Beef Farm Infrastructure Handbook

Animal & Grassland Research and Innovation Programme

Teagasc
Agriculture and Food Development Authority

Beef Farm Infrastructure Handbook

www.teagasc.ie

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1. Introduction

The guiding principal of good farm infrastructure is that it's safe, and allows for best management practices that are sustainable from an animal welfare, labour efficient, economic and environmental perspective. This handbook is designed to be used as a guide for beef farmers who wish to upgrade their existing farm infrastructure or invest in the establishment of a new farm enterprise.

The handbook covers important areas such as grazing infrastructure, water supply systems, land drainage design and installation and the importance of incorporating biodiversity in the farming system. Grazing infrastructure in relation to roadways, paddock layout and water systems is important in terms of overall herd performance as it can allow more days at grass and therefore greater profitability. The section on land drainage design and installation highlights the importance of carrying out a site and soil test pit investigation prior to installing a drainage system.

In this publication sometimes there are references to commercial suppliers and to products of particular manufacturers. By such reference, it is not intended to indicate that these are the only products, suppliers and materials available; such references are for demonstration purposes only. It is strongly recommended that farmers consult with their advisors before using the information provided.

2. Grazing infrastructure

Good grazing infrastructure will allow more days at grass, provide easier management of grass at times of peak growth and make grazing less weather dependent. In a 40 cow spring calving suckler herd, one extra day at grass in spring is worth €72/day in feed savings and animal performance (€2/LU/day). A lot of thought needs to be invested in deciding how to subdivide the farm into a paddock system and what the optimum layout of roadways should be to make animal movement most efficient. The four key issues to consider are:

1. Adequate access to all grazing areas.
2. Distance that stock are required to walk.
3. Design and layout of roadways. (See roadway design).
4. Farm security and animal disease biosecurity.

Measures to Protect Waters under the 4th Nitrates Action Plan[1]

All farmers must take measures to prevent the runoff of sediment and nutrients from farm roadways.

Whole farm stocking rate or grassland stocking rate ≥170 kg N/ha, in both cases excluding any N exports

Watercourses defined as continuous blue lines on ordnance survey 1:5,000 maps must be fenced, with the fence at least 1.5m from the edge of the bank[2]. Surface waters, that do not dry up during the summer such as ponds and lakes also have to be fenced.

Water troughs must be at least 20m from these waters.

Open the camera on your mobile phone and scan the QR Code for more information on grazing infrastructure

2.1 Paddock Layout

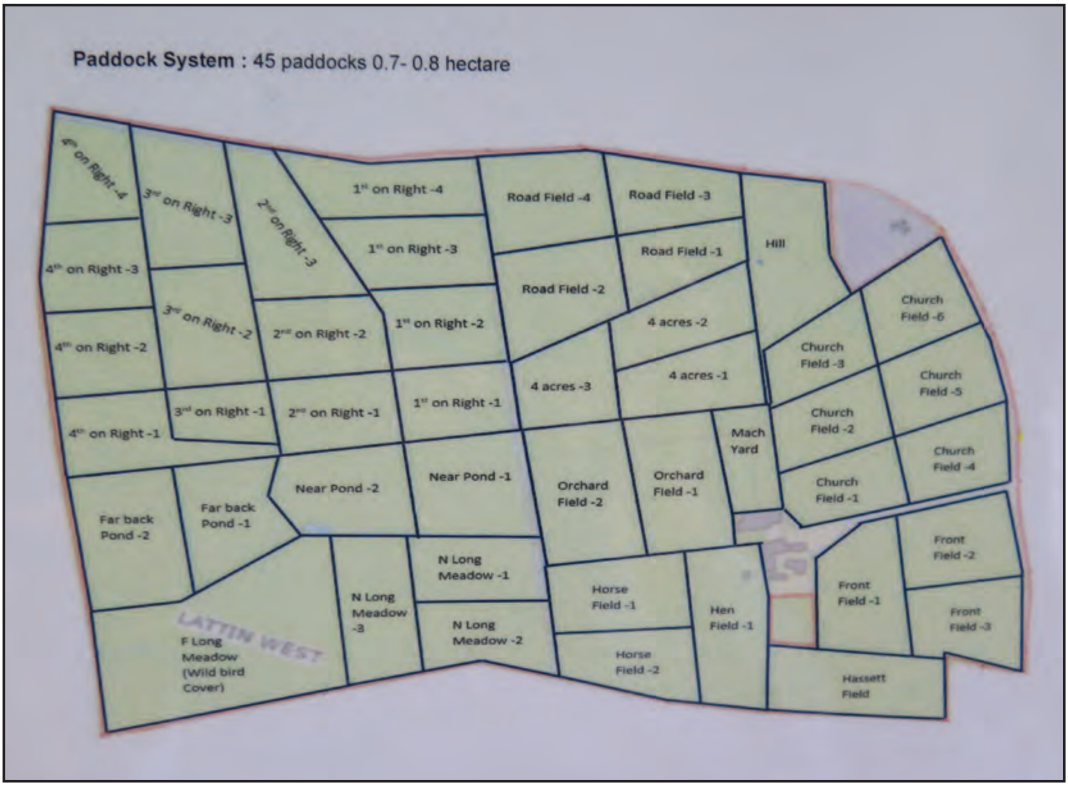
The target should be to design a paddock for 3 days grazing followed by a 21 day recovery period. Proper subdivision of grazing land into paddocks is essential to be able to successfully manage pastures and achieve desirable rotation intervals. Paddocks should ideally be connected with an efficient roadway system so that the herd can move from one paddock to any other paddock on the farm. The roadway should be designed to allow animals to be returned to housing during inclement weather in the Spring & Autumn as easily as possible and by one person. An accurate map of the farm is essential.

The ideal paddock system should include:

- The roadways from the farmyard to the paddocks should be wide, smooth and as short a distance as is practical.
- Paddocks to be rectangle to square in shape and wetter paddocks should have longest sides running adjacent to the roadways to avoid poaching in wet weather.
- Alter paddock shape to facilitate stock movement into and out of the paddock i.e. stock move down-hill to exit paddocks.
- Locate roadways on the sunny windy side of a ditch, hedge or tree line.
- Avoid putting roadways directly through springs or swampy ground.
- Main paddock access to be angled to the roadway with at least two access points for each paddock.
- Plan for multiple access points from the roadway for paddocks on wet ground. Have several access points between adjacent paddocks.
- Electrified fences divided into sections with easy to access cut-off switches.
- Number the paddocks with a tag on the gate and on a map of the farm.
- Can be split (at least in 2) with temporary electric fence to cater for variation in mob sizes. Water troughs should be central to facilitate this.

Creating paddocks

1. Get a map of the farm with areas for each existing field or paddock.
2. Use farm maps to consider several different ways of laying out the farm and consider the positives and negatives of each one.
3. Decide on the number of paddocks required; have at least six or seven and preferably nine paddocks/grazing divisions for each separate grazing group of cattle.
4. Minimising the number of grazing groups reduces the number of paddocks needed.



5. Identify the most appropriate water trough(s) position in each paddock. Where possible, share a trough between paddocks but, more importantly, position the troughs to allow further, possibly temporary, subdivision of paddocks.
6. Keep paddocks square if possible. Where rectangular, the depth of the paddock should be no more than twice the width.
7. Once a map is developed, paddock numbers and sizes can be uploaded onto Pasturebase Ireland to aid grass measuring.

Paddock size

Long narrow paddocks result in too much walking over ground to graze the end of the paddocks creating an excessive risk of poaching in difficult grazing conditions and a build up of poorer quality grass at the back of paddocks. In excessively large paddocks, where grazing takes too long, grass re-growths are affected. This will lead to poorer grass quality and reduced animal performance. Furthermore, using a strip wire to divide the paddock requires extra labour during the main grazing season. If paddocks are too small there will be insufficient grass for one grazing and a requirement for additional water troughs. Grass intake and animal performance will be adversely affected. The maximum depth of a paddock should be 250m from the access roadway reducing to 200m in wet areas more prone to poaching. The key targets for beef farms are outlined for various times throughout the year in table 1 to maximise weight gain from grass.

Table 1: Key targets for Beef Farms

	Pre-Grazing height (cm)	**Pre-grazing Yield (kg DM/ha)**	**Target days ahead**
February/March	8-9cm	1000-1250	First Rotation 45 days
April	8-10cm	1000-1500	18-21 days
May	9-10cm	1250-1500	12-14 days
June/July	9-10cm	1250-1500	12-14 days
August	9-10cm	1250-1500	25-30 days
September	10-12cm	1500-2000	35-40 days
October-December	<12cm	<2000	Closing paddocks from 10th October

* Guidelines are based on livestock grazing to a residual of 4cm and each cm above the residual is equal to 250kg DM/ha for beef farms

Why to use a Paddock System

- Farm will grow more grass
- Easier to manage and budget the feed supply (grazing days ahead of stock)
- Easier to herd stock

During the main growing season the growing cycle for high quality perennial ryegrass swards should be 18-21 days. This grass should be grazed out in 1-3 days. A paddock system enables a lot more high quality grass to grow in comparison to set stocked paddocks, without the addition of any other inputs.

