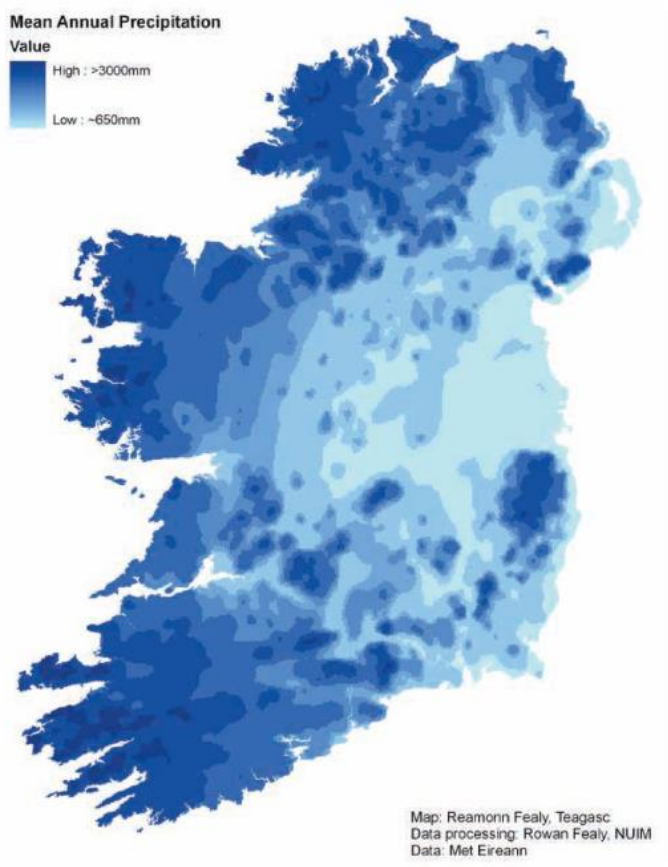
Dairying on Wet Land.
Teagasc Heavy Soils Programme

Teagasc Animal and Grassland Research and Innovation

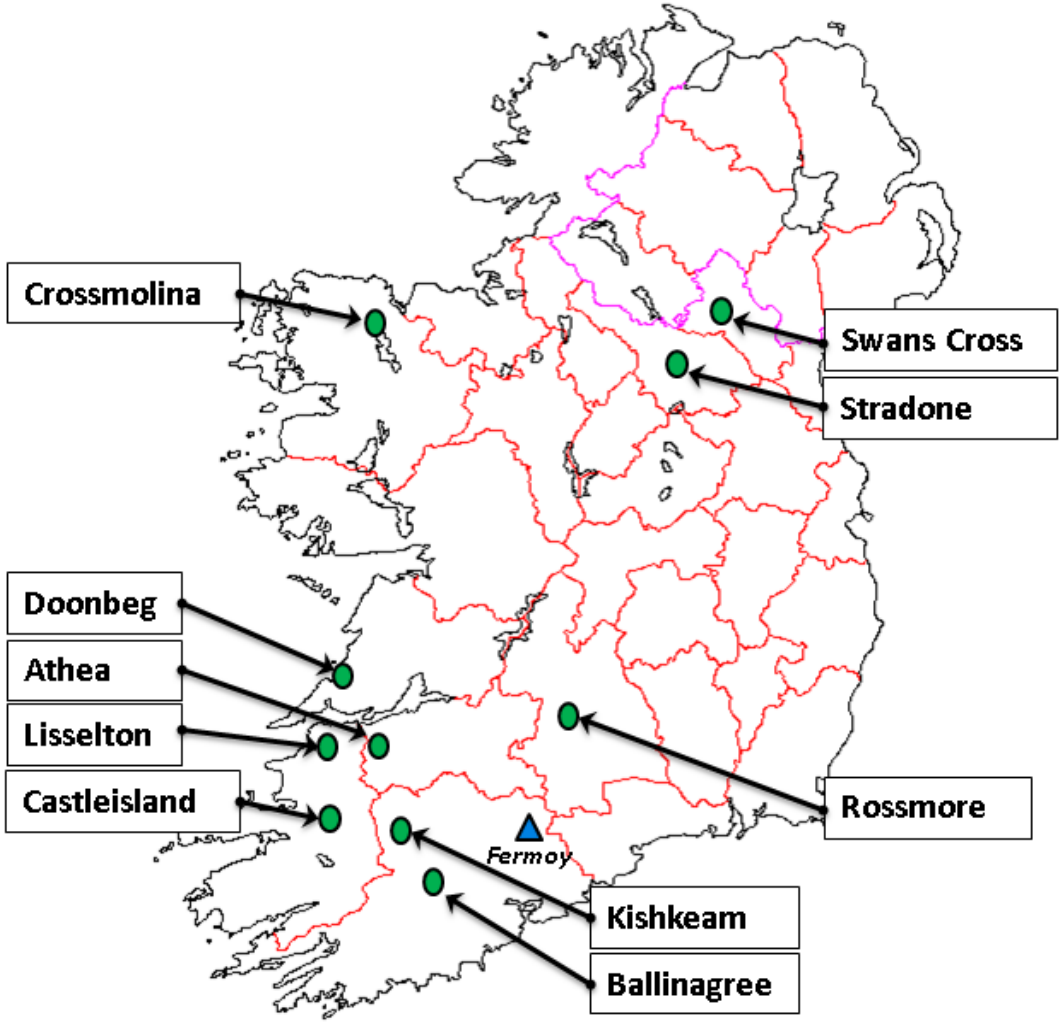
PDDFM_26Mar2019

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



HSP Farm Performance 2011 - 2018

Year	Herd Size	Stocking Rate		Herd EBI		6 week calving %
		Farm	MP	Total	Fertility	
2011	78	1.70	2.12	84	47	72
2012	85	1.71	2.27	112	73	68
2013	84	1.69	2.24	134	79	76
2014	88	1.85	2.30	150	87	74
2015	95	1.81	2.45	161	89	74
2016	100	1.85	2.56	82	35	69
2017	104	2.00	2.80	89	39	75
2018	**107**	**2.00**	**2.90**	**119**	**45**	**74**

HSP: Average Farm Performance

Year	Milk Solids (kg/ha)	Gross Output		Total Costs		Net Margin	
		(€/Ha)	(c/litre)	(€/Ha)	(c/litre)	(€/Ha)	(c/litre)
2011	850	3236	35.6	1838	20.3	1398	15.3
2012	869	3092	35.4	2143	24.7	948	10.7
2013	940	3689	40.0	2332	25.4	1357	14.6
2014	935	3725	39.0	2134	22.4	1591	16.9
2015	1091	3245	32.2	2145	21.2	1100	10.8
2016	1068	2935	28.3	1911	19.7	954	8.6
2017	1289	4508	38.4	2355	20.1	2153	18.4
2018	**1404**	**4530**	**37.6**	**2961**	**23.3**	**1571**	**12.6**

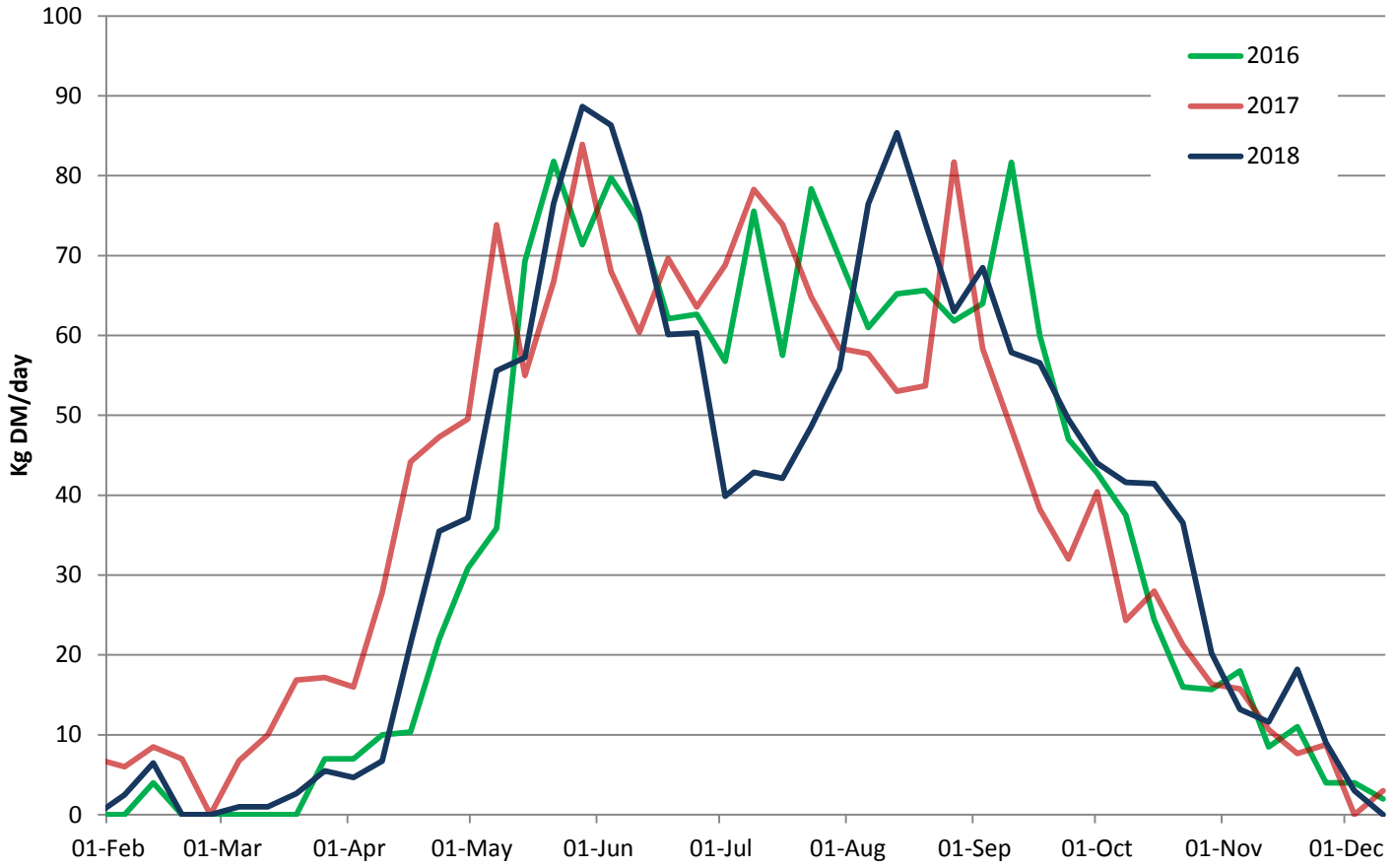
Grass Production 2018 (>22 walks)

