cafre
College of Agriculture, Food & Rural Enterprise

Improving soil and sward performance




Open

Department of Agriculture, Environment and Rural Affairs
www.daera-ni.gov.uk

rural Development Programme

'The European Agricultural Fund for Rural Development: Europe investing in rural areas'.

Contents

Assess your soil

The first key step in determining if there is either a soil compaction or drainage problem on your farm is to assess your soils. The rate at which water moves through a soil is determined mainly by its texture and structure.

Soil texture

Soil texture refers to the relative proportions of sand, silt and clay contained in the soil. These are the main components of all soils but they occur in differing amounts or proportions.

Sand –The largest particles (2 - 0.02 mm) found in soil. These also have the largest airspaces between individual particles through which air can freely circulate and water can easily drain.

Silt – Has smaller particles (0.02 - 0.002 mm) than sand but bigger particles than clay. The air-pockets and water channels are more restricted than in sandy soils.

Clay – The smallest particles (less than 0.002 mm) found in the soil. The air-pockets and water channels are very restricted and air and water movement is poor.

Soil texture can be assessed by rubbing some moist soil between your finger and thumb. Sand feels gritty and when moulded into a ball soon breaks up. Silt feels smooth, silky or floury, while clay feels sticky, looks shiny when smeared and will hold a ball shape.

Soil texture cannot be changed, but knowing what it is will help when planning future management.

Soil structure

Soil structure is the size and shape of the crumbs and lumps that make up the soil profile. A good soil structure will benefit crop growth. The structure includes the holes and cracks, called the soil pores.

A good soil structure is characterised by well formed porous soil blocks with rounded edges which are easily broken between the fingers when moist. Vertical fissures lead roots downwards and assist the passage of water.

A poor soil structure is characterised by much harder, sharper soil blocks that are more difficult to break apart. Horizontal fissures restrict root growth and development and cause water to move horizontally.

How to assess soil structure on your farm?

Take a spade and dig a square hole 50 cm wide down to 40 cm depth. Lift out a slice of soil and examine it carefully.

When to sample – You can sample soils at any time of year, but preferably when the soil is moist. If the soil is too dry or too wet it is difficult to obtain a representative sample.

Where to sample – Select an area of uniform crop or soil colour or an area where you suspect there may be a problem.

What to look for:

- **Topsoil depth** – shallower under permanent pasture than cultivated soils.
- **Compact layers** – especially near the surface. Loosening needs to get below these.
- **Colour** – topsoil rich in organic matter will be dark. Rusty, grey mottled soils indicate poor drainage and previous waterlogging.
- **Smell** – if water lies trapped in the soil for any length of time, the airless condition prevents breakdown of organic matter and manures. A foul-smelling dead layer of debris forms.
- **Roots** – will extend to 30 cm plus in healthy, well structured soil.
- **Earthworms** – there should be 10–15 earthworms in the section removed.
- **Cracks and pores** – ideally there should be vertical channels 5 mm wide between the soil blocks to allow free movement of water, air and nutrients.

Earthworms

There are three main types of earthworms in agricultural soils, namely surface dwellers, shallow burrowing and deep, vertically burrowing types. Earthworms feed on dead roots, leaves and grasses, soil and other debris. They digest these materials and reintroduce them into the soil in their casts. Their casts are rich in soil nutrients and readily available for plants use. The bodies of worms decompose rapidly when they die and increase the nitrogen content of the soil. Worm casts are rich in phosphorus containing about four times the content in the surface soil. Their feeding activity also helps to bring to the top leached soil nutrients and make them available for plants use.

Earthworms burrow through the soil and create channels which help in air and water movement in the soil. These channels also permit more extensive plant root development increasing the potential for greater nutrient uptake. Soils with healthy earthworm populations not only have improved drainage but show a sign of a healthy soil microbiome.

The chart on pages 6 and 7 will help you assess the soil structure and help you to identify soil compaction. Refer to the chart and dig out a spadeful of soil, break it up and look at the bits. Smell it, feel it and rub it through your fingers.

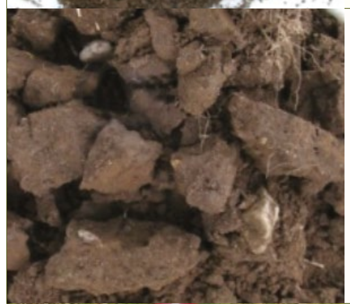
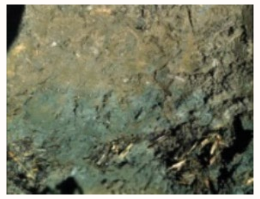
Previous Page

Visual assessment of soil structure chart

Structure quality	Size and appearance of aggregates	Visible porosity and roots	Appearance after breakup: various soils
Sq1 **Friable** Aggregates readily crumble with fingers.	Mostly < 6 mm after crumbling.	Highly porous. Roots throughout the soil.	
Sq2 **Intact** Aggregates easy to break with one hand.	A mixture of porous, rounded aggregates from 2 mm - 7 cm. No clods present.	Most aggregates are porous. Roots throughout the soil.	
Sq3 **Firm** Most aggregates break with one hand.	A mixture of porous aggregates from 2 mm -10 cm; less than 30% are <1 cm. Some angular, non-porous aggregates (clods) may be present.	Macropores and cracks present. Porosity and roots both within aggregates.	
Sq4 **Compact** Requires considerable effort to break aggregates with one hand.	Mostly large > 10 cm and sub-angular non-porous; horizontal/platy also possible; less than 30% are <7 cm.	Few macropores and cracks. All roots are clustered in macropores and around aggregates.	
Sq5 **Very compact** Difficult to break up.	Mostly large > 10 cm, very few < 7 cm, angular and non-porous.	Very low porosity. Macropores may be present. May contain anaerobic zones. Few roots, if any, and restricted to cracks.	

The images and text for this Visual Evaluation of Soil Structure chart were provided by Scotland's Rural College in conjunction with University of Aarhus and University of Aberdeen.

Next Page

Appearance after breakup: same soil different tillage	Distinguishing feature	Appearance and description of natural or reduced fragment of ~1.5 cm diameter	
	 Fine aggregates		The action of breaking the block is enough to reveal them. Large aggregates are composed of smaller ones, held by roots.
	 High aggregate porosity		Aggregates when obtained are rounded, very fragile, crumble very easily and are highly porous.
	 Low aggregate porosity		Aggregate fragments are fairly easy to obtain. They have few visible pores and are rounded. Roots usually grow through the aggregates.
	 Distinct macropores		Aggregate fragments are easy to obtain when soil is wet, in cube shapes which are very sharp-edged and show cracks internally.
	 grey/blue colour		Aggregate fragments are easy to obtain when soil is wet, although considerable force may be needed. No pores or cracks are visible usually.

Alleviating soil compaction

Soil compaction can have a significant economic and environmental cost, through decreased yields, decreased efficiency of fertiliser use, increased emissions of nitrous oxide and ammonia, increased surface runoff and soil erosion. The problem of soil compaction is complicated by the fact that its effects can be masked by high applications of nitrogen and easily available water. The problem may only manifest itself when the plant is stressed, either in terms of moisture or nutrient availability.

Soil compaction: definition and causes

All productive soils require a degree of compaction to ensure a good soil to root contact, allowing optimal uptake of water and nutrients. What is regarded as 'soil compaction' is consolidation of soil beyond an optimum level, as a consequence of an applied force (Figure 1).

This has the effect of (i) increasing soil bulk density (increases difficulty of root penetration) (ii) decreasing soil pore volume which leads to a reduction in soil aeration and natural drainage. Soil compaction is loosely categorized into two forms, surface (topsoil, < 400 mm deep) and sub-surface (subsoil, > 400 mm deep).

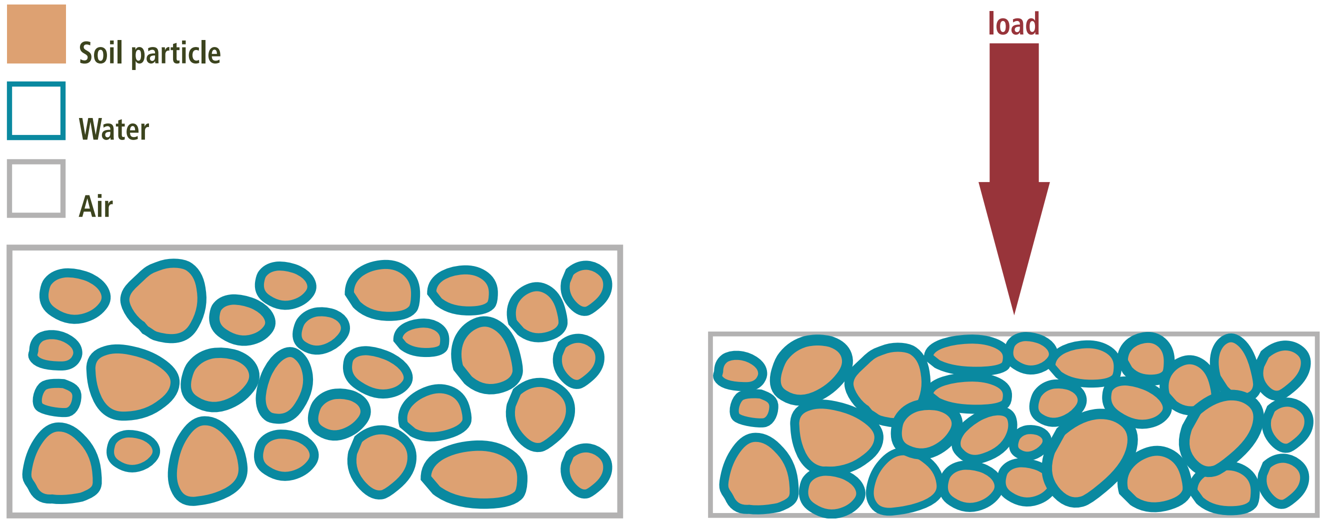


Figure 1. Soil compaction as the result of an applied force.

