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FAS Soil Drainage Event

- Soil Drainage
- -“Back To The Future”
- Seamus Donnelly BSc Soil Science
- SAC/SRUC Senior Consultant
- Stranraer

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Drainage problems-Too much Water?

- " received 125-135% between November 2011 to October 2012 as a % of 1971-2000 average".

Rainfall (mm)	**2010**	**2011**	**2012**
April – September	295mm	405mm	588mm
		(+37%)	(+199%)

"SEPA-Concession on slurry spreading

NFU Survey—assistance "targeted at drainage repairs…"

Drainage problems-Old Systems Failing?

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"In the future,farmers believe long term resiliance to volatile weather can be built into our farming systems by ensuring that Rural Development Funding supports items such as drainage ,reseeding,upgrading gateways,crop storage and slurry storage "

Nigel Miller ,NFUS

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Drainage problems

SOS SAVE
OUR
SOILS

Soil Fertility-pH 1000 samples
27% below pH5.5……56%below pH 5.8

Soil Structure

Soil Drainage

WHY ?

Scot Gov - Key Drivers in improving Carbon Footprint
Scottish Farmers---Maintain production/improve efficiency

Drainage Problems

- Ground water
- Surface water—main problem
- Springs
- Water on the surface-------major NEW problem

Drainage of permeable soils - ground water problem

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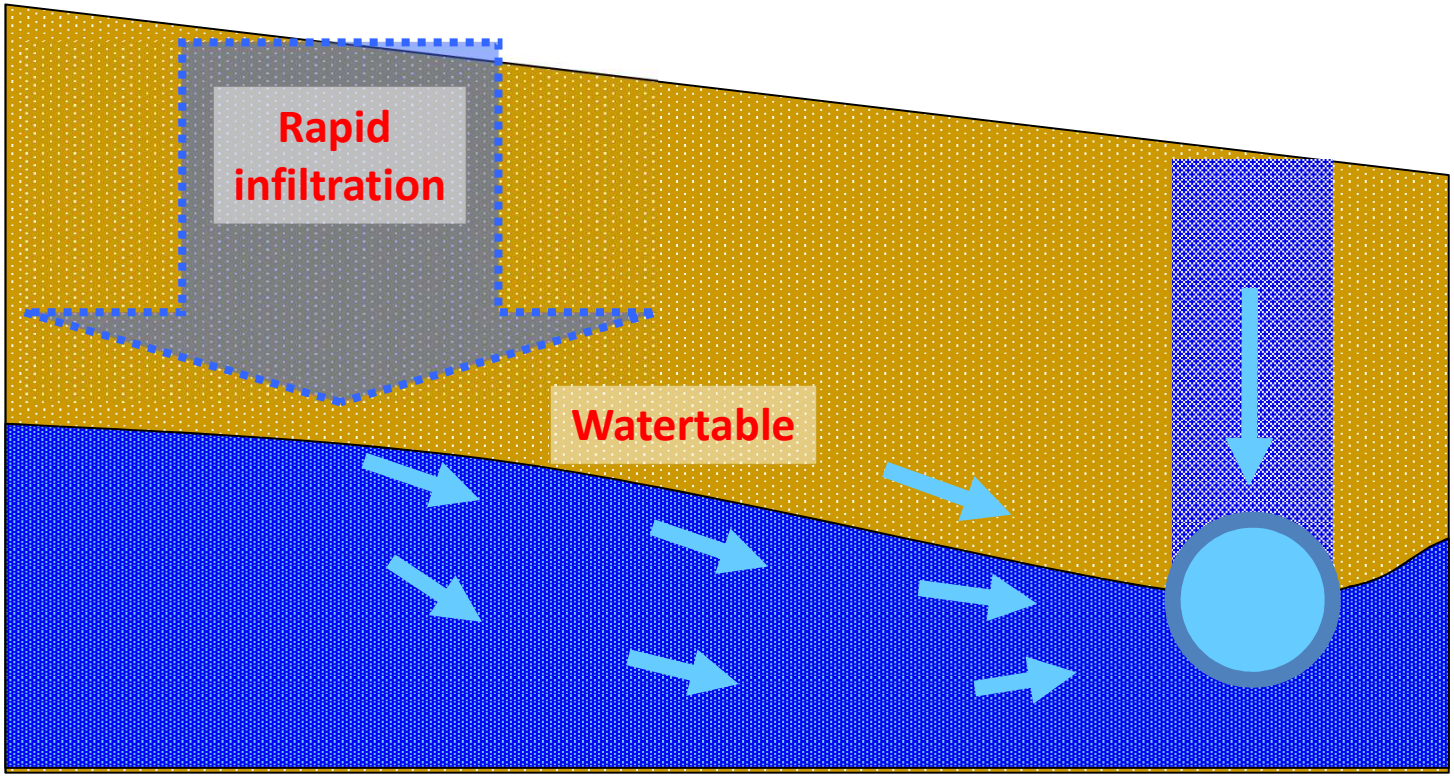