	Date		Walks	Number Grazing	Grazing* Area (Ha)	Tonnes (DM/Ha)			
	First	Last				Grown	Spring	Summer	Autumn
Castleisland	1st Feb	30th Dec	37	8	49.7	**13.0**	0.5	7.1	5.4
Ballinagree	7th Feb	20th Nov	27	8	52.8	**11.3**	1.1	6.5	3.7
Doonbeg	12th Feb	28th Dec	37	7	43.9	**11.4**	0.3	6.7	4.4
Athea	12th Jan	30th Dec	39	7	39.3	**11.6**	0.5	6.9	4.2
Rossmore	7th Jan	20th Dec	26	8	29.5	**12.7**	0.7	7.5	4.5
Kishkeam	7th Feb	19th Nov	23	7	42	**9.2**	0.3	4.8	4.1
Listowel	1st Feb	20th Nov	24	6	31.3	**12.5**	0.6	6.6	5.3
Crossmolina	8th Mar	8th Nov	24	5	11.2	**8.9**	0.1	5.3	3.5
Stradone	24th Jan	16th Nov	36	5	37.8	**11.3**	0.3	7.1	3.9
Swanscross	22nd Mar	16th Nov	22	6	33.3	**11.2**	0.2	6.7	4.3
Average	6th Feb	2nd Dec	30	7	37.1	**11.3**	0.5	6.5	4.3

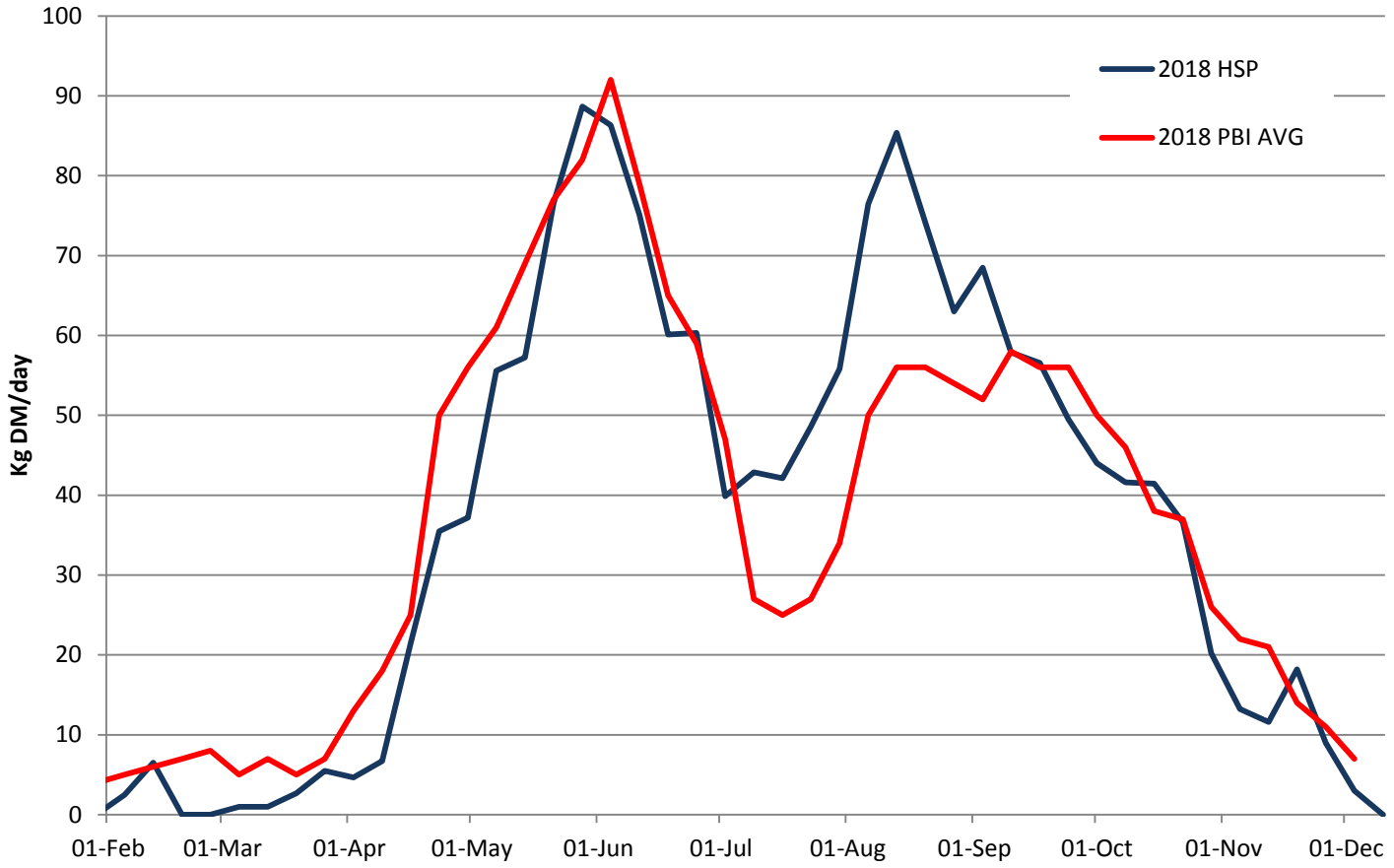
HSP Farms annual Grass growth 2011-2018

Year	Tonnes Grass Dry Matter/Ha
2011	10.6
2012	7.8
2013	10.3
2014	11.0
2015	11.3
2016	11.3 (10.7)
2017	11.9 (10.6)
2018	11.7 (11.3)

Grass Growth



Grass Growth



Soil Fertility: pH Status

Location	2013	2014	2015	2016	2017	2018
Castleisland	5.5	5.7	5.9	6.0	6.2	6.3
Doonbeg	5.8	5.8	5.7	6.1	6.1	5.8
Athea	5.5	5.8	6.2	6.5	6.6	6.6
Kishkeam	5.8	5.8	6.2	6.4	6.3	6.2
Listowel	5.7	5.5	5.9	6.0	6.0	6.0
Rossmore	5.8	5.8	6.2	6.2	6.2	6.4
Ballinagree	5.8	5.9	6.5	6.5	6.3	6.3
Crossmolina	5.4	5.6	5.7	6.1	5.9	5.8
Swanscross	--	--	6.4	6.5	6.4	6.3
Stradone	--	--	6.2	6.5	6.6	6.7
Average	5.7	5.7	6.1	6.3	6.3	6.2
Target	6.2	6.2	6.2	6.2	6.2	6.2

Soil Fertility: Phosphorus mg/l

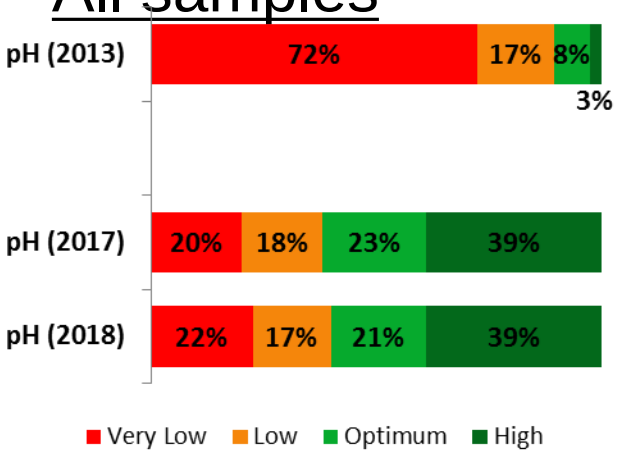
Location	2013	2014	2015	2016	2017	2018
Castleisland	4.7	6.4	4.2	5.3	5.2	7.1
Doonbeg	4.9	5.6	5.5	4.1	5.2	6.1
Athea	3.1	4.9	3.7	3.9	4.2	8.0
Kishkeam	1.9	4.4	2.8	3.1	3.4	6.2
Listowel	5.4	9.8	6.5	5.5	5.9	7.0
Rossmore	8.5	11	10.7	10.1	8.2	7.0
Ballinagree	5.6	6.5	5.1	6.2	5.5	5.8
Crossmolina	7.6	3.4	4.4	5.8	6.2	6.6
Swanscross	--	--	6.2	5.8	5.9	5.2
Stradone	--	--	3.1	5.1	4.1	6.5
Average			5.2	5.5	5.4	6.6
Target	5.1 – 8.0	5.1 – 8.0	5.1 – 8.0	5.1 – 8.0	5.1 – 8.0	5.1 – 8.0

