



GOOD PRACTICE GUIDE FOR HANDLING SOILS

Sheet 19:

Soil Decompaction by Bulldozer Drawn Tines

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MAFF FOREWORD

Standards of restoration of minerals and waste sites have steadily improved in recent years, with operators increasingly aware of their environmental responsibilities. The industry is putting forward more imaginative restoration concepts to a variety of afteruses, and is more aware than ever that it will be judged on the standard of that restoration, and the sustainability of the development.

Sustainable mineral development means balancing economic, environmental and social needs, whilst using resources wisely. The UK Strategy for Sustainable Development recognises the importance of safeguarding agricultural land to meet the needs of future generations, and minimising the loss of soils to new development*.

Improved restoration standards have sometimes enabled planning permission to be given for best and most versatile agricultural land to be worked for minerals, on the basis that it can be restored in a way that safeguards its long-term agricultural potential**. Inherent in these high standards of restoration is the requirement to handle soils in such a way that damage to their structure is minimised. It is the aim of this Guide to provide comprehensive advice on soil handling “Good Practice” to operators, soil moving contractors, consultants and planning authorities.

The Guide is in the form of 15 Sheets giving advice on soil stripping, the forming and taking down of soil storage mounds, and soil replacement operations using excavators, earth scrapers or bulldozers. There are also four Guidance Sheets on remedial works involving the removal of stones and damaging materials, and decompaction during the replacement operations.

This document should be cited as MAFF (2000), Good Practice Guide for Handling Soils (version 04/00). FRCA, Cambridge.

Any views expressed in the guidance are those of the consultant and do not necessarily represent the view of the Ministry of Agriculture, Fisheries and Food.

*(DETR, A Better Quality of Life, May 1999, paragraphs 6.66 and 8.50)

**MPG7 (November 1996, paragraph 3).

Acknowledgements

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SHEET 19 SOIL DECOMPACTION BY BULLDOZER DRAWN TINES

The purpose of this Guidance Sheet is to provide a model method for best practice where tines are used to decompact soils and basal/formation layers. Tines are most likely to be used for this purpose where soils are replaced by either earth scrapers (towed and self-propelled types) or bulldozers and dump truck combinations. The tines should be drawn by tracked bulldozer and not by wheeled tractor or grader machines. This Guidance Sheet comprises 9 pages of text, 5 figures and a user response form.

The model may need to be modified according to site conditions or requirements of the Planning Authority. Where this is the case, deviation from the model should be recorded with reasons. The guidance does not specify the type, size or model of equipment, but this should have been agreed as part of the planning conditions or as a reserved matter. The machines should be of a kind which will cause the minimum compaction whilst being operationally efficient (eg wide tracked), and must be well maintained at all times.

Persons involved in the handling of soils, overburden etc., and in the construction or removal of mounds or tips, must comply with the Health and Safety at Work Etc. Act 1974 and its relevant statutory provisions, and in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. This requirement takes preference over any suggested practice in the Sheets.

The user of these guidelines is solely responsible for all liabilities that might arise. No liabilities are accepted for any losses of any kind arising from the use of this guidance.

This decompaction method uses a tracked bulldozer to draw tines through the soil layers to relieve compaction and smearing. For this method of decompaction to be effective, there are a number of requirements to be met, in particular the

soil should be in a dry enough condition to be able to shatter and the use of effective equipment.

There are a number of key operational points to maximise the effectiveness of the decompaction treatment:

- (i) To maximise decompaction:
 - the moisture content of the soils should be at least 5% below their plastic limit, or greater than this if so advised.
 - the ripping pattern must be overlapping passes and recompaction at depth must be treated in the ripping strategy.
 - the tines should be sufficiently closely spaced to ensure that full lateral decompaction is achieved with overlapping passes.
 - the use of winged straight tines is recommended.
 - the tine length and width must be compatible with the proposed depth of decompaction, and allow for soil 'heave'.
 - tine and wings must have wear plates and be in good operating condition. Worn and deformed tools must not be used.
 - the towing unit must be capable of pulling the tine combination in an operationally efficient manner, without undue weaving and track slippage.
- (ii) To minimise rewetting:
 - ripping should not be undertaken if significant rainfall is forecast.
 - where the soil profile is partly raised to ground level, the uppermost soil layer should be left in an unripped state. Where the subsoil layer has been ripped, but the topsoil not placed, it should be sealed by blading with a bulldozer. On resumption of operations, the upper and lower layers will required decompacting.

