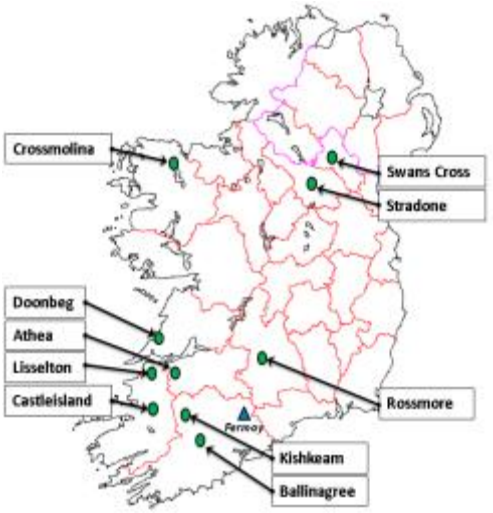
Introduction to Land Drainage

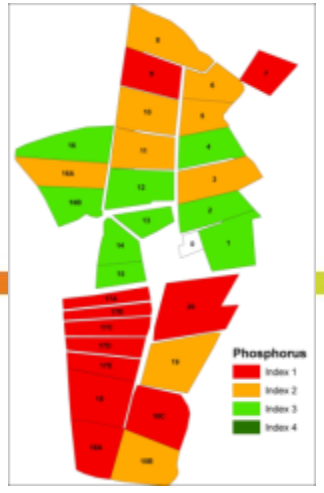
Teagasc Animal & Grassland Research & Innovation Centre, Moorepark

Kildalton Agricultural College 29/11/2018

Background

- The Heavy soils programme aims to increase profitability, improve productivity and decrease volatility on farms with poorly drained soils.
- The programme has 10 commercial farm participants; in 8 Counties.
- Focus areas include land drainage, soil fertility and nutrient cycling, soil characterization, grassland management, fodder reserves, farm infrastructure and farm profitability.
- Farms are subjected to intensive monitoring. The data being generated allows for analysis of farm systems and the development of strategies to achieve programme aims
- Collaboration between AGRIP, CELUP and Advisory with support from Co-ops (Kerry, Dairygold, Tipperary, LacPatrick)





Teagasc
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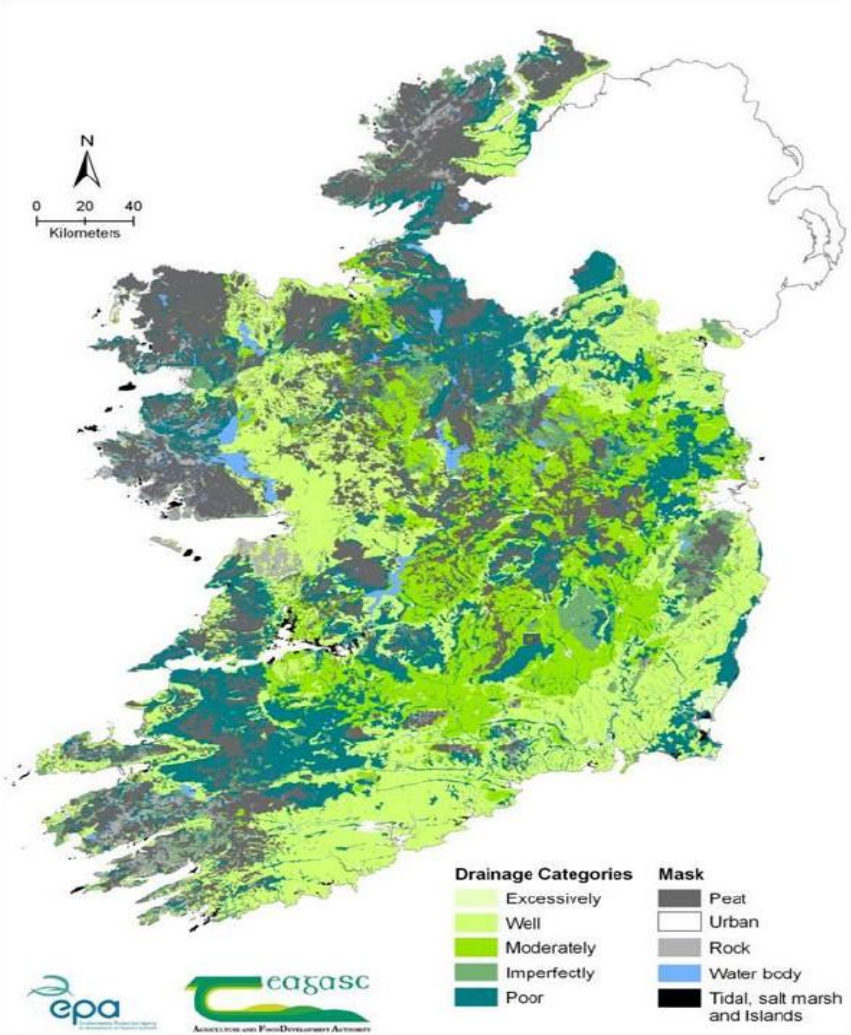
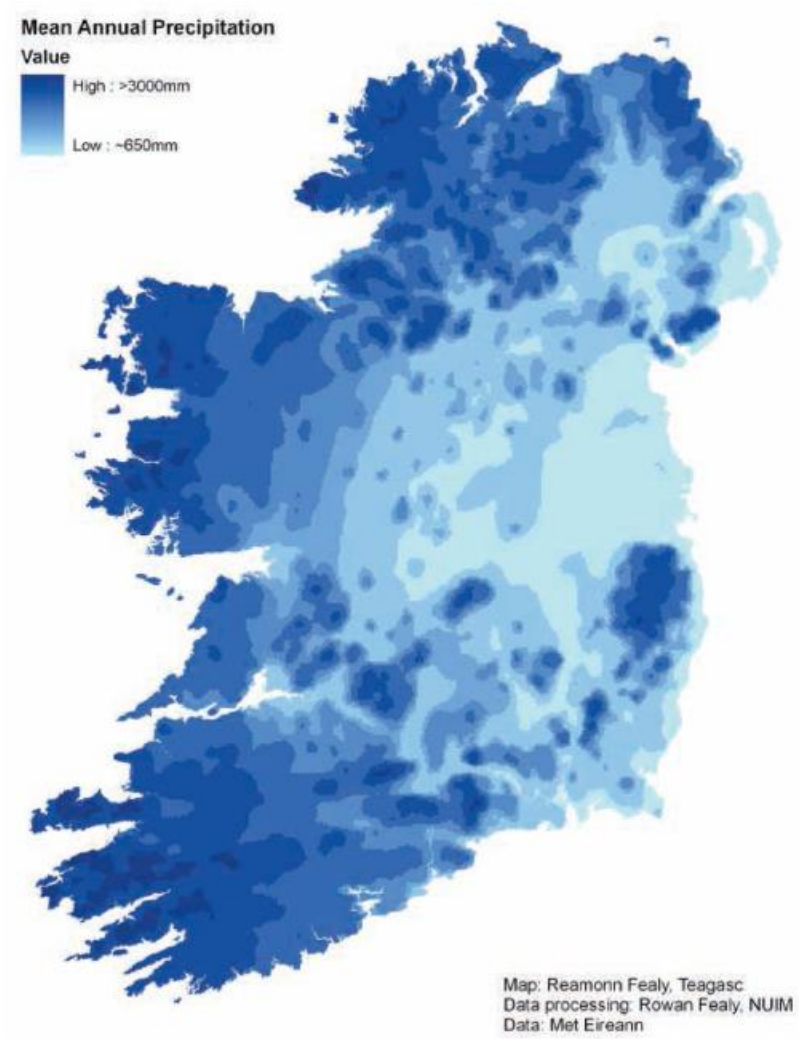

N
0 20 40
Kilometers
Drainage Categories
Excessively
Well
Moderately
Imperfectly
Poor
Mask
Peat
Urban
Rock
Water body
Tidal, salt marsh and Islands
epa
teagasc
Agriculture and Food Development Authority


Mean Annual Precipitation
Value
High : >3000mm
Low : ~650mm
Map: Reamonn Fealy, Teagasc
Data processing: Rowan Fealy, NUIM
Data: Met Eireann