In general terms, virtually all soils are liable to some form of soil compaction given the right combination of circumstances. Although soil strength varies throughout the year, a number of factors make some soils more susceptible to compaction. The most important factor is of course soil moisture, the nearer a soil comes to saturation, the lower its capacity to withstand compression. This means that soils with a high clay or organic content or soils with impeded drainage are susceptible to compaction for longer periods than are freely draining soils.

Soil structure can be regarded as the framework within the soil which organises the various soil constituents in units, significantly increasing air, water and root penetration and increasing soil strength. This means that at a given soil moisture level, a clay-rich soil with a well developed structure will be better able to withstand compaction than a similar soil with poorly developed soil structure. In general, long-term pasture has a better soil structure than land under long-term cultivation.

The degree of crop cover and root development can be important in spreading the applied load and resisting compaction. In fields with low grass cover, such as recent reseeds, capping can occur due to heavy rainfall which can reduce surface drainage.

In Northern Ireland, soil compaction is mainly caused as a consequence of traffic, treading by animals, cultivation operations and damage or destruction of soil structure.

Compaction by farm vehicles

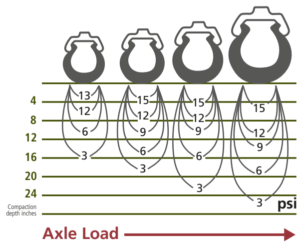
The normal operation of agricultural machinery can lead to the compaction (at surface and subsurface levels) of both grazed and silage fields. The general intensification of agriculture and the increasing use of contractors have brought heavier machinery on to farms, with more than a doubling in axle loads from the 1980's. Vehicle trafficking on grassland can be double that on arable land. In grassland used for silage for example, the equivalent of the field area can be driven over up to nine times by tractor wheels during the course of the year. All of this combined with our variable climate and susceptible soil mean there is a considerable potential for soil compaction.

The potential for wheeled vehicle compaction in any given situation is controlled by the following factors:

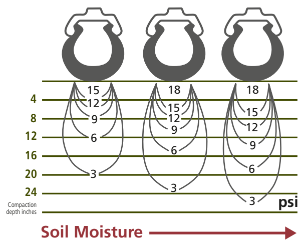
- **Total axle weight –** the higher the weight the greater the possibility of compaction. Higher axle weights can cause greater compaction and at a greater depth in the soil profile.
- **Tyre width, diameter and type** – the larger the footprint (width and diameter) of the tyre on the soil surface the less likelihood of deep compaction. Correctly inflated radial tyres have been shown to do least damage.
- **Inflation pressure** – affects the footprint of the tyre on the soil surface, with high inflation pressures meaning little or no flex in the tyre and subsequent potential for deep compaction.
- **Wheel slip** – even low levels of wheel slip has been shown to produce significant compaction down to 5 cm.
- **Number of passes** – the higher the number of vehicle passes the higher the degree of compaction. However, 50% to 80% of the soil compaction may be caused by the first wheel pass with only slight increases after the fourth pass.

Reducing compaction

Depth of compaction increases with increasing axle load



Depth of compaction increases with increasing soil moisture



Compaction by livestock

At low to medium soil moisture contents animals cause compaction at or near the soil surface. At high soil moisture contents, trampling results in poaching (penetration of the soil surface by the hoof). As the hoof penetrates the soil, the structure of the soil is damaged and soil at the base of the hoofprint is compacted. Animal-induced compaction does not generally extend beyond 10 cm, although with a combination of heavy stock and poor conditions compaction can be deeper.

To put pressures into context, a standing sheep exerts a static pressure on the soil of approximately 80 kilopascal (kPa) or 12 pounds per square inch (psi), increasing to 200 kPa (29 psi) when the sheep is moving, while for cattle, static pressure is 160-192 kPa (23-27 psi) and this pressure at least doubles when the animal is walking. This compares to 60-80 kPa (9-12 psi) pressure exerted by a typical unloaded tractor.

The potential for animal induced soil compaction in any given situation is mitigated by the following factors:

- **Total mass of the animal** – again the higher the weight the greater the possibility of compaction.
- **Stocking density** – higher stocking densities are associated with increased soil compaction.
- **Rate of rotations** – Rotating stock more frequently reduces the degree of compaction.
- **Sward type and condition** - High tillering dense swards such as those in long-term or permanent pastures are more resistant to poaching than the open swards which develop under heavy crops of silage.
- **Local issues** – such as placement of drinkers, location of shelter etc.

Impact of soil compaction

A number of studies have looked at this issue and report the following general conclusions:

1) Soil compaction can have a negative effect on grass growth, yield and quality. These adverse effects may be caused by a restriction in root depth, which reduces nutrient uptake, or because of the formation of waterlogged areas, this may in turn cause increased nitrogen losses.
2) Soil compaction has a negative effect on soil structure and soil drainage. In one study where a conventional silage system was compared to a low ground pressure system, a significant increase in soil bulk density and decrease in drainage rate was found (Ball et al 1997). Other studies that focused on poaching by animals, have indicated production losses as high as 52% in severely poached areas and persistence of the soil physical damage.

Preventing or reducing the impact of compaction

Given the nature of our climate and the necessity to carry out certain farm operations, it is probably inevitable that some soil compaction will take place. Very shallow surface soil compaction can be removed by the natural processes of wetting/drying and freeze/thawing and biological action. Severe compaction is more persistent and will not be removed by natural processes in the short term, even if the cause of the original compaction is removed.

The most cost effective way to deal with soil compaction is to adopt management strategies to avoid or reduce the risk of soil damage.

1) **Match operation to the nature and condition of the soil.** In essence stay off wet soils. If possible postpone machinery operations to fields for 48 hours after heavy rainfall, or remove or reduce stock on susceptible fields. Good timing of field operation is probably the single most important aspect to preventing soil compaction.

2) **Reduce total axle loads (ideally below 5 tonnes).** The higher the axle load the more potential for soil compaction and to a much greater depth in the soil profile. High axle loads in wet conditions can cause compaction from the surface to the subsoil. For instance, the use of umbilical systems for the spreading of slurry is one technique for significantly reducing axle weight while having no impact on the operation carried out.

3) **Reduce ground contact pressure.** With regard to vehicles, larger tyre diameter and width in combination with lower inflation pressure will reduce the severe compaction potential. In this context tandem axle have been shown to be better than dual wheels. Correct tyre pressure depends on weight to be carried and speed of travel. Once these are known, the appropriate tyre pressure can be chosen from the manufacturer's recommendations. It is preferable to run tyres at the lower end of the recommendation scale. With regard to animal compaction, stock on high tillering dense swards will have less of an impact than on open swards or recent reseeds.

4) **Use of farm tracks.** As the majority of compaction is caused in the first few trips it may be worth designating a 'sacrifice' strip where the field traffic can be concentrated. This has the effect of reducing the total impact of compaction to a known area which can be mechanically alleviated, if need be, at a minimum of cost. With animals, especially dairy cattle, access to and from milking should be via hard standing laneways as much as possible.

Techniques to alleviate soil compaction

If a compacted zone is identified it can be removed with a number of different types of soil loosening machines. All of these (apart from aerators) work on the principle of fracturing soils along natural lines of weakness, essentially the soil is lifted and loosened as the device passes through, decreasing bulk density, increasing porosity and drainage rates. Care has to be taken that work is only carried out when the soil is dry enough to fracture rather than deform, and to minimise trafficking across the loosened area for a number of days to allow the soil to stabilise. Another important consideration is the existing drainage network; any proposed subsoiling would have to be no deeper than the shallowest drain.

i) **Subsoiler/Shakerator/Paraplough.**

A subsoiler consists of one or more vertical legs with a horizontal wing at the bottom, which is capable of being worked at various depths in the soil (maximum of usually 60-70 cm). The angle of the wing can be altered to achieve a low or high degree of lift of the soil. In existing grassland a low lift is recommended as minimum surface disturbance is achieved. Another important consideration is the depth at which the implement is used. Each subsoiler has its own **critical depth** (usually taken as six times the loosening wing width). Use of the implement below this critical depth will cause further compaction.