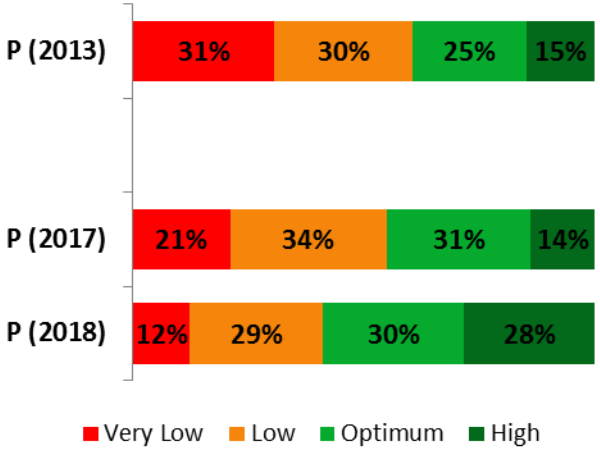
Soil Fertility: Potassium mg/l

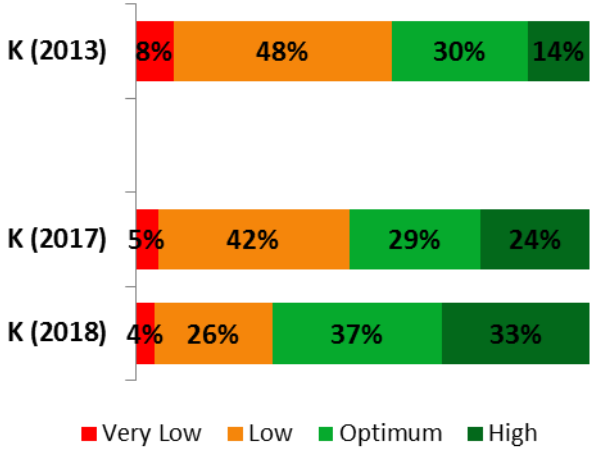
Location	2013	2014	2015	2016	2017	2018
Castleisland	94	110	87	103	109	147
Doonbeg	74	96	91	64	84	122
Athea	134	125	104	106	98	154
Kishkeam	82	112	88	86	99	142
Listowel	89	140	105	74	91	98
Rossmore	97	95	106	111	108	99
Ballinagree	144	155	115	154	145	156
Crossmolina	105	112	73	92	107	142
Swanscross	--	--	170	150	165	156
Stradone	--	--	142	153	152	145
Average	102	118	108	109	116	136
Target	101 – 150	101 – 150	101 – 150	101 – 150	101 – 150	101 – 150

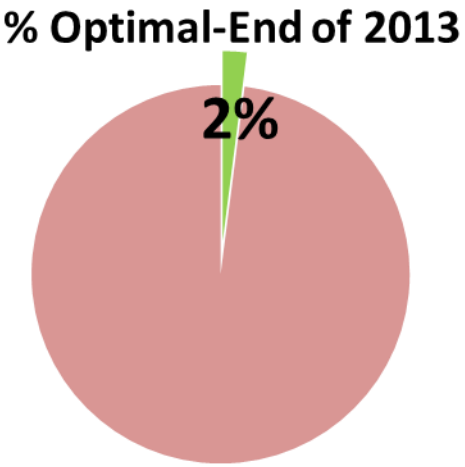
Soil Fertility: Progression

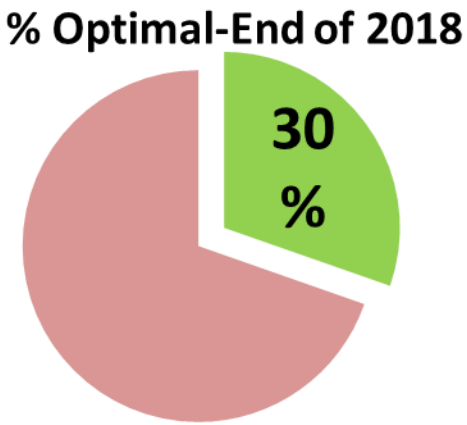
All samples





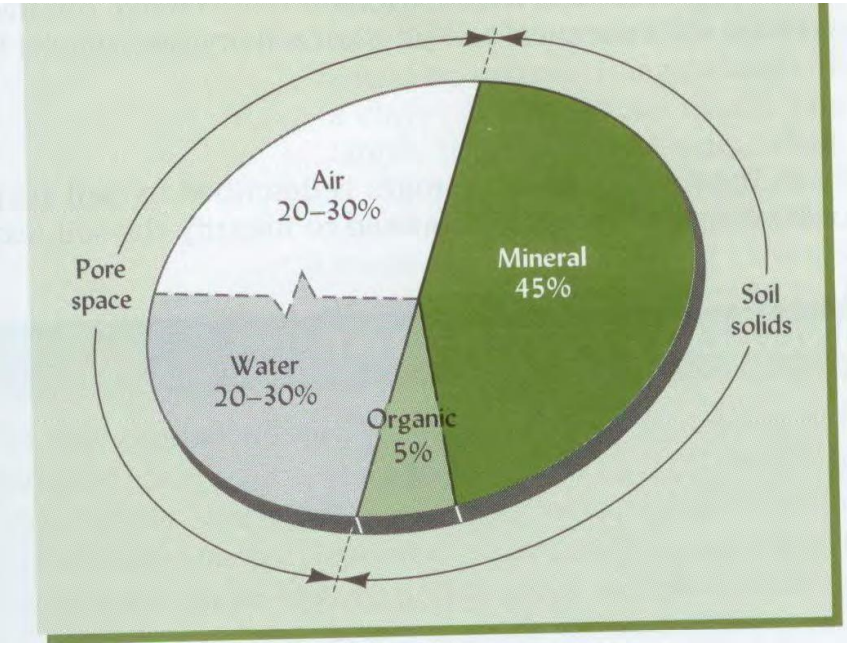






Introduction to Land Drainage

Soil Phases



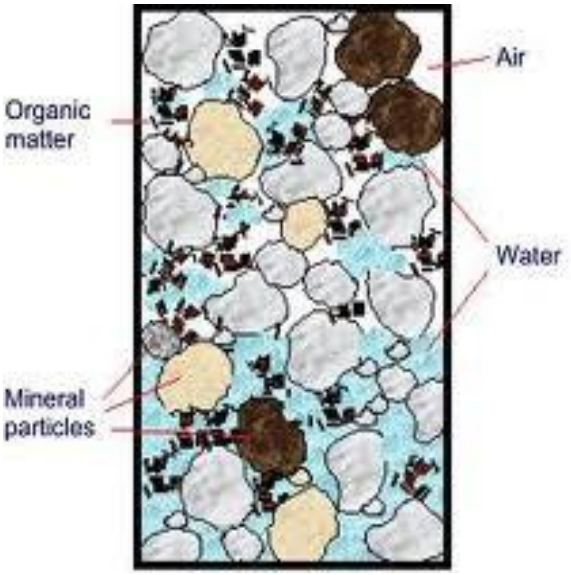
- Air and water phases occupy the pore space and are complimentary
- Pore space in a saturated soil is filled with water.
- Crops require a minimum 10 -15% air filled pore space for water and nutrient uptake

Soil Solids

Soil solids consist of mineral and organic materials

Organic Material (<10% in mineral soils)

- Stores water and nutrients
- Binds mineral particles

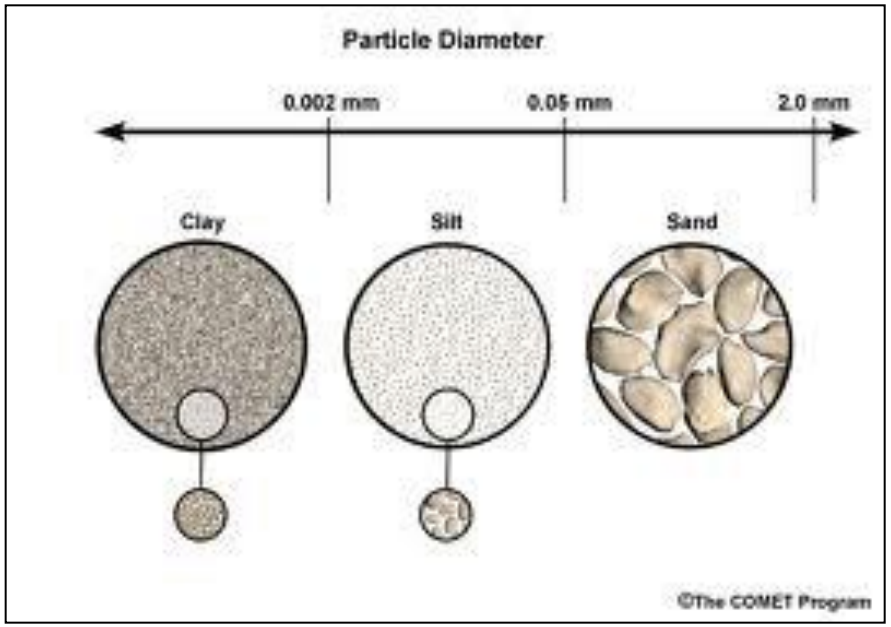


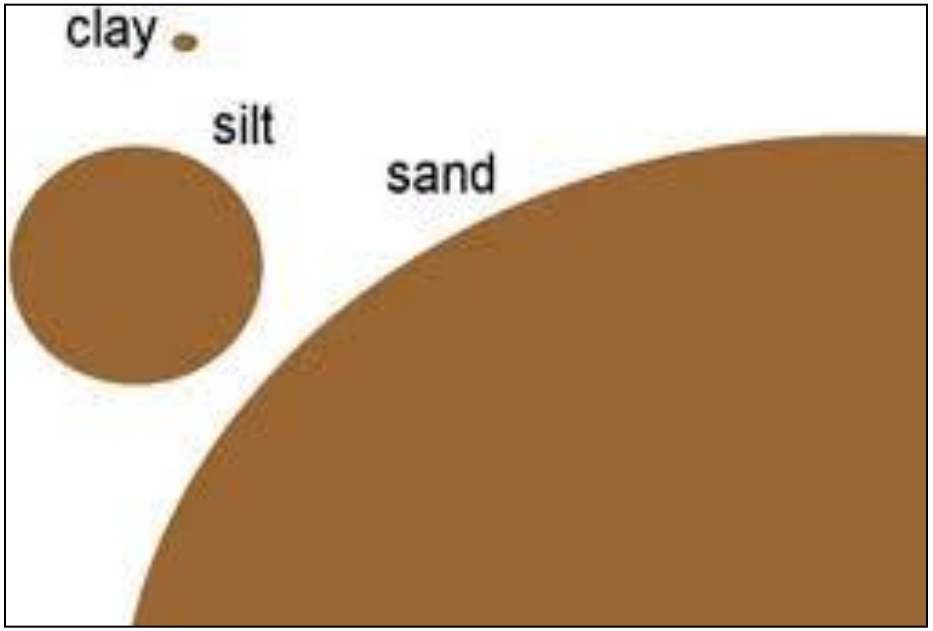
Mineral Particles

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

Soil Texture

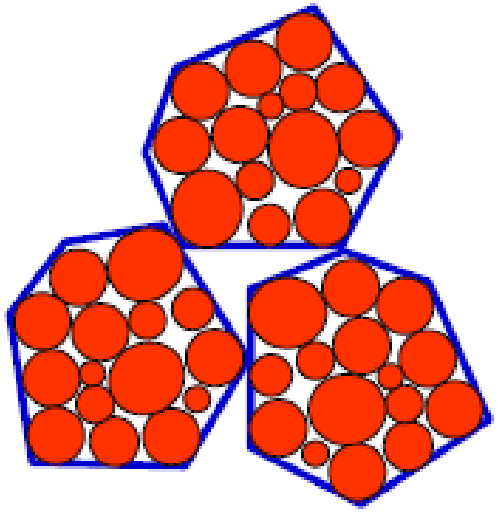
- The relative proportions of sand, silt and clay particles in a soil
- Anything bigger than 2mm is gravel/stone