No permeable backfill necessary

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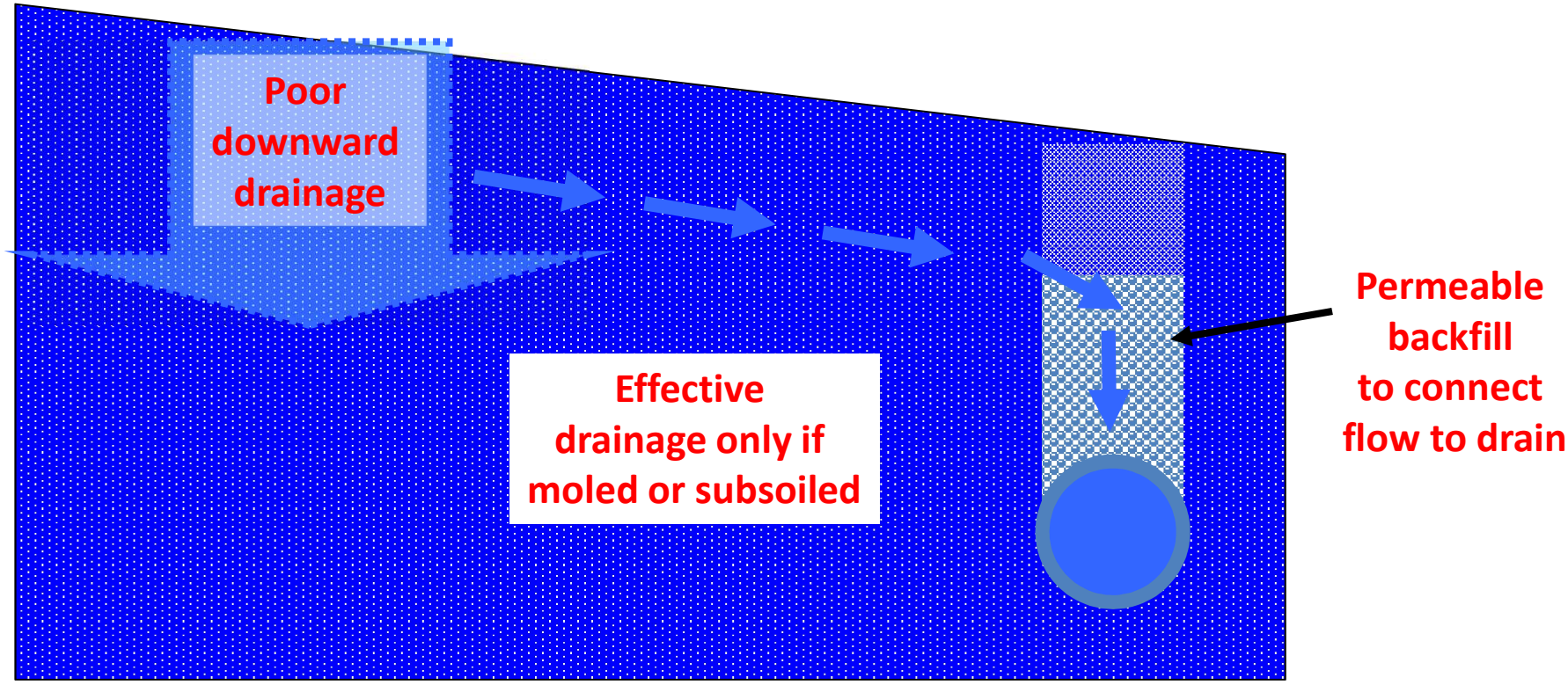
Drainage of impermeable soils - surface water problem



Must have gravel backfill to connect to drains

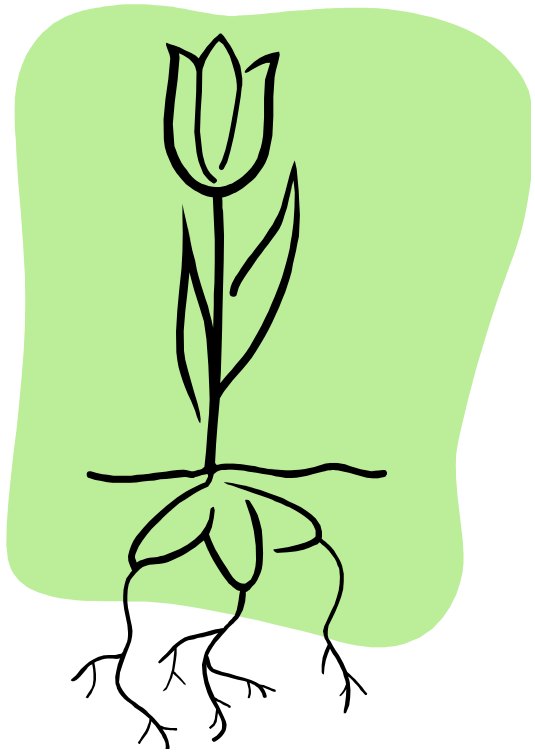
Waterlogging/Poor Drainage

- Encourages rushes/buttercups
- Reduces crop yield
  - low nutrients, toxins, oxygen deficiency etc.
- Affects soil management, e.g.
  - cultivation machinery choice
  - cultivation timing
  - cultivation energy input (number of passes required)
- Reduces access to the field
- Reduces optimum timing for harvest without causing compaction damage
- **Wastes Fertiliser!**

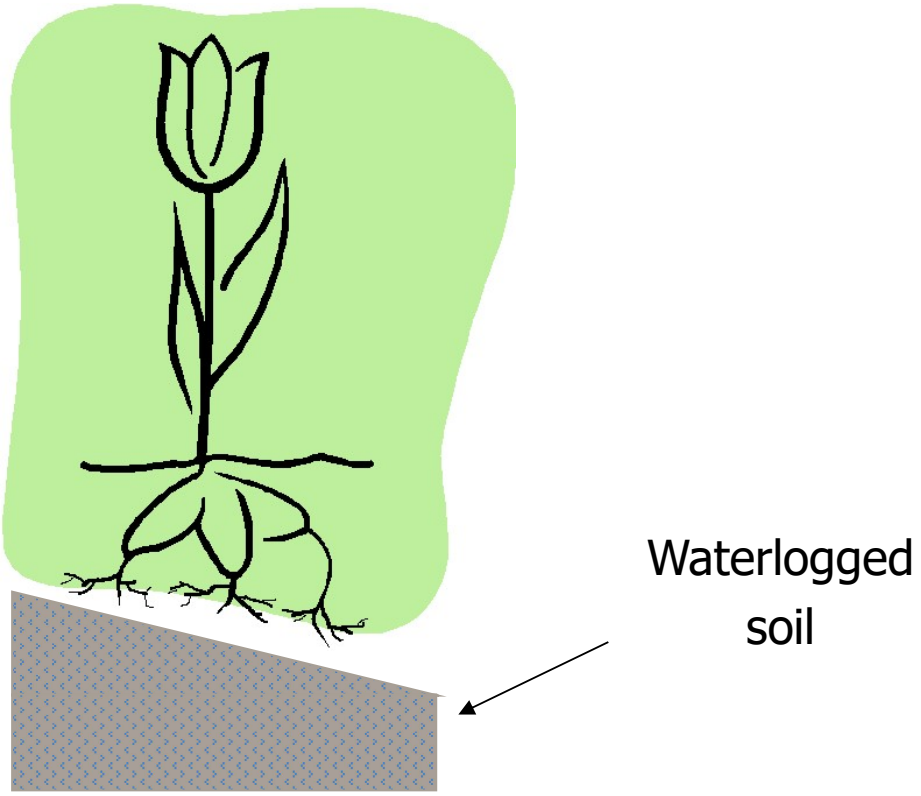
Benefits of Good Drainage

- Improved root growth
- Better crop and grass yields
- Better animal health – reduces risk of some parasites and diseases
- Less surface run-off (diffuse pollution)
- Less soil damage
- Longer utilisation of fields
- Lessens risk of flooding (in towns)