A Shakerator is essentially a subsoiler with a vibrating module attached – the vibration induced in the tines has the advantage of reducing the draught required to pull the unit.
A Paraplough is also a tined implement but differs from the conventional subsoiler in that its legs are slanted, 45 degrees from the vertical. It is designed to leave a relatively undisturbed surface, with a maximum working depth of about 35 cm.

ii) **Aerators.**
Common aerating devices work to a slightly different principle to subsoilers in that they act from the surface down rather than the sub surface up. Essentially these devices push a blade into the ground increasing air and water entry into the soil. The devices can either be of a straightforward type that create a slit in the soil or the blades can be offset to produce a rotational cut.

iii) **Cultivation.**
Normal cultivation will of course remove any near-surface compaction. This is a worthwhile option to consider where significant poaching has occurred, which can allow the ingress of other lower productive grass and weed species.

iv) **Management.**
This can include the addition of lime (which can improve soil structure and promote earthworm activity), addition of gypsum (help to promote structural stability in heavy clay soils) addition of organic matter
(in the case of soils with inherently low organic matter, this too will promote structural development).

Making the most of your existing drainage system

Many of the drainage schemes carried out in the boom period of high grant rates have now largely been neglected. However, with good maintenance a well installed drainage scheme should have a life expectancy of anywhere from 30 to 50 years, but if neglected the whole system can break down within a very short time. Past investments in drainage work will only continue to show rewards if they are protected and properly maintained. It is all a question of looking after what is there.

Maintenance of ditches

Good ditches are an indispensable part of the drainage network but often their upkeep takes low priority. Ditches should be inspected regularly to see what condition they are in. Maintenance requirements of ditches vary; with some, the water flows at sufficient speed to be self-cleaning but the majority have flat gradients and are slow flowing. Where plant growth tends to occur, this provides an ideal filter for soil particles in the drainage water and leading to a build-up of sediment. This results in a reduction of channel capacity and prevents underdrainage systems from discharging freely. In turn this leads to silting of pipes, rapid failure of mole drains and higher water table levels outfield. In many such cases annual ditch cleaning is required.

Bank slips

If bank slips occur in a ditch, flow is restricted and water level rises. Slips generally occur because the bank slope is too great for the soil type involved. More gentle slopes need to be used through sands or alluvial silts (common in low lying areas). Springs or blocked drains with waterlogging close to the bank also cause instability. If slips are a major problem a range of remedies exist such as staking, toe piling, stone revetment or even culverting in extreme cases. To avoid unnecessary expenditure on this aspect it is advisable to seek expert advice first.

Outfalls

The exposed outlet of a drain is very vulnerable to damage by the digger bucket and should therefore be conspicuous and protected by a sturdy headwall. This can be of cemented stone, block or brick or one of the easily erected custom-built structures. Large diameter pipes with a high discharge should project well beyond the bank to reduce bank erosion or use a splash plate. Headwalls should always be easily located for maintenance purposes and it is a good idea to use a distinctively coloured marker post driven into the bank at each drain outfall.

Guard fencing

Livestock can damage banks and drain outlets and drowning can occur in deep ditches. A stock-proof fence is required at least one metre back from the edge and, if access for water is needed, a properly fenced drinking bay should be constructed.

Pipe maintenance

Pipe drainage systems need very little maintenance but must not be forgotten. Outlet pipes need to be checked regularly and kept clear of silt.

Inspection chambers

The function of inspection chambers is to collect and remove silt from the system. If the level of silt in the chamber approaches the outlet pipe level then the silt pit requires cleaning. The structure should be clearly marked for easy identification.

Wet areas and surface ponding

Where wet areas develop in land which was previously well drained, the cause is often blockage of the drain. Another possibility is a leaking underground water supply pipe causing a mounting water bill. The remedy is to mark the affected area, dig to investigate and correct as soon as possible.

Surface ponding is the result of surface runoff after heavy rainfall. Local hollows left on flat sites after recent reclamation or reseeding can accumulate silt laden surface water. The silt clogs the surface drainage pores of the soil and a surface puddle can develop into a large pond if not treated properly. In most cases the problem can easily be cured by digging down to an underlying drain and stoning up to ground level. If a suitable drain is not available one can be constructed back to the nearest outlet.

Surface ponding

Annual inspection

It is worth devoting some time every year to examining the condition of the ditches and drained areas of the farm. The best time is during the winter or spring months when potential problems become most apparent.

Designing a drainage scheme for mineral soils

The objective when installing a drainage system in a field is to remove excess water from the soil thus improving the conditions for root development and the growth of plants. Improved drainage will also aid field operations including the timeliness of cultivations and the harvesting of crops. It will also result in better utilisation of grass by grazing animals.

Field investigation

The starting point for any drainage scheme is to carry out a detailed investigation of the site in order to determine precisely the cause of the problem.

An initial inspection may reveal particular features such as springs, soft ground conditions and rush lines. These can give an indication of the underlying problem.

Excavation of a number of test pits will also be necessary and these should be dug a few weeks in advance of installing the new system. They will enable the groundwater movement, soil structure and texture to be confirmed. This information is useful not only in determining the nature of the problem but also in deciding the most effective drainage system to cope with the problem.

Drainage problems and principles of design

The drainage design will depend on the problem which can fall roughly into three main categories:

(i) High groundwater table.

(ii) Impervious subsoil.

(iii) Springs or seepage lines.

High groundwater table

This problem usually occurs in areas of agricultural land which are low lying and flat. Often the soils themselves are quite permeable but the water table is high because of inadequate outfall or badly maintained open drains. Cleaning the open drains can result in a marked improvement but in addition the problem usually requires the construction of a series of equally spaced parallel piped field drains. This is commonly referred to as a conventional drainage system.

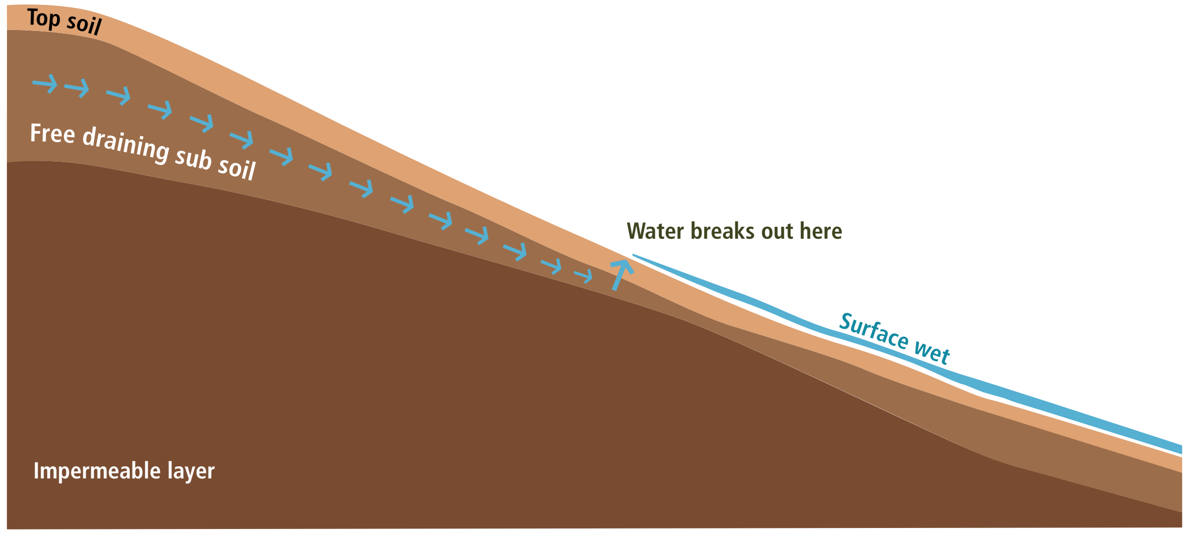
Impervious subsoil

This is a common feature throughout the province but has a special significance in Fermanagh and Tyrone. It is often characterised by a shallow topsoil overlying an impervious, poorly structured subsoil which usually contains a high proportion of clay and silt particles through which water moves very slowly. The design of the drainage system must provide for secondary treatment over a series of piped collector drains. The secondary treatment would be either mole drains or gravel tunnels.

Springs or seepage lines

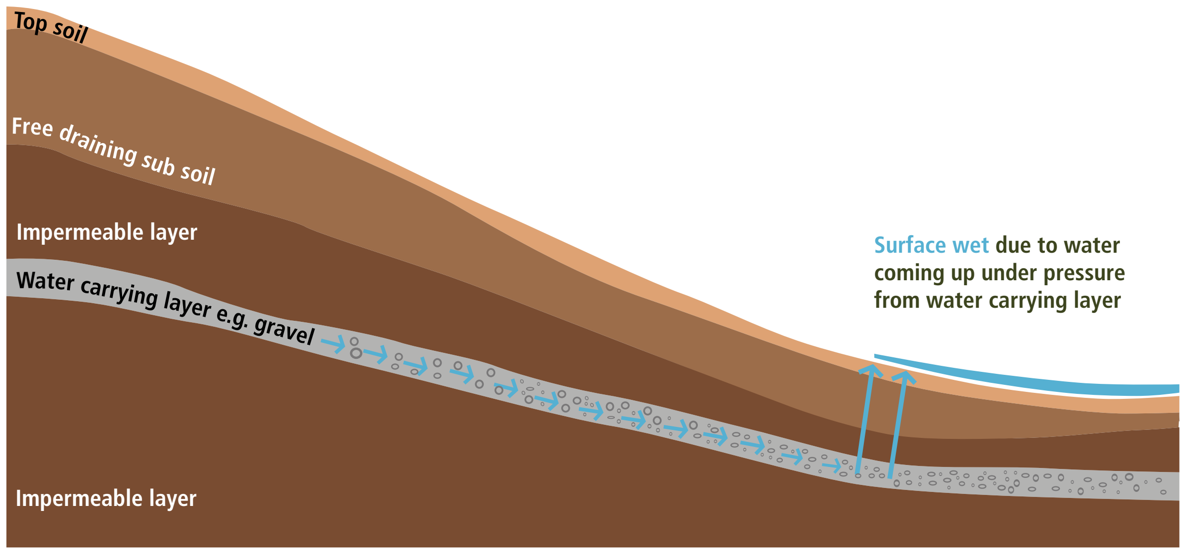
There are two distinct types of seepage problem:

(a) Hillside seepage - cross section to show hillside seepage (not to scale)



Water moves through the free draining topsoil and runs along the top of the impermeable layer bursting out at the side of the hill.

