade, for soil conservation work, depends greatly on whether the control is manual or power. Most of the disadvantages on an angle and tilt blade mentioned earlier can be more than compensated for by having these two adjustments at the fingertips. Power tilt enables the operator to keep his blade parallel with natural ground surface even when pushing in gullied areas. The adjustment enables the dropover lip above the ripped channel to be quickly knocked off, prior to the initial pushing. Power tilt is also convenient to assist with machine tracking in difficult pushing conditions. Power angle adjustment is used by many operators to alter the blade angle during the pushing phase of an operating cycle. A slightly angled blade reduces the tendency for the blace to 'jump' over rips, and helps to even out the blade load when taking only part blade. The combined PAT adjustment is very advantageous when shaping up batters on broad based cultivated banks. Most of the uses for angle and tilt control mentioned here are not practical on a machine with manual adjustments.

5.5 Rippers

Two types of ripper assemblies, radial arc and parallelogram lift are used by dozers engaged in soil conservation work. The parallelogram lift is the better arrangement, ensuring the angle of penetration of the tine remains constant, regardless of depth of working. This becomes even more critical if using knock'on sweeps, and varying the depth of ripping.

The ideal ripper unit has three C shaped, veed front edge, swivel tines, 0.6 m apart, the centre tine slightly leading. When mounted with a 0.75 m ground to frame clearance, this unit should not choke, even in the most difficult working conditions. If soil conditions are ideal and stumps not a problem, attaching sweeps or looping a cable through the rear of the tines will improve the efficiency of ripping.

The radial arc lift, while being less expensive and also having the ability to be lifted higher, is not as efficient in normal soil conservation construction.

Figure 22. Types of ripper assemblies