Ripping Strategies

Ripping to decompact soils is an integral part of the soil replacement procedures using towed or self-propelled earth scrapers or bulldozer-dump truck combinations. The primary aim of the ripping strategy is to ensure that there is no significant compaction within the soil profile which might impede root growth or drainage. There are two basic ripping strategies that can be used. These are; when the soil profile is ripped sequentially as the soil layers are built up, or when it is ripped only after the profile is complete. Each have their own limitations and the selection should be matched to the soil profile in question and the specification of the equipment to be used. It may not be possible to treat deep compaction, or even compaction at moderate depth, once the profile has been completed, hence it is essential that the correct strategy is adopted. In some circumstances it may be necessary to adopt a combination of both strategies to achieve satisfactory results.

- (i) Sequential ripping of each layer before next is placed (Figure 19.1a):
 - appropriate when profile/horizon thickness exceeds the effective depth of the tine or capacity of the towing unit being used; a number of sequential rips are required, each layer ripped before the next is placed.
 - the depth of subsequent sequential ripping must relieve any recompaction of the lower layers following the placement of the new overlying layer or other surface operations.
 - appropriate where stones and/or damaging materials are to be released and removed from sub-surface horizons.
 - has to be carried out during the replacement operations.
 - the final surface layer ripping can be delayed (as with (ii) deep ripping approach) until all strips complete and works finished.

- (ii) Single deep ripping on completion of profile (Figure 19.1b):
- appropriate when profile thickness is equivalent to or less than the effective depth of tine and capabilities of towing unit.
 - appropriate where stones and/or damaging materials are absent or need not be removed from sub-surface horizons.
 - appropriate where artefacts or stones need only to be removed from surface topsoil layer, where a shallower surface cultivation would be carried out prior to final ripping.
 - appropriate where sequential ripping has been undertaken and there is still recompaction at depth.
 - final ripping can be delayed until all strips and final works complete, or later in aftercare period.

Equipment

- 19.1 Crawler-tracked tractor units of a minimum 300hp are required. [Expect 30hp/leg or shank on multiple tine beam cultivator to 750mm depth and 100hp/tine three leg or shank to 750mm depth.]
- 19.2 There are two types of ripping units: i) frame-mounted on tractor unit and usually hydraulic operated, and ii) mounted on towed trailers/tool carriers and either cable or hydraulic operated. Control mechanisms have to be matched between tractor unit and tool carriers.

- 19.3 There are two types of tines: straight leg and curved leg. The former is the most commonly used and is the principal tool for decompaction. Straight tines are to be used where there are obstructions or the soils/formation layer is excessively stony. Curved tines are typically used, in combination with straight tines, and set to operate at shallower depth for the purpose of reducing the ‘drag’ resistance of the following straight tines. Often the straight tine is operated in a raked mode (about 10 degrees backwards from the foot) rather than in an upright stance to promote decompaction by uplift and also to reduce drag.
- 19.4 Straight tines (leg) should have a wedge foot (Figure 19.2) at the base to reduce drag, aid penetration and assist with the upward displacement of the soil and shattering effect.
- 19.5 There are two forms of straight tines, those with and those without wings (Figure 19.2). Wings of 250-400mm total span (outer tip to outer tip) are welded either side of the tine leg or foot at angle 20-30 degrees. This is to promote upward displacement and lateral shatter, but also has the effect of significantly increasing drag. Straight tines without wings will require either more overlapping passes or closer spaced tines (the latter will increase drag).
- 19.6 There are two critical dimensions which determine the potential effectiveness of the tines, these are tine length (which determines the potential depth of decompaction) and tine thickness (which determines the potential amount of heave and therefore shatter and decompaction). The achievement of the potential of the ripping tools is dependent on the moisture content of the soil/formation material (it must be dry enough to shatter otherwise the soil material simply deform around the tool).
- 19.7 The length of the tine is the most common limiting dimension of the tool. The length of the tine from the heel of the foot to the base of the tool bar/carrier