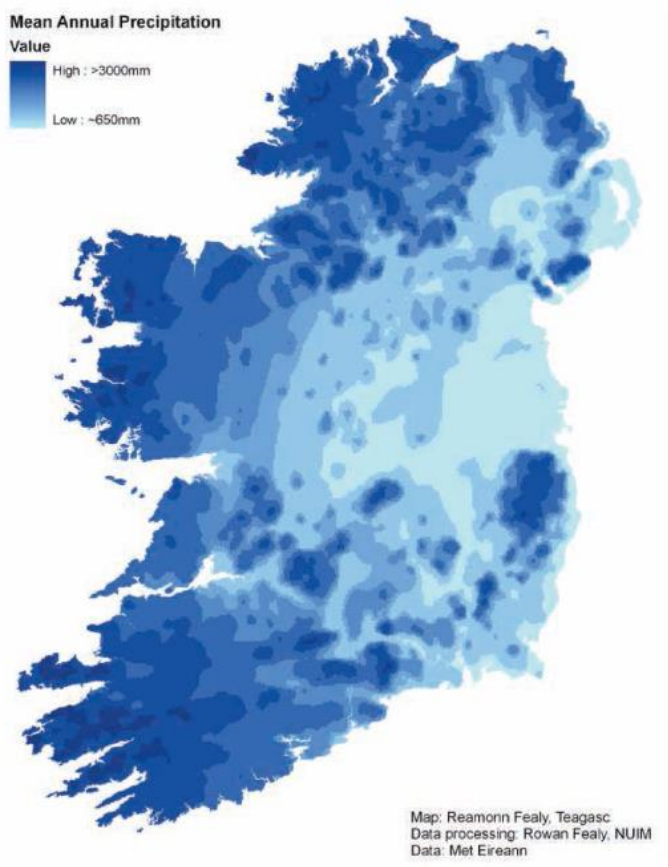
Irish Landscapes



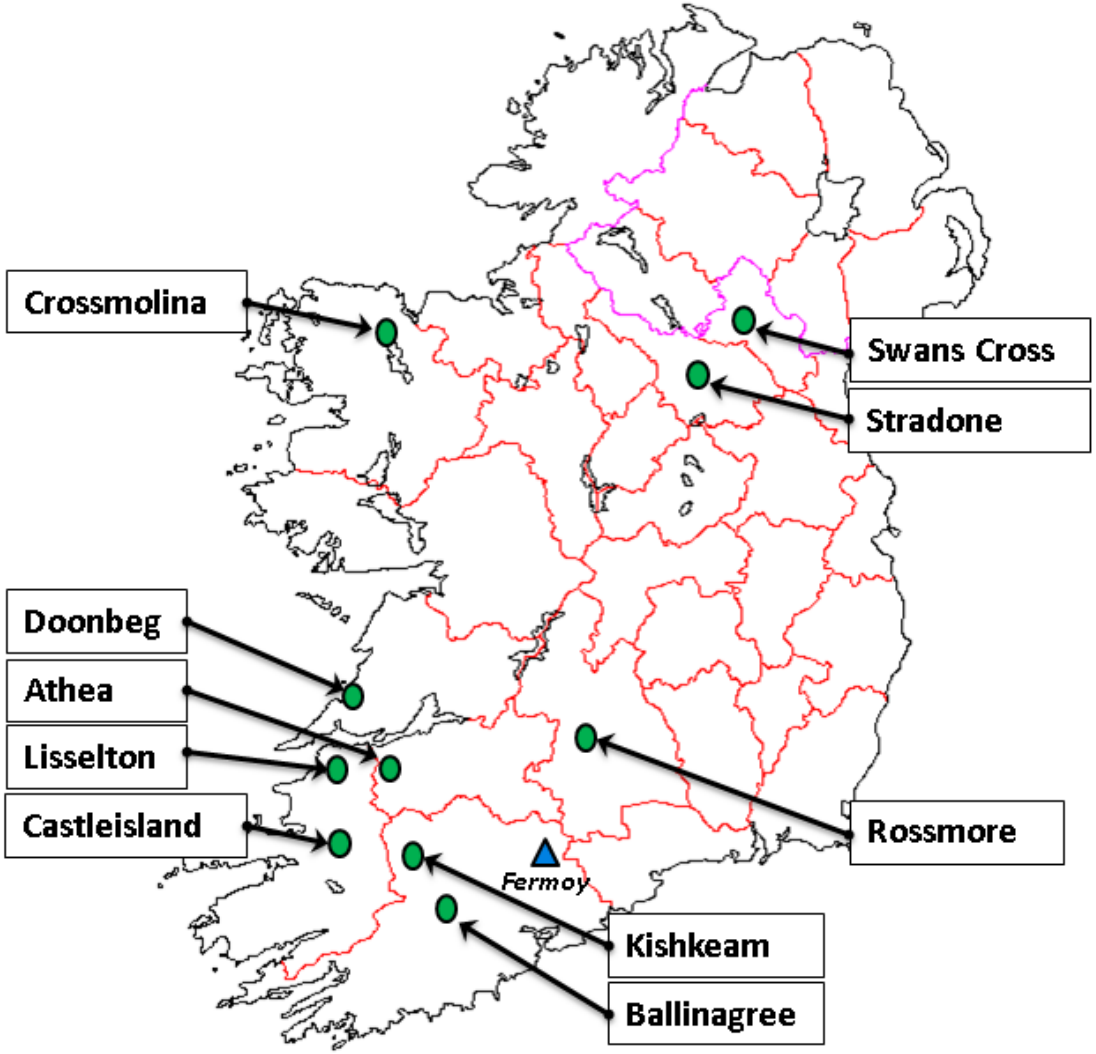



Soils and rainfall

- Marginal land occupies just under 50% of Irish land area
- Trafficability for machinery and livestock is a major limitation in wet conditions
- Use of such soils is curtailed due to;
  - Reduced stocking capacity and grass yields.
  - Increased susceptibility to surface damage and compaction.

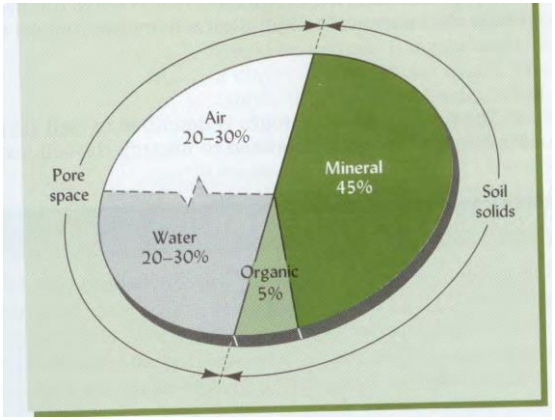


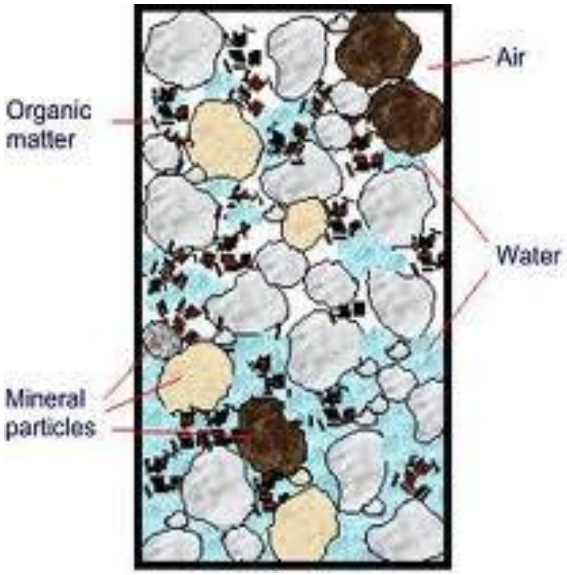
Heavy Soils Programme Farms

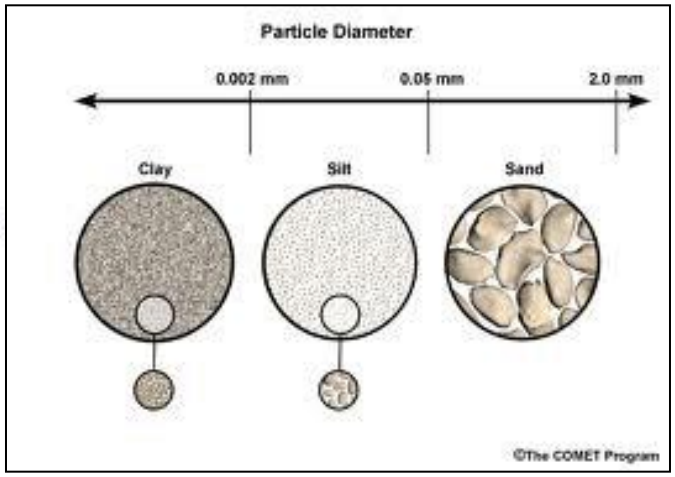


Soil Characteristics

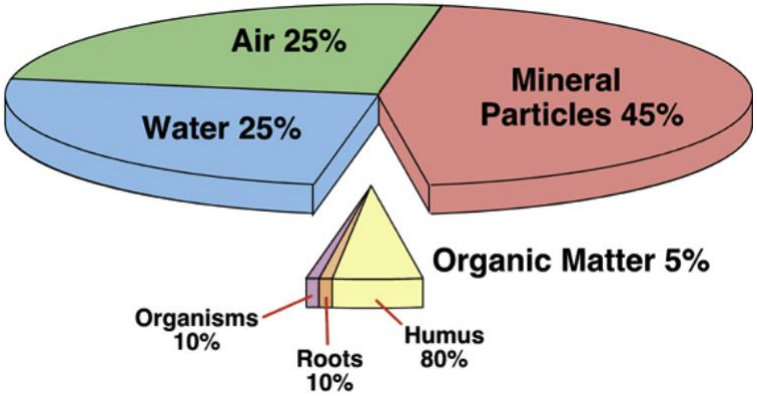
Heavy Soils

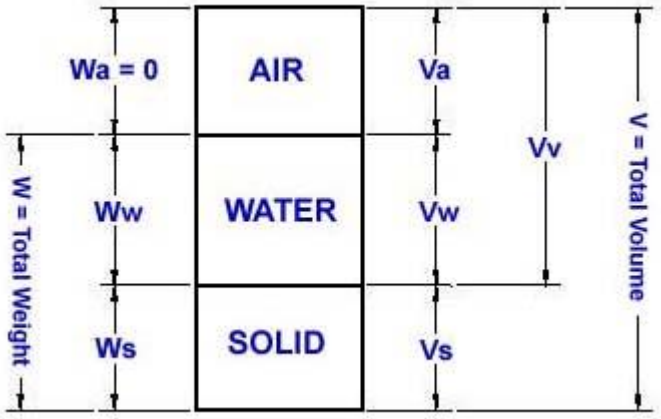






Soil Phases





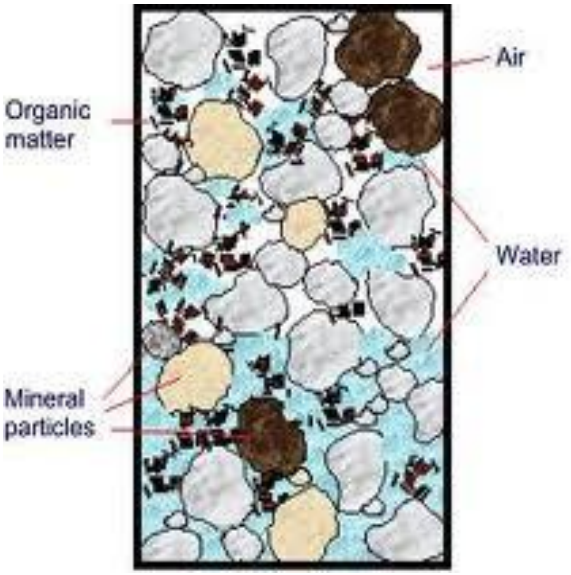
- **Soil solids** and **pore space**
- Air and water phases occupy the pore space and are complimentary
- Pore space in a saturated soil is filled with water.
- Crops require a minimum 10 -15% air filled pore space for water and nutrient uptake