Understanding High Quality Grass

Most farmers know that having a paddock system delivers a lot of benefits for them and their farm, and in turn have invested money in creating a paddock system. However, it is evident from working with farmers on the ground that knowledge on managing paddocks to exploit these advantages is variable, this has a significant impact on animal performance. The liveweight difference between high quality grass and poor quality grass is about 0.25 kg per day. Over 200 days this is an additional 50kg liveweight per animal, at current prices this results in earning €100 per animal extra over the grazing season. So every day counts with high quality grass!

Figure 1. demonstrates the growth pattern of the perennial ryegrass plant. After the plant has been grazed it will immediately grow a new leaf (regrowth) from the point at which it has been grazed which is ideally 4cm (the residual). **The plant should be grazed at 2.5-3 leaves (1,200-1,400 Kg DM/ha or 9-10cm)**, as it has highest amount of leaf at this point. The higher the leaf content, the higher

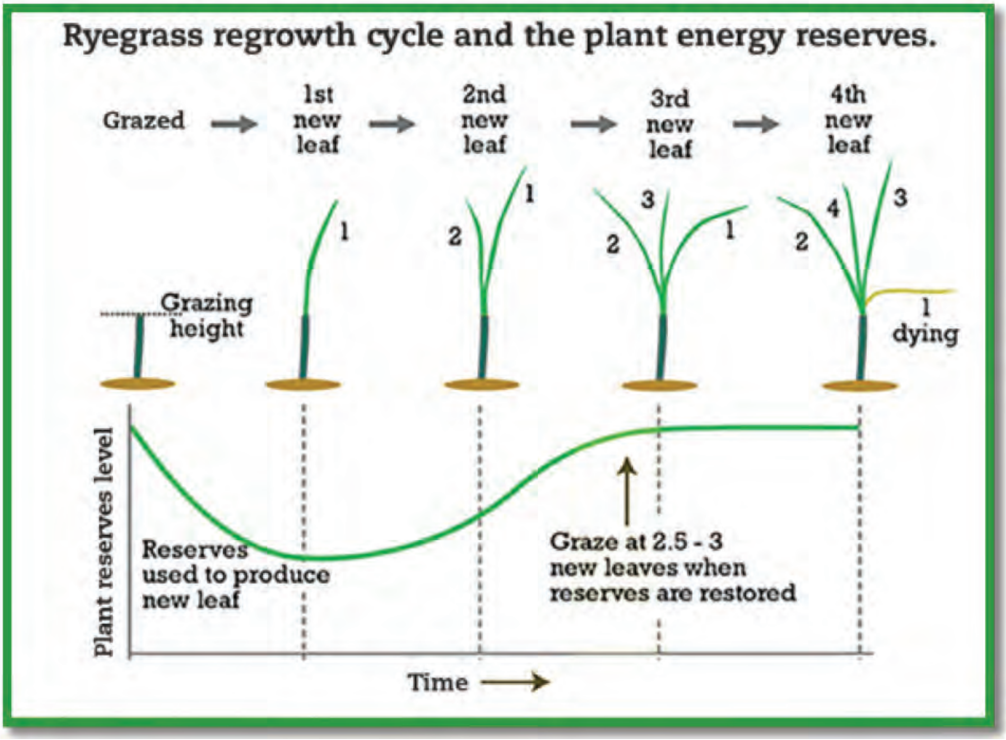


Figure 1. The Growth Pattern of Perennial Ryegrass

the energy content, **which in turn means higher animal performance**. It takes roughly 18-21 days for the plant to reach this stage, growing about one leaf per week (during the main growing season). However, the 2nd leaf is larger than the 1st and the 3rd leaf is larger than the 2nd. This is why farmers often say “grass grows grass”, and why a paddock system will grow more grass than set stocking.

Letting the perennial ryegrass plant reach the 4th leaf, means the 1st leaf begins to die as it can only support three live leaves. Stem also begins to develop at this point. Stem is a lot less digestible than leaf, so it is lower in energy and therefore animal performance suffers. Grazing down to 4cm is then more difficult as animals usually choose to eat leaf over stem. Recovery is then slower and the grass quality at the next grazing is lower. More stem leads to less tillering, a more open sward and this can increase the weed burden in the sward.

Underneath the ground the roots require time to recover their energy reserves after the plant has been grazed. This is because the plant requires energy from the roots to produce a new regrowth. Once the 1st leaf is growing, the plant can convert light energy from the sun through photosynthesis using it to grow more leaf and restore energy reserves in the roots. The root reserves are fully recovered once the plant reached the 2.5 – 3 leaf stage.

In times of low grass growth it is important to hold grass covers by slowing stock down once they begin grazing covers 1,000 kg DM/ha (8cm) or less, or else face a further downward spiral in grass growth and run out completely. Continuously grazing light covers means the plant is not allowed the opportunity to grow to its potential, hence the annual yield will be lower.

What size paddock?

Normally a 3 day grazing duration per paddock should be the target. However, in spring and autumn, the allocation may be for ½-1 day to allow paddocks to be fully grazed out when numbers of cattle grazing may be low since not all cattle are at grass. These are also the two periods of the year when grazing conditions are likely to be most challenging and walking over previously grazed areas has to be avoided to minimise soil damage and subsequent regrowths.

For the greater part of the grazing season, 7-8 grazing paddocks/blocks should be the target. Where cattle/cows spend longer in a paddock, emerging regrowth will be eaten, less grass will be available at the next rotation, and overall grass production will be lower.

The recommended paddock size for 40 suckler cows and 40 calves is 1.5 Ha (3.7 acres) as outlined in table 2.

Table 2: 40 sucker cows with calves at foot

Stock numbers	Liveweight	Days	Total Kg Liveweight
40 cows	650kg	3	78,000
40 calves	200kg	3	24,000
		Total	102,000
			@2% body weight
		Intake in 3 Days	2,040 kg
		Target grazing cover	1,400
			1.5Ha (3.7 acres)

Table 3: 50 yearlings paddock size

Stock numbers	Liveweight	Days	Total Kg Liveweight
50 yearlings	470kg	3	70,500
		Total	70,500 Intake in 3 Days
			@2% body weight
		Intake per day	1400
		Target grazing cover	1,400
			1Ha (2.5 acres)

Table 4. Grazings per paddock

Grazing per paddock	Advantages	Disadvantages	Best Practice
1 day per paddock	Good grass utilisation Protects regrowth and grows more grass Makes grazing more manageable in wet weather Easy to identify surplus/deficit of grass	Most labour intensive Risk of allocating too little area and cattle/cows are underfed Suckler cows and heifers can suffer, especially at breeding time More water troughs required	Only recommended where the operator has excellent grass budgeting skills to allocate correct area for grazing
3 days per paddock	Protects Regrowth Cows/heifers less restricted Cattle more settled due to less movements Easier machinery access due to larger paddock sizes	More difficult to manage in wet periods when grazing conditions are poor More difficult to graze out well when low numbers grazing in early spring or late autumn	Recommended as the option that optimises labour efficiency, grass utilisation and grass production
5+ days per paddock	Less movement of cattle required Fewer paddocks required	Extremely difficult to manage surplus grass Much more difficult to graze out and to maintain grass quality	Least recommended option

Peak grass growing months April/May/June will normally determine paddock numbers. The essential requirement for an effective paddock system is to have enough paddocks during the peak period of grass growth which is highlighted in Table 4. More and not less should be the target. A number of farm mapping tools are now available via the mobile phone (and other devices) to map farms, measure out paddocks etc.. They use GPS to get exact paddock sizes and will lay out paddock, water and road systems to meet individual requirements.

Fixed or Flexible Paddocks

An alternative to a fixed paddock system is to adopt a flexible paddock system whereby large fields that are grazed using temporary wire divisions for all grazings. The area available for grazing and the size of the paddock at any grazing can easily be adjusted throughout the year. Larger paddock size can be given where grass covers are low, smaller paddock size can be given when grass covers are higher. Surplus grass is easily harvested. Key to success is having a least three temporary grazing divisions set up for each grazing group at any given time.

(i) the paddock cattle turned into today,
(ii) the paddock for grazing in two days' time,
(iii) the paddock for grazing in four days' time.

The flexible paddock system entails the use of a farm roadway and permanent post at specific distance along the side of the roadway. Temporary electric fences are used to allocate grass with a backfence used to prevent stock going back to graze the previous area. Multiple access points exist from the roadway to the grazing area. If permanent posts are sited every 25 meters along the roadway it becomes very easy to measure distances.

If we examine the advantages and disadvantages of both paddock systems, farmers should be able to decide which system best suits their own farm and management ability, as seen in Table 5.

Table 5. Advantages and Disadvantages of fixed and flexible paddock systems

Fixed Paddocks	Flexible Paddocks
Advantages	
Set daily area	Less expensive to construct
See quantity of grass ahead	Very flexible
No regular movement of fences	Interchange of grazing & silage fields
Disadvantages	
Expensive to construct	Regular movement of temporary fence
Less flexible	Difficult to manage calves
Doesn't allow for changing herd size	More water troughs required to allow flexibility

2.2 Roadways

Without ease of access to paddocks and between paddocks, grass utilisation and stock management are much more difficult to operate to a high level of efficiency. The road layout must allow for good flow movement of cattle between all paddocks and between the paddocks and the yard. A well-designed, carefully built and properly maintained farm roadway system has many benefits, including, faster and easier stock movement and more efficient paddock access.