Effect on root growth



With drains



Without drains

Effect of poor drainage on yield

Ton/ha	Freely drained	Poorly drained
Potato	40	15
Bean	10	2
Carrot	40	5

How do you know when a soil has poor drainage?

How do you know when a soil has poor drainage?

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- Water lies on the surface
- Water can be seen in a soil pit-often base topsoil
- Roots are brown and shallow
- Dull grey colours (rusty or multi-coloured)
- Mottled colours in subsoil
- “Sour” smell
- Unrotted manure or crop residues

Imperfectly drained soil

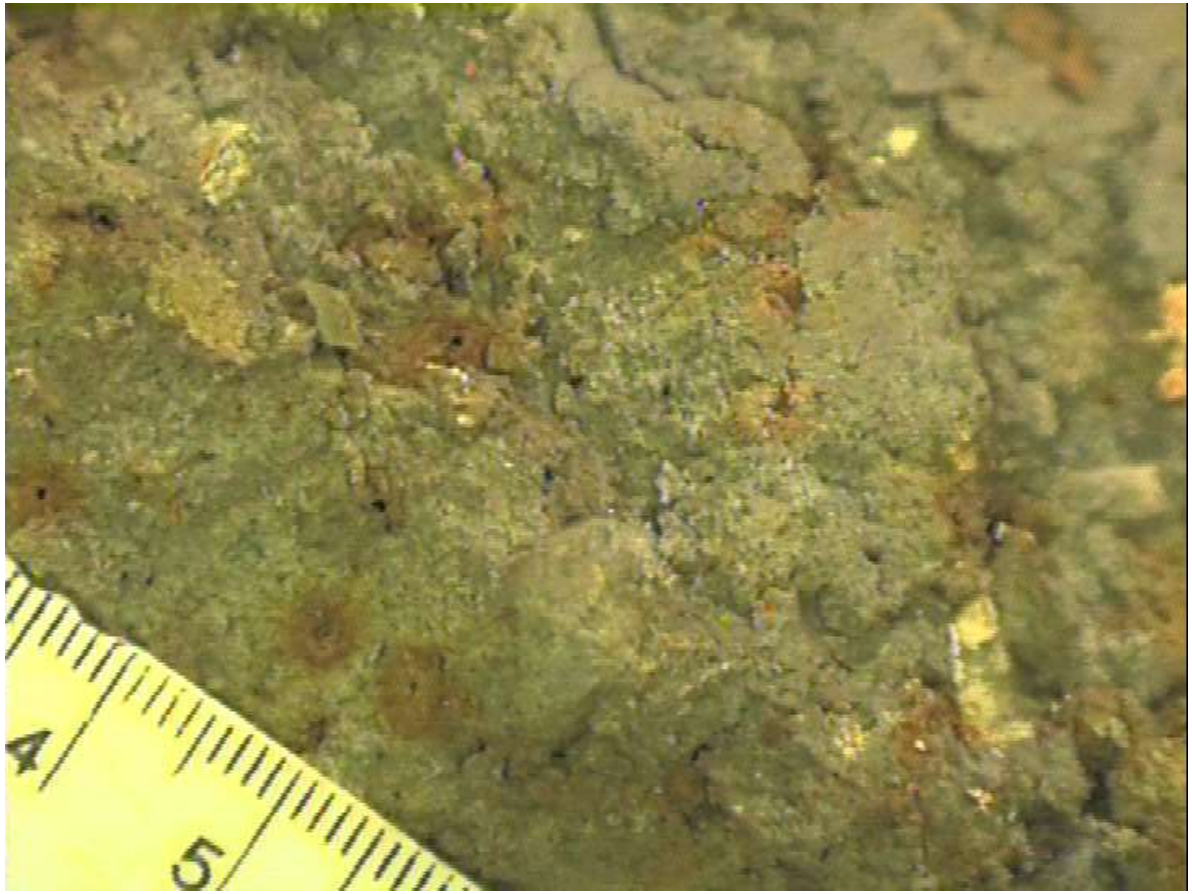
Subsoil texture impedes drainage

Dull blue/grey colours

Rusty mottles

Surface Water Gley

Mottled subsoil



Gleys soils

Blue/grey colours

Rusty mottles

Shallow groundwater leads to waterlogging

Well drained soil

Brown Earth

Which is the gley?

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How do you Improve Drainage ?

- Investigate the site
- Identify the problems
- Prepare a plan
- Budget the plan
- Prioritise the solutions
- Carry out the work
- Record the work carried out

Soil damage due to Livestock

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Soil Damage due to Machinery

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Where do you start? Identify the problem

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Start with Ditch/Outfall

- Does main ditch need cleaning-when/how
- (Exclude livestock where possible)
- Are pipe outfalls and culverts clear-is water running

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Where do you start?
Investigate existing drainage scheme

(Speak to father/grandfather etc----look out old 1:2500 maps/drainage reports-late 70's)

- Dig Holes to look at existing Drains- are they silted /rooted up/ochre/clear/under water
- Decide what is the REAL problem
- Decide Maintenance vs Partial vs New