Soil Solids

Soil solids consist of mineral and organic materials

Organic Material (<10% in mineral soils)

- Stores water and nutrients
- Binds mineral particles



Mineral Particles

- Sand, silt and clay (plus larger particles - gravel, stones, etc.)
- **Size (Texture) and arrangement (Structure)** of solid particles bear huge influence on water movement

Soil Horizons

- **The action of soil forming processes as influenced by soil forming factors gives rise to distinct soil horizons**

- These layers are assigned letters which define their characteristics. The main horizons identified are:

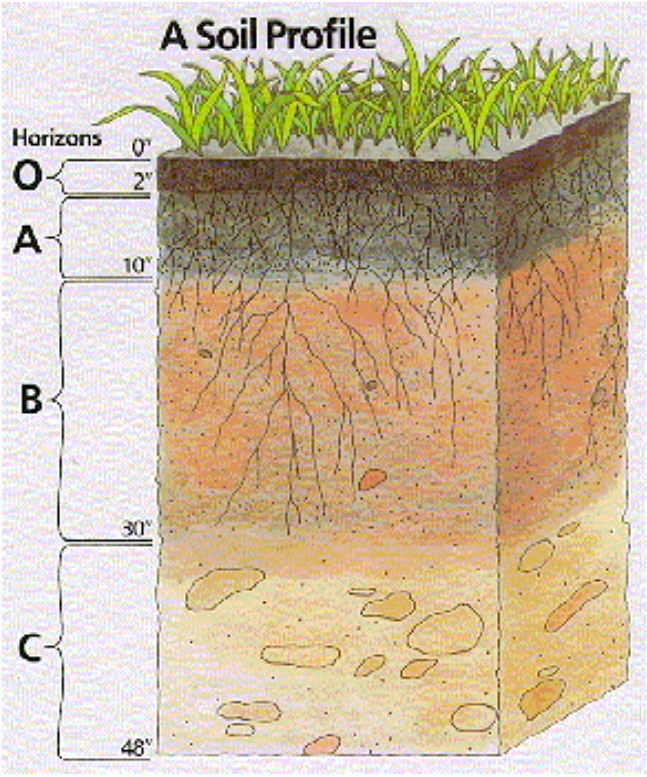
  - O: An organic horizon

True Soil

  - A: Mineral horizon formed at or near surface
  - B: Formed by material removed from A horizon or the alteration of the parent material

Parent Material

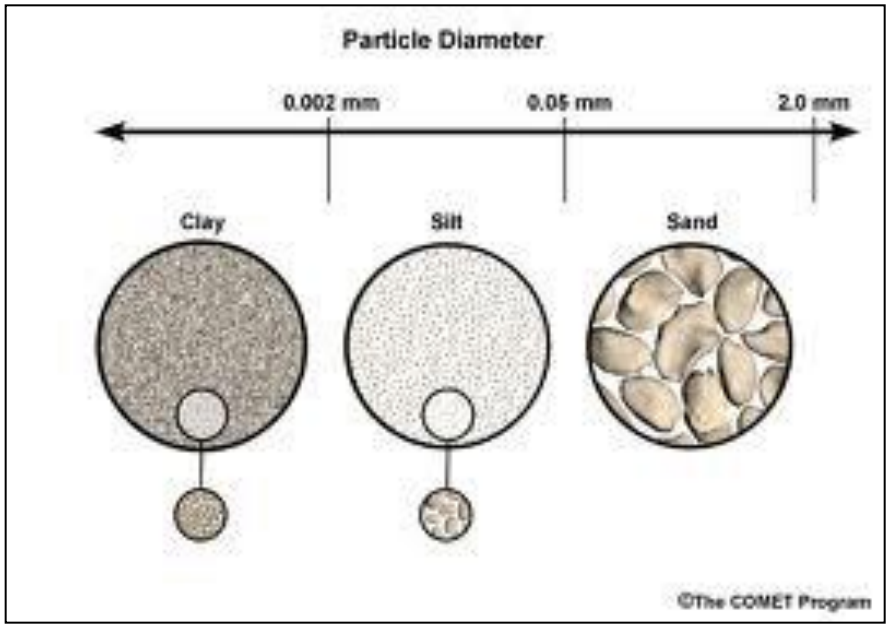
  - C: Horizon with little evidence of soil formation activity
  - R: Bedrock

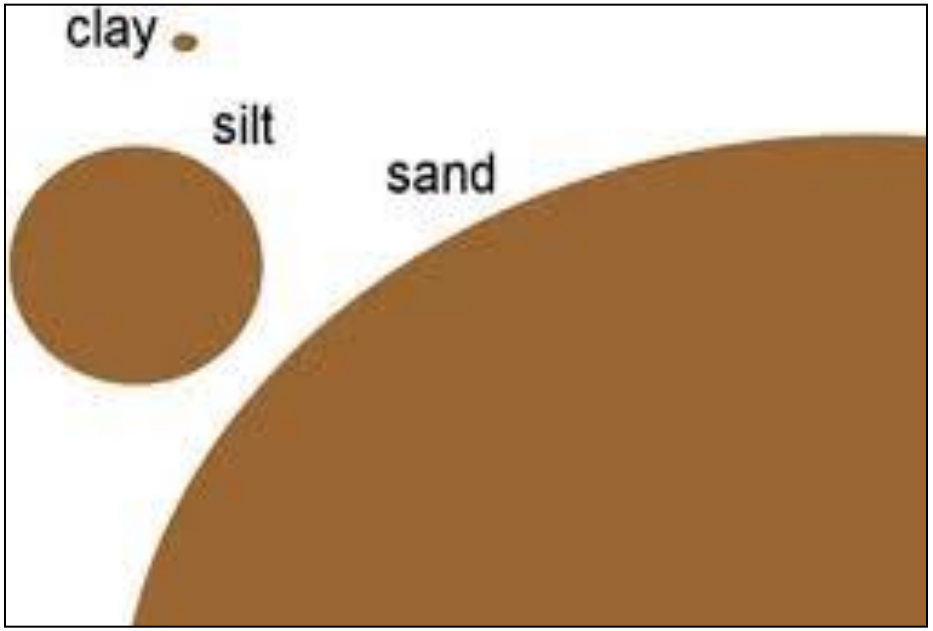


-Where complex, sub-horizons may be identified; A1, A2, A3
-Specific characteristics are identified by lowercase letters;
Ap (A mixed by cultivation), Ah (uncultivated A), Bg, Cu, etc…..

Soil Texture

- The relative proportions of sand, silt and clay particles in a soil
- Anything bigger than 2mm is gravel/stone





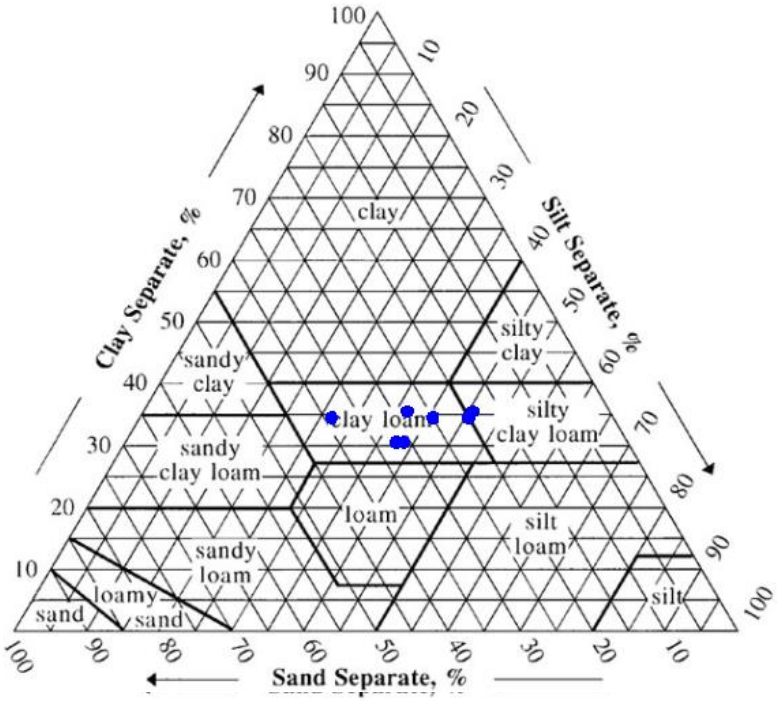
Soil Texture

- Sand: Feels gritty, large enough to be seen with the naked eye
- Silt: Feels smooth/floury, Individual grains not visible.
- Clay: Feels sticky & cohesive, resists breaking, mouldable
- Estimating soil texture by feel: http://www.ksre.ksu.edu/library/crpsl2/mf2852.pdf

Property	Rating associated with soil particles		
	Sand	Silt	Clay
Drainage Rate	High	Slow to medium	Very slow
Water holding capacity	Low	Medium to high	High
Compactability	Low	Medium	High
Warm-up in spring	Rapid	Moderate	Slow