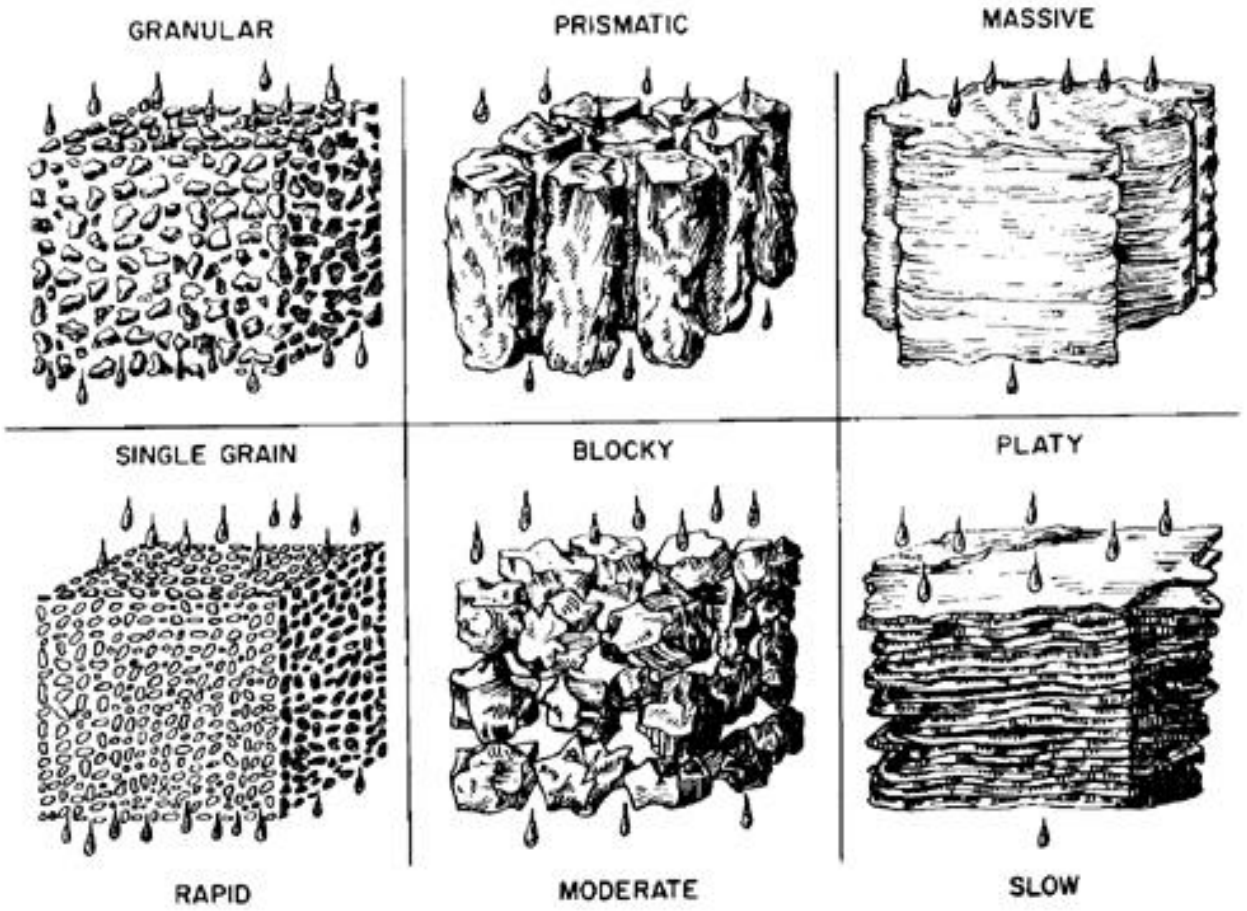
Soil Structure

- 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



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:

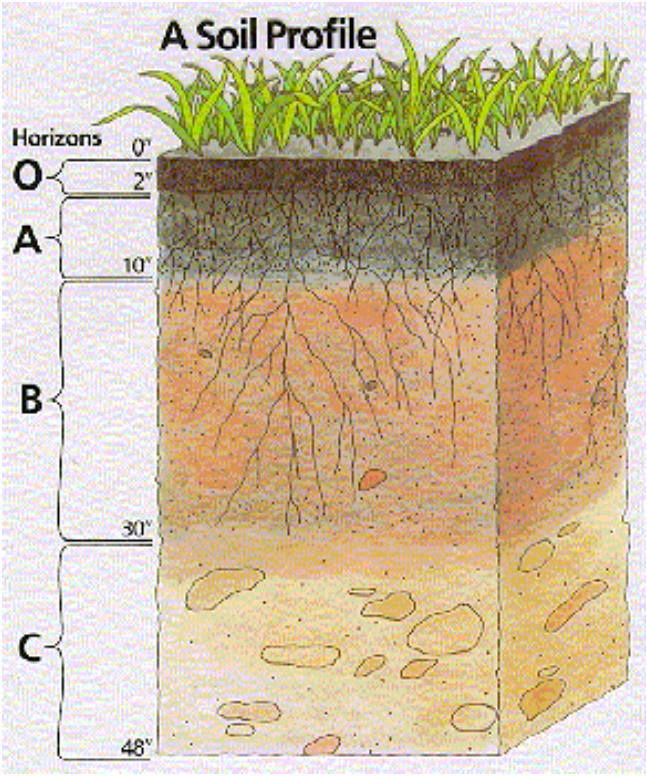
  - O: An organic horizon

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…..


20
40
60
80
1
20
40


20
40
60
80
1
20
40


20
40
60
80
1
20


20
40
60
80
1
20

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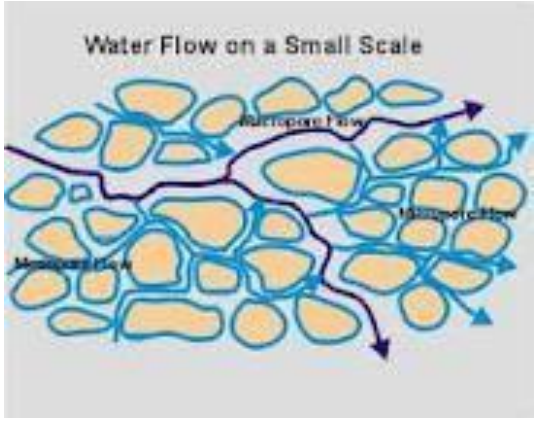
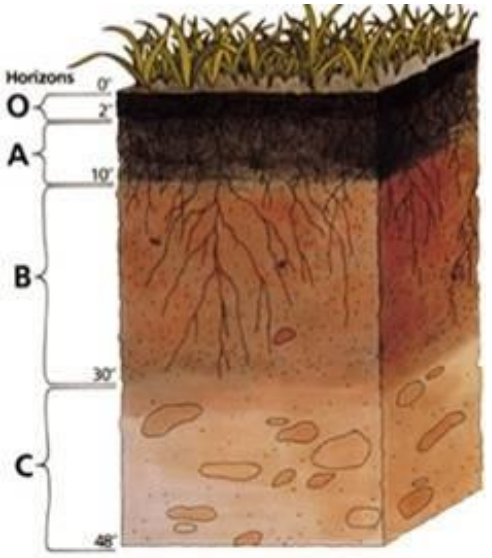
Water movement through Soil

- 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 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 of the test pits.

