



The Institute  
of Quarrying



# **Good Practice Guide for Handling Soils in Mineral Workings**

# GOOD PRACTICE GUIDE FOR HANDLING SOILS

## In Mineral Workings

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The information in this publication is general guidance on the best practices and approaches to soils guidance. Specialist advice should always be sought if you need more details about what action to take in your own circumstances.

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# GOOD PRACTICE GUIDE FOR HANDLING SOILS

## In Mineral Workings

PART TWO: Model Methodology

### - Sheet D -

Soil Replacement with Excavators and Dump Trucks  
- Sequential Bed/Strip Practice

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## Preface

**The purpose of Sheet D of the guidance is to provide a model method of best practice where excavators and dump trucks are to be used to replace soil using the sequential 'bed'/strip by strip practice.**

The guidance is intended for use by planning officials, statutory consultees, mineral operators and their supporting teams and specialist consultants, and earth-moving contractors, their site supervisors and machine operators.

Successful soil handling schemes are dependent on the soil resources being clearly identified and the conditions in which they are to be handled. This information should be contained in the Soil Resource & Management Plan (SRMP) and communicated to those involved in its implementation.

Key issues to be addressed are:

- i) Avoiding conditions when soils are wet/plastic during handling
- ii) The minimisation of soil compaction caused by trafficking and soil wetness
- iii) Using appropriate remedial treatments where these are necessary
- iv) Minimising soil loss, and mixing of soil layers or different soil types

The SRMP should specify the type of earth-moving machinery and soil handling practice, and the soil wetness condition (see Part One of the Guidance) to be deployed to achieve the planned after use, soil functioning, and the environmental and ecosystem services. It is to be communicated in full to all involved and in particular to the supervisors and machine operators by appropriate means; including tool-box talks and site demonstrations. Supervision by trained supervisory staff is essential, as are monitoring and reporting.

The guidance does not specify the size or model of equipment as this is left to the mineral operator and contractor to specify and provide. The machines must be of a kind which are appropriate for the task and the outcomes required, and to be able to carry out the work safely and efficiently.

Should the agreed methodology need to be modified or changed significantly, this should be agreed in advance with the mineral planning authority. The SRMP should include a mechanism whereby unexpected less significant changes can be quickly resolved through consultation between the operator, the planning authority and statutory consultee, and soil specialist.

All persons involved in the handling of soils must comply with all relevant legislation with respect to Health and Safety, in particular the Health and Safety at work Act 1974 and in the case of mineral extraction operations The Quarries Regulations 1999 and its relevant statutory provisions; in particular those aspects which relate to the construction and removal of tips, mounds and similar structures. These requirements take preference over any suggested practice in this Sheet and the SRMP should have taken these into account.

The users of this guidance are solely responsible for ensuring it complies with all safety legislation and good practice, including the manufacturer's specifications for the safe operation of the specific machines being used, and that all machines are in a good condition and well maintained and are suitable for the task. It is important that those involved in the operation of earth moving machines are competent and have the necessary training and certification.

## Introduction

**In this soil handling option, back-acting excavators are used to replace the soil resources tipped from dump trucks at the area being restored.**

The replacement practice involves the sequential building up of the individual layers of soil identified in the Soil Resource & Management Plan (SRMP) as vertical slices through the soil profile and advancing as successive strips. Hence, the practice is often referred to as the 'Strip' or 'Bed' method.

The lower layer (subsoil) is placed first within the safe and efficient operational reach of the excavator boom which defines the width of each strip. For each subsequent soil layer, the process is repeated until the top layer (usually topsoil) is placed. When the soil resource/profile sequence within the strip is completely replaced, the process is repeated on the next strip to be replaced with soil and until the whole receiving area is completed. The following guidance can also be adopted where only a single soil horizon is to be replaced.

Unlike the stripping and storage practices, the replacement of soils is usually in concert with other work to remediate soil conditions such as compaction (**Sheets N & O**) and removal of stones/non-soil debris (**Sheets L & M**) to facilitate the intended after use, soil functions, and environmental and ecosystem service provisions. These actions have their own practices which need to be integrated into this model methodology of soil handling. The need for these will have been specified in the SRMP and/or in soil replacement conditions attached to the planning consent, or as determined by the soil specialist during the soil stripping/storage/replacement operations.