Assessing roadway condition

Take a quick look at the condition of your farm roadways for defects that may be causing problems. These defects can include, potholes, a roadway that is level or almost level, wheel track depressions, a raised hump of soil under the fence at either side and cattle tracks made between the fence and the roadway or on the roadway.

Problems are caused by; pebbles and loose stones on the surface,

Water trapped on the roadway lodges at low points. Cattle are following tracks due to a less than perfect surface.

a bumpy surface with secure stones, lodged/trapped water on the surface, very dirty section near the farmyard, and a roadway level with or lower than the field. The reasons for these defects are many but may be due to flawed construction methods, unsuitable materials and lack of maintenance. The appearance of the roadway now bears little resemblance to what it looked like when it was initially constructed.

Roadway width

The width of roadways depends on the number of animals in the herd. Typical widths of 3 m are suggested for 50-cow suckler herds or similar number of beef cattle. For ease of machinery access , 4 m wide roadways are advised.

The fence should be positioned about 0.5m (20 inches) from the edge of the roadway. This will allow cattle to utilise the full width of the roadway while at the same time prevent them from walking along the grass margin. A track in the grass margin usually means that the fence is too far out and there may be an issue with the roadway.

Roadway Location

The length of the roadway required will depend on the size and general layout of the farm. On farms with heavy soils a more intensive roadway system makes grazing management easier. The intensity or land area devoted to farm roadways ranges from 1-2% of the grazing area.

The surface needs to be smooth, fine and strong enough to support animals but with a little give in it also. Ideally, the hoofprints from the cattle should be visible across the roadway, but not so much to damage the surface when the weather is wet.

Roadway Construction

New farm roadways must be laid in good weather when soil conditions are dry. This is primarily to ensure that the roadway material does not mix or get pressed into soft soil. Ideally remove a thin layer of topsoil before placing the roadway material. Topsoil contains pores, organic matter, is generally weak and is likely to deflect and shear under load. Be careful not to remove too much topsoil as the depth of the roadway will have to be increased to bring the roadway surface above field level. If too much soil is removed the finished roadway may end up being too low. The finished level of the roadway must be above the level of the field, otherwise drainage will be onto the roadway instead of off it.

A wide variety of locally sourced materials may be used as the main road material. If this material is available on the farm, so much the better. However, the cost of using it should be weighed up against the cost of purchased material.

This foundation layer is made up of granular fill material. The usual depth is about 200-300 mm (8-12 inches). **The biggest stones should be no bigger than about one third of the thickness of this layer.** The intended slope (crossfall) should be formed in the foundation layer. This means that the surface layer will have the same slope and an even thickness.

Generally, 75 or 100 mm (3 or 4 inch) down material is used. This is a graded mixture of different sized stones from 75 or 100mm down to dust. Crushed rubble can also be used.

Compact with a vibrating road roller before the surface layer is spread. Compaction interlocks the material to give a stronger roadway and helps prevent loose stones from mixing with the surface layer.

All farm roadways need to be assessed in the light of new regulations that oblige all farmers to take appropriate measures to prevent the runoff of sediment and nutrients from roadways to water bodies. For more information contact your local adviser/consultant or the ASSAP adviser covering your area.

Agricultural Sustainability Support and Advice Programme – ASSAP

ASSAP advisors work with farmers in a free and confidential advisory service to help improve water quality.

https://www.teagasc.ie/environment/water-quality/farming-for-water-quality-assap/people/

See Department of Agriculture, Food & the Marine (DAFM) S199 Minimum Specifications for Farm Roadways:

https://www.gov.ie/en/collection/28f4c-specifications/#structures-specifications

Geotextile

Consider using a geotextile membrane between the road materials and the soil. A geotextile is a synthetic porous fabric used to separate the foundation layer from the ground underneath. It prevents the stones from becoming mixed with the soil and vica versa. The geotextile keeps the roadway foundation material clean, free-draining and therefore dry and strong. Farm roadways can suffer considerable deformation in use and the role of the geotextile in this situation is to provide physical support, as well as separation.

A geotextile is also highly recommended where soil is heavy or wet. It won't solve drainage problems; therefore any necessary drainage works should be tackled beforehand. A geotextile also highly recommended on roadways used for heavy machinery. A geotextile suitable for farm roadways costs about 75 cent per square metre.

Crossfalls

Getting water off the roadway quickly will extend the life of the surface and reduce the cost of maintenance. Potholes will also be less likely to develop. To remove water quickly from roadways they should slope to one or both sides. A roadway that slopes to one side is easier to construct and machinery runs better on it. However, cattle apparently spread out better on a roadway that slopes to both sides. A crossfall of 1 in 25 is about right. A 4 m (13ft) wide roadway with the fall to one side will be 160mm (6.3 inches) higher on one side, or if the fall is to both sides, the centre will be 80mm (3.2 inches) higher than the sides. Water must not be trapped at the edge of the roadway or in wheel tracks; it must be shed completely and allowed to soak away in the soil.

DAFM Specification S199 outlines construction details and measures farmers can undertake to prevent runoff from roadways.

Table 6. Key Specifications

Cross fall/ slope	1:25 or 2.3° (whether from the centre to both sides or just one side)
Construction	Geotextile (optional) 200 – 300 mm hard core plus 25-50 mm fine material
Road slope	Max of 1:3 or 18°
Fencing	0.5m from edge of road
Approx. cost	€7.50 per square metre.

Surface layer

The roadway should be completed with about 25-50 mm (1-2 inches) of a fine material on the surface. If the surface is poor most of the benefits of having a farm roadway are gone. The surface layer needs to be laid evenly and compacted. Spread it out to the slope formed in the foundation layer. Many different types of fine material can be used for the surface layer.

Costs

A 4.0m wide roadway, with 0.3m depth of material and will need one 25 tonne load to cover a length of approximately 10 metres. This assumes a density of

about 2 tonnes per m^3 for the material used. A similar sized load would cover 45-50 metres with a 63mm (2½ inch) thick surface layer. The price of road making material, both crushed stone and dust for the surface, is typically €7-10 per tonne plus VAT. As the construction material amounts to over 80% of the overall cost, strict control over the depth and width of the roadway, in line with needs and good construction practice, is essential. Farm roadways typically cost approximately €7.50 per square metre. Calculate costs in advance and monitor progress. This will avoid surprises and cost overruns. VAT is refundable on new farm roadways but not on repairs.

Tracks/Spur roads

Tracks can be installed as extra roadways, as spur roadways off normal wider roadways or at the end of the main farm roadway. They are generally only suitable for short runs. They are useful for getting access to paddocks in the spring to turn stock out early. Tracks/Spur roads are also valuable in the autumn to extend the grazing season. A depth of about 150mm of material is laid on the surface of the ground. This should be compacted and topped off with a fine surface layer and the surface layer should be compacted also. The width should range between 1.8m and 2.5m, costing €8-€11 per metre run.

Some key points

- Do not site water troughs on farm roadways or near paddock gateways.
- Remove trees that shade the roadway causing dirty wet surfaces.
- Allow stock to move along roadways at their own pace to minimise lameness. This also keeps them calm.
- Slow down with farm machinery.
- If stock slow down on a farm roadway they do so for a reason.
- Repair potholes in good time and with fine material.

The key targets to be achieved each month vary depending on grass growth throughout the year. This will dictate the pre-grazing yield of the paddocks and the target days ahead as outlined in table below.

2.3 Fencing

Fencing is an essential element of grassland management. Good fencing is critical for controlled grazing where the farm target is to increase grass yield and maximise the utilisation of grass.

The level of control you require is the most important consideration when erecting a fence. A permanent fence will require different design than a temporary one. Boundary fences may be designed differently than internal divisions.

Materials

The quality of materials will have a major influence on the longevity of the fence. The choice of posts, wire, insulators, gate openings etc. can vary. When erecting a fence use quality materials. These may not always be the cheapest but will be more reliable and require less maintenance in future years.

Strain Posts: These form the backbone of any fence. For most fencers the strainer post should be 20 - 25cm diameter (8-10 inches) and 2.1 - 2.5m (7-8ft) long. This will allow approximately 1.2m (4ft) of the post to be driven into the ground. These posts may be softwoods or hard woods provided they are treated. The distance between straining posts may be up to 200m depending on type and topography of the land.

Intermediate Posts: The ideal post for most fencers would be round posts 10-12cm (4 inches) diameter, 1.7m (5ft 6ins) long. Square posts 7.5 cm X 7.5 cm (3 inches X 3 inches) are also suitable.

Wire: 2.5 (12 gauge) high tensile wire is most suitable for electric fencing. Proper galvanised wire will have a life of 20 -25 years, poor quality wire decays after 7 - 8 years.

Choice of Fence

Single strand electrified fence. This is cheap, easy to erect and very effective against cows and adult cattle. It is most suitable for internal divisions such as paddocks. The height of wire for cows is 90cm (35 inches). Intermediate post spacing should be 14 metres.