(b) Artesian seepage- cross section to show hillside seepage (not to scale)



Pressure forces groundwater up through a crack or weakness in the impermeable layers and causes waterlogged ground conditions.

In both cases the drainage system design must allow for a drain or series of drains to be constructed deep enough to intercept the water in the soil layer in which it is moving and in some instances this can be more than two metres deep.

Drain depth and spacing

In order to have a depth of soil capable of absorbing a reasonable amount of rainwater the design should always cater for drains to be installed with at least 600 mm of cover over the pipes. The main drain must always have a lower pipe level than the feeder drain.

Where there is a high groundwater table problem, the design can either be for drains to be widely spaced and deep or closely spaced and reasonably shallow. It must always be remembered that the water table is controlled by the depth of the drains. In free draining soils with a high water table it is advantageous to place the drains as deep as possible thus enabling drain spacing to be increased and costs reduced.

Obviously widely spaced and deep is the most cost effective but in these areas depth is usually governed by the outfall available. In practice it is rarely an advantage to go beyond one metre deep and provided the soil is reasonably permeable spacing will be in the order of 12-15 metres.

If the subsoil is impervious the depth of the collector drains is determined by the type and depth of the secondary treatment (either moling or gravel tunnelling) to be used. Spacing in this case will depend on the soil type and topography of the land. In our conditions a depth of 900 mm is quite adequate.

To control seepage problems the depth of the drains depends on the depth of the soil layer carrying the ground water flow. The drain must be deep enough to penetrate the water carrying layer or at least connect into it.

Drainage layout

The aim should be to provide for the minimum number of outfalls and it is essential to check that there is an adequate fall for the drainage discharge. In Northern Ireland, where much of the land has variable slopes, the herringbone design has been popular over the years.

Gradients are important and steep falls should be avoided. On sloping land side drains should run across the slope and as a guide the gradient for piped field drains should not exceed 1 in 20.

When the drainage system is being installed any old drains which are still functional should be connected into the new system. Not only will this give better drainage but it will prevent problems of 'boil-ups' at a later date.

Permeable fill

The function of permeable fill is to act as a filter or as a connector for drainage systems involving secondary treatment over a series of collector drains. In certain circumstances it can also act as a drain improver but it must be stressed that the common belief, that in itself permeable fill exercises a drawing power on water, is wrong. There is little point in filling drains to the surface with permeable fill unless it is specifically to solve a problem of ponded water on the surface.

The choice of material usually boils down to broken stone or gravel. The aim should be to use stones in the range 12-36 mm.

Outfalls

Every drainage scheme is only as good as its outfall. Cleaning and upgrading of open drains that act as outfalls from land drains is an important step in any drainage scheme. Before commencing land drainage the proposed outfall should be assessed and where necessary upgraded. Open drains, running in the direction of maximum slope, should be established to as great a depth as possible. This will maximise the potential for land drainage, with associated benefits.

When a drainage scheme has been completed, the layout should be drawn and noted on a farm map. This map can then be used as a guide when maintaining the works, as well as a record of the works. Land drain outlets should be regularly cleaned and maintained especially if open drains are cleaned/upgraded as this may result in blockages at the drain outlet. The use of a concrete or unperforated plastic pipe over the end of the drain pipe, minimum 1m in length, will protect the outlet from damage and will make locating and maintaining it easier.

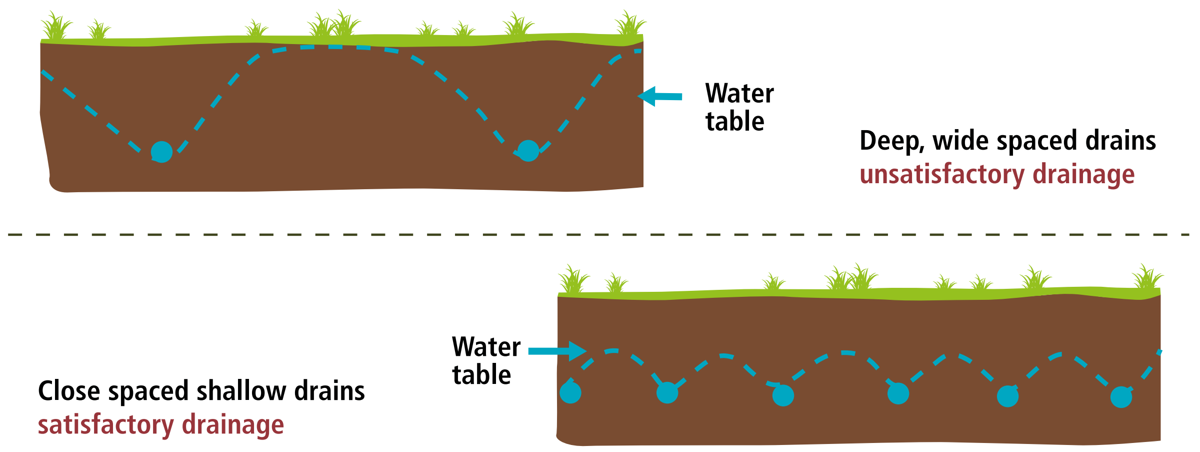
Conclusion

Installing a drainage system, while being a costly investment, can provide substantial benefits in both grassland and cropping areas. Taking the time and effort to identify the problem and design an effective drainage system, will pay dividends.

Field drainage - secondary treatments

The objective of field drainage is to rapidly lower the level of ground water to the point where it has no adverse effect on either root growth or on surface conditions. In permeable soils this is usually achieved by laying drains at a depth of 900 mm. In heavy clays, water movement can be so slow that the traditional piped drains spaced at 7 metres apart are not adequate to provide satisfactory drainage. Reducing the spacing from 4 to 5 metres is expensive and does not solve the basic problems.

In these low permeability soils it is necessary to speed up water movement by both loosening the subsoil and providing closely spaced channels to carry the water to the drain. This can be done successfully with either the mole drainage system or permanent gravel filled moles.



Moles or gravel tunnels?

Both these secondary treatments provide comparable results in stable soil conditions but moles are preferable because they are cheaper to install.

The mole system does however lack permanency and periodic renewal of the channels is usually necessary to maintain a satisfactory drainage effect. The mole system is not suitable for unstable soils where channel collapse can occur rapidly nor is it satisfactory in a stony subsoil.

The gravel tunnel system provides effective drainage where a secondary treatment is required and has the following advantages over mole drains.

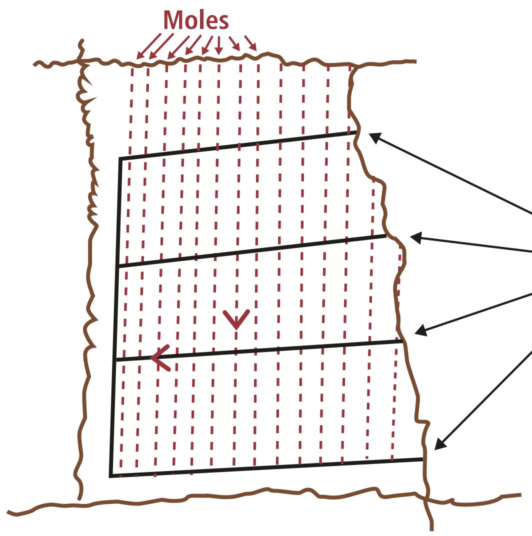
- A permanent system.
- Can cope with unstable soils – since the stone infill prevents structural collapse of the mole channel.
- Can cope with stones in the subsoil.
- Can be drawn on steep slopes – deterioration due to erosion or siltation is reduced compared to mole drains.
- Greater flexibility in soil moisture content at installation.

Mole drainage

Collector drains

Mole drains cannot operate on their own. They require a good, well designed system of piped, collector drains. These collector drains should be spaced 20-30 metres apart. If there is doubt about the suitability of the subsoil for moling then collectors should be spaced closer together. Collectors should be at least 900 mm deep and the pipe covered with stone up to plough depth. The mole drains can then be drawn across the collectors passing through the gravel fill. The gravel acts as the collector between the mole channel and the piped drain.