### Advantages & Disadvantages

The advantages of this machinery combination and handling practice are:

- i) Provided the soils are not put into storage mounds, it is the most likely to result in soil profiles with the least compacted soils, which may not require remedial treatment or only minimal of action, as trafficking on the relayed soils is avoided
- ii) It can be easier to create localised changes

- iii) in soil types and variation in horizon depth  
It is suited both to the replacement of deep and uniform soils (including peat) as well as thin and 'patterned' soil layers
- iv) It is more flexible and quicker in responding to stoppages and restarts due to wet weather
- v) There is a greater certainty that a transpiring vegetation cover can be established during the soil replacement programme

The disadvantages are:

- i) That it requires greater supervision, skill and discipline in its deployment, and is best suited to experienced operators
- ii) Without good control and regular monitoring of soil layer depths, use of profile boards or machine fitted GPS it can be harder to gauge the rate of use of soil resource
- iii) There is a risk of some soil 'loss' and mixing of soil horizons at the exposed edges of multi-layered soils as the profile is built up
- iv) The bed system involving sequential remedial works may take longer to complete than other practices and machinery options
- v) Steep gradient/complex topographies may limit the safe and practical deployment of this handling practice

### Suitability

The excavator-dump truck combination with the bed/strip handling practice methodology is considered 'best practice' by Natural England and the Welsh Government for agricultural soils and preferable for all soils. In particular, it is the most suitable of any of the methods available where:

- i) The soil is prone to compaction and where decompaction treatments cannot be relied upon to be effective
- ii) The intended after use, environmental and ecosystem services are dependent on soils maintaining their functional characteristics such as, porosity and hence drainage and aeration, plant available water capacity, and low resistance to plant root growth. This includes productive agricultural, horticultural and forestry land, many types of natural habitats, and where water storage/infiltration is of importance for the risk of flooding. Where the soils are stored prior

- to replacement some remedial treatment may have to be relied upon
- iii) As the bed/strip method offers the most flexibility in respect of short soil drying periods and likely wet weather, and can be less prone to delays and stoppages, it is particularly suited the wetter geographical locations
- iv) The full benefit of the practice for soils lies in their direct placement, this requires the mineral extraction scheme to be organized to minimize the need for soils storage.

## MODEL METHODOLOGY

### Basic Soil Replacement Operation

D.1 The following is the basic model methodology using excavators and dump trucks and the bed/strip practice. It is presented here, firstly without any remedial interventions to give clarity of the methodology. Further on the methodology is repeated to demonstrate how the interventions can be integrated in to the soil replacement process.

D.2 Key operational points to minimise the risk of severe soil compaction and soil wetness are summarised in Boxes D.1 and D.2.

D.3 The timing of soil handling operations in England and Wales is set out in **Part One, Supplementary Note 4**. For directly placed soils this will use the in situ soil wetness protocol for soil stripping operations to determine the timing for soil replacement (Box D.3). For soil that has been stored, the relaying operation should be governed by the weather (rainfall) criteria set out in Box D.4. Here, the operation will generally need to be completed no later than the end of September unless the establishment of a satisfactory vegetation cover can be assured.

D.4 Soil handling is not to take place during rain, sleet or snow and in these conditions should be prohibited if unsafe for machine operations. Prior to commencing operations, a medium/long term weather forecast should be obtained which gives reasonable confidence of soil handling being completed without significant interruptions from rainfall events. The soil based criteria set out in

#### Box D.1 - To minimise compaction:

- The dump trucks should only operate on the 'basal'/non-soil layer and not run on the replaced soil layer(s)
- The excavator must only operate on the basal layer
- The machines are to only work when ground conditions enable their efficient operation
- If compaction has been caused, then measures are required to treat it (see **Sheets N & O**).

#### Box D.2 - To minimise soil wetness and re-wetting:

- The bed/strip system provides a basis to regulate the exposure of lower soil layers to periods of rain and a means of maintaining soil moisture contents. The soil profile within the active strip should be completed including the topsoil layer before rainfall occurs and before replacement is suspended
- Measures are required to protect the face of the soil layer from ponding of water and maintain the basal layer in a condition capable of supporting dump trucks
- The area to be restored is to be protected from in-flow of water, ponding etc. Wet sites must be drained in advance. Before the operation starts the basal layer should be to level and clean.

Box D.4 are to be used to determine whether soil handling should cease or be interrupted with the occurrence of rain.

D.5 All machines must be in a safe and efficient working condition at all times. The machines are to only work when ground conditions enable their efficient operation. The work should only be carried out when the basal layer supports the machinery without ruts or is capable of repair/maintenance. Otherwise the operation is to be suspended until suitable remedial measures can be put in place.