Quick History of Drainage

360 AD Palladius-”trenches half-filled with pebbles (or sticks)

1610 De Serres-”mother trench with henfoot branches”

1650 Capt Blyth-”problems of groundwater or surfacewater”

1735 Hugh Dalrymple Invented hollow-pipe drainage

1763 Elkington-”deep ditches to intercept water”

1831 James Smith ,Perth-”parallel shallow drains never over 30”deep and 10-24ft spacing”

1843 John Reede –invented the clay tile

1955 Ziegler invented HDPE-the plastic pipe used in 1970s

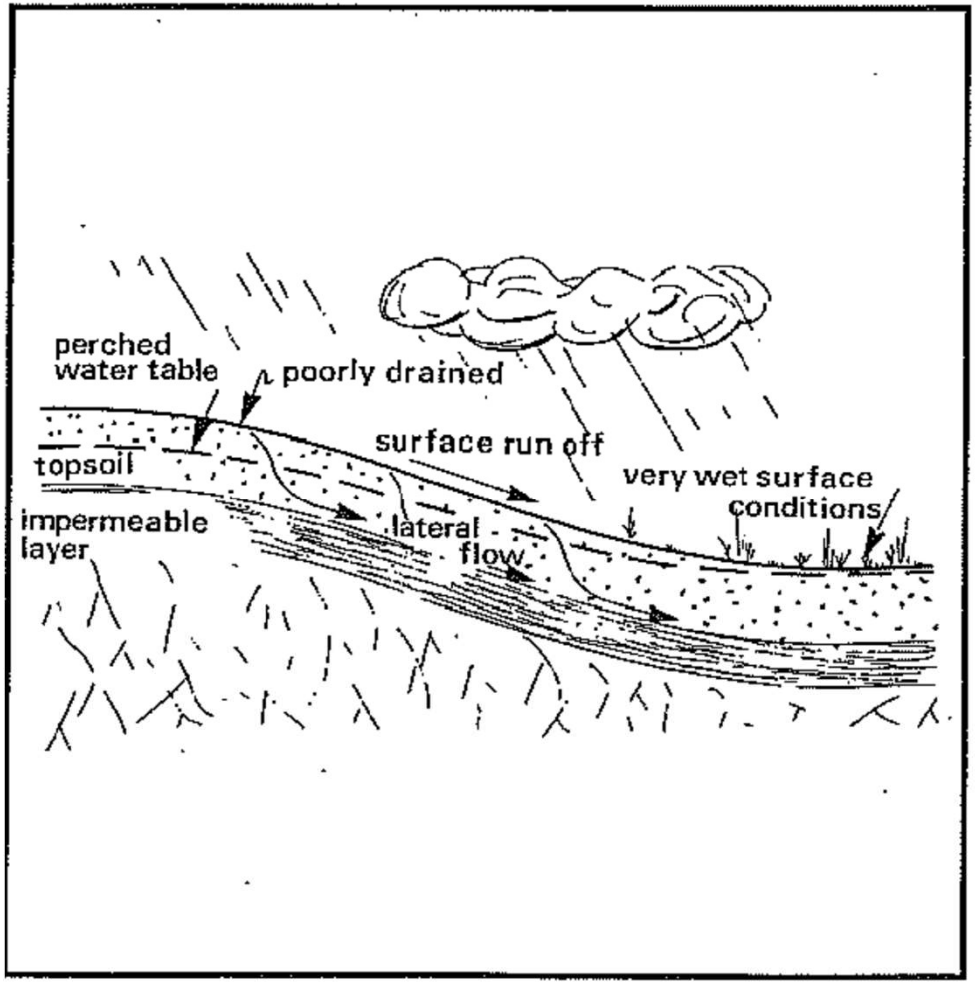
1976 Trencher/Trenchless Machines into D & G

New Drainage

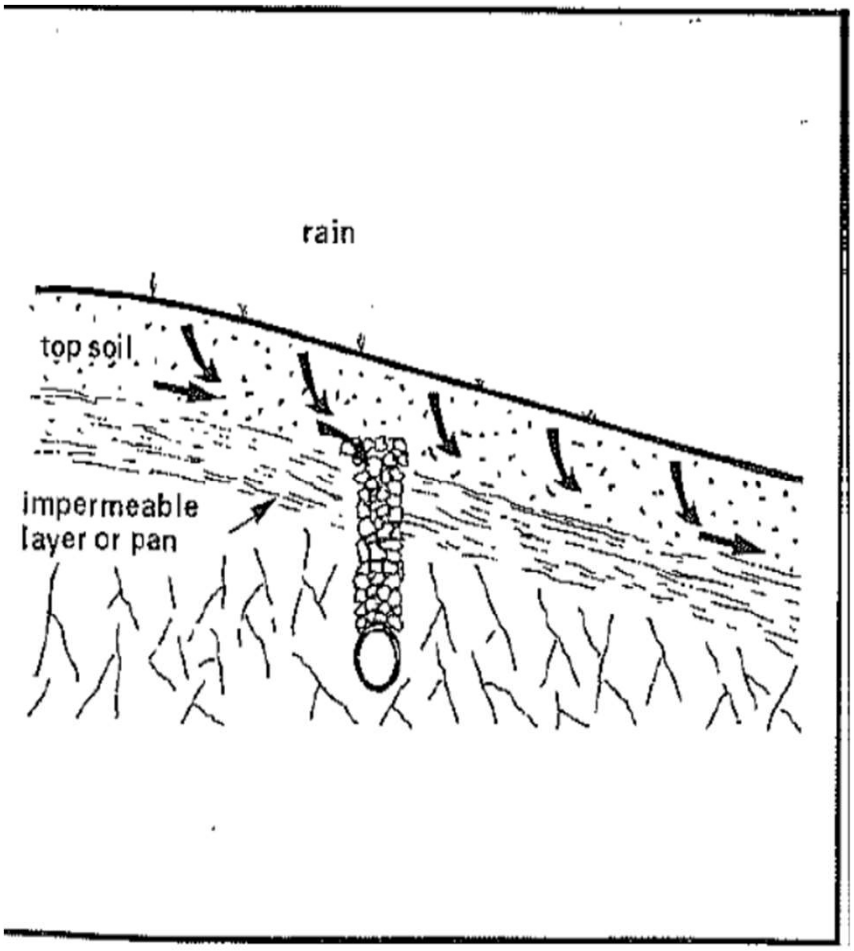
- Drainage is expensive – prioritise areas to be drained ---if no old system avoid