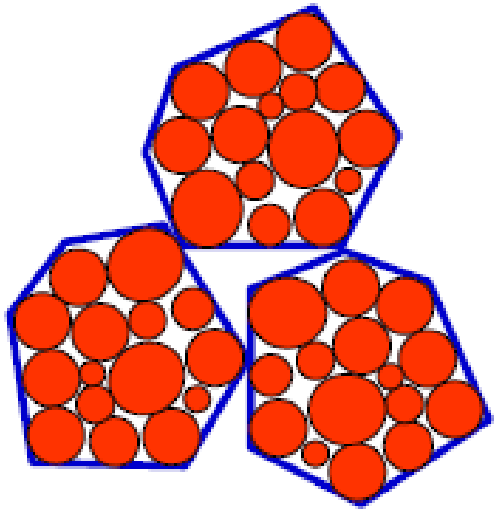
Texture Triangle

- Classification of soils into textural groups
- Classification is assigned after lab or fie analysis of soil samples
- Moorepark (RED-48% sand, 48% silt, 4% clay)
- Blue-35% sand, 35% silt, 30% clay
- Green-5% sand, 38% silt, 57% clay
- HSP farms topsoils
- HSP farms subsoils



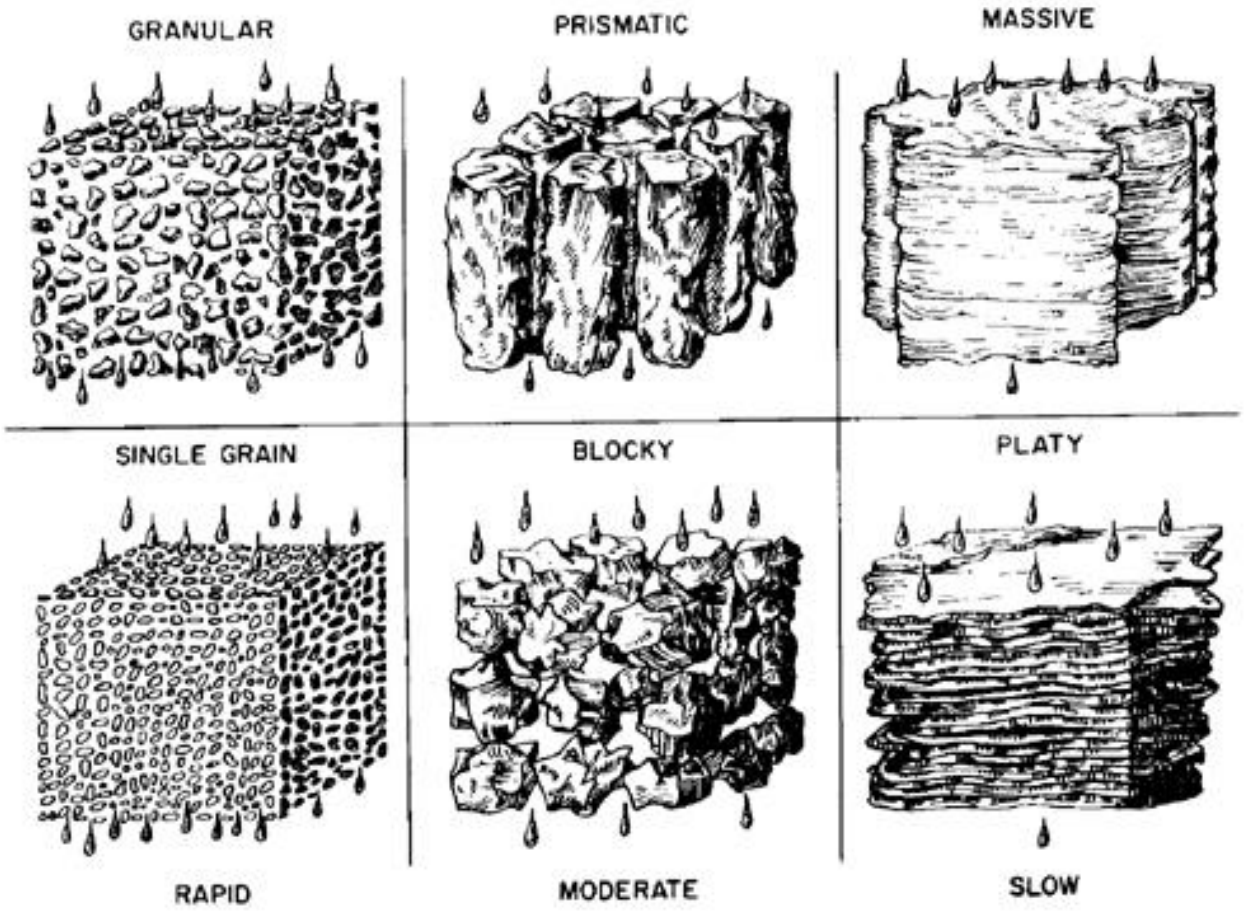
Soil Structure

- Arrangement of particles/level of cracking
- Structural development influenced by formation, texture and management.
- Greatly influences:
  - Water/Air infiltration & movement
  - Root penetration & growth



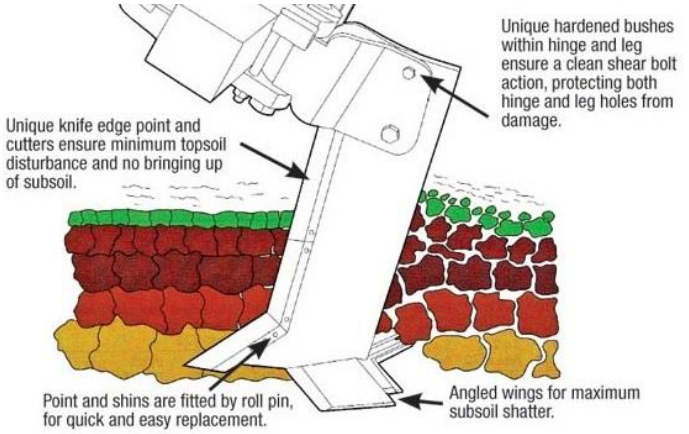
Three soil aggregates comprising many sand, silt, clay and organic particles

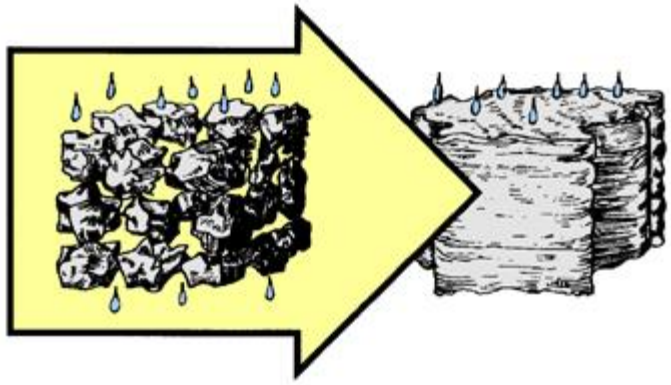
Soil Structure



Altering Soil structure

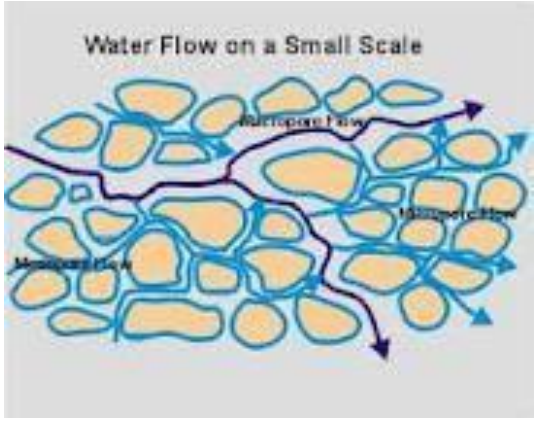
- Greatly Influenced by management
- Weathering: Wetting/drying and freezing/thawing
- Biological process's: plant roots, earthworms
- *Negative manmade changes*: excessive cultivation, untimely operations on wet soil, heavy machinery.
- *Positive manmade changes*: tilling, drainage, sub-soiling, mole ploughing etc.





Water movement through Soil

- In free draining soils the rate of water flow through the soil will be higher than all bar very extreme rainfall rates.
- In poorly drained soil the rate of water flow can be regularly exceeded by rainfall rate due to:
  - Low hydraulic conductivity
  - High Water table due to low lying position and poor out-fall
  - Upward movement of water from seepage and springs



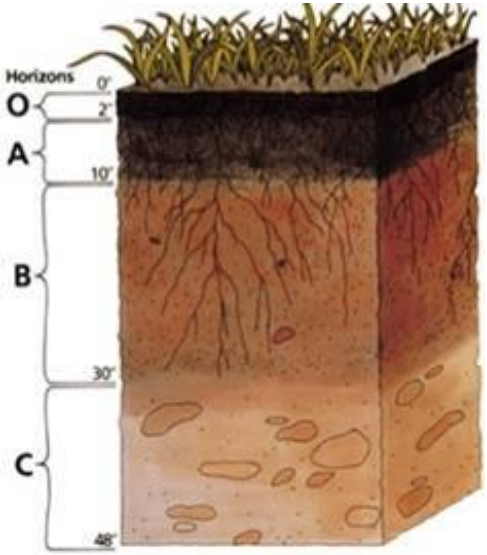
Drainage

Heavy Soils

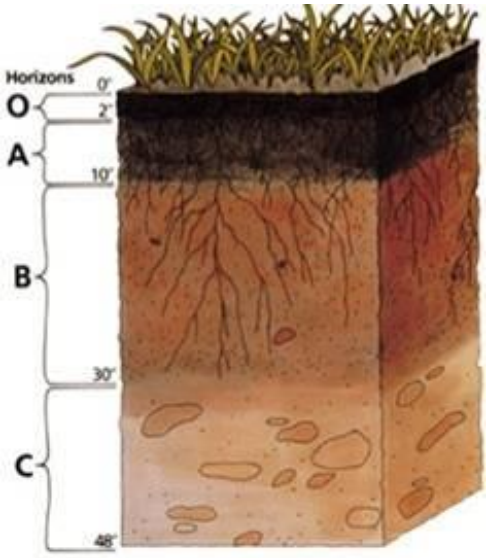
Land Drainage

Definition:

“Ireland lies in the temperate zone, where the main role of drainage is the removal of excess water in the root zone of crops from surplus rainfall, while a secondary objective is to provide good trafficability for farm machinery and livestock”



Drainage Investigations



- **When planning a drainage system an investigation into the causes of poor drainage must first be undertaken**
- No “one size fits all” solution
- A number of test pits (at least 2.5m deep) should be dug within the area to be drained
- As the test pits are dug the faces of the pits are observed, soil type (texture and structure) should be established (varying with depth) and rate of water seepage (if any) recorded.
- **Are there layers impeding or permitting water movement ?**

Types of drainage system

- The depth and type of drain to be installed depends entirely on the interpretation soil characteristics.