D.6 The operation should follow the detailed SRMP replacement plan showing the soil units to be replaced, haul routes and the phasing of vehicle movements. The soil units should be defined on the site with information to distinguish types and layers,

**Box D.3 - Test for Dry and Friable Soils**

Soil tests are to be undertaken in the field. Samples shall be taken from at least five locations on the soil handling area and at each soil horizon to the full depth of the profile to be recovered/replaced. The tests shall include visual examination of the soil and physical assessment of soil consistency.

**i) Examination**

- If the soil is wet, films of water are visible on the surface of soil particles or aggregates (e.g. clods or peds) and/or when a clod or ped is squeezed in the hand it readily deforms into a cohesive 'ball' means **no soil handling to take place**
- If the sample is moist (i.e. there is a slight dampness when squeezed in the hand) but it does not significantly change colour (darken) on further wetting, and clods break up/crumble readily when squeezed in the hand rather than forming into a ball means **soil handling can take place**
- If the sample is dry, it looks dry and changes colour (darkens) if water is added, and it is brittle means **soil handling can take place**

**ii) Consistency****First Test**

Attempt to mould soil sample into a ball by hand:

- Impossible because soil is too dry and hard or too loose and dry means soil handling can take place
- Impossible because the soil is too loose and wet means no soil handling to take place
- Possible - GO TO SECOND TEST

**Second Test**

Attempt to roll ball into a 3mm diameter thread by hand:

- Impossible because soil crumbles or collapses means **soil handling can take place**
- Possible means **no soil handling to take place**

NB: It is impossible to roll most coarse loamy and sandy soils into a thread even when they are wet. For these soils, the Examination Test alone is to be used.

**Box D.4 - Rainfall Criteria:**

- In light drizzle soil handling may continue for up to four hours unless the soils are already at/near to their moisture limit
- In light rain soil handling must cease after 15 minutes
- In heavy rain and intense showers, handling shall cease immediately

In all of the above, after rain has ceased, soil tests shall be applied to determine whether handling may re-start, provided that the ground is free from ponding and ground conditions are safe to do so.

and thickness and conveyed to the operational supervisor/operator. Different soil units to be kept separate are to be marked out and information to distinguish types and layers, and ranges of thickness needs to be conveyed to the operational supervisor/operator. Detailed daily records should be kept of operations undertaken and site and soil conditions.

D.7 The excavator and dump trucks are only to stand, work and travel on the basal/formation layer.

D.8 The soil layers above the base/formation layer are to be replaced in sequential strips with the sub-soil layer(s) replaced first, followed by the topsoil layer, each layer being replaced to the specified thickness. The next strip is not to be started until the profile in the current strip is completed. This is often referred to as the 'bed' or 'strip' system which involves the progressive sequential laying of the soil in strips across the area to be restored (**Figure D.1**).

D.9 The initial strip width and axis is to be demarcated. The strip width is determined by excavator boom length less the stand-off to operate; typically, about 3-4m (Box D.5). Excavators with long booms ('long reach') can be used, but may be more restricted by gradient limitations, and require skilled and experienced operators.

D.10 The preferred type of bucket to place the soils is usually a digging/bulking bucket with an attached blade or a wide ditching bucket, but a toothed

bucket can be used.

D.11 Profile boards should be used to control soil horizon thickness in each strip and overall levels achieved verified using soil pits. Allowances (i.e. a bulking factor) should be made for any settlement that may take place of the replaced loose soil.

#### **Box D.5 - Orientation of the Excavator**

Usually, the excavator is orientated and operates with its tracks at 90° to the axis of the bed being stripped as this is the most stable position. Whilst the reach of the boom and hence the width of the bed/strip can be significantly increased by orientating it with the tracks parallel to edge of the soil being spread, this may affect the stability of the excavator, particularly on a gradient or where the basal layer has a low bearing capacity. Hence, its safe deployment needs to be checked before its adoption.

D.12 The dump trucks reverse up to edge of the current strip and tip the lowest layer (subsoil) soil, without the wheels riding onto the strip (**Figure D.1**). The dump truck should not drive away until all the soil is deposited within the strip without spillage over the basal layer; this may require assistance from the excavator to 'dig away' some of the tipped soil (**Figure D.2**). The excavator is to spread the tipped soil to full thickness by digging, and using the pushing and pulling action of bucket.