Moles over collector drains

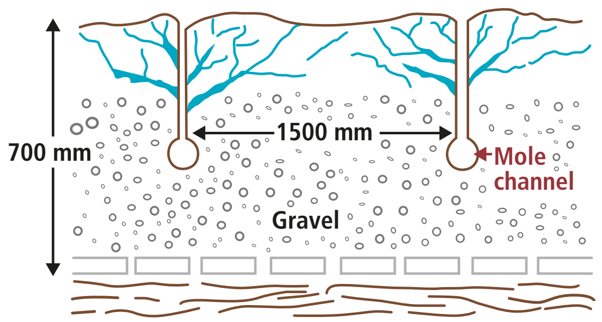


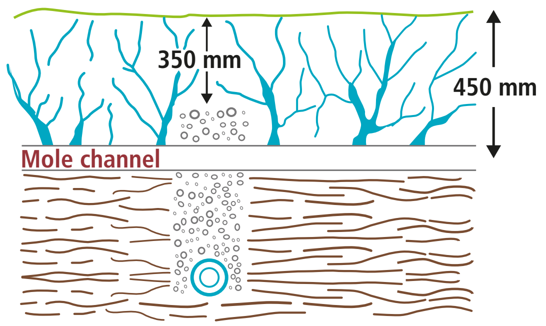
Mole channels

A stable subsoil containing at least 30% clay and having few stones, gravel or sand pockets is the basic requirement for a successful mole drainage system. Under good conditions where the subsoil is stable mole channels can last five to ten years.

For good mole drainage:

- Mole channels should be drawn at a depth of 450-500 mm and spaced at 1500-1800 mm apart.
- Avoid steep slopes. Moles with a gradient in excess of 10% are likely to collapse due to erosion of the channel walls.
- Avoid flat sites where water will tend to lie in the moles because this will hasten their collapse.





Suitable conditions

Ground and weather conditions at the time of moling are important. The ground surface should be dry enough for efficient traction. At moling depth the subsoil should be plastic enough to form a stable channel while above the mole the clay should be sufficiently dry to enable it to crack and form the numerous fissures required to increase the permeability of the soil. Water can then pass freely into the moles and on via the collector drains to the open sheughs.

Wet weather during moling or shortly afterwards can cause rapid channel deterioration and eventual collapse.

Mole ploughs

There are two different basic designs of mole plough used – the long beam and the short beam. The long beam is designed to 'iron out' undulations on flat land. In Northern Ireland most of the land is on a slope so there is no problem maintaining a suitable fall in the mole channel. The cheaper, short beam plough, operated from the three-point linkage of a heavy tractor is therefore quite adequate. The bullet of the mole drainer and the mole expander must be properly set to ensure that the mole channel is well constructed. The temptation to shorten the top link to obtain better penetration should be avoided because this will 'toe down' the bullet forming a weak oval shaped channel that will rapidly deteriorate and collapse. The bullet is usually 75 mm in diameter followed by an expander with a diameter which is 12-15 mm larger.

Remoling

Moles can last many years in stable clays but the normal life expectancy is five years. They should therefore be installed with the intention of remoling every few years. A farmer with his own equipment can carry out this operation at a fraction of the cost of reseeding which is accepted as a routine farm operation.

Gravel tunnel drainage

The gravel tunnel drainage system is a form of mole drainage whereby stability is ensured by the insertion of washed gravel or stone chips into the mole channel to prevent its collapse. The technique is sometimes referred to as 'gravel filled moles' because, although a specialised machine is used to install the stone in the channel, the system does incorporate the principles of mole drainage and soil cracking.

A series of conventional collector drains are laid over the area to be drained. Closely spaced (usually 1.5 m) gravel tunnels are drawn across these. The tunnels are made with a specialised machine which creates a 450-500 mm deep 75 mm mole channel and fills it with stones. The specialised machine cracks the soil and leaves a slit which extends to the surface. The slit can also be filled with stone but this is seldom a necessity.

Requirements

The general requirements for a successful installation are:

- Good outfall for main drain.
- Well designed collector system.
- Proper spacing and depth of gravel tunnels.
- Dry soil conditions.
- Complete cracking between drains.
- A very high-powered tractor.

Collector drains

Collector drains should be:

- At least 900 mm deep.
- Filled with permeable backfill up to plough depth.
- Spaced 30-40 m apart where the slope is uniform. Where the site is undulating and has a poor slope collectors should be installed where there are hollows.

Gravel tunnels

Gravel tunnels should be:

- At least 450-500 mm deep.
- Spaced 1.5 m apart.
- Filled with 10-15 mm clean quarry chips or washed gravel to a minimum depth of 75 mm.
- Drawn through the permeable backfill in the collector drains.
- Drawn with the slope.

Conclusion

A secondary treatment is an essential component in the drainage of impervious soils. The selection of the actual secondary treatment to use on a particular site will depend on channel stability, cost and willingness to carry out repeat treatments.

Drainage works: on-farm environmental advice

When considering new drainage works, farmers must abide by the rules of Cross Compliance and Good Agricultural and Environmental Conditions (GAEC). Further restrictions regarding drainage works may apply to Agri-Environment (AE) Scheme participants. Agri-Environment Schemes include the Countryside Management Scheme, Environmentally Sensitive Area Scheme and Organic Farming Scheme.

Cross Compliance

All farmers and landowners claiming under direct aid schemes, including Single Farm Payment, must meet the Cross Compliance conditions. One requirement is to maintain all their land in good agricultural and environmental condition. As part of this farmers are not permitted to remove field boundaries (which includes dry stone walls, ditches/sheughs, hedges and earth banks) except by prior permission from DAERA. This also includes infilling or laying drainage pipes in open sheughs.

Environmental Impact Assessment (EIA) Regulations

The EIA (Agriculture) Regulations (NI) 2007 seek to protect environmentally important agricultural land and preserve the landscape for future generations. The EIA Regulations require that you receive consent from DAERA before carrying out land improvements on uncultivated or semi-natural areas. The Regulations apply to two different types of project:

- Projects which increase the productivity for agriculture of uncultivated land or semi-natural areas.
- Projects which physically restructure rural holdings.

Examples of land improvement covered by the EIA Regulations include: drainage, ploughing, reseeding, sub-surface harrowing, discing, tining, infilling, chemical spraying or applying increased amounts of fertiliser. Land is considered to be uncultivated if it has not received physical cultivation or chemical treatment in the last 15 years. Semi-natural areas include: species rich hay meadow, semi-natural grassland (including calcareous, acid and neutral), coastal and floodplain grazing marsh, scrub, fen, marsh and swamp, moorland and heathland, broadleaved, mixed and yew woodland, peat bogs, bracken, land above the treeline (usually 600 m above sea level), and standing water and canals. Compliance with the EIA Regulations is a requirement of Cross Compliance, starting work without prior permission could affect your Single Farm Payment and other support schemes.

Agri-Environment (AE) Scheme participants

The primary function of sheughs (or ditches) is to drain land. However, they are also valuable landscape and wildlife features, important for many plants, insects, fish, birds and mammals. Sheughs should therefore be managed, not only as drainage channels, but also as valuable wildlife habitats.

The general requirements of AE Schemes state that participants must not install new or improved drainage systems on any land except for 'improved' or 'semi-improved' grassland. All sheughs must be kept open. Infilling or laying drainage pipes in sheughs is not permitted without prior approval from DAERA. Existing drainage systems can be maintained and repaired where necessary.

Sheugh maintenance

It is recommended that sheugh cleaning should only be carried out every 3 - 4 years between autumn time and late winter. Only vegetation and silt should be cleared from the sheugh, avoid deepening or widening the sheugh. Try to leave the vegetation untouched along one side of the sheugh at cleaning. Try to retain a balance of trees, shrubs and fringing vegetation to maintain the natural appearance of the sheugh in the landscape. When cleaning out sheughs, retain as many water-loving plants as possible. Bulrush, water-plantain and water-crowfoot bring benefits such as algae control, provide fish spawning beds and encourage insects. Sheughs cannot be widened, deepened or extended. Areas of disturbed soil should be levelled out close to the drain and allowed to regenerate naturally.

For further information on sheugh management please contact your local DAERA office.

Managing soil nutrients to maximise performance

As soil plays such an important role, it is important to assess and monitor its nutrient levels and chemical properties to help maximise crop performance.

Soil analysis

Soil analysis is the starting point in determining the crop nutrient requirements for optimum grass and crop production. An up-to-date soil analysis will provide the quantity of lime required to correct the soil pH (soil acidity) for grass and crops. It will also provide the information required to calculate the Phosphorus (P) and Potassium (K) crop requirements.

The annual cost of completing a soil analysis, once every four years, can be as low as 54p/ha. This is a very small cost compared to current fertiliser prices and if the information is used correctly, will ensure the long-term productivity of your soils.

Lime

The target pH for mineral soils is 6.0 for grass and 6.5 for arable crops. Your soil analysis will give a lime requirement which, if applied in the growing season post sampling and at the stated application rate, should maintain soil pH within the optimum pH range for four years.

In recent years 63% of soils sampled through CAFRE's Knowledge Advisory Service had a pH of 5.9 or lower and required lime. Correcting soil pH levels by liming will increase the availability of soil nutrients (Table1), help promote biological activity and improve soil structure.

Liming increases fertiliser performance as shown in Table 1.

Table 1

Percentage nutrient availability to plants at a range of pH values

	N	P	K
pH 5.0 (very strongly acidic)	53%	34%	52%
pH 5.5 (strongly acidic)	77%	48%	77%
pH 6.0 (medium acidic)	89%	52%	100%

Available nutrients

The soil analysis report lists the available amounts of Phosphorus (P), Potassium (K) and Magnesium (Mg). This is summarised in the form of a soil index and ideally should be **2 for Phosphorus** and **2- for Potassium**.