Double strand electrified fence: This is suitable for cows, cattle and calves. The height of top strand would be 90 cm with the second strand 37.5 cm (15 inches) lower.

Four/Five strand electrified fence: Cattle, sheep and lambs will be controlled. This fence requires annual maintenance. Grass and weeds underneath the fence must be continually cut or sprayed. The five-strand fence is particularly effective against dogs and foxes. This type fence may be useful where stray dogs are present. The spacing for the five strand from the ground up is 12.5 (5 inches), 15 cm (6 inches), 17.5 cm (7 inches), 20 cm (8 inches) and 22.5 cm (9 inches). Intermediate posts are spaced at 10 metres apart.

Temporary fencing of paddocks is widely practised for strip grazing. Geared reels with wire and white electrified tape are most suitable. There are flexible, light and easily moved.

Key Criteria

Strain Posts

- 20 - 25cm diameter (8-10 inches) and 2.1 - 2.5m (7-8ft) long.
- Approximately 1.2m (4ft) of the post to be driven into the ground.
- May be softwoods or hard woods provided they are treated.
- Distance between posts up to 200m depending on type and topography of the land.

Intermediate Posts

- Round posts 10-12cm (4 inches) diameter, 1.7m (5ft 6ins) long.
- Square posts 7.5 cm X 7.5 cm (3 inches X 3 inches) are also suitable.

Wire

- 12 gauge high tensile wire is most suitable for electric fencing.
- Proper galvanized wire will have a life of 20 -25 years, poor quality wire decays after 7 - 8 years. Wire should comply with one of the Irish or British standards.

Single strand electrified fence

- Cheap, easy to erect and very effective against cows and adult cattle.
- Suitable for internal divisions such as paddocks, post spacing about 14 metres.
- Height of wire for cows is 90cm (35 inches).

Double strand electrified fence

- Suitable for cows and calves.
- Top strand would be 90 cm high, second strand 37.5 cm (15 inches) lower.

Four/Five strand electrified fence

- This fence requires annual maintenance, not used widely.

Sheep mesh with a single electrified strand

- Suited to farm boundaries, around farmyards, internal roadways and calf paddock for young calves.
- 80cm (32 inches) sheep mesh is commonly used, topped with a single strand of electrified wire.
- Barbed wire could also be used. Intermediate posts are spread at 7 - 8 metres apart.

2.4 Electric Fencers

Power fencing is a means of controlling stock by giving them a sharp but safe shock. It consists of a fencer which transmits electrical current through conductors of wire supported by insulators and posts.

Types of fencers

Battery Operated: Normally used for temporary fencing such as strip grazing and back fencing. Operated by a 6volt battery.

Mains Operated: Permanent power fencing main operated fences are normally used. Normally supplied by ESB supply.

Solar power operated: Obtain energy from the sun and charge a small battery, system mainly suited to out farm where there is no electric power.

There are many benifits of each as outlined in Table 7.

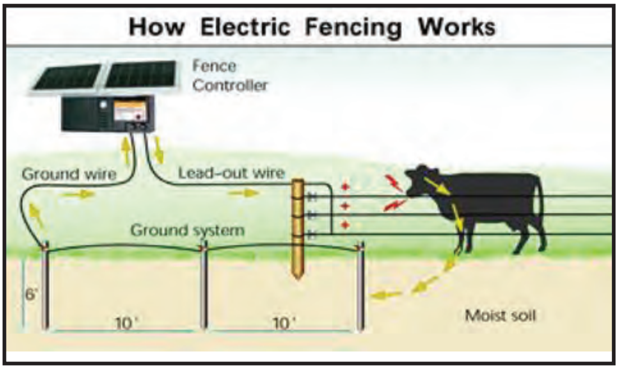
Table 7. Types of fencers

	Mains	**Battery**	**Solar**
Installation	**Easy-medium**	**Simple**	**Medium**
Use	Perimeter of farm Temporary fencing	Strip Grazing Strip Grazing	Temporary fencing Temporary fencing on out farm
Key Benefits	Longevity if maintained correctly Suitable for larger areas Greater strength	Easy to install Relatively inexpensive Greatest flexibility and portability	Easy to install Suitable when no power source on farm No re-charging of battery
Caution	Dependant on electricity supply	Risk of theft Battery recharged regularly	Risk of theft Maintenance over winter

How mains works?

Fencer (Energiser) steps up volts to 8,000 to 11,000 volts approximately through a transformer. Each pulse lasts 0.003 of a second. The high voltage electricity is fed to the fence line wire. An earth lead is securely earthed into the ground by means of metal bar. When livestock touch the fence wire, the circuit is then completed giving a shock.

Checking the Installation



Source: Gallagher Fencing

Ensure the connections between fencer and fence are firm and with a good connection. If the wires are passing through a wall you need to make sure that they are properly insulated. If this is not done there is the possibility of power being diverted from the fence into the ground. All installations must be open circuit with the outgoing wire fully insulated to avoid shorts to earth. All joints and connections should be made simply, firmly and above all be very tight, using the correct joiners for the purposes and good quality insulators.

Regular inspection of the line is essential of permanent fences. Weeds and branches touching the line should be removed. Avoid vegetation growth or other items touching the wire fence as this reduces efficiency and performance, particularly during damp and wet conditions or periods of lush growth.

Earthing System

Without an earthing system for the fencer there would be no shock at the fence line. An earthing system works in much the same way as an aerial does for a radio but instead of collecting airwaves, the earthing system picks up electrons from the ground, which are transmitted with each pulse out along the fence line.

The stronger the fencer the better the earth required. Electrical current passes through soil but does so more easily in moist or mineral soils than would be the case in dry stony soil.

Therefore before deciding how many earth bars are required, take three factors into consideration:

1. The type of soil.
2. High power or low power fencer.
3. The load one can expect on the fence system and the length of fence.

Earthing/Grounding rod

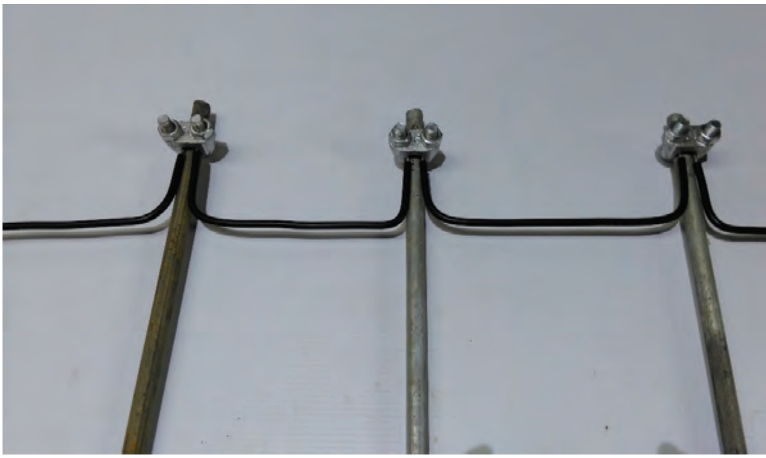
Use the proper type of grounding rod. In most cases, pipe or rebar can be used. The grounding rod needs to be made of galvanized steel and also needs to be at least four feet in length for best results. Using copper rods will diminish the overall effectiveness of the electrical fence system.

In some cases, it may be necessary to add several grounding rods to the grounding system. In fact, the majority of electrical fence systems will actually require at least three grounding rods. These rods should be about 10 feet/3 m apart and should be placed at the start of the fence.

Grounding rods can actually interfere with phone service as well as electrical lines that may be located on the farm. For this reason, it's important to place grounding rods as far away as possible from utilities. This is especially true in relation to phone lines.

Installing the Earthing System

For the exact number of earth bars to be used refer to the manufacturers guide. Having decided on the amount of bars required for the size of your fence, dig a trench 150mm deep from where the first bar is going to be, to where the last one is. Then using 1 m galvanized rod earth bars drive all bars, spaced 3m apart, down until they are flush with ground level. Connect heavy duty High Tensile Underground Cable from one earth bar to the other until all earth bars are connected in a daisy chain manner not breaking the connection from the first earth bar to the last. Ensure they are securely bonded.



Double insulated cable is UPVC coated 1.6mm/2.6mm mild steel wire. It is highly recommended for permanent electric fence installations to ensure all the energy from your electric fence fencer gets to your electric fence line. This versatile cable is used to also connect your fencer to your earthing system and to carry high voltage power under your gateways.

Checking Earthing System

When the earthing system is installed, it is vital to test it. First you need to simulate heavy vegetation loading on the fence line. Place an iron bar in the ground about 100m out along the fence and lean it against the fence wires. Plug in the fencer and check the voltage reading along the fence line. If it reads 1000 volts or less, a sufficiently heavy load has been put on the fencer. If the voltage is still above this, place more iron bars along the line until the voltage drops to 1000 volts or less. Leaving this load on the line, take a voltage reading on the earthing system. A small reading on the earthing wire is ok as long as it does not exceed 300 volts. If it does exceed 300 volts, the earthing system is not sufficient and you have to install more earth bars.

Visibility and Maintenance of the Earthing System

Visibility of an electric fence is very important too. The animal will remember the shock it received and will respect the fence as a barrier. It is important to monitor the voltage of the fence on a weekly basis to ensure there is sufficient current throughout the fence line.