D.13 Each load of soil should be spread following tipping before another is tipped. Should the spread soil comprise of large blocks (>300mm), normally these should be broken down by using the excavator bucket into smaller pieces before the next load is spread. The process is repeated until the strip is completely covered with the required depth of the soil layer (**Figure D.3**).

D.14 On completion of the lowest (subsoil) layer, repeat the process spreading the next layer (subsoil/topsoil) (**Figure D.4**). Tip the soil by reversing to the outer edge of strip/soil previously laid, but without the truck wheels riding onto the already placed layer (see Box D.6 for deep soil profiles). The soil is to be

spread by the excavator to full thickness by digging, and using the pushing and pulling action of bucket described above. Repeat the process progressively along the strip. Profile boards should be used to control the soil thickness in the strip and overall levels.

D.15 Where the profile is made up of further soil layers (subsoil/topsoil) the above process should be repeated on completion of the strip.

#### **BOX D.6 - Soil Profiles Greater Than 1m Thickness**

When the replaced soil profiles reach about 1m in height from the basal layer it may not be possible to discharge the load from smaller dump trucks directly onto the previously placed lower layers because of the height of the dump truck body. The preferred solution is to tip the soil against the partially completed profile as heaps without the dump trucks rising onto or reversing into the placed material. The soil material is then lifted by the excavator onto the profile. It is considered preferable to accept some limited soil losses rather than to contaminate the topsoil with overburden. The loss of top-soil is minimised if the basal/ formation layer is kept to level and clean.

D.16 On completion of topsoil layer, the processes outlined above should be repeated for the next strips until the area to be restored is completed. Before the operation starts the basal layer should be to level and cleared of any residual soil.

D.17 At the end of each day the current strip must be completed if rain is forecast. If during a day it is evident that a full strip cannot be completed, then complete the part of a strip that has been started.

D.18 At the end of each day, or during the day if interrupted by rain, make provisions to protect base of restored strip from ponding/runoff by sumps and grips, and also clean and level the basal layer. At the start of each day ensure there is no ponding in the current strip or operating areas, and the basal layer is to level with no ruts.



### Method with Integration of Remedial Actions

D.19 Usually there should be less of a need for remedial treatment during the replacement operation with this machinery combination and handling practice (unless the soils were compacted during stripping or storage). Where compaction occurs, treatment will need to be integrated into the replacement process as will the need for the removal of stones or non-soil debris. Both decompaction and the removal of materials are covered in **Sheets L to O**. Where required, the early installation of under drainage can either be integrated sequentially during the replacement of the soils or later during the aftercare period.

D.20 The placement of the stripped soils in storage is likely to result in compaction and negate this particular benefit of the handling practice. Box D.7 sets out some of the remedial options/combinations to facilitate decompaction, and where necessary, the removal of stones and non-soil debris for a final profile comprising a basal layer, subsoil and topsoil layers. Except for Option 3, these actions need to be undertaken sequentially as each soil strip is placed.

D.21 The following is the model methodology integrating the remedial interventions within the bed/strip handling practice.

D.22 The key operational points to minimise the risk of severe soil compaction and soil wetness are summarised in the above Boxes 1 and 2.

D.23 Prior to commencing operations a weather forecast should be obtained which gives reasonable confidence of soil replacement proceeding without interruptions from rainfall events (Box D.4).

D.24 If significant rainfall occurs during operations, the replacement must be suspended, and where the soil profile has been started it should be replaced to topsoil level. Replacement should not restart unless the weather forecast is expected to be dry for at least a full day and the soils are in a dry condition (Box D.3).

D.25 The operation should follow the detailed replacement plan in the SRMP showing the soil units to be replaced, haul routes and the phasing

### Box D.7 - Integration of Decompaction & Stone/Debris Removal

**Option 1:** is where the basal layer needs to be treated but is left until the subsoil is placed when both are decompacted together, followed by the decompaction of the topsoil and subsoil layers together (and basal layer) using tines that are long enough. This option is not suited to digging where the soil horizons would be mixed.