The higher the soil index the lower the need for additional nutrients from slurry, farmyard manure or chemical fertiliser. Soils at index 0 and 1 will have lower yields than soils that are at the optimum indices and they will require additional nutrients to meet crop demand. Soils at index 3 or above will require little or no additional nutrient application, and therefore provide an opportunity to save on purchased fertilisers.

Soil analysis results should be used to identify fields with a lower nutrient reserve. This will allow for targeted application of slurry and manure rather than applying it to the same fields year after year.

Balancing the nutrient supply

Selecting the correct chemical fertiliser to balance the nutrient requirements of the crop will depend on the soil nutrient status, from soil analysis, and the quantity of organic manure applied.

Crop Nutrient Recommendation Calculator

CAFRE have developed an online Crop Nutrient Recommendation Calculator to help you comply with nutrient limits while meeting the crop NPK requirements. The program will:

- Determine the N, P and K requirements for your crops.
- Calculate the quantity of nutrients provided by organic manures.
- Allow you to select the most appropriate chemical fertiliser and its application rate to balance soil nutrient availability with applied organic nutrients and crop nutrient demand.
- Retain information required under the Nitrates Action Programme 2015-18 and Phosphorus regulations.

The program can be accessed by visiting the DAERA website **www.daera-ni.gov.uk**

Additional information on soil analysis and the interpretation of results can be obtained from your local CAFRE Development Adviser, or by attending the CAFRE Nutrient Management training course. For information on training courses visit: www.cafre.ac.uk/industry-support/industry-training/agri-environment

Methods of sward improvement

There are several methods of improving swards, which can be subdivided into three categories.

- **Sward replacement or reseeding**

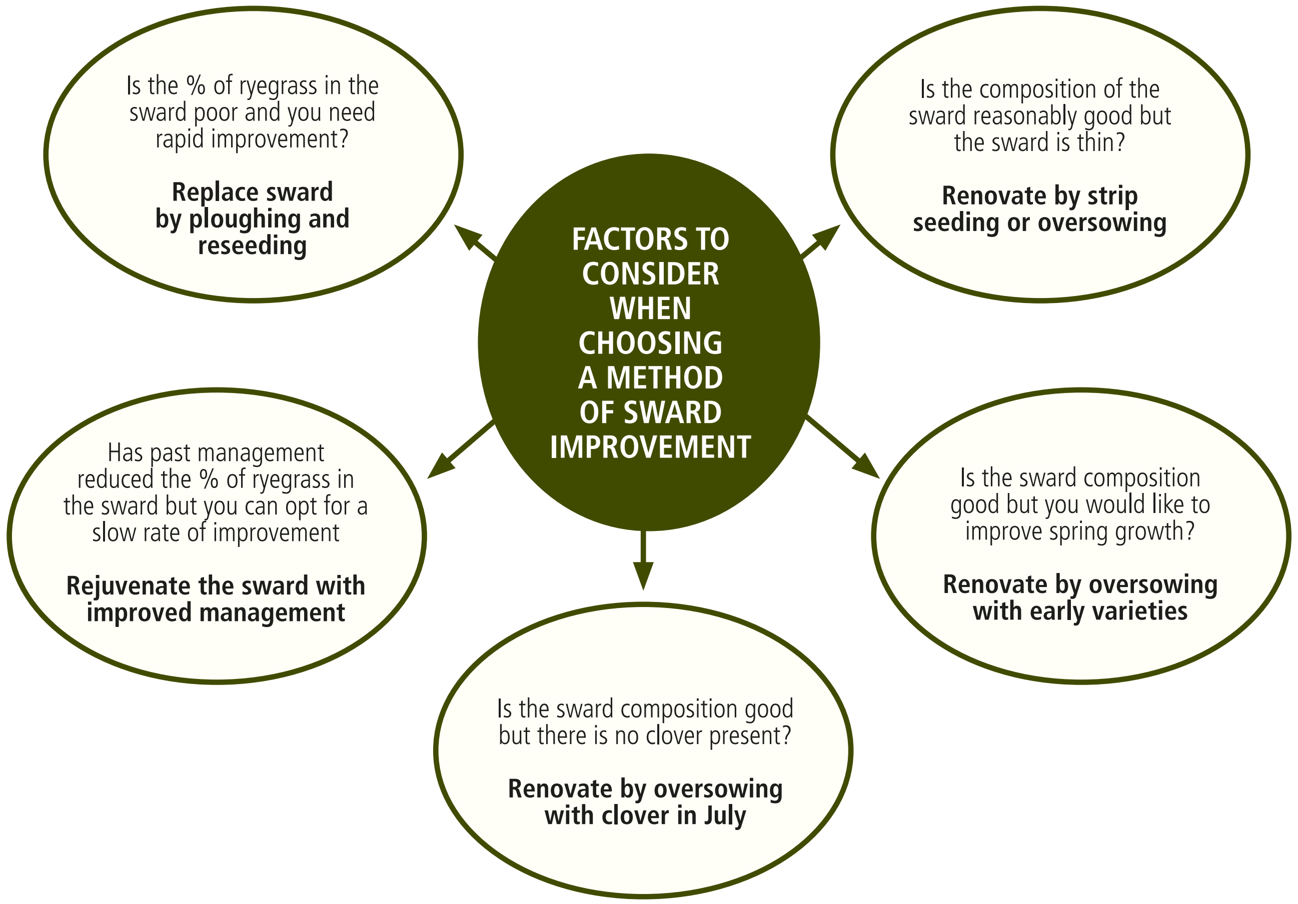
This involves the destruction of the old sward and its replacement by a completely new reseed. This can be accomplished by either ploughing or by using minimal cultivation techniques.

- **Sward renovation or stitching in**

This involves introducing seed into an existing sward without cultivation by overseeding, slot seeding or by minimal cultivation techniques.

- **Sward rejuvenation**

This involves gradual improvement brought about by the general improvement in management e.g. use of lime, better use of nitrogen and other nutrients or improved grazing management.



Sward replacement or reseeding

This is the most reliable and conventional method of replacing a sward and is practised by the majority of Northern Ireland farmers.

Timing of reseeding

A spring reseed between mid March and early May is often best for long term leys based on late heading grass varieties and clover. This is because these seeds are slower establishing and spring conditions are usually more favourable. Spring sowing does limit production during the seeding year and you may consider this unacceptable if you are intensively stocked. The use of an appropriate herbicide in the new sward is essential as spring reseeds often have a heavier weed burden than late summer reseeds.

Late summer reseeds should normally be carried out between mid July and late August; however if rapidly establishing grasses like Italian ryegrass are being sown then the sowing date deadline is mid September.

Sward destruction

If the old sward contains scutch or bent grasses and/or perennial weeds such as dock and thistle, these should be destroyed before cultivation work commences. Regrowth of these weeds can be difficult or impossible to control in the newly established sward.

Preparation of the seedbed

Poor seedbed preparation is the commonest cause of failure of grass reseeds.

Grass and clover seeds are very small so they do not have the capacity of cereal seed for germination and establishment. The aim should be to prepare a fine and firm seedbed without causing too much loss of moisture in the top few centimetres of soil. Aim to consolidate the seedbed without compacting it. Roll the seedbed prior to broadcasting or drilling the seed (cross-drilling is preferred). For a spring reseed, if possible, plough in the late autumn allowing frost to break down the soil to finer particles over winter thus reducing the need for cultivation.

Sowing

Aim to place the seed at 6 -12 mm depth. If the seedbed is being drilled, then cross-drill if the drills are more than 12 cm apart. If the seed is buried too deep then it will be slow to germinate and establish. This will lead to a patchy reseed and weed problems. If broadcasting the seed mixture, shallow harrow to cover the seed and roll the seedbed slowly with a heavy roller or a Cambridge roller. If the grass seedlings have established better in the tractor wheel marks then the ground has not been consolidated sufficiently.

Pest damage

The main pest problems are slugs, frit fly larvae, leatherjackets and wireworms. They are often a common cause of poor establishment especially in late summer and autumn reseeds.

Sward renovation or overseeding

This represents an alternative to the conventional method of reseeding after ploughing and is gaining popularity. With careful preparation, excellent results can be achieved.

It is particularly suited to:

- Stony soils, which are difficult or impossible to plough.
- Heavy land that takes considerable time drying to plough depth.
- Fields where rapid establishment is required.
- Swards that do not have old, matted grass cover.
- Worn-out silage swards.

Specialist drills can sow grass and clover seeds into the soil without the need for ploughing and may be used as a method of upgrading existing swards (e.g. Moore Unidrill, Einboch, Aitchison,Vertikator or Guttler). Costs are lower and work rates are higher when compared to conventional methods. These methods have some potential in bare open swards and in situations where the preparation of a conventional seedbed is difficult or not possible (for example, when soil conditions are not suitable due to the presence of excessive stones or rock or for timeliness reasons).