less 200/250mm or 30%, whichever is the lesser, is the potential maximum effective ripping depth of the tine (Figure 19.3). The deduction allows for upward displacement of the soil as the tool is drawn through the profile. Without this allowance the soil heave will rise to or above the tool bar and increase drag and reduce the decompaction achieved (Figure 19.3). The most commonly used tines have maximum effective depths of about 500-700mm. Whilst longer tines can be provided these may cause problems with mobility of the tractor unit. One exception is the British Coal specification SIMBA MK IV Ripper with 1.2m carrier borne tines which has a potential effective depth of 900-1000mm.

- 19.8 The width of the tine (front to back) co-determines the potential effective ripping/ decompaction depth, with a ratio of 5 times the width of the tine (Figure 19.2). Typically the width of the tine is 300-400mm, giving a potential effective depth of 1500-2000mm and operationally is not usually a limiting factor. The thickness and width of the tine used is usually determined by other factors, the mechanical stresses imposed by the work undertaken (ie its strength) and the slot dimensions in the tool bar carrier.
- 19.9 The thickness of the tine (typically 40-80mm) contributes significantly to its strength but also to drag. The tine should have a welded wear plate on the leading edge to reduce wear, as should the leading edge of the attached wings (Figure 19.2).
- 19.10 The minimum number of tines must be two, each following the mid point of the tracks of the tractor unit (Figure 19.4). Generally, the most common configuration is three with a tine central to the tractor unit. The tines may be arranged in a straight line or as a triangle with the central tine leading to reduce drag. The tines may or may not have wings, often the central tine may be without wings to reduce drag. Three winged tines are the preferred

configuration. However, straight tines are more appropriate where there are significant artefacts/obstructions, and where soils are excessively stony.

- 19.11 Mixed combinations of curved tines leading straight tines (as a double beam configuration) are an alternative and can potentially achieve more effective lateral shatter.