- Two principle types are distinguished:

  - **Groundwater drainage system:** A network of deeply installed piped drains exploiting permeable layers

  - **Shallow Drainage system:** Where soil is heavy and infiltration of water is impeded at all depths and permeability needs to be improved

Groundwater Drainage System

- **A Groundwater drainage system is a network of field drains collecting groundwater which can move through soil layers of high permeability**
- They work by exploiting the natural capacity for movement of water at a certain depth in certain soils
- By “tapping” into this natural capacity for water movement the system works by lowering the watertable and reducing the amount of water stored in the soil

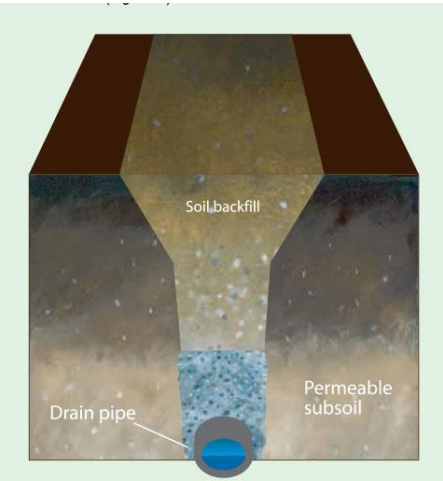
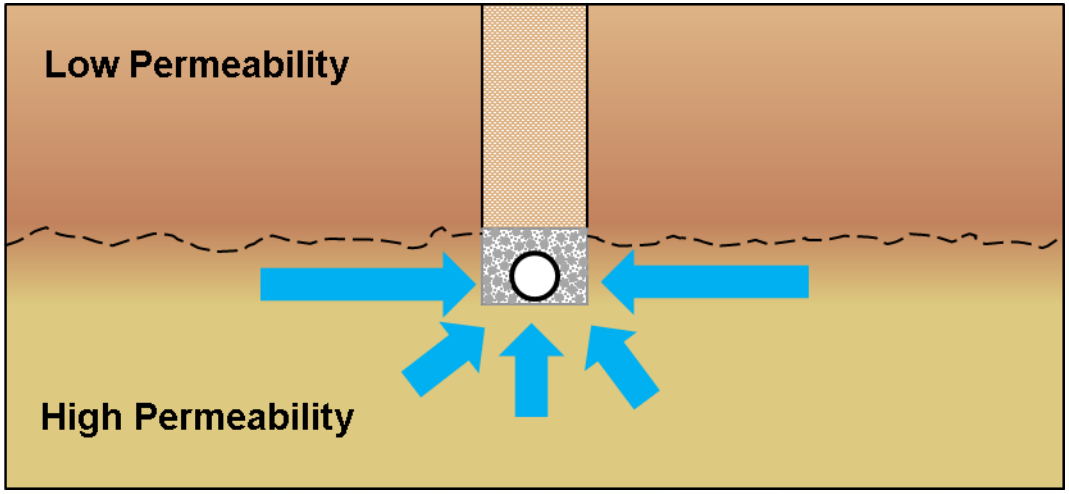
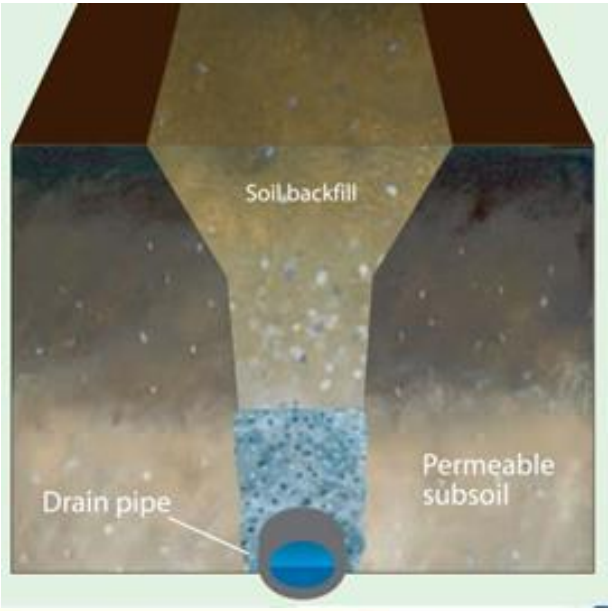


Figure 1. Connection with permeable layer.



Backfilling groundwater drains

- Drainage stone should:
  - be filled to a **minimum depth of 30 cm** from the drain bottom
  - provide connectivity with layer of high permeability
  - be **clean** aggregate (10-40 mm / 0.4 -1.5 inch)



Shallow Drainage System

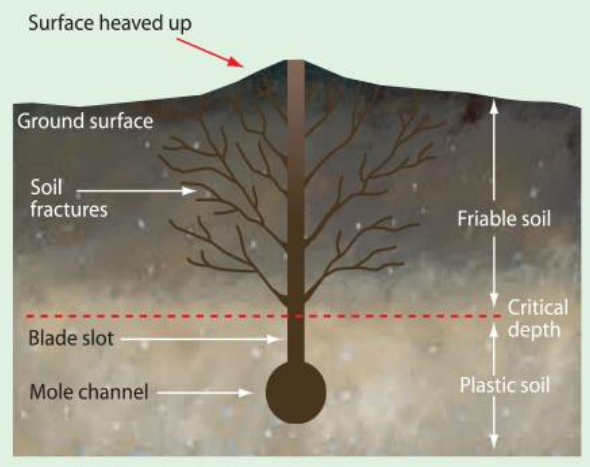
- **A shallow drainage system is a network of field drains in tandem with surface disruption techniques which promote water infiltration and drainage**

- Used where soil permeability is low at all depths and aims to introduce new pathways for water movement in the soil

- Methods include: Mole drainage, gravel mole drainage, sub-soiling (pan busting) and land forming

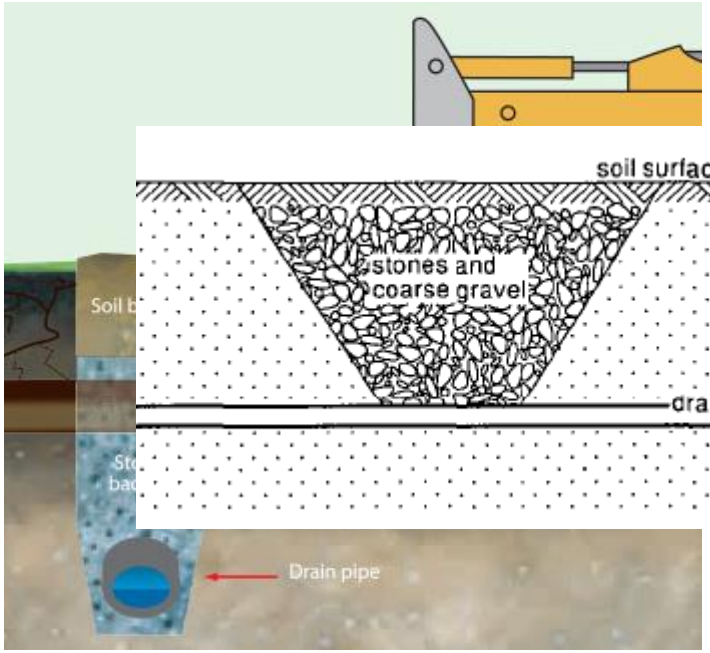
Shallow Drainage

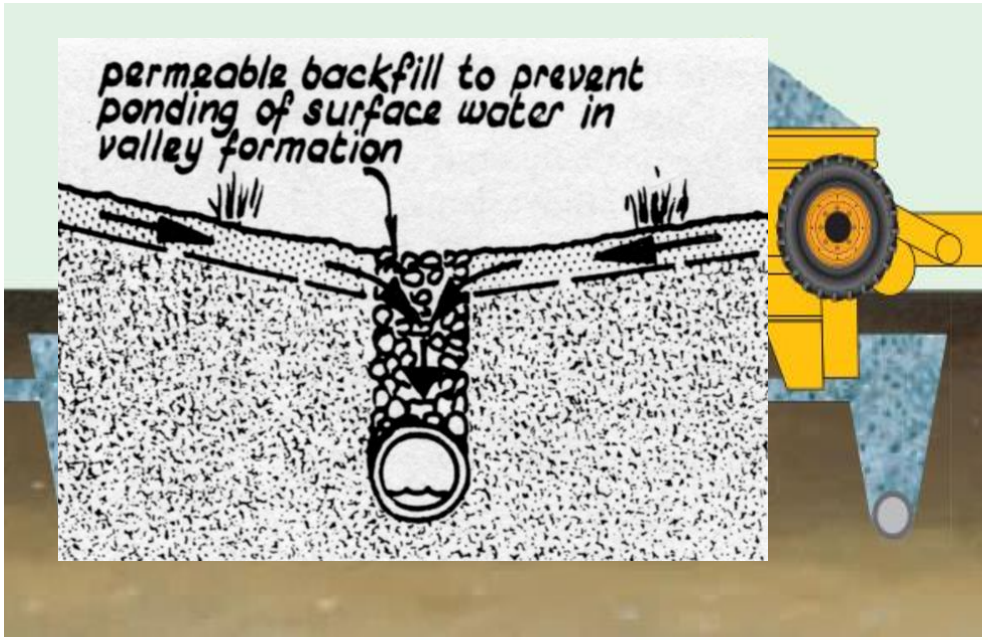
- **Mole drainage**
  - Increased permeability at shallower depths and creates drainage channel
- **Gravel mole drainage**
  - Gravel moles increase lifespan (extra cost)
- **Subsoiling/Ripping**
  - To break a pan at shallow depth or to supplement both shallow and groundwater drainage systems
- **Carried out when upper soil layers are dry**
- Installed at spacings of 1.0 to 2.5m at 0.4 – 0.6m depth.