Lightning Diverter System

It is recommended that all permanent fencers be fitted with a lightning diverter to help protect from lightning damage. It diverts lightning from the fence to the earth to protect the fencer.

Mains Fence- Installation & Operating

1. Please read all installation and operating instructions carefully.
2. Install indoors and out of reach of children.
3. Do not install near combustible material, i.e. hay or straw. As there is a remote possibility that a lightning strike through the earth system could generate a fire risk condition.
4. Any electrode connected shall be separated from the earthing system of any other circuit, and shall not be situated within a distance of 100m of any electrode used for protective earthing.
5. Each fencer must have a separate earthing system.
6. Never fit more than one fencer onto any fence.
7. Every electric fence line and associated controller shall be installed so that it is not liable to come in contact with any power or communication apparatus or wiring, including an overhead power line, telephone, or radio aerial.
8. Any electric fence or portion thereof installed along a public road or as a boundary-line fence shall be identified by signs, clamped to the fence wiring or fastened to posts at suitable intervals.
9. Never place earthing system for electric fence within 10 meters of a household.
10. Never tamper with internal mechanism of a fencer as they have the potential to be extremely dangerous.

2.5 Farm Safety - Health and Safety

Please refer to **'Build in Safety, An Advisory Booklet for Farmers'** re the need to appoint Project Supervisors before undertaking drainage work, farm road construction etc. Available at ***https://www.teagasc.ie/publications/2018/build-in-safety.php***

Connecting to the Fencer

The cables connecting the fencer to the fence and the fencer to its earth should be special electric-fence run out cable. This is highly insulated with a galvanised steel conductor. Ordinary domestic electric cable is not suitable as it does not have sufficient insulation for the high voltages involved.

The Fence Line

The following guidelines apply to both mains and battery operated electric fences. Try to avoid erecting electric fences closer than 6 metres (20 feet) to overhead power lines. When an electric fence wire has to be taken underneath an overhead line:

DO position it 1-2 meters from the pole and take it at right angles to the overhead line; avoid running it parallel to and under the line. Always mount it on its own supports – never support it on an ESB pole.

DON'T 'twitch' the fence wire when crossing beneath overhead lines, particularly when working it across undulating or sloping ground.

NEVER use barbed wire as a fence line – it is very dangerous – because it could trap a person or an animal.

Where an electric fence is erected near a public road, footpath or right-of-way it should be fitted with a suitable warning notice. For further information: ESB Networks Farm well Farm safely booklet www.esb.ie

What size fencer?

Fencers are mainly advertised in terms of Output Joules and Stored Joules. Don't get these confused, and be aware of which is on the charger. A charger may advertise 30 Joules, but only refer to the stored joules (A fence charger will always store more joules than it outputs). Stored Joules represent the amount of power stored inside your charger. This is ran through an output transformer, which converts the power to a higher voltage. Some of the power is lost during this conversion. Output Joules refer to the actual output of the charger – the power available to shock the animal.

The size of fencer depends on the area to be fenced. Always choose a fencer to match the area (Table 8). It is better to choose a fencer greater than your requirement rather than less than recommended and expect it to cover more area than advertised.

Table 8. Output Joules required depending on distance, area to be fenced and earthing rods required by a mains fencer.

Mains Fencers			
Output Joule	**Distance (Km)**	**Area (Acres)**	**Earthing rods**
0.12	1.5	4	1
1	1.6	10	1
1.10	10	30	2
2.5	11	50	1-2
3.3	15	50	3
4.9	22	75	4
6.1	32	110	4
7	32	100	3
15	72	200	5
33	145	300	6

Note: This is a guide. Always read and follow manufacturer's guidelines

Battery Fencers

Battery fencers are used for short or temporary fences where portability are flexibility are the main considerations. A Dry Battery is used in many cases. While a Wet 12V Battery allows rechargeable batteries to be used and facilitates a more powerful battery powered fencer (Table 9).

Table 9. Output Joules required depending on distance, area to be fenced and earthing bars required by a battery fencer.

Battery fencers				
Output Joule	**Distance (Km)**	**Area (Acres)**	**Earthing rods**	**Recommended use**
0.2	1.5	4	1	Strip Grazing
0.35	4	12	1	Small/Medium area
0.43	5	14	1	Medium/Strip Grazing
1	8	25	2	Small/Medium
2	11	40	1-2	Medium/Large

Note: This is a guide. Always read and follow manufacturer's guidelines

Understanding Alkaline vs Saline Batteries

There are 2 types of 9 volt dry cell batteries used to provide energy to a battery energiser, these are Alkaline and Saline. Both are air-oxygen batteries therefore they need oxygen to create the chemical reaction which produces the energy. Both are free from of mercury and cadmium and therefore environmentally friendly and should be disposed of at your local WEEE collection centre. However the varying chemical composition of Alkaline and Saline batteries means their performance varies greatly with the Alkaline battery proving to be more efficient.

Advantages of Alkaline Batteries

- The rate of discharge of Alkaline and Saline batteries are very different see Figure 2 below. The tension of an Alkaline battery remains at approx. 8 Volts for the majority of its life whereas the tension of a Saline battery decreases at a pretty even pace over its life from 8.4 Volts to 5.5 Volts. With a decreasing battery tension, the energiser will use more electrical current to maintain the output energy and this will result in accelerated battery discharge.

- The Alkaline batteries function better at lower temperatures due to the fact the electrolyte of Alkaline batteries contains less water than Saline batteries.

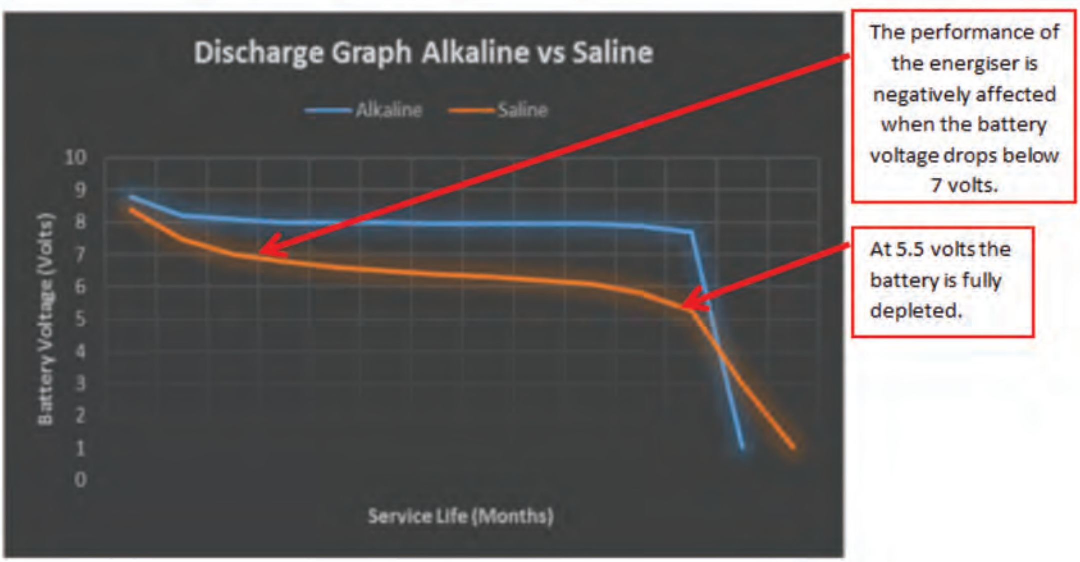


Figure 2: Discharge Graph – Alkaline vs Saline

- The cathode and anode in an Alkaline battery are much more efficient than that of a Saline battery therefore there is less material used for the same capacity so in turn Alkaline batteries are lighter and smaller than Saline batteries. This results in reduced transport costs and reduced WEEE charges.
- The electrical current increases throughout the life of a Saline battery whereas it remains constant with an Alkaline battery, therefore a Saline battery depletes approx. 20% faster than an Alkaline.

Solar powered fencer

Solar electric fences rely on sunlight to power the charger, rather than an A/C outlet or a standard battery. Most solar-powered electric fences are used on out farms or in remote areas where there is no easy access to electricity. The solar chargers require batteries, but the batteries last a long time because they are constantly recharged by the sun.

Advantages	Disadvantages
Ideal for remote areas	Price
Low maintenance	Not as powerful
Less Labour charging batteries	Dependent on weather
No energy costs	Risk of theft

Maintenance

The solar panel should be cleaned from time to time - a dirty or dusty panel will not operate at peak efficiency. Simply use a soft cloth and water.

The battery requires some maintenance, too, if you want it to last for several years. When the battery is not in use, make sure it is fully charged before it is stored. And during any period when the battery is stored, place it in the sun for three days every three months to recharge.

Installation of Solar fencer

1. Ensure there is adequate access for inspecting frequently.
2. Consider some secure way to install solar fencer to avoid theft.

3. Locate the fencer, panel and battery to an appropriate earth site area away from livestock interference.
4. Try to position the fencer at a central location to minimise the resistance of current flow over the length of the fence.
5. Assemble the panel to be positioned to obtain maximum daily sunlight exposure. Ensure that shadows will not fall on the panel at any time during the year.
6. The panel should always face toward the equator (facing south).