Decompaction Operations

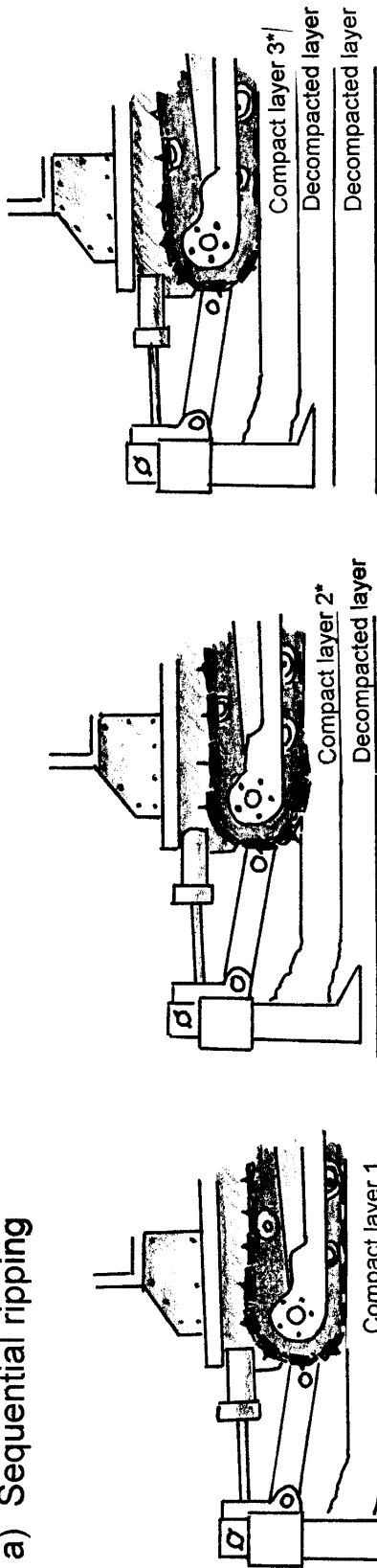
- 19.12 Ripping to decompact materials must only to be undertaken when the soils are dry enough to shatter and must be suspended before the soil become plastic. Ripping should only be undertaken in dry weather and is to be suspended when the tractor unit loses traction/weaves under normal operating conditions. If the soils are inherently wet consideration should be given to deep ripping later following the establishment of a crop to dry out the upper horizons; this may require several successive years of treatment to progressively decompact the profile.
- 19.13 The tines are to be drawn through the basal/formation or soil layer at the required depth according to the decompaction strategy and capability of the equipment and towing equipment. The tines are to be drawn at sufficient and constant speed, and at their optimum angle (rake) to achieve maximum heave with the least drag, and without track slippage or the tractor unit weaving.
- 19.14 The ripping is only to be undertaken both ways along one axis and at an orientation to promote down-slope drainage, but never cross-wise or across slope. Where ripping is in one direction, as down slope on steep gradients, the machinery is to travel back only on unripped ground.

- 19.15 The ripping must achieve the required depth in the first pass without the heave rising above the base of the tool bar (Figure 19.3), the tine is to enter to its full depth on the first pass and all subsequent passes. The area should not be ripped to a shallow depth first and then re-ripped to a greater depth. However, this may be unavoidable in the first pass in order to 'break' ground and reduce resistance to be able to achieve the required penetration. Headlands are to be ripped first to enable quick and full penetration; this is essential at the base of slopes. Ripping must extend into and out of sides of ditches.
- 19.16 Where the final profile thickness is equivalent to or less than the effective depth of the tine, the ripping operation can be undertaken after all the horizon(s) have been laid (Figure 19.1b), except where it is necessary for stones or artefacts to be removed.
- 19.17 Where the profile thickness exceeds the effective depth of the tine, the profile must be ripped in a sequence of successive layers. The ripping is to be undertaken sequentially following the placement of each layer and before the next layer can be laid. This usually takes place after the placement of each horizon (ie lower subsoil, upper subsoil and topsoil) (Figure 19.1a). If the proposed horizon thickness exceeds the effective depth of the ripper tine, then the soil horizon needs to be laid in sub-layers, with each of these being ripped before the next is laid.
- 19.18 In the ripping of successive replaced horizons/layers, allowance must be given to recompaction caused in the lower layers by the laying and spreading of the soil by scrapers or bulldozer. The allowance necessary depends on the soil type and moisture content. For scrapers, recompaction to 400mm should be allowed for in specifying the thickness of the next layer of soil to be placed and decompacted. A minimum of 300mm should be allowed for bulldozers with standard or narrow tracks. The recompacted soil layer must be

decompacted along with the thickness of the new layer laid. This requires the depth of decompaction of the next layer to include the thickness of the recompacted soil layers. The thickness of the new layer that can be laid over the recompacted layer(s) will be governed by the potential effective depth of the tine. Hence, after the laying and decompaction of the first soil layer, subsequent soil layers will have to be laid at shallower thickness (Figure 19.3).