Backfilling collector drains

- Drainage stone should:
  - fill the trench to within 25 cm of ground surface
  - provide connectivity with mole channels and topsoil
  - be **clean** aggregate (10-40 mm / 0.4 -1.5 inch)





Drainage System Materials

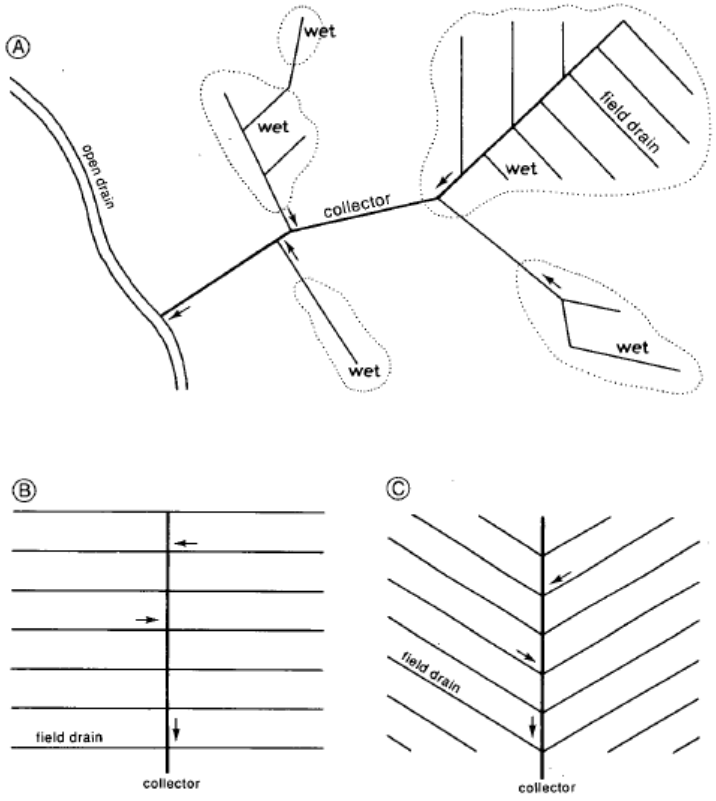
- The drainage pipe facilitates a unobstructed flow path from the field drain.
- Perforated corrugated pipe is the cheapest and most convenient
- Drainage stone has three functions
  - Hydraulic: to facilitate water flow to the pipe
  - Filter: to prevent the entry of fine particles to the pipe
  - Bedding: to provide support for the pipe and prevent collapse
- Synthetic filters are common in other parts of the world, where creating an outlet and discharging water are enough to create gradients and remove water.
- Some Irish soils would be suited to these systems

Layout patterns

Drainage system layout patterns:

- A: Natural
- B: Parallel
- C: Herringbone

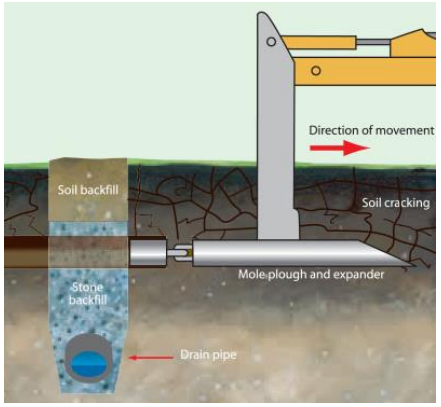
- In uneven terrain drains are most effective when they pass through depressions in the land.
- Where land is relatively flat, a regular network of drains is more suitable.
- In a parallel system field drains should be aligned across the slope with collectors running down the slope.
- In a Herringbone system field drains are aligned across the slope but at a slight angle to aid falls



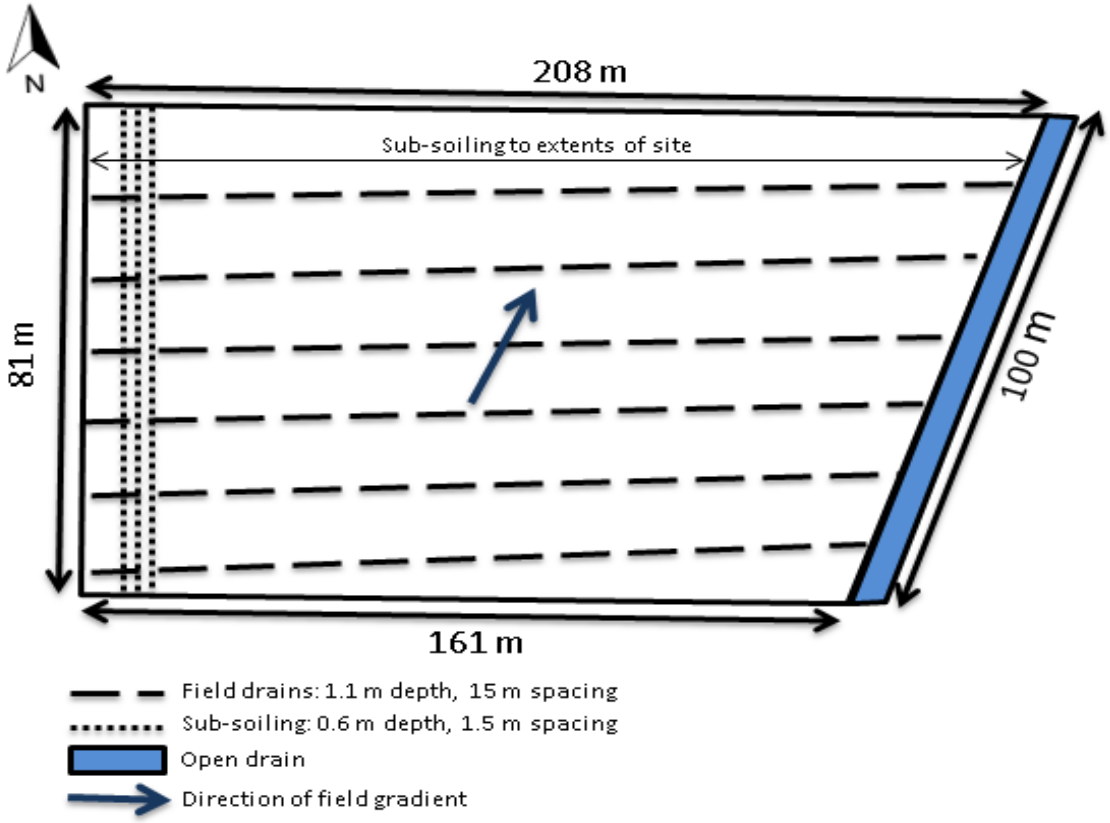
Smedema & Rycroft, 1983

Land Drainage Design: Kishkeam Farm

Problem Diagnosis



Drainage system design



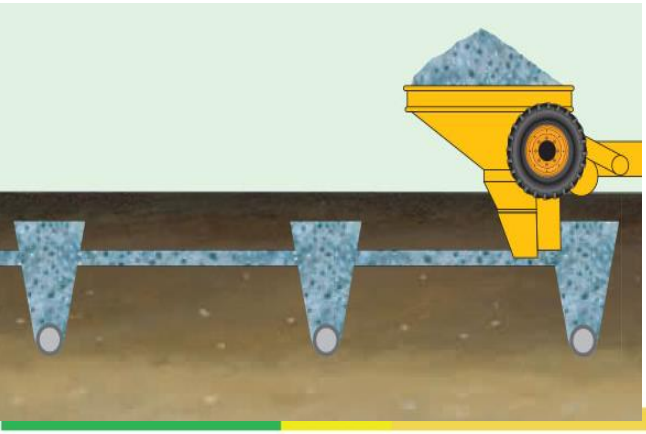
Drainage Costs: Kishkeam Farm

Costs	Total/ha
Drain installation @ €45/hr (36 hrs)	€1,625
Drainage pipe @ €1.03/m (566 m)	€585
Drainage stone @ €10.78/t (101 t)	€1,085
Subsoiling	€125
Drainage cost	**€3,420**