  ---peat-low priority(unless Irish)
- Are you allowed to drain /need concessions?
- Collaborate with neighbours where possible to maximise benefits e.g. arterial burns/catchment
- Need for gravel backfill and spacing

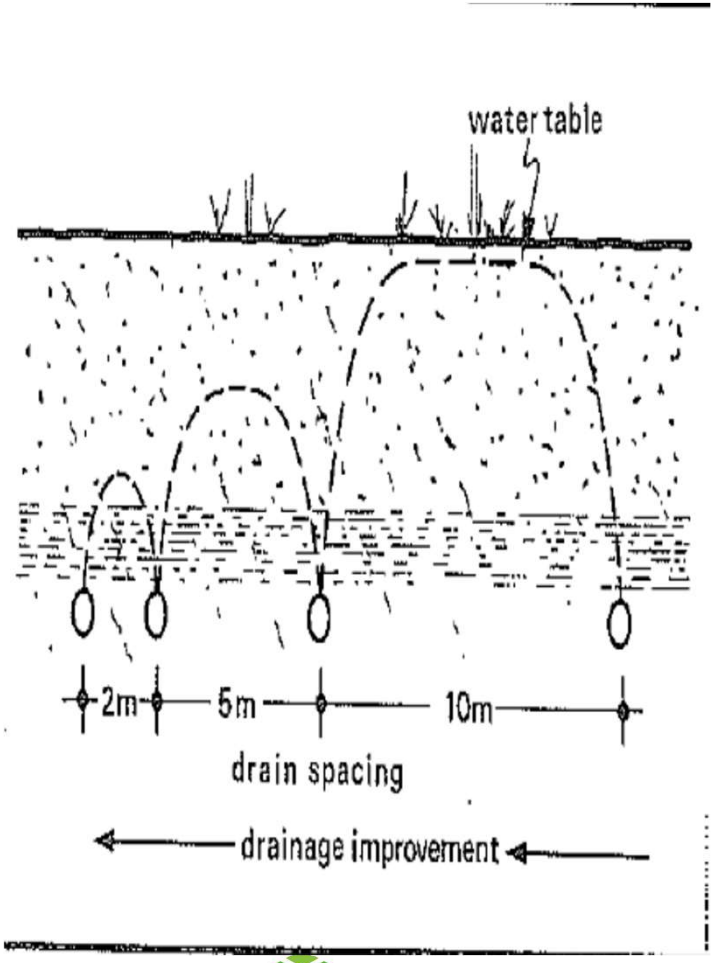
The Problem impermeable soils - surface water problem