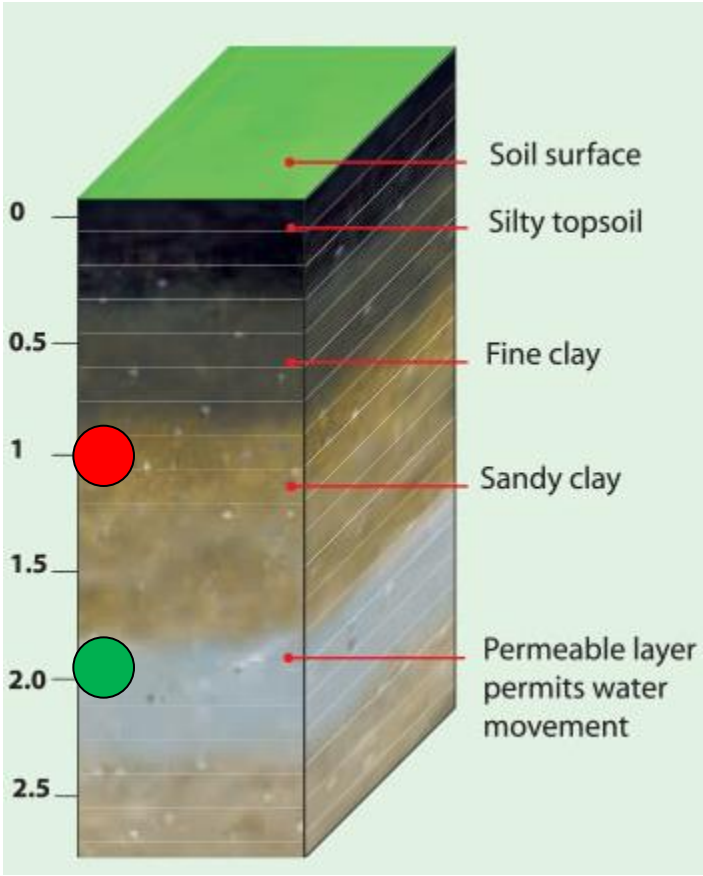
- Two principle types are distinguished:

  - **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

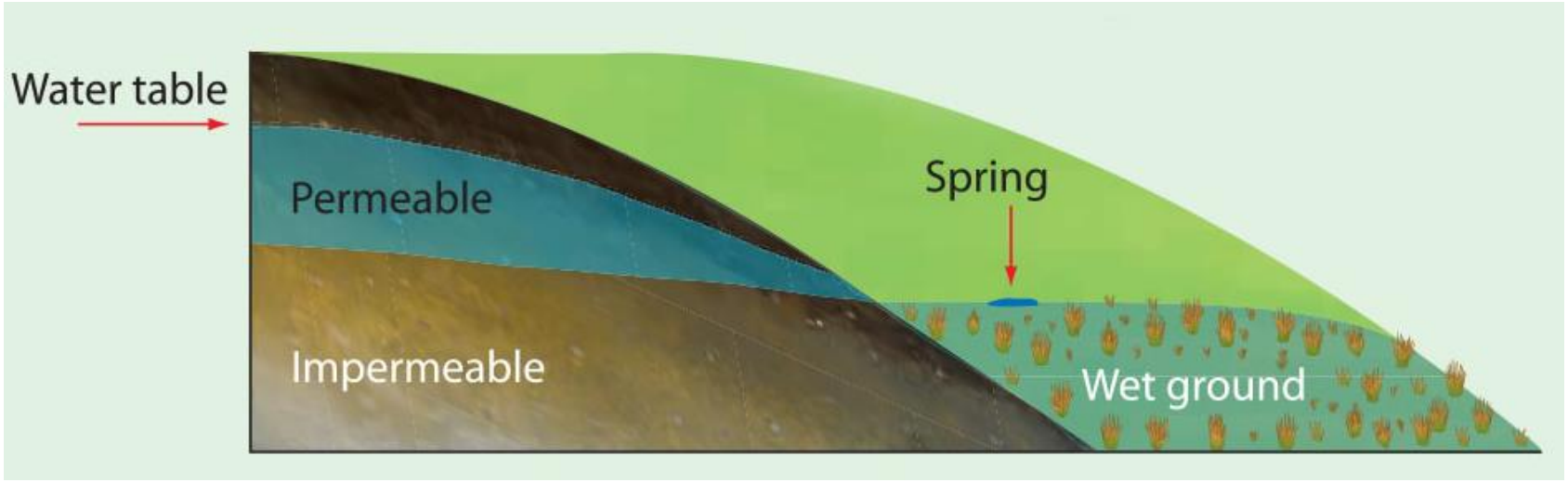
Groundwater Drainage System

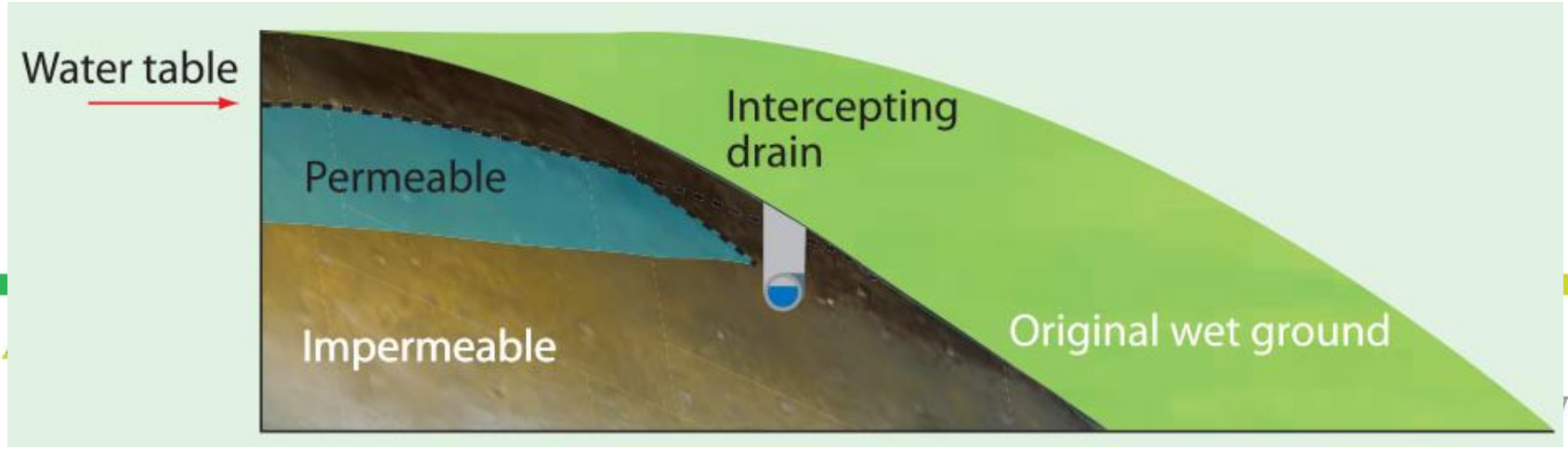
- **Where inflow of water to test pit**
- Controls the watertable by discharging groundwater
- Exploit layers of high permeability
- Lower watertable allows for natural (cracking, root penetration) or artificial (sub-soiling/ripping) improvements in permeability in the shallower layers



Groundwater Drainage System

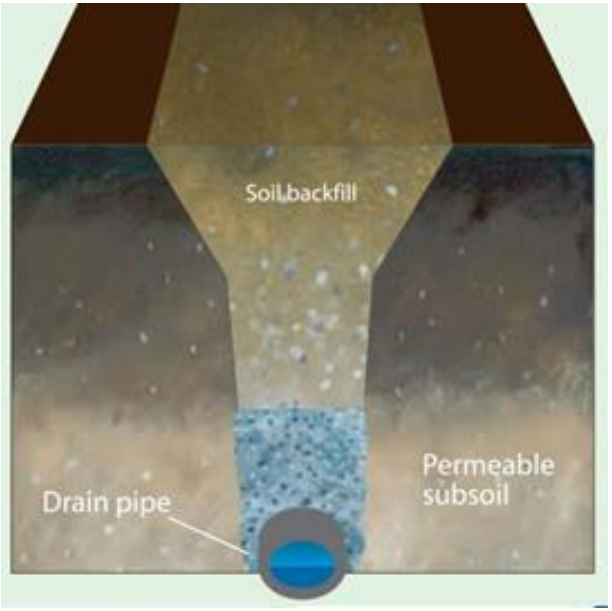
- Groundwater seepage and springs





Backfilling groundwater drains

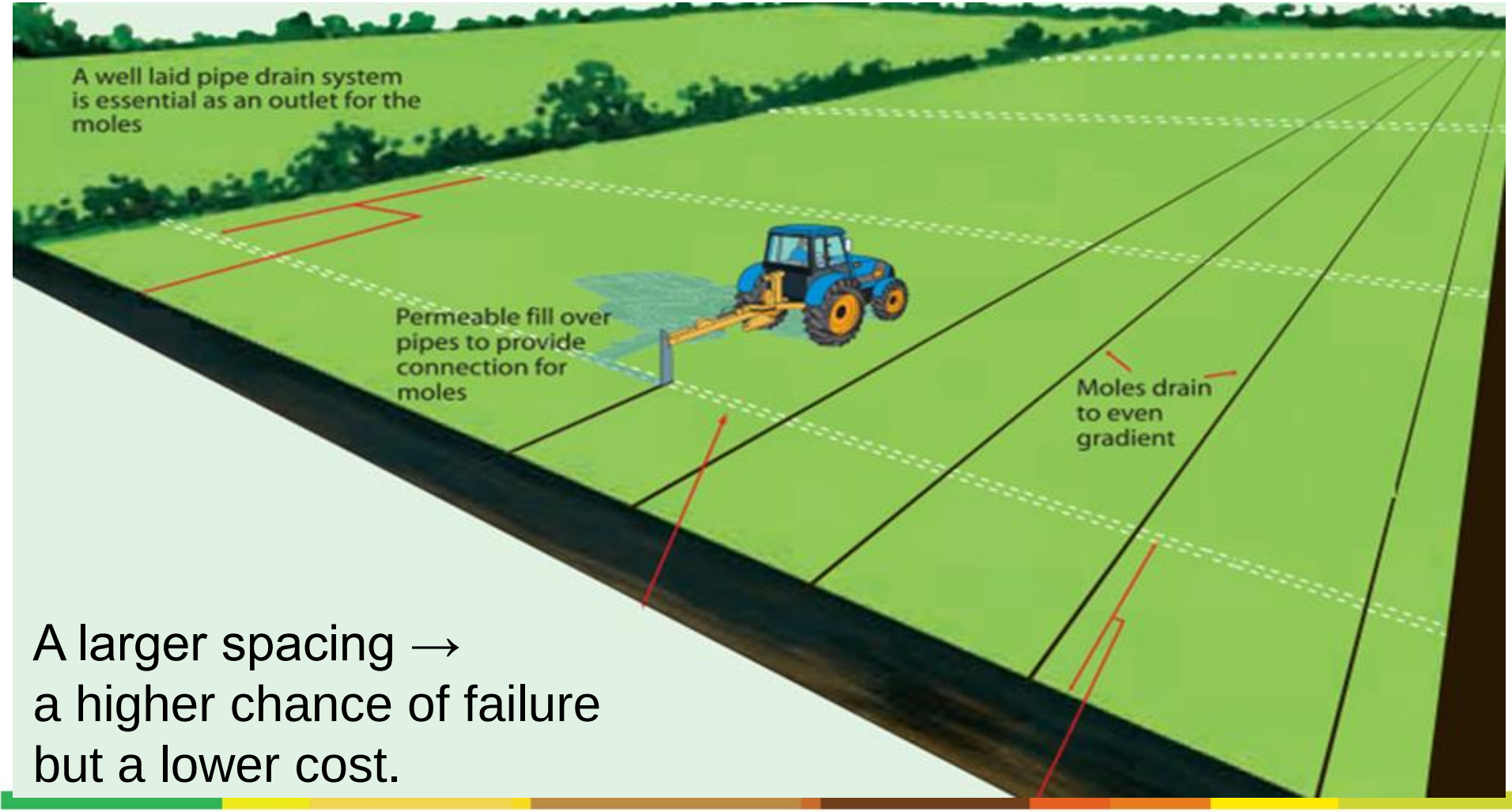
- Drainage stone should:
  - be filled to a **minimum depth of 30 cm** from the drain bottom
  - provide connectivity with layer of high permeability
  - be **clean** aggregate (10-40 mm / 0.4 -1.5 inch)