We would like to acknowledge the help of Cheetah Electronics , Forcefield , Gallagher fencing systems for their help compiling this chapter.

3 Rows of polywire with pigtail post with 2 attachments - €1.20/m

3 Reels of polywire with white temporary posts- €1-1.50/m

One Reel 3 rows looped polywire with white temporary posts - €1-1.50/m suitable for short distances

Electrified sheep fencing - €1.90/m

Gallagher Smart fence- four strands of wire with integrated plastic post - €2.90/m

Temporary fencing options

Pig tail posts and one reel of polywire- €0.40/m

2.6 Water system

A good water supply is extremely important for production, health and welfare of livestock. The water supply system must be good enough to supply adequate water needs in the paddocks. On most farms the water system consists of a series of expansions or additions carried out over the years as requirements changed. Only when the system fails to cope, such as during a dry summer, do people realise how marginal their system has become.

Common problems on most farms centre on inadequacies in areas such as, water source, pumping plant, pipe sizes, ballcocks and troughs.

Table 10. Key requirements for water system

Water intake	10 - 15 litres per 100kgs body weight per day
Trough size	Allow 5-7 litres per livestock unit
Ballcock	Medium pressure-gives flow rate of 32 Litres/ min versus 8 Litres/min with high pressure
Main pipe layout	Ring/Loop system preferable

Water Source

A bored well is the most common source on farms. If the well is unable to meet peak demand, the installation of a reservoir of, for example, 9,000 litres (2000 gallons) which can be a pre-cast concrete tank will rectify the situation. The tank can be buried in the ground or placed overground.

A booster pump is then used to pump the water from the reservoir into the water supply system, at whatever flow rate and pressure are necessary. Modern frequency controlled centrifugal pumps will automatically maintain pressure and flow in response to demand. The pump speed will increase when an extra tap or ballcock comes into use and vice versa.

Pumping Plant

Submersible or surface pumps may be used in water supply systems. In general, only submersible pumps should be used to pump from deep wells (boreholes). The running costs of a surface pump, being used to pump from a deep well, can be up to five times higher than for a submersible pump, because some water has to be pumped down into the well to bring water to the surface. Maintenance costs are higher also. Surface pumps can be used for shallow wells where the water can be sucked directly by the pump. Consider replacing an existing deep well surface pump with a submersible pump.

In deciding on pump size, take into account the depth of the well, the output of the well and the working pressure required to overcome any rise in ground level from the well to the top of the system. Where a new pump replaces a previous unit, the size of the electric cable used to supply the pump must be taken into consideration. Poor standards of installation lead to bad performance and unreliability. Lack of starter switches or wrongly adjusted starters fail to give motors adequate protection. Experienced pump suppliers will be able to help you in planning the system to suit your requirements.

Small Pipe Sizes

This is probably the most common problem with water supply on farms. Even on farms where piping was laid in recent years under-sizing of pipes still occurs. This is illustrated in table 8. Table 8 shows the pressure loss in psi for different pipe bores over a range of flow rates for 100 metres length of water pipe. For example, at a flow rate of 3m^3 per hour (50 lit/min or 11gal/min) with a 32mm (1¼ inch) pipe the pressure is reduced by 4.83psi for every 100 metres of pipe. The reason the flow rate reduces is because of friction between the water and the inside surface of the pipe.

Table 11 doesn't take into account the extra pressure required if you are pumping uphill or the pressure gained pumping downhill. Pressure lost due to restrictions at ballcocks and fittings is also extra.

Table 11 doesn't show values for 12.5mm (½ inch) pipes because at any of the flow rates shown the pressure loss would be very high. Where 12.5mm pipes are used on farms the flow rate is reduced to a trickle due to pressure loss.

Table 11. Pressure loss in psi for different pipe sizes at various flow rates for 100 metres length of water pipe

Pipe bore (mm)	Flow rate m^3 per hour (litres per minute)				
	1 (17)	2 (33)	3 (50)	4 (67)	5 (83)
20	14.20				
25	3.27	11.50			
32	0.64	2.27	4.83	7.60	11.65
38	0.34	1.21	2.49	4.05	6.25
50	0.11	0.38	0.88	1.34	2.06

With regard to pipe size it's the change in cross-sectional area in relation to its bore (diameter) that's important. It's hard to imagine that a 20mm (3/4 inch) pipe has approximately twice the cross-sectional area of 12.5mm (1/2 inch) pipe. Similarly, a 25mm (1 inch) pipe has four times the cross-sectional area of 12.5mm (1/2 inch) pipe, although it's only twice the bore.

The pressure loss is also affected by the pipe length. The pressure loss and the resultant reduced flow rate are directly proportional to the length of the pipe, i.e. if you double the length of the pipe you double the pressure loss. You can use table 11 to judge how much pumping pressure is lost with various pipe sizes and flow rates, while taking the pipe length into account.

The net effect of pressure loss is reduced flow rates. Increasing system pressure to maintain flow rate is not a good solution. It would be extremely energy inefficient and give rise to damaging levels of pressure. The answer is to use the right pipe size.

Ring system

If you are installing a new main line, incorporate the existing line as well if it's in good condition and not too difficult to do. This is worthwhile where pressure is low or the main line is long and the end of the new line and the existing line are not too far apart. Connecting up the ends of two main lines (of the same size) to form a ring main will almost double the flow rate.

Laying pipes

If you are using a mole plough to lay the pipe, do it in stages, using a digger to make holes at intervals where connections are going to be made. Try to get the pipe down to a depth of 450mm or more. Tractors with double-acting rams on the arms can add enough weight to the mole plough to get the depth. Do a "dummy run" first before feeding in the pipe and allow the pipe time to recover from the stretching before making connections.

Ballcock Problems

Very often the ballcocks are the weak link in an otherwise satisfactory water supply system. Ballcocks are frequently over restrictive, even on systems where the pipe sizes are adequate. A high pressure 12.5mm ballcock in the drinking trough is not capable of allowing an adequate flow rate, which is in most situations about 16 to 22 litres per minute (3.5 to 5 gal/min).

In general, standard ballcocks are described by their size and pressure. Ballcocks can have high, medium or low pressure jets. The high, medium and low pressure refers to the pressure the ballcock can withstand without leaking when the trough is full.

Photo 1. The high-pressure jet has the smallest hole and the low-pressure jet the biggest.

The high pressure jet in a standard ½ ballcock is only 1/8 of an inch in diameter whereas the medium jet is ¼ of an inch in diameter. Other ballcocks are available that have openings of ½ inch or greater.

In most systems medium pressure ballcocks will provide an adequate flow rate (see table 12). In practice, most standard ballcocks are sold with high pressure jets in them, which is one reason why so many farms have flow rate problems.

High or medium pressure jets will fit into all 12.5mm ballcocks (see photo 2). The low pressure jet will not fit up against the gasket in standard 12.5mm ballcocks. If you want the option of using a low-pressure jet get the 12.5mm ballcock that can take any size of jet. It has a bigger plunger and a bigger gasket (photo 3).

Photo 2. Two standard ½ inch ballcocks, one showing a shorter float arm. High and medium pressure jets can be used with this type of ballcock.

Photo 3. This is a bulkier version of the ½ inch ballcock, in which fits the low pressure jet as well. Note the bigger seating gasket for the jet inside.

Using a longer float arm or a larger float can solve the problem of leaking ballcocks by increasing the force on the gasket with the extra leverage. Longer float arms are available or they can be lengthened by braising on a piece.

Ballcock jets should be checked from time to time to see that they are free flowing because they can become encrusted with lime scale or partially blocked with dirt.

Table 12. Flow rate l/min (gal/min) with a standard 12.5mm (½ inch) ballcock and a system pressure of 3.6 bar (52psi) for different jet sizes

	12.5mm (½") Ballcock		
Jet type	Low pressure	Medium pressure	High Pressure
Jet size mm (inch)	10mm (3/8")	6mm (1/4")	3mm (1/8")
Flow Rate l/min (gal/min)	42 (9.25)	32 (7)	8 (1.75)

Table 12 shows the effect of using different jet sizes on flow rate. We put the three different jets in turn into the same standard 12.5mm ballcock at a trough in a paddock. The system pressure at the trough with no water flowing was 3.6 bar (52psi). The most striking finding is the massive increase in flow rate between the high and medium pressure jets, going from 8 to 32 litres per minute. Table 13 shows the combine effect of pressure and ballcock jet size on flowrate. Note that quadrupling the static pressure will double the flow rate while quadrupling the jet size will increase flow rate by a factor of 16.

Table 13. Flow rate (gal/min) through ballcock at varying static pressure and ballcock jet size

Static Pressure (P.S.I.)	**Ballcock Jet Size**			
	1/8"	**¼"**	**3/8"**	**½"**
0.5	0.20	0.82	1.84	3.28
1.0	0.29	1.16	2.61	4.65
2.0	0.41	1.65	3.69	6.57
4.0	0.58	2.33	5.22	9.29
7.0	0.77	3.08	6.90	12.30
10.0	0.92	3.69	8.27	14.70
15.0	1.13	4.52	10.10	18.00
20.0	1.31	5.22	11.70	20.80
25.0	1.46	5.82	13.00	23.20
30.0	1.60	6.40	14.30	25.50
35.0	1.73	6.90	15.50	27.50
40.0	1.85	7.38	16.50	29.50

Note: The pressure is at the ballcock and NOT at the pump.