- 19.19 The final decompaction of the topsoil layer should be to the full effective depth of the tine.
- 19.20 In carrying out the ripping operation, each successive pass is to overlap, with the tine on the ripped side bisecting the pass of the outer and central tine of the previous pass (Figure 19.4). Where full depth or lateral consistency of decompaction is not achieved, the overlap should be increased by further bisection.
- 19.21 The degree and consistency of loosened soil must be checked as the ripping is taking place, especially across the junctions between strips (the latter may require inspection by pits). Routine qualitative assessment can be made with a 15mm diameter steel probe with blunt convex end. The probe is pressed in soils at 150mm intervals along a number of transects across the line of ripping, and the depth to penetration and feel of resistance recorded (Figure 19.5). Alternatively soil penetrometers may be used. Both methods should only be used in conjunction with a method of on-site 'calibration' of compactness; this is essential as soil water content and stoniness have a major influence on interpretation.

a) Sequential ripping



*ripping depth to include recompaction in lower layers

b) Final deep rip

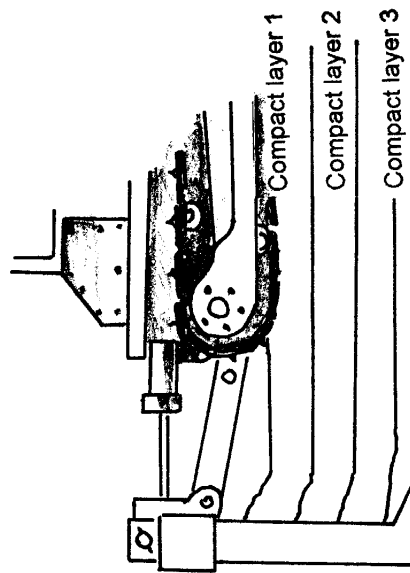


Figure 19.1 Decompaction by bulldozer drawn
tines

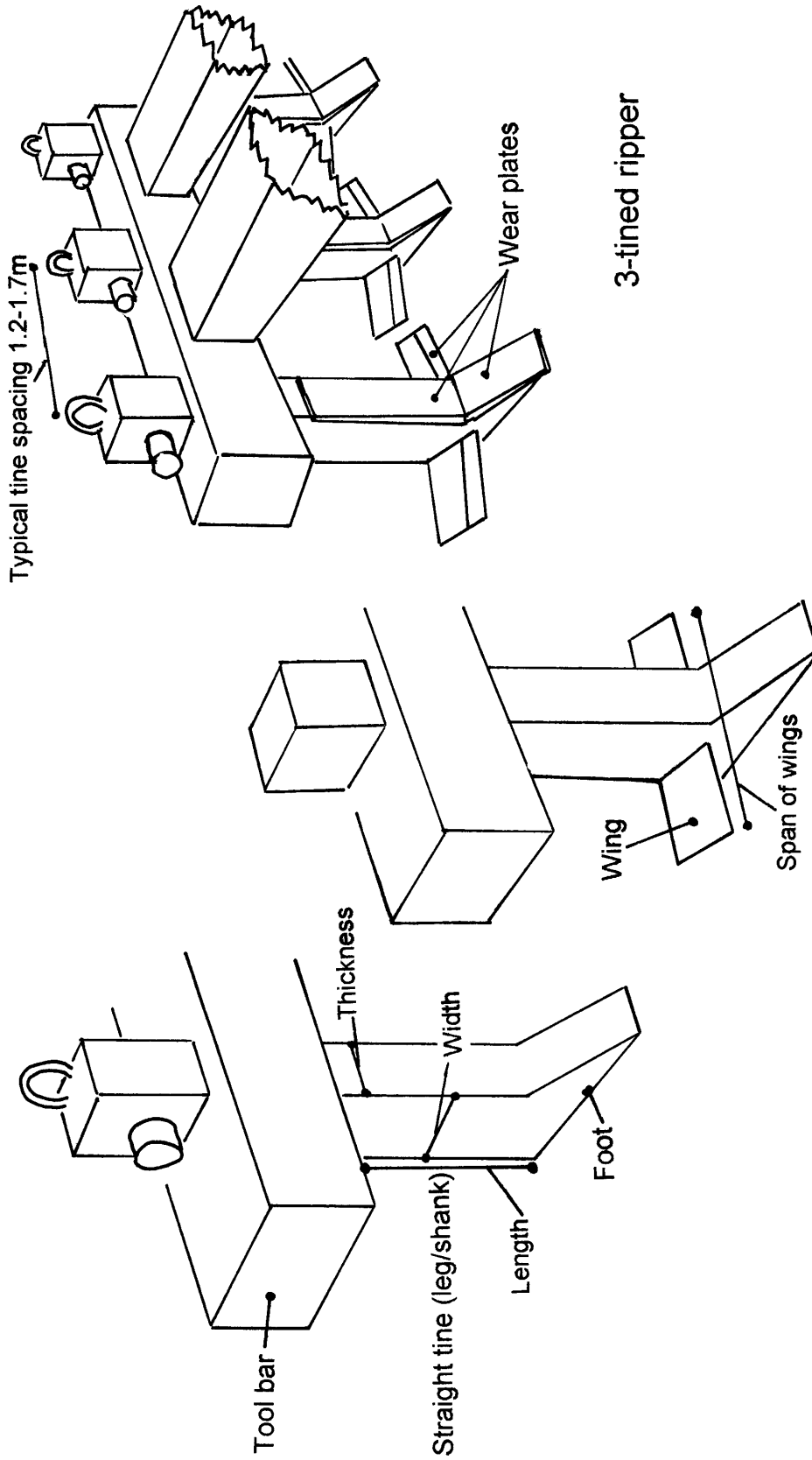
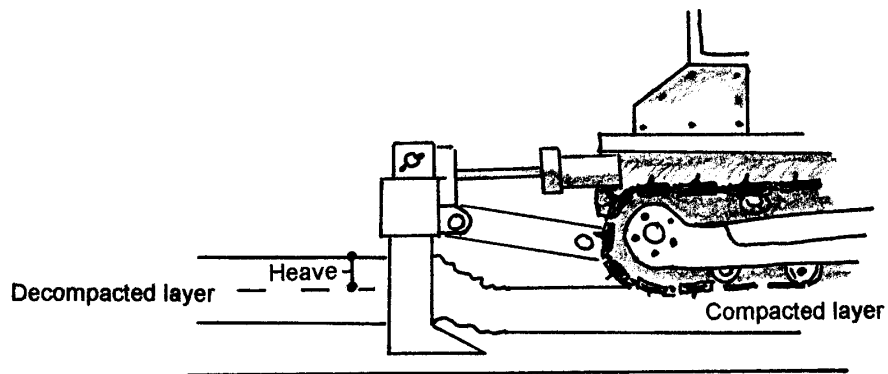
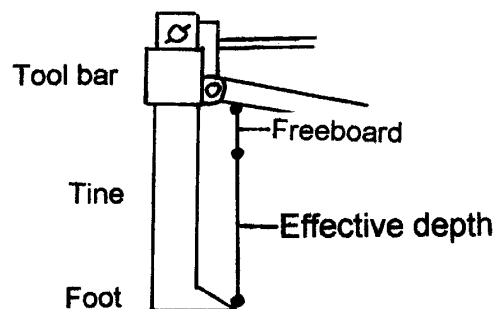


Figure 19.2 Features and critical dimensions of bulldozer drawn tines



Heave = freeboard required below tool bar



Calculation of effective depth of tine of 300mm width & 900mm in length below tool bar:

- i) potential maximum depth of decompaction is 1500mm with tine of 300mm width and 900mm with tine of 900mm length
- ii) potential effective operating depth for first soil layer is $900 - 200$ (freeboard) = 700mm
- iii) potential effective operating depth subsequent soil layer is $900 - (200 + 300$ [eg depth of recompacted lower material]) = 400mm