Shallow Drainage System

- **Where no inflow of water to test pit**
- NO permeable layer to be exploited
- Drainage must incorporate a soil disruption technique in tandem with collector drains.
- The aim of such a system is to improve soil structure and permeability

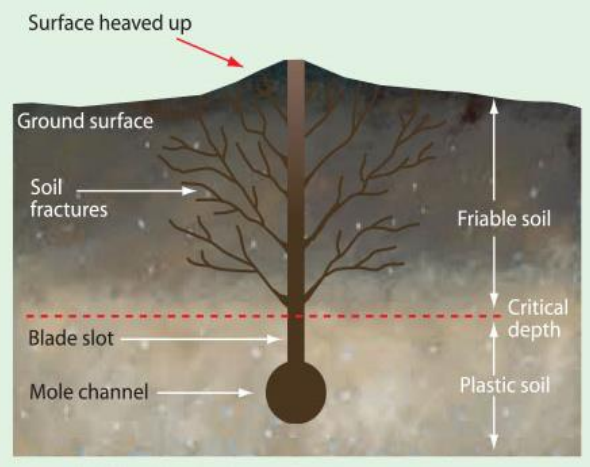
Shallow drainage-collector drains



A larger spacing →
a higher chance of failure
but a lower cost.

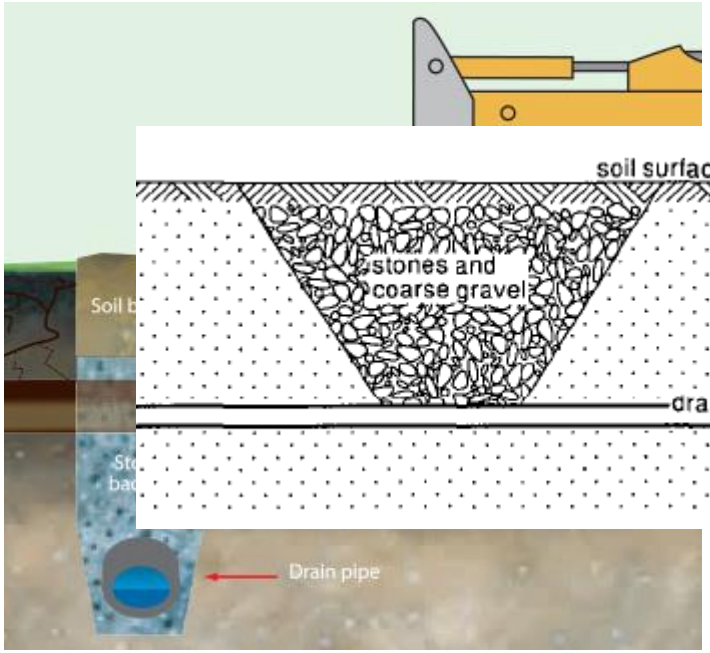
Shallow Drainage

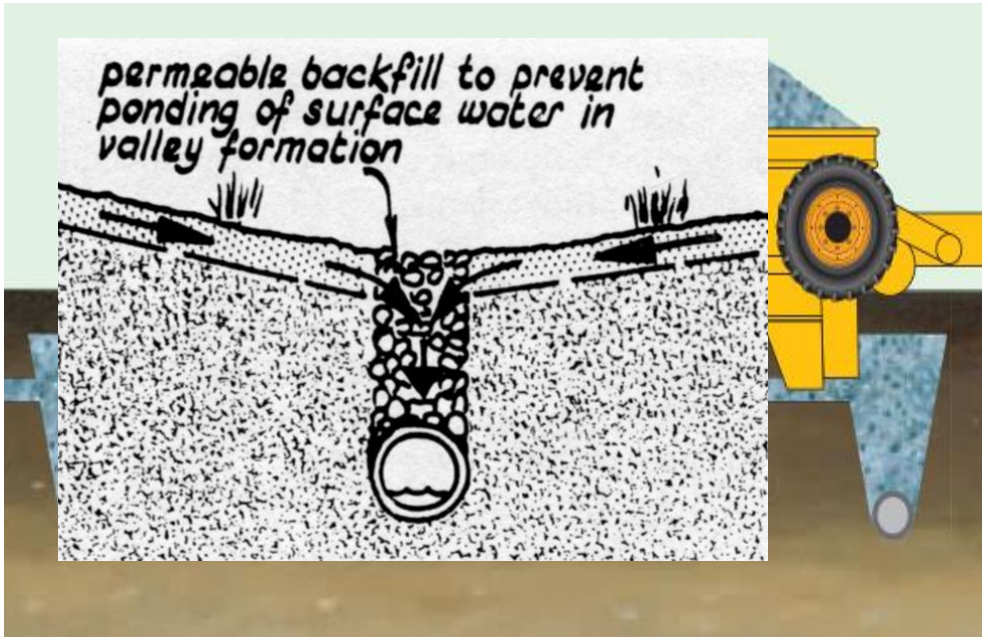
- **Mole drainage**
  - Increased permeability at shallower depths and creates drainage channel
- **Gravel mole drainage**
  - Gravel moles increase lifespan (extra cost)
- **Subsoiling/Ripping**
  - To break a pan at shallow depth or to supplement both shallow and groundwater drainage systems
- **Carried 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)





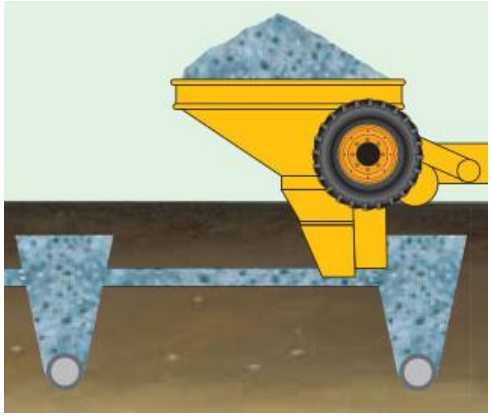
Drainage pipe and stone

- The drainage pipe facilitates a unobstructed flow path from the field drain.
- Only short drain lengths (less than 30 m) are capable of operating at full efficiency without a pipe. (also allows maintenance)
- 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
- Stone backfill should be **clean** aggregate (5-40 mm)

