Land drainage: Design and implementation

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Almost half (49.5% – 3.4 m ha) of the total land area of Ireland is classified as "marginal land" because it is affected by natural limitations related to its soil, topography, relief and climate. The most common limitation on marginal land is poor drainage status and much of it is in need of artificial drainage if its productivity is to be improved.

In wet years, poorly drained soils may never dry out at all, as persistent rainfall maintains high soil moisture content. 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 situations of prolonged waterlogging, plants will eventually die due to a lack of oxygen in the root zone. Furthermore, waterlogged soils are impassable to machinery and livestock for long periods, due to the high soil moisture content and reduced soil strength. This reduces the number of grazing days and hinders silage harvest, thus introducing higher costs related to imported feedstuffs.

Excavating a test pit.

Installing mole drains.

Environmental considerations

The implementation of land drainage works is known to affect the dynamics of water movement from drained sites and the potential impacts on water quality need to be recognised.

Examination of the potential environmental impact of these systems showed that both phosphorus and nitrogen attenuation capacity is dependent on surface and subsurface soil chemistry and drainage design specification.

The potential for nutrient loss is related to soil type, chemistry and the level of interaction that drained water has with nutrient attenuating layers or elements of the soil body. Shallow drainage systems, for example, are more likely to promote high intensity flows that have little interaction with the soil body relative to groundwater systems, which promotes water movement through the soil.

Furthermore, soils with high levels of organic matter are known to have poor nutrient retention capacity, which makes them vulnerable to nutrient loss. Land drainage system design needs to account for such variability and works should mitigate against negative 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 (N_2O) and allowing for extended grazing, though drainage is linked to carbon loss on carbon-rich soils such as peats.

The cessation of drainage works and the re-wetting of some organic soils has been proposed. The amount of carbon stored by soils provides an important sink to counterbalance and negate against the effects of increasing levels of carbon dioxide (CO_2) in the atmosphere.

Management of these soils will dictate the amount of carbon that is stored in the long-term and land management strategies will need to be informed by the relative amounts of carbon stored in different soil types and their capacity to build carbon. 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.

Installing field drains.

Planning for land drainage

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. We need a better understanding of the underlying causes of drainage problems and of the design and implementation of appropriate drainage systems to resolve these issues.

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.

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.

Careful thought is needed before deciding on the most appropriate part of the farm to drain. From a management point of view, it is better to drain the land which is nearer to the farmyard and work outwards, however it may be more beneficial to target the areas with high potential for improvement to ensure a better return on the investment.

Drainage investigations

What exactly is the problem? Collect all the information at hand, over an

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A soil test pit

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extended period to establish where and what the root causes are. Where does the water gather? Where does overland flow occur? Where are the worst underfoot conditions? Where are the poorest areas of grass growth? How good is the existing drainage network? Is the whole profile made up of poor soils or is the problem caused by specific layers? Is there water movement at any depth? This information will help in deciding where best to invest in drainage works.

Knowledge of previous drainage schemes in the area, and their effectiveness will often provide key insights. A number (approx. one per ha) of test pits (at least 2.5 m deep) should be excavated within the area to be drained to investigate.

These should be dug in areas that are representative of the area as a whole; consider digging in wet and dry areas for comparison. Remember 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 drain to be installed will depend on the interpretation of the characteristics revealed by the test pits.

There are two principle types of drainage system:

- **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 piped drainage systems (at the depth of inflow) are 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.

Clean aggregate, in the 10 – 40mm grading band (with further benefits evident for smaller (10-20mm) material) should to be used to surround the drain pipe. The gravel should be filled to a minimum depth of 300mm 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.

Shallow drainage systems

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

Mole drainage is suited to stone-free

Adding stone aggregate to a field drain.

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 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.

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 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.

Washed aggregate within a 10-20mm 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.

Collector drains, which are installed across the slope at 0.8 – 1.0m deep, are required for all shallow drainage systems. Depending on the topography and slope, the collector drains will be at a spacing of 10–40m. 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 1.0-1.5m and a depth of approximately 0.4-0.5m. Stone backfill for collectors should be filled to within 250mm of the surface to ensure interconnection with the disruption channels when installed afterwards.

Outfalls/maintenance

Every drainage scheme is only as good as its outfall. Maintenance vastly improves the capacity and the lifespan of the drainage system, but also helps with water storage, sediment trapping and remediation of nutrient losses.

Drainage systems are poorly maintained in most cases. A maintenance plan should be adopted for both in-field and open drains, focusing on areas susceptible to blockages. This provides a cheap and effective means of improving drainage by maximising the effectiveness of existing drainage infrastructure.

Fine soil particles are many times smaller than the aggregate (e.g stone) around a pipe or the slits in the actual drainage pipe. This means they can get washed from the soil and ultimately settle in field drains and impede flow.

Iron (ochre) can also block drains where it accumulates after being washed out of the soil. Plants and their roots can thrive in open channels, at the pipe outlet and deep within the pipe system causing blockages.

Collapse/sedimentation of open drains, due to flow conditions, undercutting of banks or livestock damage can also cause impediments.

•Drainage systems will deteriorate at a fairly steady rate until blockages become established and "self-cleaning" is inhibited.

•If flow is slowed or stopped entirely then large volumes of sediment will be deposited in the system. Relatively minor blockages can quickly undermine the whole system.

•Regular inspection, cleaning and maintenance is required.

Open drains, culverts and outfalls must be cleaned regularly to remove any obstructions while they should be established to as great a depth as possible to aid flows. Prevent livestock access to open drains.

Field drain pipes and outlets should be jetted/flushed or rodded regularly to maintain flow, and their outlets should be well marked and protected during the cleaning of open drains.

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.

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 mid-May and mid-September.

Further detailed guidance is available in the Teagasc Manual on Drainage – and soil management, which has been recently updated.