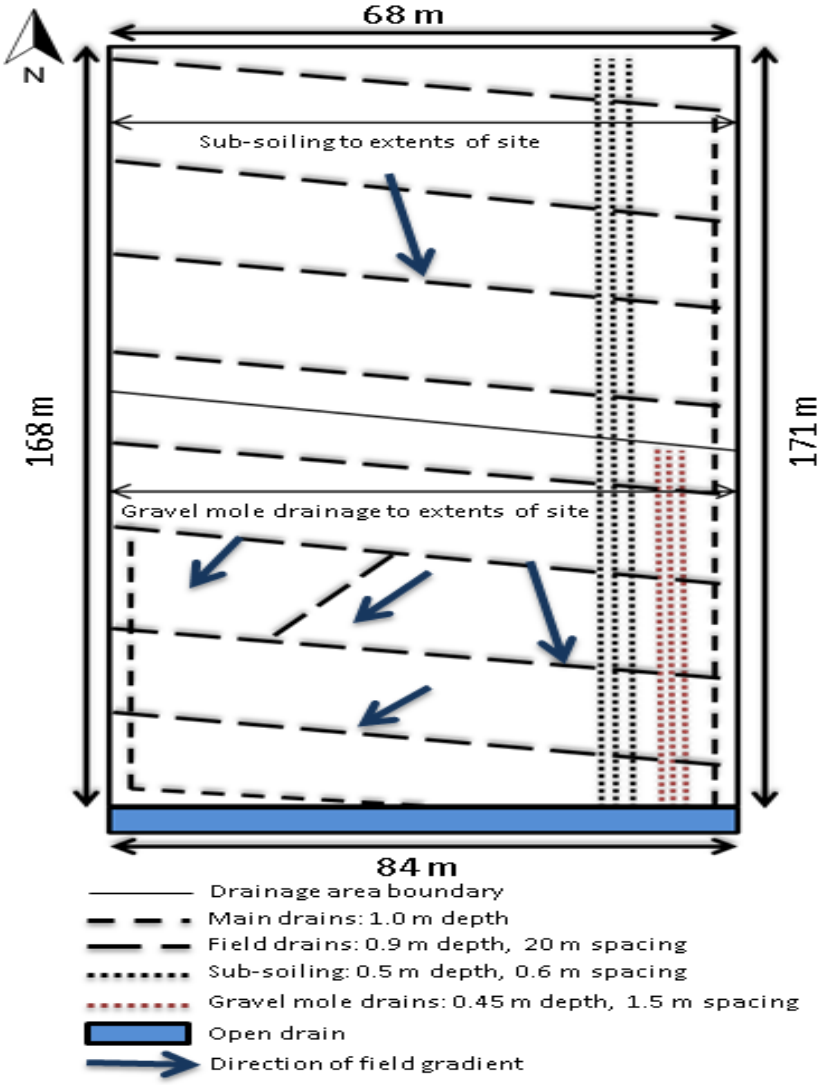
Land Drainage Design: Castleisland Farm

Heavy Soils

Problem Diagnosis



Drainage System Design

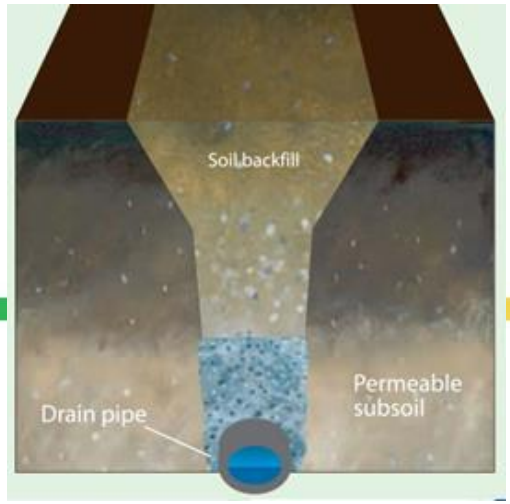


Drainage Costs: Castleisland Farm

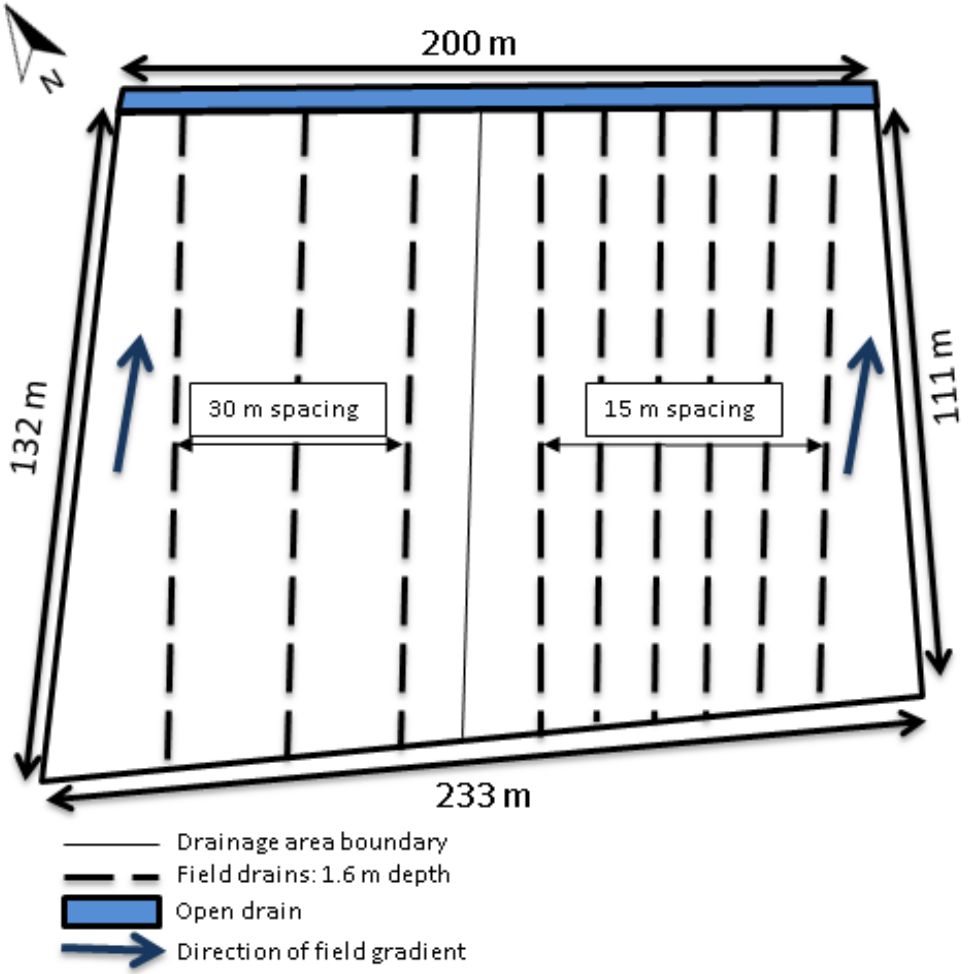
Costs	Total/ha
Drain installation @ €45/hr (40 hrs)	€1,800
Drainage pipe @ €0.93/m (677 m)	€630
Drainage stone @ €12.30/t (193 t)	€2,378
Sub-soiling	€222
Gravel mole installation	€510
Gravel mole stone @ €24/t (100t)	€2,400
Drainage cost (Subsoiling)	€5,030
Drainage cost (Gravel moling)	€7,940

Land Drainage Design: Rossmore Farm

Problem Diagnosis



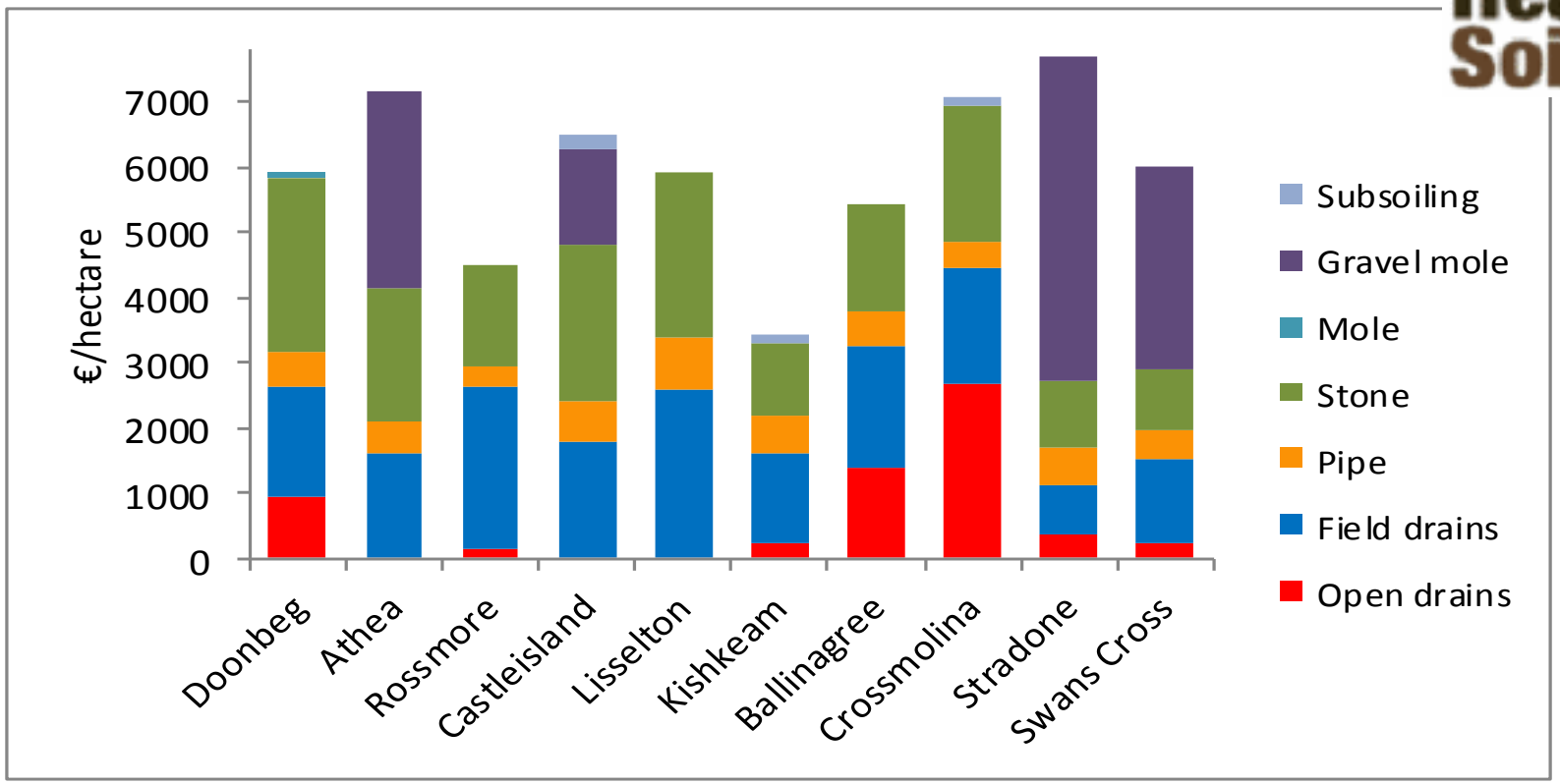
Drainage System Design



Drainage Costs: Rossmore Farm

Costs	Total/ha
Drain installation @ €45/hr (55 hrs)	€2,476
Drainage pipe @ €0.70/m (429 m)	€300
Drainage stone @ €11.10/t (141 t)	€1,562
Drainage cost	**€4,338**