**Option 2:** is where each layer is treated separately by either tines or digging.

**Option 3:** is where the basal layer is treated or left untreated, followed by the placement of the subsoil and topsoil layers, which are to be decompacted by the use of tines. In the case of deep horizons this option can be limited by the capability of the machinery, the tines or bucket used. This option is not suited to digging where the soil horizons would be mixed.

of vehicle movements. The soil units should be defined on the site with information to distinguish types and layers, and thickness and conveyed to the operational supervisor/operator. Different soil units to be kept separate are to be marked out and information to distinguish types and layers, and ranges of thickness needs to be conveyed to the operational supervisor/operator. Detailed daily records should be kept of operations undertaken and site and soil conditions (including the removal of stones and other non-soil debris that needs to be removed), and the results of the effectiveness of the work undertaken, and any need for additional remedial treatments.

D.26 The excavator and dump trucks are only to stand, work and travel on the basal/formation layer. Only where the remedial work involves the use of a bulldozer does machinery have to traffic the soil surface being treated, as the excavators work from the basal layer.

D.27 The soil layers above the base/formation layer are to be replaced in sequential strips with the subsoil layer(s) replaced first, followed by the topsoil

layer; each layer being replaced to the specified thickness. The next strip is not to be started until the profile in the current strip is completed. This is often referred to as the 'bed' or 'strip' system which involves the progressive sequential laying of the soil in strips across the area to be restored (**Figure D.1**).

D.28 The initial strip width and axis is to be demarcated. Strip width is determined by excavator boom length less the stand-off to operate; typically, about 3-4m (see Box D.5).

D.29 The preferred type of bucket to place the soils is usually a digging/bulking bucket with an attached blade or a wide ditching bucket. However, where a bucket is being used to decompact soils, it should be a 'digging' type and have teeth or a stone-rake type with multiple tines is to be used.

D.30 Where there is a requirement to treat compaction and/or remove stones/damaging materials in the basal layer, these need to be carried out along the demarcated strip prior to the first layer of soils being laid.

D.31 Decompaction of the basal layer can be by digging with the excavator bucket or by bulldozer drawn tines (**Sheets N & O**). Stone removal may require prior ripping/digging to release them from the basal material, followed by the excavator using a stone-rake bucket (the stone to be loaded on a dump truck and removed (**Sheet L**).

D.32 Profile boards should be used to control soil horizon thickness in each strip and overall levels achieved verified using soil pits to verify. Allowances (i.e. a bulking factor) should be made for any settlement that may take place of the replaced loose soil.

D.33 On completion, the loaded dump trucks reverse up to edge of the current strip and tip the lowest layer subsoil without the wheels riding onto the strip (**Figure D.1**). The dump truck should not drive away until all the soil is deposited within the strip without spillage over the basal layer; this may require assistance from the excavator to 'dig away' some of the tipped soil (**Figure D.2**). The excavator is to spread the tipped soil to full thickness by

digging, and using the pushing and pulling action of bucket.

D.34 Each load of soil should be spread following tipping before another is tipped. Should the spread soil comprise of large blocks (>300mm), normally these should be broken down by using the excavator bucket to break the blocks into smaller pieces before the next load is spread. The process is repeated from left to right until the strip is completely covered with the required depth of the soil layer (**Figure D.3**).

D.35 Where there is a requirement to treat compaction and/or remove stones/damaging materials in the subsoil layer, these need to be carried out along the demarcated strip prior to the next overlying layer of soils being laid. Decompaction can be by digging with the excavator bucket or by bulldozer drawn tines (**Sheets N & O**). Stone removal may require prior ripping/digging to release them from the soil (particularly if it is wet), followed by the excavator using a stone-rake bucket (to be loaded on a dump truck and removed (**Sheet L**).

D.36 On completion of the lowest (subsoil) layer, repeat the process spreading the next layer (topsoil or upper subsoil) (**Figure D.4**). Where the profile is made up of further soil layers (subsoil/topsoil) the process outlined above should be repeated on completion of the strip. Tip the soil by reversing to the outer edge of strip/soil previously laid, but without the truck wheels riding onto the already placed layer (see Box D.6). The topsoil is to be spread by the excavator to full thickness by digging, and using the pushing and pulling action of bucket described above. Repeat the process progressively along the strip. Profile boards should be used and soil pits to verify soil thickness and overall levels in each strip.

D.37 Where there is a requirement to treat compaction in the topsoil layer within each strip as it is completed (see Box D.8), this can be by digging with the excavator bucket or by bulldozer drawn tines (**Sheets N & O**). If required, stone removal may require prior ripping/digging to release them from the soil clods, followed by the excavator using a stone-rake bucket (the stone to be loaded on a dump truck

and removed) (**Sheet L**).