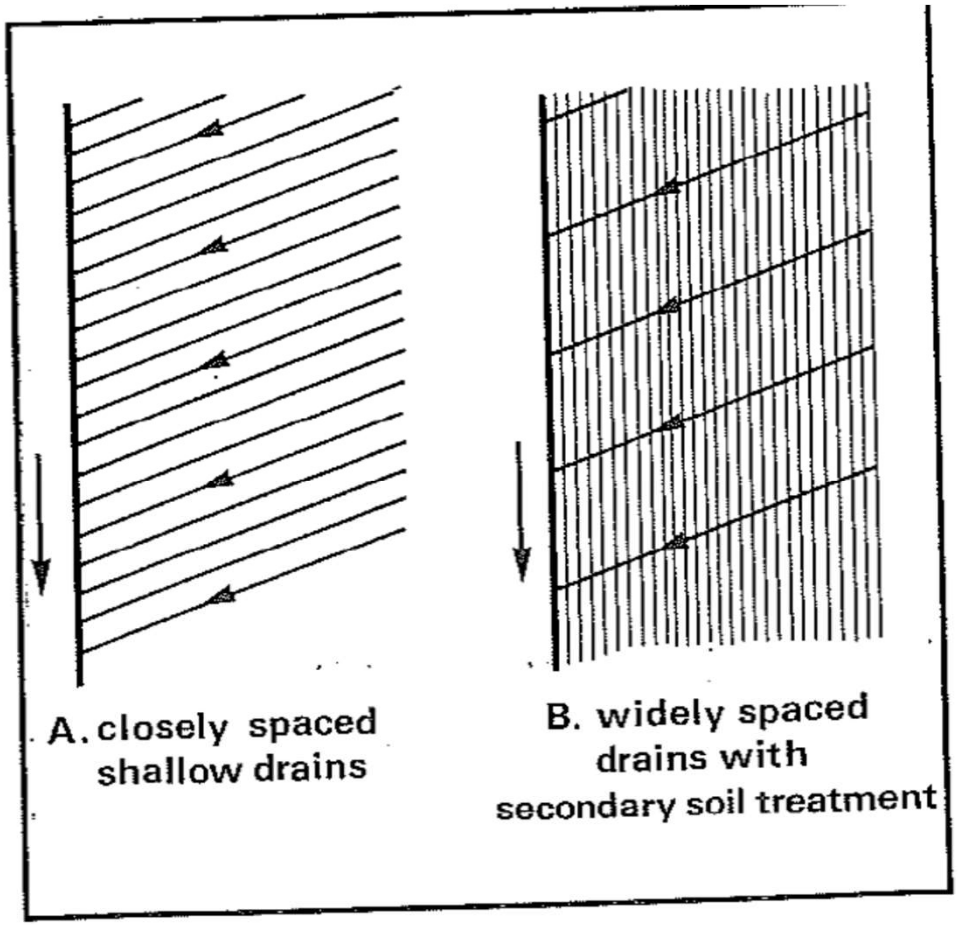
The SOLUTION



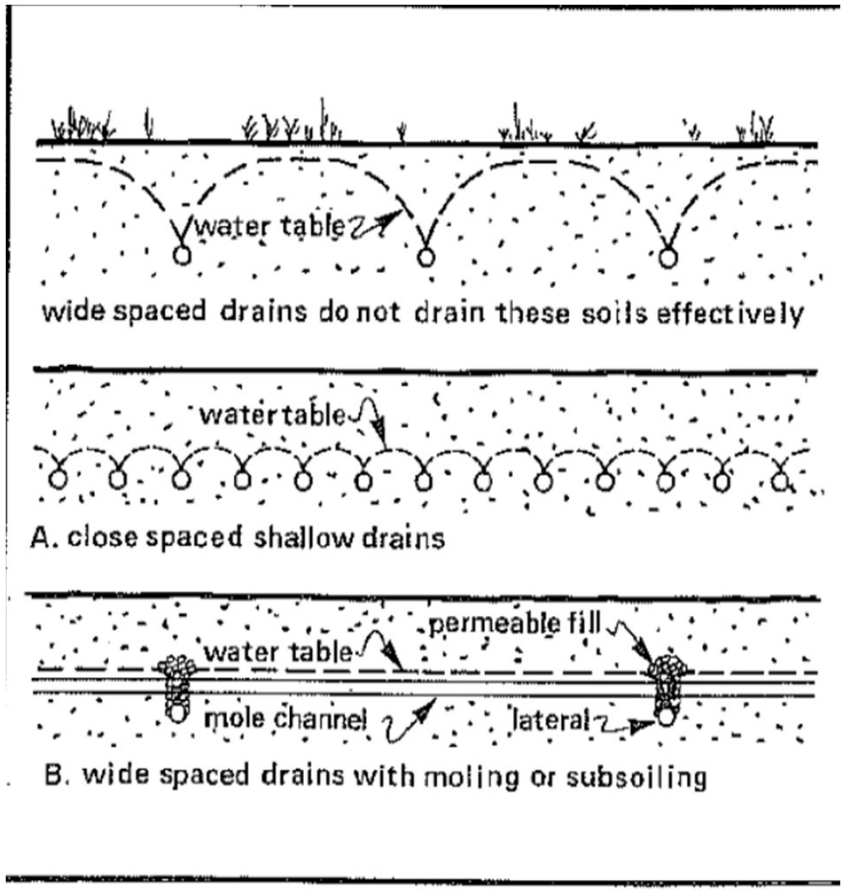
Effect of Closer Spacing



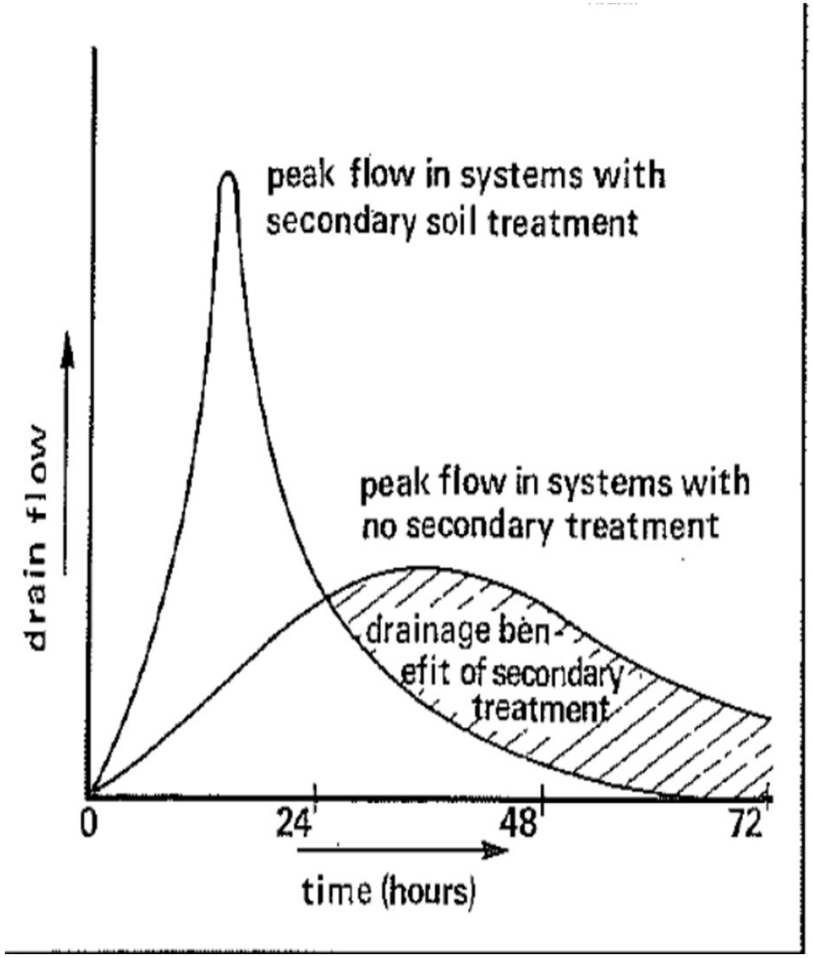
A Better Solution



Alternative method



Flowrate with /without Secondary Treatment



Problem Occurrence

- During the late 1970,s the various drainage problems were broken down into the following types,

Drainage Problem %	Scotland	North East	South West
Water Table	25	22	11
Impermeable Subsoil	20	13	25
Springs	12	39	9
Failure of Old Drains	31	25	**26**
New Scheme Failure	**8**	**2**	**22**
Other	4	1	7

Failure of New Schemes – Why?

- New Materials –Plastic pipes introduced
- New Installation Method-Backactor replaced by Trencher then Trenchless
- Gravel used but not connected