Approximate costs



All costs included, high intensity systems. The average cost of drainage systems was €5,960/hectare (€3,420/ha to €7,690/ha)

Cost Factors for all sites

1. Soil type/landscape position
    1. System type
    2. Intensity of installation

2. Extent of open drains available (at the desired depth?)

3. Field conditions during drainage works
4. Site access

5. Materials needed, availability and transport, storage on site
6. Cost of materials

7. Cost of the contractor
8. Experience/Skill of the operator (paid by the hour or meter?)

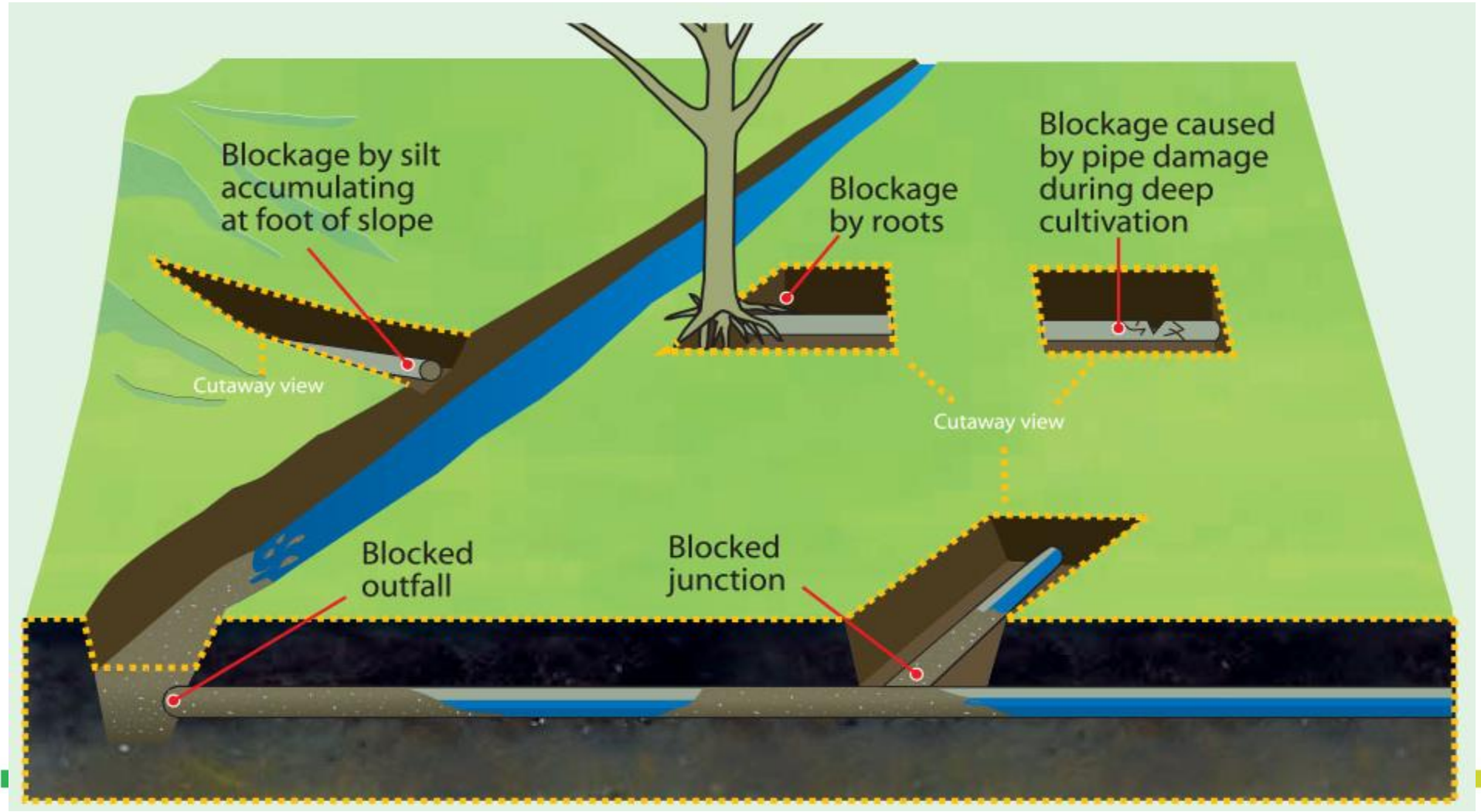
9. Farmers own input-machinery, mole ploughing, time

10. Lifetime of the drainage works (i.e. depreciation)

Balance cost with benefits….

- Increase in grass growth **(@€200/t DM utilised ?)**
- Access-Longer grazing season-utilisation
- Access to spread nutrients/slurry-improved fertility
- Access to harvest fodder
- Reduced imported feeds/concentrates
- Allowing for higher stocking rates
- Proximity to grazing platform?
- Will depend on future weather conditions-unknown but general trends predictable

Maintenance



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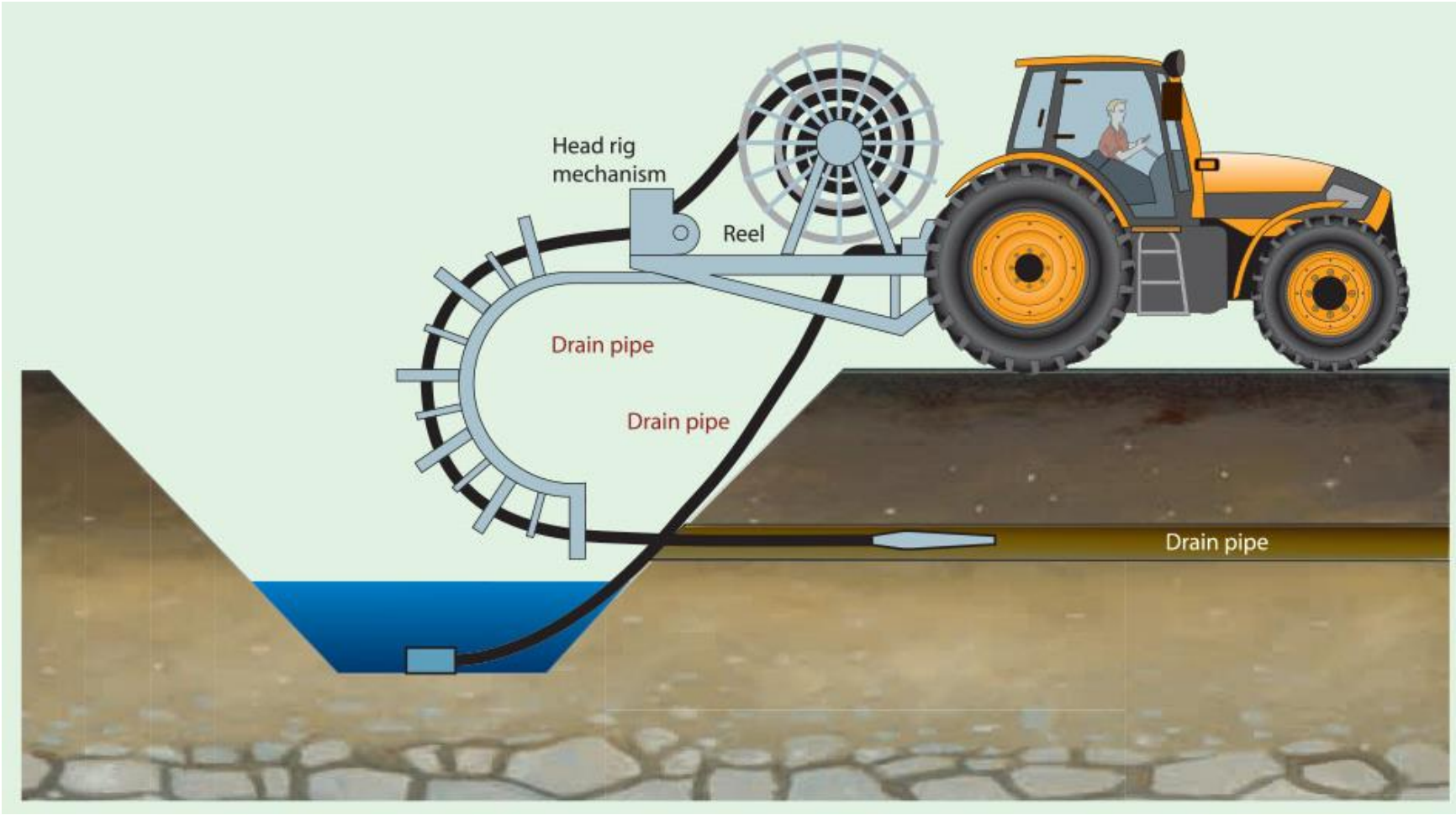

References

- Teagasc Land Drainage guidebook
- Heavy Soils Open Day booklets
- https://www.teagasc.ie/crops/grassland/heavy-soils/
- Teagasc Manual on Drainage and soil management

Heavy Soils