Figure 19.3 Effective decompaction depth by tines

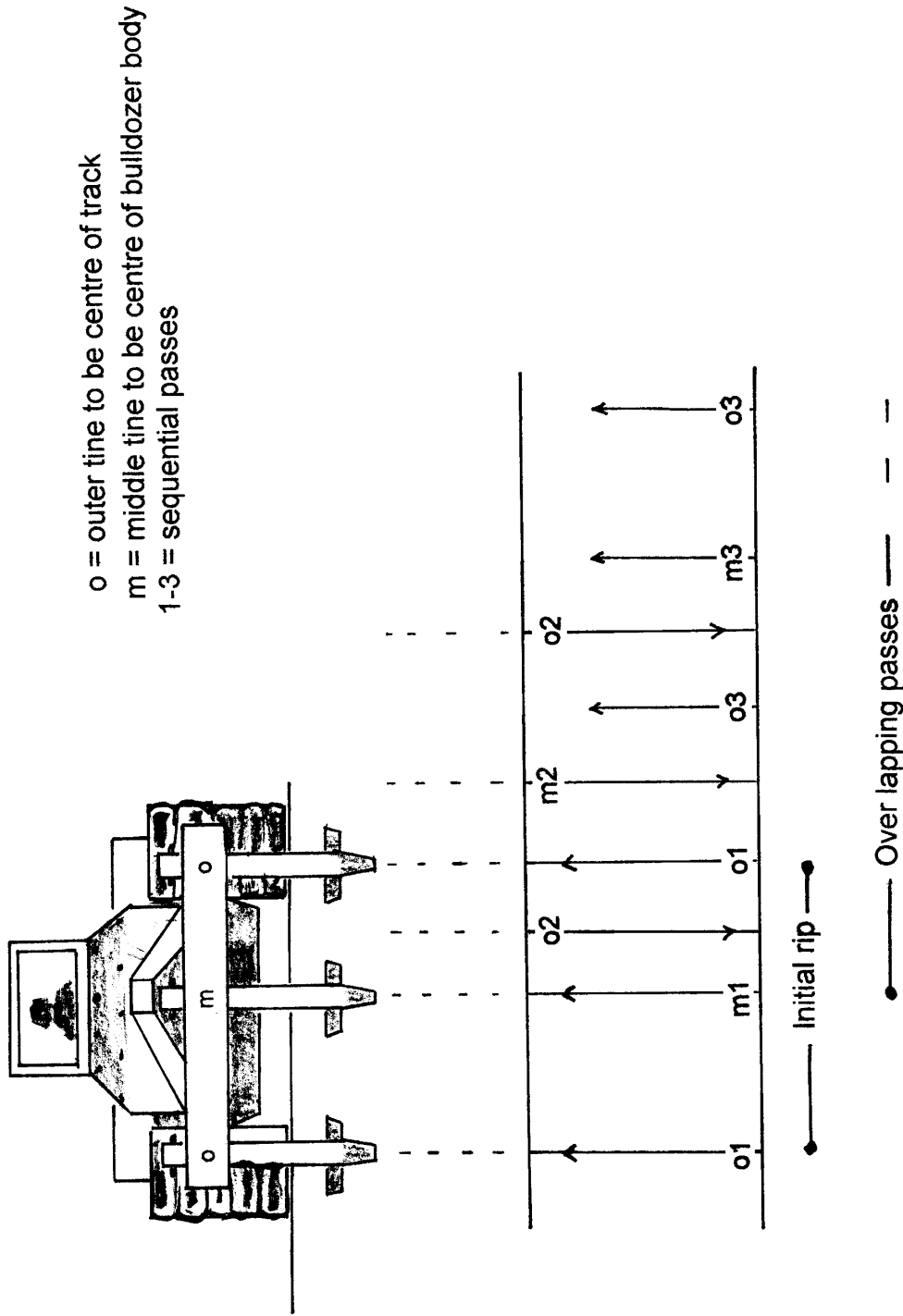


Figure 19.4 Decomposition by overlapping passes
 of bulldozer drawn tines

*target not consistently achieved between tines, ridges present