High work rates can be achieved by using specialist drills

Guidelines:

- Preferably sow before the end of July provided there is enough moisture.
- Control perennial weeds before overseeding by spraying with a selective herbicide, as they may be difficult to control without damaging newly stablished grass/clover.
- Minimise competition from the existing grass sward. Graze hard (3-5 cm) or cut for silage immediately prior to overseeding.
- Sow when soil conditions are neither excessively dry nor wet. In dry weather follow with a heavy roll.
- If aiming to establish clover-rich swards apply slug pellets by broadcasting around the time of clover seedling emergence (do not include with seed). The risk of slug damage can increase with overseeding when compared to traditional methods. Before routine application of slug pellets it is advisable to check if there is a risk of slug damage to the reseed. This is done by creating a slug trap at five or six random locations across the field before undertaking any cultivations. Place a small quantity of cereal-based animal feed on the ground at each trapping location, cover it with a piece of plastic 0.5 m x 0.5 m and weigh it down at each corner. Check the trap early the following morning while conditions are still suitable for slug movement. If the average number of slugs at each trap is five or more it is considered economic to apply a slug treatment.
- The risk of damage from leatherjackets is likely to be lower when sowing takes place during July.
- Graze lightly once the grass seedlings are 10 cm high and continue at frequent intervals until winter. Aim to graze to a sward height of 5 cm. Avoid long intervals between successive grazings and do not close off for silage as this may allow constituents of the original sward to become dominant and reduce establishment of sown seeds. It is vital that poaching is not allowed to happen while grazing. If the aim is to establish clover-rich swards, graze with sheep or light cattle to a height of 3-5 cm during November/December.
- Chemical weed control, post-sowing, is less likely to be required than with conventional reseeding.

Damaged sward after overseeding

Same sward just 16 days later

Renovating by minimal cultivation

Minimal cultivation represents an alternative to overseeding in that the technique does not involve ploughing. It is however more aggressive towards the existing sward than overseeding as the surface is partially cultivated. This method is suited to 3-4 year old Italian and hybrid silage swards which have thinned excessively due to continuous cutting, or damaged swards in need of improvement.

Guidelines for success are similar to those for stitching-in or overseeding.

- Graze hard or cut for silage.
- Prepare a shallow tilth by discing and/or harrowing prior to broadcasting or drilling of the seed and rolling.
- The risk of damage from leatherjackets is likely to be lower when sowing takes place during July.

Open silage swards damaged by machinery are prime candidates for renovation by minimal cultivation techniques.

Table 2

	Reseeding with ploughing		Reseeding with minimal cultivation		Sward renovation by stitching-in (Overseeding)	
	£/Ha	£/acre	£/Ha	£/acre	£/Ha	£/acre
Soil analysis	3	1	3	1	3	1
Burning off (including spray and spraying)	40	16	40	16		
Plough	75	30				
Power harrow	75	30	38	15		
Roll	20	8	20	8		
Seed	113	45	113	45	75	30
Sow	30	12	63	25	63	25
Roll	20	8	20	8	20	8
Fertiliser: 100kg 18:14:14 + sowing	95	38	95	38	95	38
Lime: 2t + application	125	50	125	50	125	50
Slug pellets			23	9	23	9
Total £	**596**	**238**	**540**	**215**	**404**	**161**
Reliability	High		Moderate - high		Moderate	
Rate of improvement	Rapid (2-4 months)		Very rapid (2-3 months)		Moderate (3-6 months)	
Loss of grass production	High		Moderate		Low	

Sward rejuvenation

Sward rejuvenation is the identification and correction of poor management practices that result in the deterioration of the content of productive grass species in a sward. Possible causes and remedies of sward deterioration are outlined below

Table 3

Cause of sward deterioration	Explanation	How to rejuvenate
Poor drainage	Productive grasses thrive best on well-drained soils.	Correct any drainage problem e.g soil that has become compacted by machinery, before carrying out any re-seeding or fertiliser programme.
Excess fertility	Can result in shallow rooting and grass pull.	Lower nutrient application.
Poor soil fertility	Ryegrass requires good growing conditions such as adequate P&K, pH > 6.	Test soils regularly every 3-4 years to monitor soil indices and soil pH. Apply nutrients and or lime as required.
Weed infestation	There is a vast burden of weed seeds in most soils. Severe infestations will significantly reduce herbage yield and quality.	Weeds should be identified and appropriate herbicide selected and applied accordingly.
Insect/ pest damage	A well established, vigorously growing sward, can often recover from pest attack e.g. leather jackets or frit fly. However, a weak seedling sward will only recover if sown early enough in the season to allow significant growth recovery, even if pests have been effectively controlled.	Identify the pest and extent of the damage to sward and take appropriate action.
Overgrazing	Especially in early spring, tends to weaken the productive grasses and allows grass and broadleaf weeds to enter the sward.	Identify grazing stocking rates and calculate grazing areas throughout the grazing season. Aim to meet pre and post grazing grass cover targets.
Understocking	Poor utilisation of grass during the main growing season reduces tillering of sown grasses and allows weeds to establish in the sward. Bent grasses and Yorkshire Fog are the most likely. If understocking is unavoidable then regular topping will help to check the development of these weeds.	Identify grazing stocking rates and calculate grazing areas throughout the grazing season. Aim to meet pre and post grazing grass cover targets.
Excessive intervals between silage cuts	Excessive intervals between silage cuts will lead to the thinning out of a sward. An open, cut sward will allow less preferred grasses and perennial broad leaved weeds to enter the sward.	Cut silage earlier and/or implement an integrated grazing/silage system.
Poor integration of grazing and cutting	Repeated intensive cutting or grazing will lead to thinning-out of a sward. An open, cut sward will allow less preferred grasses and perennial broad leaved weeds to enter the sward.	Consider rotating the cutting and grazing areas over the farm. In grazing fields the presence of patches containing either no grass or less preferred grasses can considerably reduce the sward productivity.
Excessive use of slurry	Excessive use of slurry smothers young grass tillers and encourages certain weeds such as docks.	Reduce the slurry application rate and/or the number of applications. Slurry should be applied when good grass growth response can be achieved.
Poaching in wet periods	Creates bare patches of soil which become quickly infested with broad leaved weeds and grasses. This generally happens in early spring and autumn. Productive grasses recover slowly compared to meadow grasses and weeds. Poaching may also result in long-term soil damage which may hinder recovery of sown species.	Reduce grazing time and/or grazing stocking density. Implement an extended grazing system. Remove stock from grazing area until conditions improve.

Grassland weed control

With swards getting badly damaged over the past two years weeds have encroached and are reducing yield potential. While the initial treatment is costly, trials have shown that long term there is a beneficial economic return to be gained.

Replicated dock trials carried out at the Institute of Grassland and Environmental Research has shown that an average increase in grass yield of 2t DM/ha is achievable by controlling docks. This means extra grass to the value of £140/ha (£56/acre) in the first year of treatment.

Looking at the problem from a different angle by keeping weeds out of the sward the useful life of a reseed can be extended, vastly reducing reseeding costs.

Weeds cause economic loss in several ways:

- They compete with the grass for nutrients and light.
- The area taken up by the weeds is not available for grazing.
- Silage or hay made from weed-infested pasture has a lower palatability and energy content.

These factors result in lower animal performance from grassland.

Weed control

Table 4 outlines some of the main problem weeds and how they can be controlled.

Table 4

Weed	Growth habit	Control measures
Docks	Seeds germinate rapidly after soil disturbance. Plants persist and develop through deep tap roots resulting in dense populations. Mature plants can produce up to 60,000 seeds/year which can survive several years in the soil.	Cutting alone will not control docks since new shoots regenerate from the taproot. Spraying with a herbicide can be effective if docks are at a seedling growth stage. Spraying established docks rarely results in a total kill even from expensive herbicides. Usually a followup spray is required. Optimum time to spray docks is in late spring during rapid growth period before flowering.
Thistles	Plants germinate from seed. Perennial creeping thistle can be spread by underground roots which can survive in a dormant state for some years before pushing up shoots into poor growing open swards.	Cutting thistles does not kill the plant but can weaken it. Spraying with a suitable herbicide is effective in controlling thistles especially when they are in the vegetative growth stage. Stock must be kept out of sprayed fields since senescing material may be eaten causing digestive upsets.
Chickweed	Chickweed is an annual plant and infestations arise from seed previously shed and present in the soil. It has a rapid rate of growth and becomes very competitive shading out sown species.	Since it is an annual plant it can be grazed out with cattle or sheep at a high stocking rate. Herbicides may need to be used to control high infestations of the weed in silage swards especially in first cuts.
Ragwort	Ragwort is a biennial plant which develops prostrate leaves in its first year and then flowers and grows to maturity in its second. Plants can germinate from seeds which are wind borne.	Control by cutting is not satisfactory as it can keep the plant vegetative and encourage it to become perennial. While sheep will graze ragwort the toxin will also affect them and hence they should not be used to graze out infections. Spraying can be highly effective in controlling infestations especially in late spring when plants are still at the rosette stage. Stock should not be put into a sprayed field until at least 4 - 6 weeks after spraying to allow the poisonous decaying material to die.
Rushes	Soft rush is perennial and establishes from seed in poached or open swards. Common weed in acidic, wet ground low in fertility.	Repeated cutting may give some control. Applying lime and improving nutrient status of the soil will reduce competitiveness of this weed. Spraying can be effective especially if cutting can be carried out 4 weeks after spraying or alternatively if the rushes are very mature and brown cutting first and spraying when the regrowth reaches 30 cm will improve control.