D.38 On completion of the topsoil layer the processes outlined above should be repeated for the next strips until the whole area to be restored is completed. Before the operation starts the basal layer should be to level and clean.

D.39 At the end of each day the current strip must be completed if rain is forecast. If during a day it is

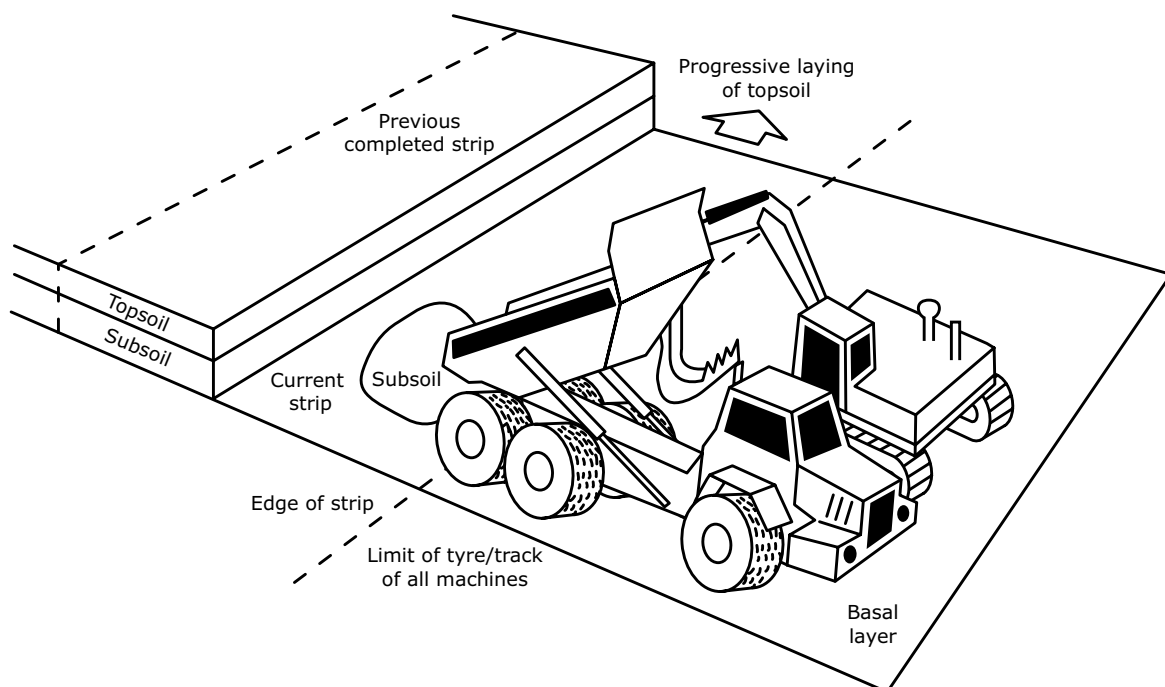
#### **Box D.8**

It is important that the decompaction and any stone/debris is removed from the topsoil layer as each strip is completed. Leaving it until the entire area is soiled will mean that the equipment, and in particular where the dump trucks collecting stones, have to traffic the soil surface resulting in compaction of the topsoil and the underlying subsoil.

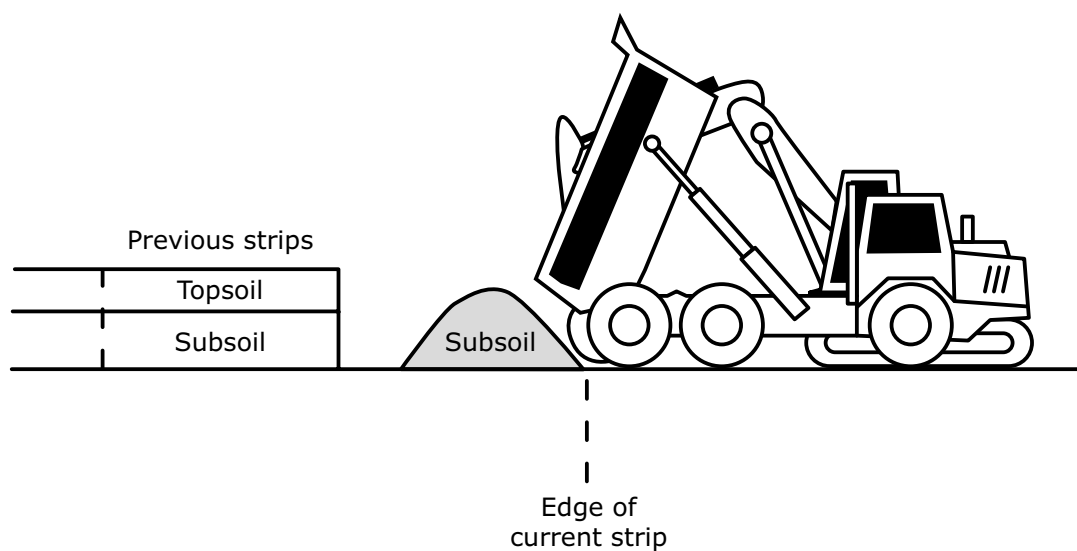
Decompaction might be undertaken from the topsoil surface once the placing of the soils is completed (see **Sheet O**). However, this only advisable where it is certain that it will be effective and no other earth-moving machinery is to traffic the replaced soil and that soil wetness and weather conditions are suitable (see **Part One, Supplementary Notes 3 & 4**).