Water Troughs

Cattle will drink 10 - 15 litres of water per 100kgs body weight per day. Adult cattle can drink at the rate of 14 litres a minute from a trough. Peak water intake generally coincides with peak grazing periods. Water flow rates must be capable of supplying these peaks of demand.

Water Troughs Locations

Check water troughs regularly to ensure that ballcocks are working properly and that there are no leaks; a leak at a water trough is a real disaster.

Flow rate should be considered before trough size in ensuring adequate supply. However, large troughs provide more drinking space and can compensate a bit for poor flow rate at peak drinking time. The main advantage of big troughs is they give more space for drinking. Each cow drinking at a trough needs 450mm of space measured along the trough rim. For large herds it may be necessary to install a second trough in the paddock. Siting troughs underneath a paddock wire fence will more than halve drinking space. Young stock and timid cows may also get bullied if adequate drinking space is not available.

The area around the trough should be able to take a lot of traffic i.e. a similar surface to a farm roadway and ideally have good drainage.

This is a typical 0.5m3 (110 gallon) rectangular water trough.
It is located on a high point in the field with a good surface around the trough.
The length of the rim of the trough all around is 4.8m (16ft.).

Leaks

Troughs can overflow and pipes can leak. Leaks can make a mess and add considerably to water bills. Overflowing troughs and leaking pipes frequently go unnoticed. A leak in a metered supply downstream of the meter may lead to massive water bills. Leaks in a private supply are costly also because electric motors are very expensive to run, if running continuously. Use quality fittings and install isolation valves on pipelines to isolate different sections of the paddock water supply. Isolate all the sections during the housing period.

Portable water troughs

It may be necessary to use portable water troughs in some situations e.g. strip grazing. To provide a portable trough use frost-proof gate valves and good quality non-restrictive quick-couplers. Connection points should ideally be away from fixed troughs because they can be damaged and some valve types can be opened by stock, causing leaks.

Key points

- Daily drinking water requirements vary but typically amount to 10-15 litres per 100kgs body weight.
- Weight gain and animal health are affected by inadequate water supply.
- Many water systems are inadequate especially if poorly maintained.
- Allow 450mm (18 inches) drinking space per cow so that close to 10% of your herd to drink at the same time.
- The internal bore of main pipelines should be at least 20mm and 25 or 32mm for larger herds.
- Use 12.5mm medium pressure standard ballcocks or newer bigger types; avoid high pressure ballcocks.
- Correct siting of water troughs is important.

Solar Powered Water Pump

With fragmented land parcels on many beef farms, implementing a paddock system can be a challenge particularly getting access to water. A solar powered pump is a solution to this issue. Depending on your requirement there are both surface models for shallow water courses (up to 5m vertical suction depth) and submersible models for bored wells (up to 80m in depth). These systems are fully pressure regulated and can pump to multiple water troughs to enable a paddock system. The system will also power an electric fence. The solar pump systems have the option to be bolted down to a concrete slab/base and the option to padlock over the lid if desired. The system comes as a full unit that is ready for use. All that is required from the customer end is the outlet pipe and troughs to be in place. It is a plug and play, ready to use solution, with an average set-up time of 15-20 minutes.

How does it work?

The solar powered water pump is powered using PV solar panels, which means they require daylight alone to generate energy and can work all year round. Housed inside the unit there is a battery bank, the panel charges the battery and it is always the battery that is powering the pump. Because the battery is housed inside it also means it can power a 12V electric fence. The system is fully pressure regulated, it can pump to numerous drinking troughs, it can pump 1.5km in distance and the systems can pump to a vertical elevation of 60m (models ranging between 40-100psi).

Key Benefits:

- High pressure water on demand
- Fully automated
- Power electric fence
- Paddock grazing
- No running costs
- Improve stocking rates and grass management
- Qualifies for ACA (Accelerated Capital Allowance)
- Vat refundable as ‘Fixed Equipment’

We would like to acknowledge the help of Solar Pump Solutions for their help compiling this

3. Land drainage design and installation

- No drainage work should be carried out before the drainage characteristics of the soil are established by a site and soil test pit investigation.
- Two types of drainage system exist: a groundwater drainage system and a shallow drainage system. The design of the system depends entirely on the drainage characteristics of the soil.
- While drainage of poorly drained mineral soils has positive effects on greenhouse gas emissions by reducing losses of nitrous oxide, drainage is linked to significant carbon loss on carbon-rich soils, such as peats. As such, peat soils should not be drained.
- Distinguishing between the two types of drainage systems essentially comes down to whether or not a permeable layer is present (at a workable depth) that will allow the flow of water with relative ease. If such a layer is evident a piped drain system is likely to be effective, at this depth. If no such layer is found during soil test pit investigations, it will be necessary to improve the drainage capacity of the soil. This involves a disruption technique such as moling, gravel moling or subsoiling in tandem with collector drains.
- Drains are not effective unless they are placed in a permeable soil layer or complimentary measures (mole drainage, subsoiling) are used to improve soil drainage capacity. If water isn't moving through the soil in one or other of these two ways, the watertable will not be lowered.

- Land drainage works should be designed to negate against impacts on water quality. Amendments to design/construction can reduce losses of nutrients and sediment.
- Drain pipes should always be used for drains longer than 30 m. If these get blocked it is a drainage stone and not a drainage pipe issue.
- Drainage stone should not be filled to the top of the field trench. Otherwise it is an expensive way of collecting little water.
- Most of the stone being used for land drainage today is too big. Clean aggregate in the 10–40 mm (0.4 to 1.5 inch approx.) range should be used, with further benefits evident for smaller (10-20 mm) material.
- Subsoiling is not effective unless a shallow impermeable layer is being broken or field drains have been installed prior to the operation. Otherwise it will not have any long-term effect and may do more harm than good.
- Maintenance or re-instatement of outfalls and open drains are great ways to kick start a drainage project. Most land drainage systems are poorly maintained.
- If cleaning an open drain, it is vital that weeds/debris should be removed from the drain bed and one bank only. The other bank should be left undisturbed throughout that season. Sediment traps should be installed to prevent sediment losses and excessive erosion.

In wet years poorly drained soils may never dry out as persistent rainfall maintains high soil moisture contents. Grass yields are limited due to the adverse effect of excess water and a lack of air at rooting depth, which limits plant respiration and growth. In cases of prolonged waterlogging, plants will eventually die due to a lack of oxygen in the root zone. Furthermore waterlogged soils are impassable to agricultural traffic (both machinery and livestock) for long periods, due to high soil moisture content and reduced soil strength. This reduces the number of grazing days and hinders silage harvesting, thus introducing higher costs related to imported feedstuffs.

The purpose of land drainage is to remove excess water from the soil as quickly as possible. How best to achieve this will vary with soil type. There is a need therefore for a better understanding of the underlying causes of drainage problems and of the design and implementation of appropriate drainage systems to resolve these problems. We must move away from the short-sighted approach that a broadly similar drainage system can be installed in every wet field regardless of soil and site conditions. An assessment of soil type and its drainage status is a vital first step.

3.1 Environmental Considerations

The implementation of land drainage works is known to affect water movement from drained sites and as such the potential impacts on water quality need to be recognised. Shallow drainage systems, for example are more likely to promote high intensity flows which have little interaction with the soil body relative to groundwater systems which promote water movement through the soil. Furthermore, soils with high levels of organic matter are known to have poor nutrient retention capacity and as such are vulnerable to nutrient loss. Land drainage system design needs to account for such variability and implement works that identify and negate against impacts on water quality.

Artificial drainage of poorly drained mineral soils has positive effects on greenhouse gas (GHG) emissions by reducing losses of nitrous oxide (N2O), and indirectly through the benefits of extended grazing, while drainage is linked to significant carbon loss on carbon-rich soils such as peats. As such, peat soils should not be drained as the amount of carbon stored by these soils provides an important sink to counterbalance and negate against the effects of increasing levels of carbon dioxide (CO_2) in the atmosphere. Precision management will be required for each soil type and for each farm system to ensure improved water quality and carbon storage can be prioritized within profitable production systems.

3.2 Causes of Impeded Drainage

The difficulties of drainage problems in Ireland are largely due to our complex geological and glacial history. Soil layers of varying texture and composition have the effect of irregularly distributing groundwater flow, with fine textured soils acting as a barrier to movement, impeding drainage, and lenses of gravels and sands promoting water flow, transmitting groundwater over large areas with resulting seepages and springs on lower ground. In poorly drained soils the rate of water infiltration at the soil surface is regularly exceeded by the rainfall rate due to:

- Low permeability in the subsoil (or a layer of the subsoil).
- High watertable due to low lying position and poor/poorly-maintained outfall.
- Upward movement of water from seepage and springs.

3.3 Objectives of Land Drainage

To achieve effective drainage the works will have to solve one or more of these problems. The objective of any form of land drainage is to lower the watertable providing suitable conditions for grass growth and utilization. A controlled watertable promotes deeper rooting which improves productivity and improves load-bearing capacity of the soil.