**target consistently achieved between tines, no ridges present

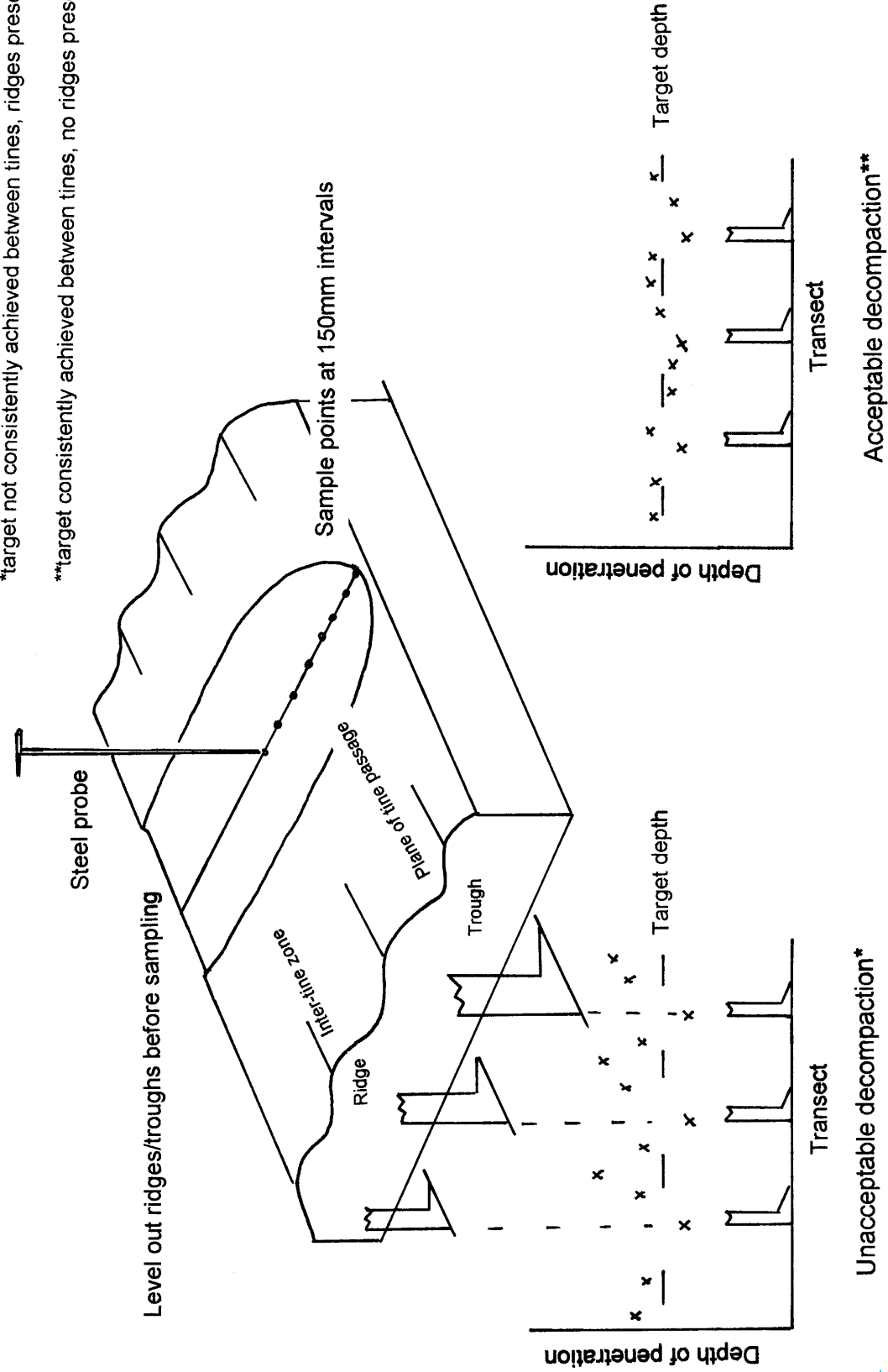


Figure 19.5 Assessment of decompaction achieved

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FEEDBACK

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