Weed control in reseeds

A dense vigorously growing sward is the basis of good weed control and should always be the aim when reseeding as this denies weed seedlings the space and provides the competition needed to suppress weeds. To achieve this it is important to ensure that the following management points are achieved:

- Adequate drainage conditions.
- Minimise competition from the old sward or established weeds.
- Adequate lime and nutrient status.
- Appropriate choice of seed mixture composition and seed rate.
- Timely sowing and good conditions when sowing.

Weed control before reseeding

The ideal time to deal with perennial weed problems, such as couch (scutch), creeping thistle, or docks is before reseeding. These weeds are best controlled before ploughing by spraying with glyphosate. Some glyphosate formulations can be applied to the old sward before the final cutting or grazing (check labels for further details).

Weed control after reseeding

Many weeds can be effectively controlled by 'topping' or grazing measures, especially when dealt with at the correct stage in their life cycle.

- **'Topping'.** In direct-sown swards, or swards undersown with an arable silage crop, 'topping' or forage harvesting can control most annual broad-leaved weeds, except chickweed which spreads and smothers below cutting height.
- **Grazing.** Grazing, preferably with sheep, whenever the grass is 10 cm tall can provide a useful degree of control of annual weeds, for example chickweed, hempnettle and redshank. However, care must be taken to avoid overgrazing and poaching, especially when soil conditions are wet. Periods of frost can allow grazing with minimal damage.
- **Spraying**. Chemical control of annual weeds is best achieved as soon as possible, when the grass and/or clover has reached the herbicide tolerance stage (usually 2-3 leaves, check carefully individual product labels). Weeds become more difficult to control as they increase in size. The application timing will then depend on the size of the weeds and the growing conditions. For most products the best results will be achieved if the weeds are actively growing.

The herbicides listed in the table on the next page can be used after crop and weed emergence. Other products are also available for use pre-emergence when first establishing new swards.

Table 5

Herbicides for control of weeds post emergence in newly sown all-grass swards

Active ingredients	Proprietary name	Weeds controlled	Application timing
2,4-DB + MCPA	Clovermax	Limited range of broadleaved weeds. Does not control chickweed, cleavers or mayweeds.	Consult product label.
2,4-D	Various	Buttercup, dandelion, dock, ragwort and others. Does not control chickweed.	Varies – Treat weeds at their most susceptible stage.
Fluroxypyr	Various	Charlock, chickweed, cleavers, seedling docks and speedwells.	Autumn or spring.
Florasulam and Fluroxypyr	ENVY	Broadleaved weeds in newly-sown leys. Chickweed.	Ideal timing for application is when the weeds are small and actively growing.
Clopyralid, florasulam and fluroxypyr	Leystar	Broadleaved weeds including chickweed, fat-hen, mayweeds, seedling docks and thistles.	Established and newly-sown grass leys.

Dock at the correct stage for treatment.

Table 6

Herbicides for the control of perennial weeds in established grass swards

Active ingredients	Proprietary name	Weeds controlled	Application timing
Aminopyralid + Triclopyr	Forefront T	Broad leaved and curled docks, nettles, thistles, buttercup, and ragwort.	**Grazing swards only** Apply at rosette stage when weeds are actively growing 7 days before grazing.
Fluroxypyr + triclopyr + clopyralid	Pas Tor agronomy pack	Broad leaved and curled docks, nettles, thistles.	Apply at rosette stage when weeds are actively growing 7 days before grazing and ideally 4 weeks before cutting.
Fluroxypyr + triclopyr	Doxstar Pro	Broad leaved and curled docks.	When weeds are actively growing, at least 21 days before harvest.
Thifensulfuron-methyl	Pinnacle	Broad leaved docks **(clover safe)**.	When weeds are actively growing, at least 7 days before harvest.
Amidosulfuron	Squire Ultra	Broad leaved and curled docks **(white clover safe)**.	Between 1st February and 30th June on rotational grass or up to 15th October on permanent grass provided weeds are actively growing. No grazing for 7 days after treatment. Leave 21 days before cutting.
Triclopyr + clopyralid	Grazon Pro	Nettles, docks, and thistles.	Knapsack treatment.
MCPA	Various	Rushes, creeping thistles.	Varies – treat weeds at their most susceptible stage.
2,4-DB + MPCA	Clovermax	Range of broadleaved weeds.	In established swards determined by growth stage of weeds. Apply to young grass leys when grasses have begun to tiller.
Clopyralid, florasulam and fluroxypyr	Leystar	Broadleaved weeds including chickweed, fat-hen, mayweeds, seedling docks and thistles.	Established and newly-sown grass leys.

Plant protection products listed in this booklet are registered and approved for use at the time of writing. The plant protection product register (www.hse.gov.uk/pesticides) is regularly updated. For the latest information on product availability and application advice consult a BASIS registered agronomist. Always read the label and product information before use and adhere to label recommendations.

Table 7

Herbicides for the control of weeds in newly sown grass/clover swards

Active ingredients	Proprietary name	Weeds controlled	Application timing
Tribenuron methyl	Triad	Chickweed, seedling docks.	From three leaf stage of grass. May check clover. Can tank mix to broaden weed control.
Amidosulfuron	Squire Ultra	Broad leaved and curled docks non resistant chickweed.	Where grass/clover has been newly established Squire Ultra can be applied from the three leaf stage of the grass and 1-2 trifoliate leaves of the clover. Between 1st February and 30th June on rotational grass or up to 15th October on permanent grass provided weeds are actively growing. No grazing for 7 days after treatment. Leave 21 days before cutting.
2,4-DB	Various - Headland Spruce, Clovermaster, DB Straight.	Buttercup, fat hen, seedling docks, thistles from seed. Common tank-mix partner with Triad to give broader weed control.	At seedling stage when weeds are growing rapidly. May check clover.

In addition some products containing MCPB or 2, 4-DB + MCPA can be used. Their latest time of application is usually dependent on weed size, except MCPB which must not be applied to red clover once the flower stalk has begun to form.

Apply pesticides carefully to prevent water pollution

Pesticides used by livestock farmers are found in water by environment agencies and water companies. These may pose a risk to local aquatic life and increase the cost of treating drinking water by your local water company. Stringent standards are set for water quality across Europe and sophisticated monitoring techniques can detect pesticide levels below **one part in a billion – equivalent to one stem of hay in 111,000 bales!** The European drinking water standard is so low that the pesticide on one foil seal would need to be diluted with the water from 30 km of stream to meet the standard.

Care should be taken to fill sprayers away from drains and observe buffer zones for water courses. Further details of good spraying practice to protect water quality are available on the Voluntary Initiative website **www.voluntaryinitiative.org.uk**

Acknowledgements

Trevor Alcorn, *College of Agriculture, Food and Rural Enterprise*
Dr Bruce Ball, *Scotland's Rural College*
Robin Bolton, *College of Agriculture, Food and Rural Enterprise*
John Courtney, *Countryside Management Unit, DAERA*
Jim Freeburn, *College of Agriculture, Food and Rural Enterprise*
Gary Haslem, *College of Agriculture, Food and Rural Enterprise*
Alex Higgins, *Agri-Food and Biosciences Institute*
Albert Johnston, *College of Agriculture, Food and Rural Enterprise*
John Sands, *College of Agriculture, Food and Rural Enterprise*
Norman Weatherup, *College of Agriculture, Food and Rural Enterprise*

Contacts

CAFRE Development Advisers are based in the following DAERA Direct Offices and can be contacted on Tel: 0300 200 7843

Atek Building
Edenaveys Industrial Estate
Newry Road
Edenaveys
ARMAGH, BT60 1NF

Rathkeltair House
Market Street
Demesne of Down Acre
DOWNPATRICK, BT30 6LZ

Sperrin House
Sedan Avenue
Lisnamallard
OMAGH, BT79 7AQ

Units 36-38
Meadowlane Shopping Centre
Moneymore Road
Townparks of Magherafelt
MAGHERAFELT, BT45 6PR

Academy House
121A Broughshane Street
BALLYMENA BT43 6HY

Crown Buildings
Thomas Street
Drumcoo
DUNGANNON, BT70 1HR

Glenree House
Unit 2, Springhill Road
Carnbane Industrial Estate
Carnbane
NEWRY, BT35 6EF

Castleton House
15 Trench Road
Grange of Mallusk
Mallusk
NEWTOWNABBEY, BT36 4TY

Government Offices
18 Urney Road
STRABANE BT82 9BX

Sketrick House
16 Jubilee Road
Corporation South
NEWTOWNARDS, BT23 4YH

Crown Buildings
Artillery Road
Millburn
COLERAINE, BT52 2AJ

Inishkeen House
Killyhevlin Industrial Estate
Killyhevlin
ENNISKILLEN, BT74 4E5

Other useful contact:
Alex Higgins
Agri-Food and Biosciences Institute, Newforge
Tel: 028 9025 5356

For further information, contact
Knowledge Transfer Team
kt.admin@daera-ni.gov.uk

CAFRE, Greenmount Campus
45 Tirgracy Road, Muckamore
Antrim, BT41 4PS

ISBN: 978-1-84807-906-9

Previous Page