evident that a full strip cannot be completed, then complete the part of a strip that has been started.

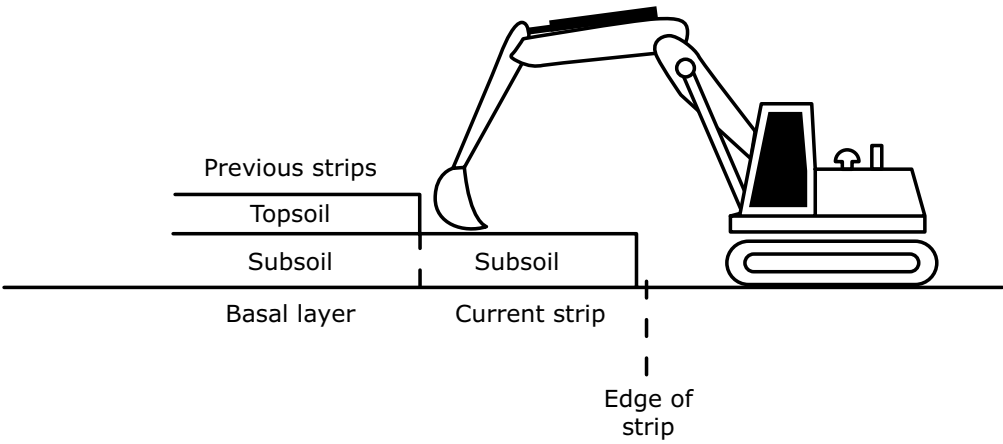
D.40 At the end of each day, or during the day if interrupted by rain, make provisions to protect base of restored strip from ponding/runoff by sumps and grips, and also clean and level the basal layer. At the start of each day ensure there is no ponding in the current strip or operating areas, and the basal layer is to level with no ruts.



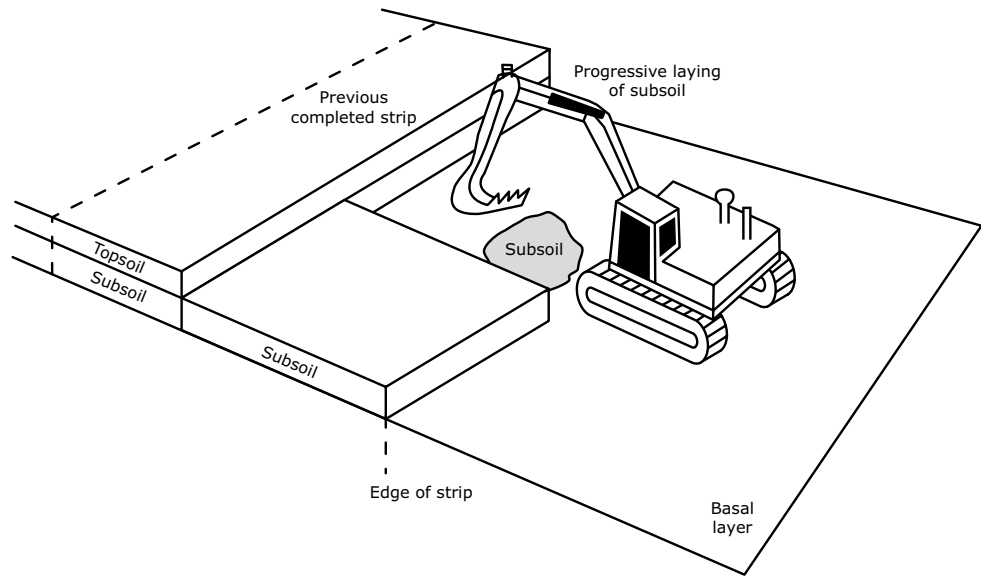
**Figure D.1:** Soil replacement with excavators and dump trucks: Subsoil layer.