JCB Backactor

Trencher Machine

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Trencher Machine

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- Bruff

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Trenchless Machine

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Trenchless Machine

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Trenchless-Interdrainer

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Drainage Design

- WATER takes line of least resistance

Audience Help/Flipchart

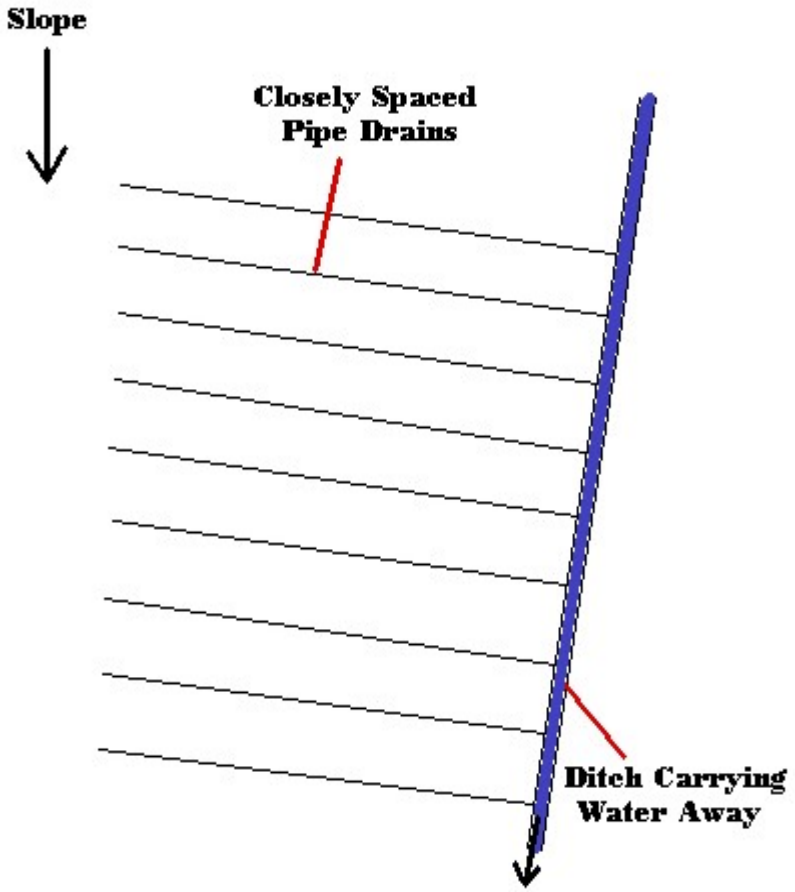
Drainage Design

- Design for required outcome – allow for expansion at a later date
- Design from the outfall back
- Install ditches on boundaries where possible
- Isolate The Site-gravel catchment drain
- Minimise requirement for culverts – potential for blockage in the future.
- Install correctly sized pipes where required – use gravel if necessary

Drainage system components

- Field drains
  - ditches
  - laterals - plastic or clay pipes
  - Catchment drain-MUST isolate the site
- Leader pipes
  - larger pipe or ditch which collects water from many field drains and conducts it to the outfall
- Outfall
  - where water leaves the drained area and enters a ditch, burn or river

Drain layout & spacing



- Drains must be laid **across** the slope to intercept water
- Old drains that run down slope are ineffective
- Less permeable soil ➔ closer drain spacing
- 20-30m is most common
- Drains lead directly into a ditch or large, leader drain

Design-Max Permeable Lateral Length

– depends on slope & Rf (45”)and pipe type

- **Gradient on Pipe**

	2”/chain (¼”)	4”/chain (½”)	8”/chain (1%)
60mm	80m	100m	140m
80mm	170m	220m	300m

Design –Sizing the Leader

• **Leader Drains**	**Hectares Drained 1% slope**
• 100mm plastic	1.4ha
• 125mm plastic	2.6ha
• 170mm plastic	5.0ha
• 160mm R Drain	8.0ha

Lateral Spacing

Spacing	m/ha	m/acre
5m	2000m	800m
10m	1000m	400m
15m	750m	300m
20m	500m	200m

Ditches

- Design for self cleaning – no wider than required at base
- Ensure gradient does not cause ditch base erosion
- Ensure ditch is large enough to contain flood flows
- Remove trees and bushes from banks
- Fence out livestock fence to be at least 500mm from top of bank
- Ensure bank sides sloped to be stable for soil type
- Spread spoil in field well away from ditch (on downslope side if possible)
- Remove the minimum bank vegetation where possible

Ditch Crossing's

- Locate crossings to minimise number required
- Ensure pipe is large enough (minimum size 225mm diameter)
- Ensure pipe is well bedded in ditch to prevent leakage round sides
- Cover depth and type should be suitable to carry heaviest vehicle crossing—Gravel backfill increases strength
- Install headwalls to secure crossing track
- Install armouring at outlet to prevent ditch bed erosion

Piped Drainage

- Pipes to be sized to accommodate drainage flow (both surface and spring water)and type of problem-slot size
- Drainage layout designed to drain problem areas-be flexible
- Cut drainage tracks straight in line and depth with even gradient
- Minimum cover over pipe 600mm for lateral, 750mm for leader and at least 900mm for pipes in peat.
- Use gravel backfill where necessary (20-40mm clean washed stone or crushed rock or peagravel)
- Connect pipes with purpose made connectors
- Outfall to ditch should have last 2m of pipe as rigid and sealed.
- Where pipes pass trees or hedges the drainage pipe should be sealed
- Connect old systems to new using either pipe or clean gravel connections.

Drainage (Cont.)

- Carry out drainage when conditions are dry
- Don’t backfill pipes with wet or slurried soil
- Outlet to ditches should ideally be 150mm above normal water flow
- Inspection chambers to be installed at changes in pipe gradient
- Piping open ditches should be planned very carefully as it is easy to under estimate the carrying capacity of a ditch during high rainfall events.
- Armour ditch at pipe outlets to prevent erosion of ditch
- Headwall should be constructed of stone or concrete to ensure outlet kept firm.
- Ensure filters (straw bales or gravel) are in place to prevent silt and sediment entering watercourses.

Why Use Gravel Backfill

Scheme will work better and last longer

- Maintains EASY route to drain
- Connects old system
- Can act as stone drain
- Allows Secondary Treatment, **but** is expensive
- Doesn't mean you can always go wider but could if you can use secondary treatment

Tons Gravel per 20m run

Depth:	**18”**	**24”**	**36”**
Width			
70mm	1.4t	1.8t	2.8t
300m	5.4t	7.2t	11t
450mm	8.1t	11.0t	16t

Problems to look out for

Peat

- As it dries it shrinks and can move
- Avoid pipes on deep peat– install pipes on mineral soil where possible
- Don't cut ditches into sloping ground with deep peat to avoid peat slippage

Other Problems

- Iron Ochre blocks pipe drains – design to allow pipes to be jetted.
- Running sand – problems with pipe stability
- Spring and seepage water – make sure the system collects these.
- Wet sites it may be necessary to carry out the drainage in stages by using preliminary drainage to allow access for main scheme
- Roots.