When planning any drainage programme, the potential of the land to be drained needs to be first assessed to determine if the costs incurred will result in an economic return through additional yield and/or utilisation. Some thought is needed in deciding the most appropriate part of the farm to drain. From a management point of view it is better to drain that land which is nearer to the farmyard and work outwards, however it may be more beneficial to target areas with high potential for improvement. This ensures a better return on the investment.

3.4 Drainage Investigations

What exactly is the problem? How good is the existing drainage network (if any)? Is the whole profile made up of poor soils or is the problem caused by specific layers? Is there water movement at any depth?

Knowledge of previous drainage schemes in the area, and their effectiveness will often provide an insight. A number (approx. 1 per ha) of test pits (at least 2.5 m deep) should be excavated within the area to be drained to investigate. These are dug in areas that are representative of the area as a whole; consider digging in wet and dry areas for comparison sake. Soil test pits are very dangerous and prone to collapse. You should not enter soil test pits but instead observe from a safe distance. Inspect different soil layers as they come up in the excavator bucket. As the test pits are dug, the faces of the pits are observed, soil type should be established and the rate and depth of water seepage into the test pit (if any) recorded. Visible cracking, areas of looser soil and rooting depth should be noted as these can convey important information regarding the drainage status of the different layers. The depth and type of the drain to be installed will depend on the interpretation of the characteristics revealed by the test pits.

Two principle types of drainage system are distinguished:

- Groundwater drainage system: A network of piped drains exploiting permeable layers.
- Shallow drainage system: Where movement of water is impeded at all depths.

Groundwater Drainage System

Strong inflow of groundwater or seepage from the faces of test pit walls, indicate that layers of high permeability are present. Under these circumstances the use of a piped drainage system (at the depth of inflow) is advised to capture and remove this water, thereby controlling the watertable. Deep piped drains are usually installed at a depth of 1.5-2.5 m and at spacings of 15–50 m, depending on the slope of the land and the permeability and thickness of the drainage layer. Piped drains should always be installed across the slope to intercept as much groundwater as possible, with open drains and main piped drains running in the direction of maximum slope. Where groundwater seepage and springs are identified, deep drains, 2 to 4 m deep can be used to intercept flow. Pipe drains are most effective in the layer transmitting groundwater flow, characterised by high water breakthrough. This issue is very site specific.

Clean aggregate, in the 10 – 40 mm grading band, should to be used to surround the drain pipe. The gravel should be filled to a minimum depth of 300 mm from the bottom of the drain to cover the pipe. The stone should provide connectivity to a layer of high permeability and should not be filled to the ground surface. The purpose of a drain pipe is to facilitate a path of least resistance for water flow. In long drain lengths (greater than 30m) a drain pipe is vital to allow a high a flow-rate as possible from the drain, stone backfill alone is unlikely to have sufficient flow capacity to cater for the water volume collected.

Test pit excavation

Drainage trench excavation

Shallow Drainage Systems

Where a test pit shows no inflow of groundwater at any depth a shallow drainage system is required. These soils with very low permeability throughout are more difficult to drain. Shallow drainage systems aim to improve the capacity of the soil to transmit water by fracturing and cracking the soil. They rely on soil disruption techniques, namely; mole and gravel mole drainage and sub-soiling.

Mole drainage is suited to stone-free soils with a high clay content which form stable channels. Mole drains are formed with a mole plough comprised of a torpedo-like cylindrical foot attached to a narrow leg, followed by a slightly larger diameter cylindrical expander. The foot and trailing expander form the mole channel while the leg creates a narrow slot that extends from the soil surface to the mole channel depth

Mole plough showing cylindrical foot and expander

The mole plough creates both a zone of increased permeability adjacent to the mole leg (shallower depths) and a channel for water flow at moling depth. The effectiveness of mole drainage will depend on the extent soil cracking during installation. As such the ideal time for carrying out mole drainage is during dry summer conditions, to allow for maximum cracking in the upper soil layers and adequate traction to prevent wheel-spin on the surface.

Gravel Mole plough showing hopper

Gravel filled moles employ the same principles as ordinary mole drains but are required in soils which will not sustain an unlined channel. The gravel mole channel is filled with gravel from an attached hopper which supports the channel walls. Gravel moles require a very specific size range of gravel aggregate to ensure that they function properly. Washed aggregate within a 10-20 mm size range should be used. Sub-soiling is used effectively where an iron pan or cemented layer impedes drainage. The effect is to break the layer and crack the soil. A stable channel will not be formed.

Single leg winged sub-soiler

Collector drains, which are installed across the slope at 0.8 – 1.0 m deep, are required for all shallow drainage systems. Depending on the topography and slope, the collector drains will be at a spacing of 10–40 m. A larger spacing reduces costs but results in a much higher chance of failure. The disruption channels themselves are drawn at right angles to the collectors (up-slope) at spacings of 1.0-1.5 m and a depth of approximately 0.4-0.5 m. Stone backfill for collectors should be filled to within 250 mm of the surface to ensure interconnection with the disruption channels when installed afterwards.

3.5 Outfalls/Maintenance

Every drainage scheme is only as good as its outfall. Cleaning and upgrading of open drains acting 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 a great a depth as possible. Spoil from such works, where suitable, can be spread over the adjoining land filling depressions. Unsuitable spoil should be buried and covered with topsoil or removed to waste ground.

To protect fish eggs and small salmonids, drainage works and the maintenance of drainage systems in areas likely to contain these species should be carried out between July and September. One should note that The Fisheries Acts state that it is an offence to disturb channel beds where fish may spawn during the autumn or winter. If in doubt, consult Inland Fisheries Ireland (www.fisheriesireland.ie). If cleaning an open drain, it is vital that weeds/debris should be removed from the drain bed and one bank only. The other bank should be left undisturbed throughout that season. Sediment traps should be installed to prevent sediment losses and excessive erosion.

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 will result in blockages at the drain outlets. The use of a concrete or un-perforated plastic pipe over the end of the drain pipe, minimum 1 m in length, will protect the outlet from damage and will make locating and maintaining it easier.

3.6 Indicative Costs

The cost of drainage works will vary depending on such factors as soil type, site access, extent of open drains, availability/cost of backfill stone, and experience with drainage works among other factors. As such, costs are quite variable and will be specific to a particular job. Table 14 provides guidelines only. Cost for the provision of open drains is not included.

Table 14 (overleaf) covers as far as possible the general arrangements available. Where a shallow drainage system is considered the price will depend largely on the collector drains required. If an existing drainage system of closely spaced piped drains is already in place at the appropriate depth it may be possible to pull mole drains through this existing network or from an existing open drains. In this case the cost of mole drainage can be very cost effective. Where a collector system needs to be installed the total cost will be higher.

It is of the utmost importance that the selection of a drainage system for a particular site is not decided on the basis of cost. Alternatively an effective drainage system should be designed and costed and then a decision made as to whether or not to proceed. It is important to remember that the closer the drain spacing the higher the cost.

Table 14: Approximate costs of drainage systems

Drainage System	Drain Spacing (m)	Depth (m)	Cost/m (€)	Cost/Acre (€)	Cost/hectare (€)
	Groundwater Drainage System				
Groundwater Drainage	15 - 50	1.5 - 2.5	9-11	1500-2500	3700-6200
	Shallow Drainage System				
Mole Drainage	1.5 - 2.0	0.45 - 0.6	-	50-100	125-250
Gravel Mole Drainage	1.5 - 2.5	0.35 - 0.5	-	600-1400	1500-3500
Collector Drains	20	0.75- 1.0	5-8	1000-1600	2500-4000
Collector Drains	40	0.75- 1.0	5-8	500-800	1200-2000
Collector Drains	60	0.75- 1.0	5-8	350-600	800-1400

More in-depth Information

Land Drainage Manual

The Teagasc Manual on Drainage - and Soil Management is available from Teagasc offices or can be ordered via the Teagasc website, **www.teagasc.ie/publications.** Search ***"Teagasc Manuals".***

Notes:

1: SI 605 of 2017 (as amended)
2: Existing fences within 1.5m from the watercourse have to be moved. If there is an existing fence and roadway within 1.5m of the watercourse there is no specific requirement to move the fence and roadway although in many cases it will make sense to extend the roadway into the field so that a channel can be created on the inside and the runoff diverted away from the watercourse at intervals. If the roadway is relatively flat creating a cross fall away from the watercourse may be sensible. The watercourses on the 1:5,000 maps tend to convey water throughout the year.

https: store.osi.ie/index.php/osi-place-map.html and www.osi.ie

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Agricultural Sustainability Support and Advice Programme – ASSAP

ASSAP advisors work with farmers in a free and confidential advisory service to help improve water quality.

https://www.teagasc.ie/environment/water-quality/farming-for-water-quality-assap/people/

See Department of Agriculture, Food & the Marine (DAFM) S199 Minimum Specifications for Farm Roadways:

https://www.gov.ie/en/collection/28f4c-specifications/#structures-specifications

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Measures to protect Waters under the 4th Nitrates Action Plan

See Your Questions Answered etc. at:

https://www.gov.ie/en/publication/c9563-rural-environment-sustainability-nitrates/

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