**Figure D.2a:** Soil replacement with excavators - dump trucks: Subsoil layer.



**Figure D.2b:** Soil replacement with excavators - dump trucks: Subsoil layer.



**Figure D.3:** Soil replacement with excavators and dump trucks: Subsoil progressively laid.

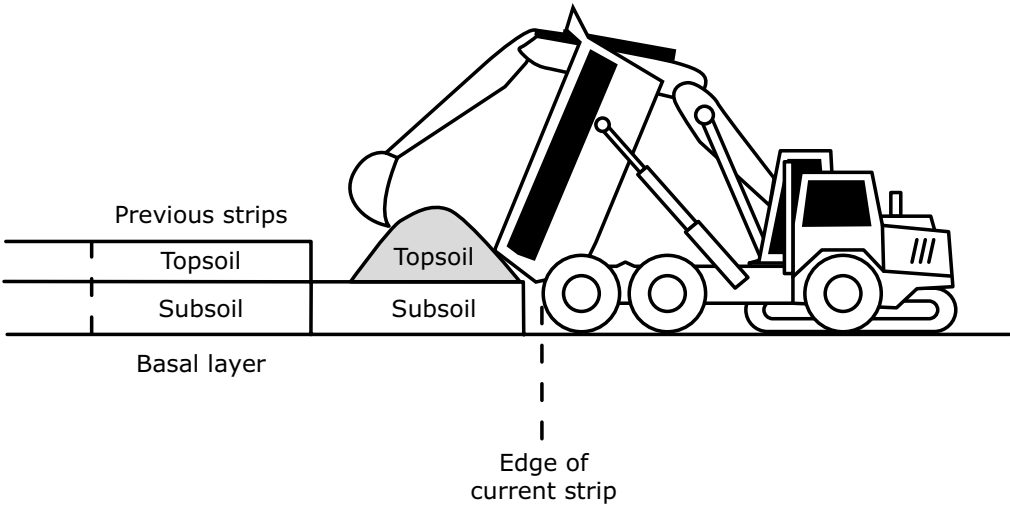


Figure D.4a: Soil replacement with excavators - dump trucks: Topsoil layer.

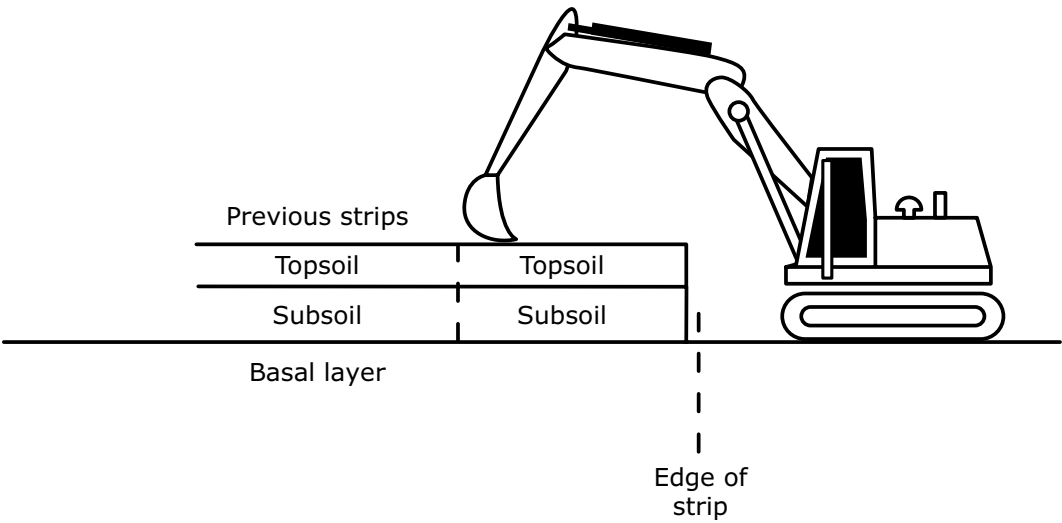


Figure D.4b: Soil replacement with excavators - dump trucks: Topsoil layer.