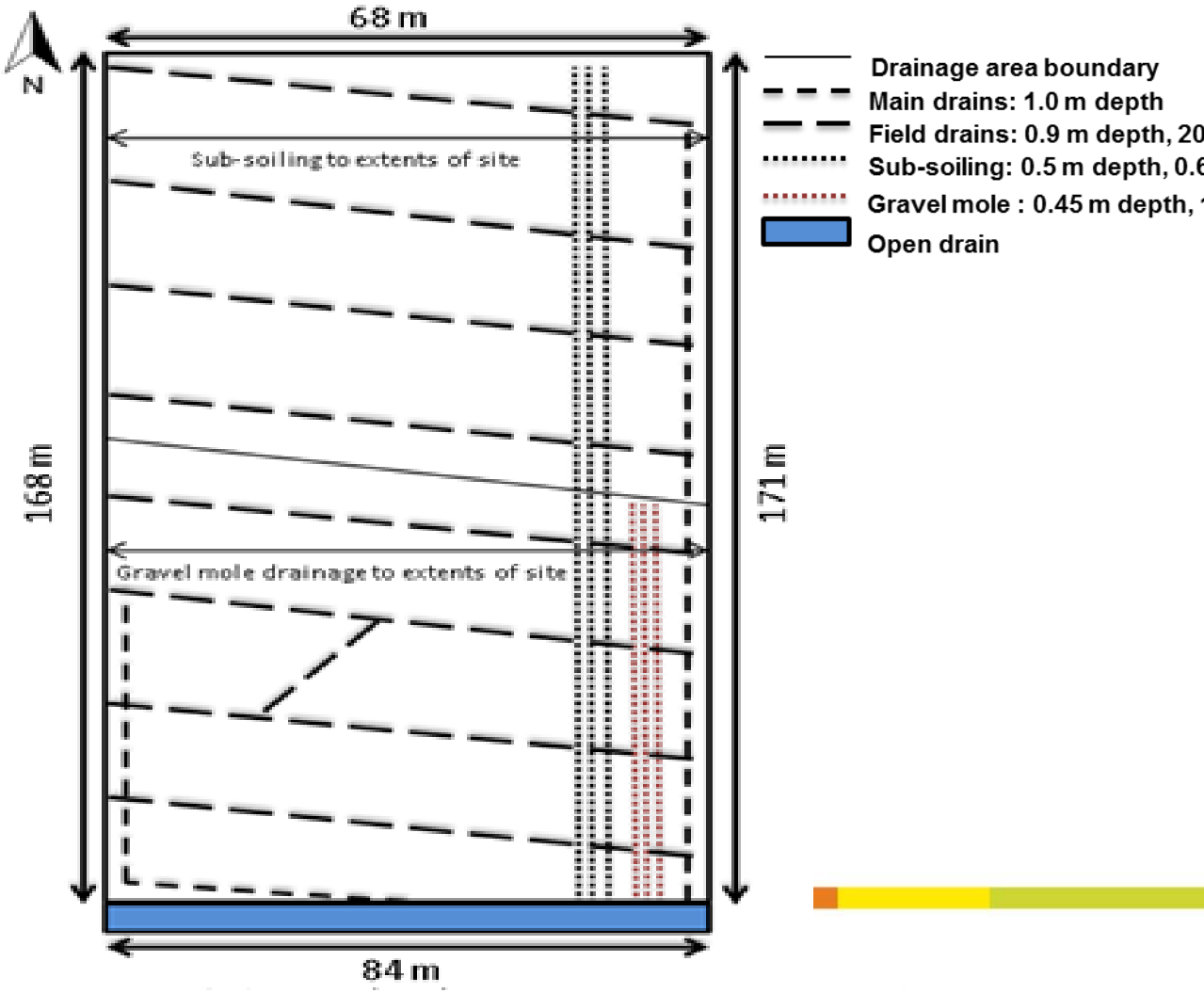
Land Drainage Design: Castleisland

Heavy Soils

Problem Diagnosis



Drainage System Design



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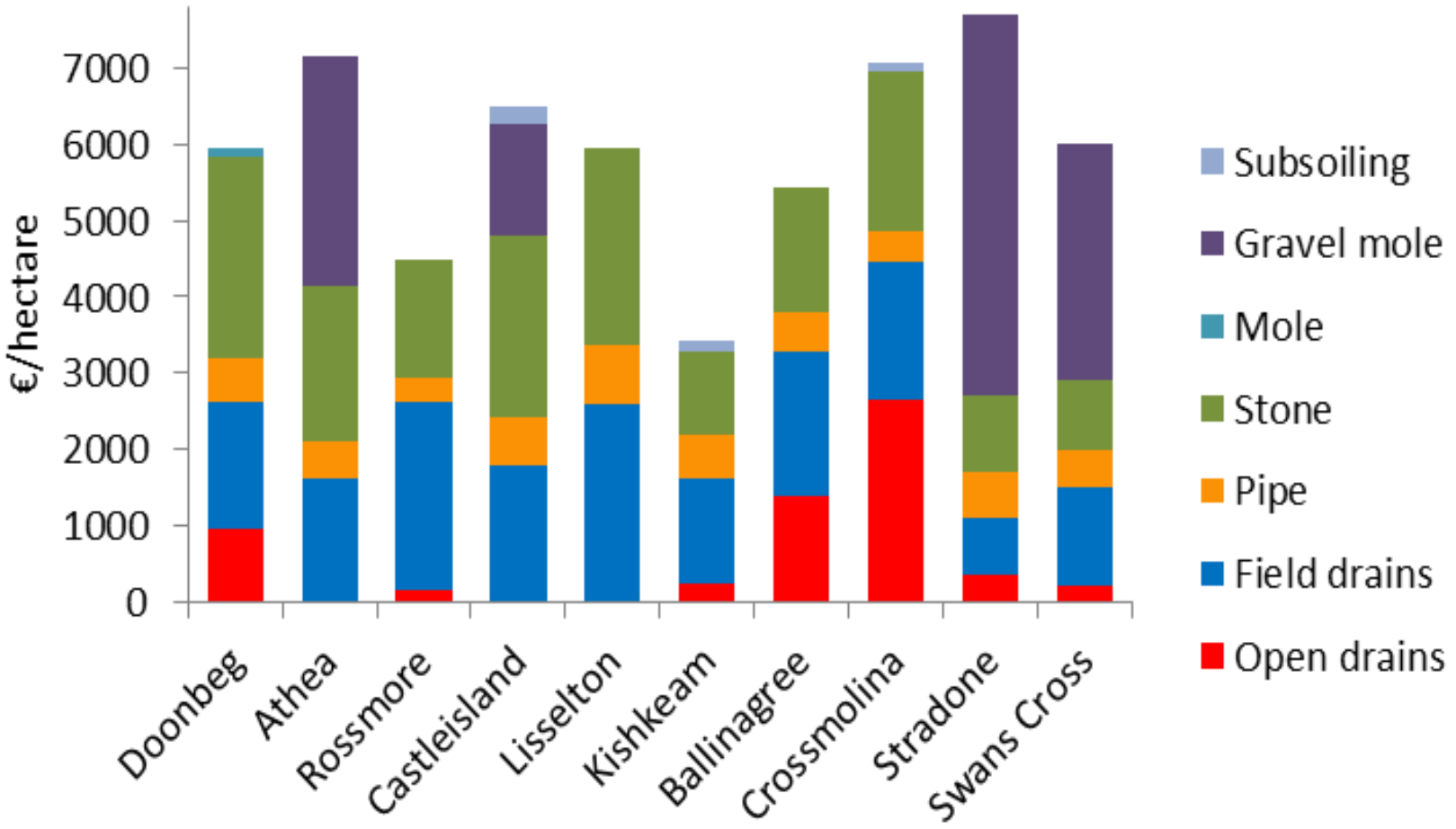
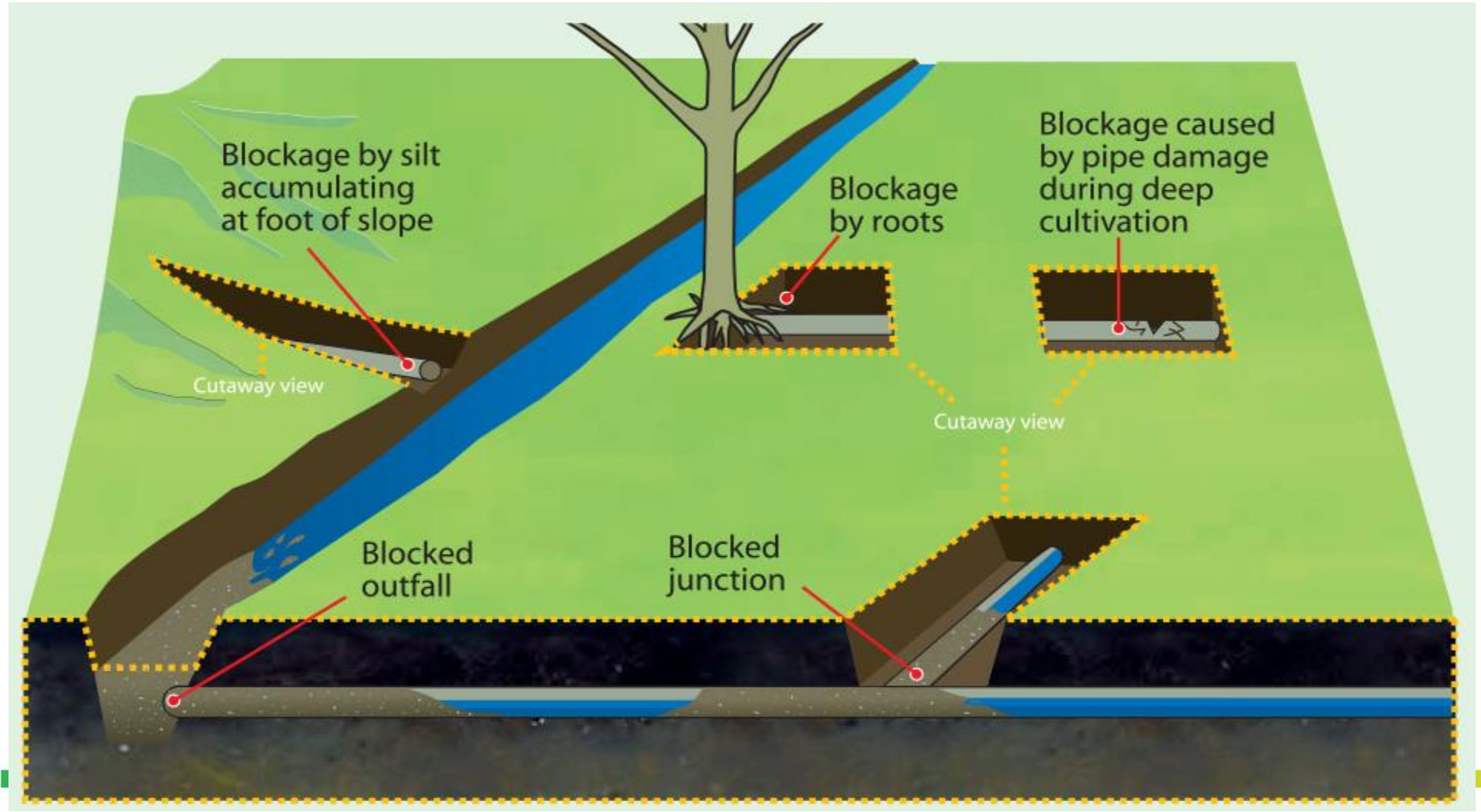
Drainage Costs: Rossmore Farm

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

Approximate costs



Maintenance



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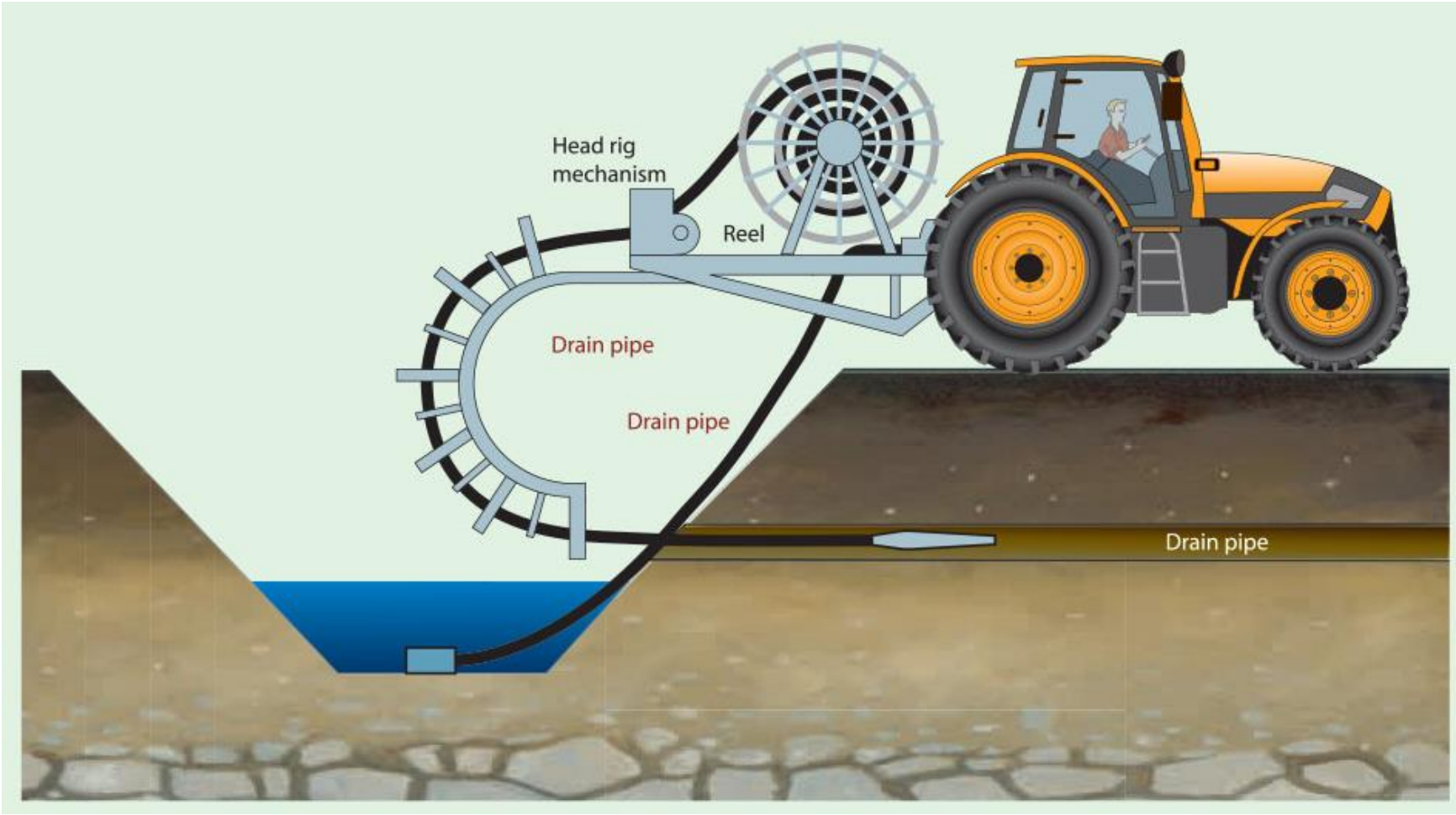


References

- Teagasc Land Drainage guidebook
- Teagasc Manual on Drainage and soil management

Grazing Infrastructure-Main Issues

- An audit of infrastructure carried out on HSP farms during 2018

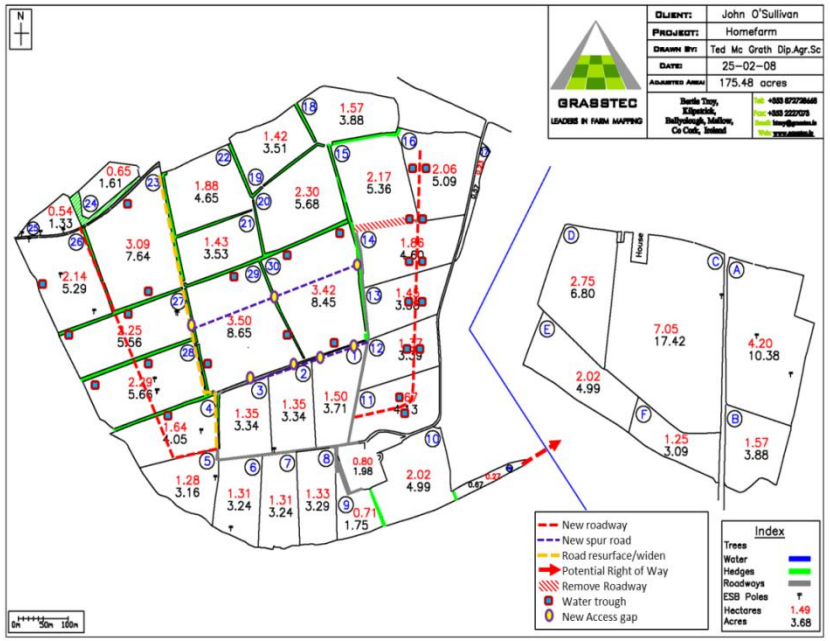
- Paddocks
  - Inadequate sizes
  - Access-too far from roadway network or too few gaps
  - Poor use of spur roads in larger paddocks
  - **Drainage issues**

- Roadways
  - Large variations in surface condition
  - Inadequate width
  - Poor layout/configuration in places

- Water supply
  - Not enough troughs
  - Poor flow rates

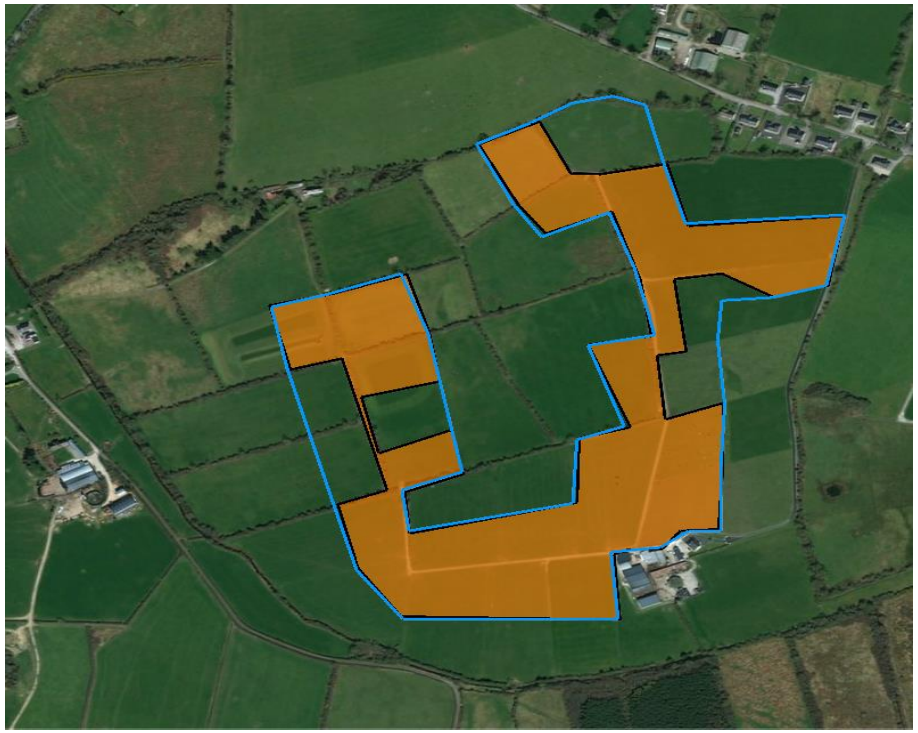
Infrastructure Audit-J. O' Sullivan

- 570 m of roadway (Paddocks 11 – 16) plus fencing
- Additional water troughs
- 615 m of spur roadways
- Additional gaps through boundary ditch (rented ground)
- Road surfaces and gaps, particularly those on rented ground need attention.
- 550 meters of new roadway to service rented ground planned
- Potential access to nearby out-block, 320 m away (Right of way)

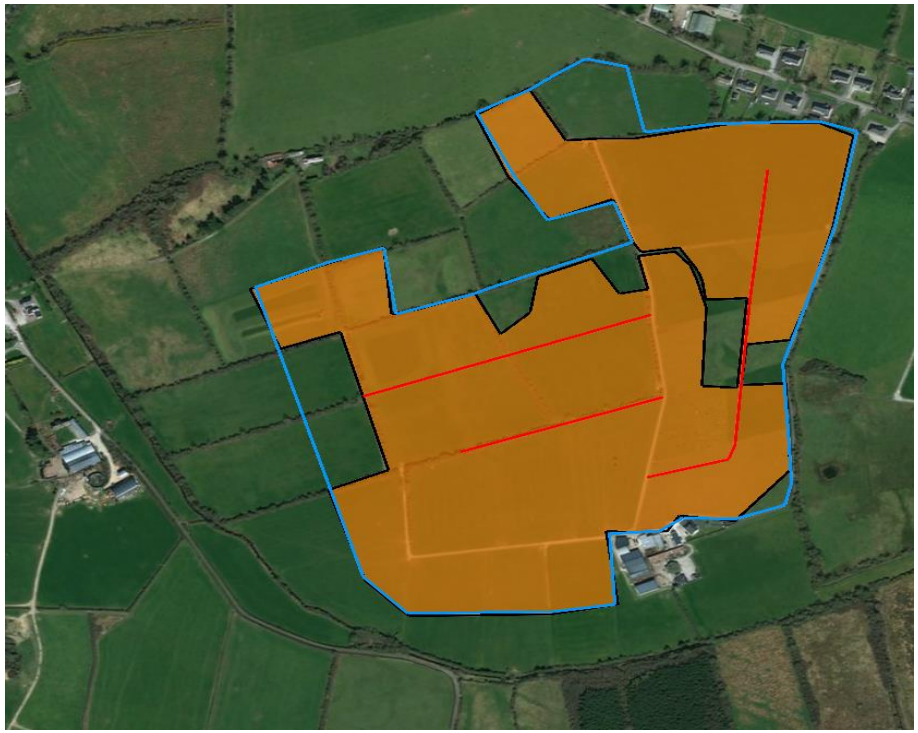


Infrastructure Audit-J. O' Sullivan

Previously



Currently



Questions?