Secondary Treatment

- Increases effectiveness
- Can rejuvenate the system

BUT use the **Right treatment** at the **RIGHT time**

Subsoiler

Mole Plough

Paraplow/Lifter

Spike /Aerator

Plough

Subsoiling – secondary drainage

- Some soils benefit from subsoiling
- Subsoiling aims to **loosen** the soil and allow water to flow more freely through it—can also bust pans
- Can be effective in soils of low clay content or stony soils where mole drains would not work

Subsoiler

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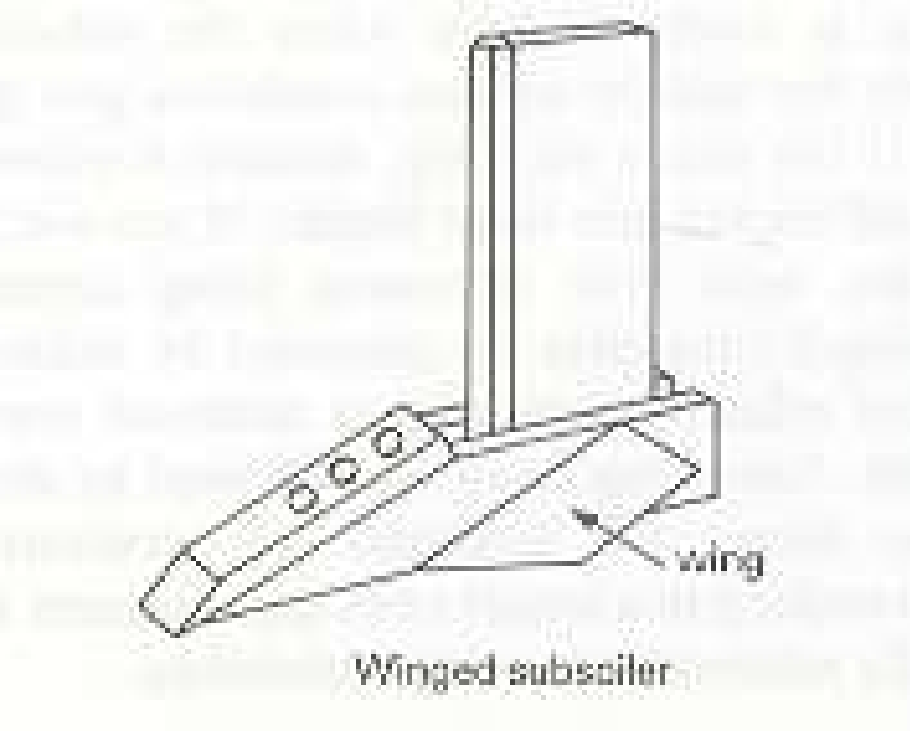
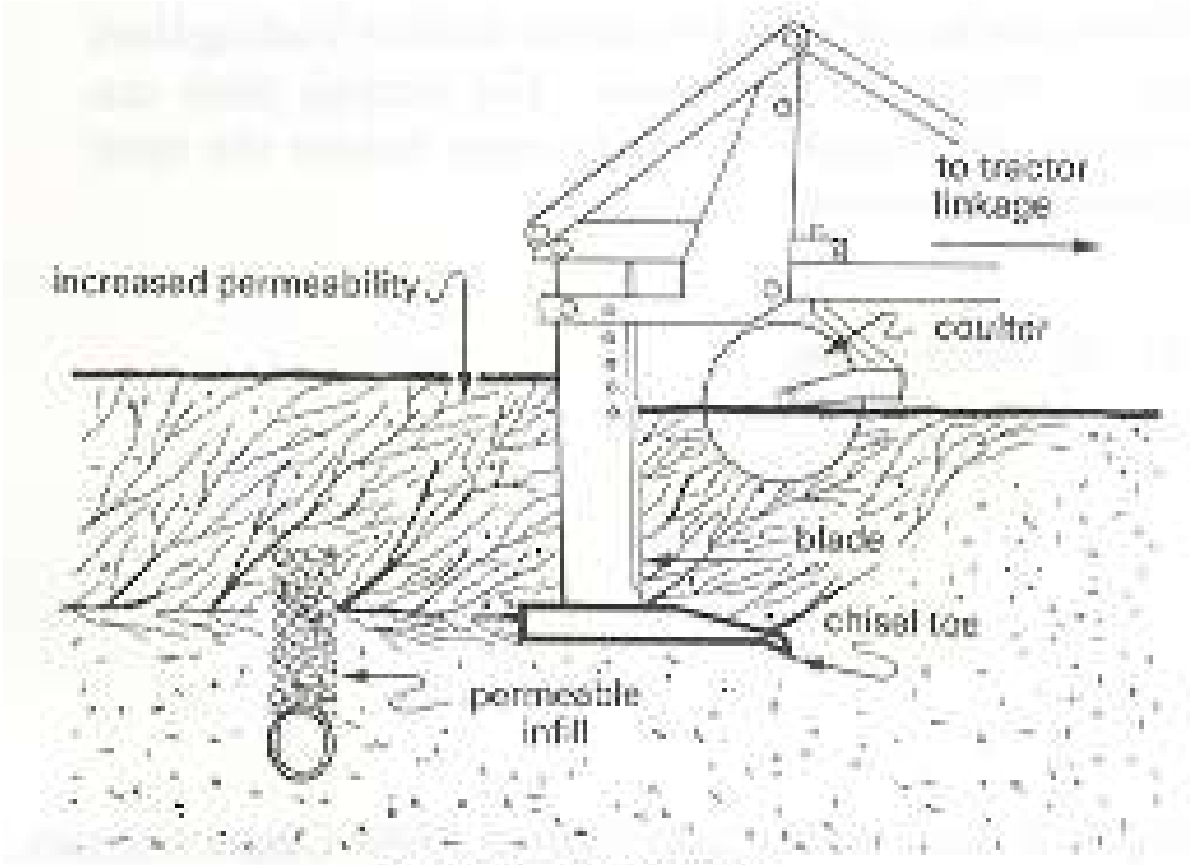
Subsoiler tine

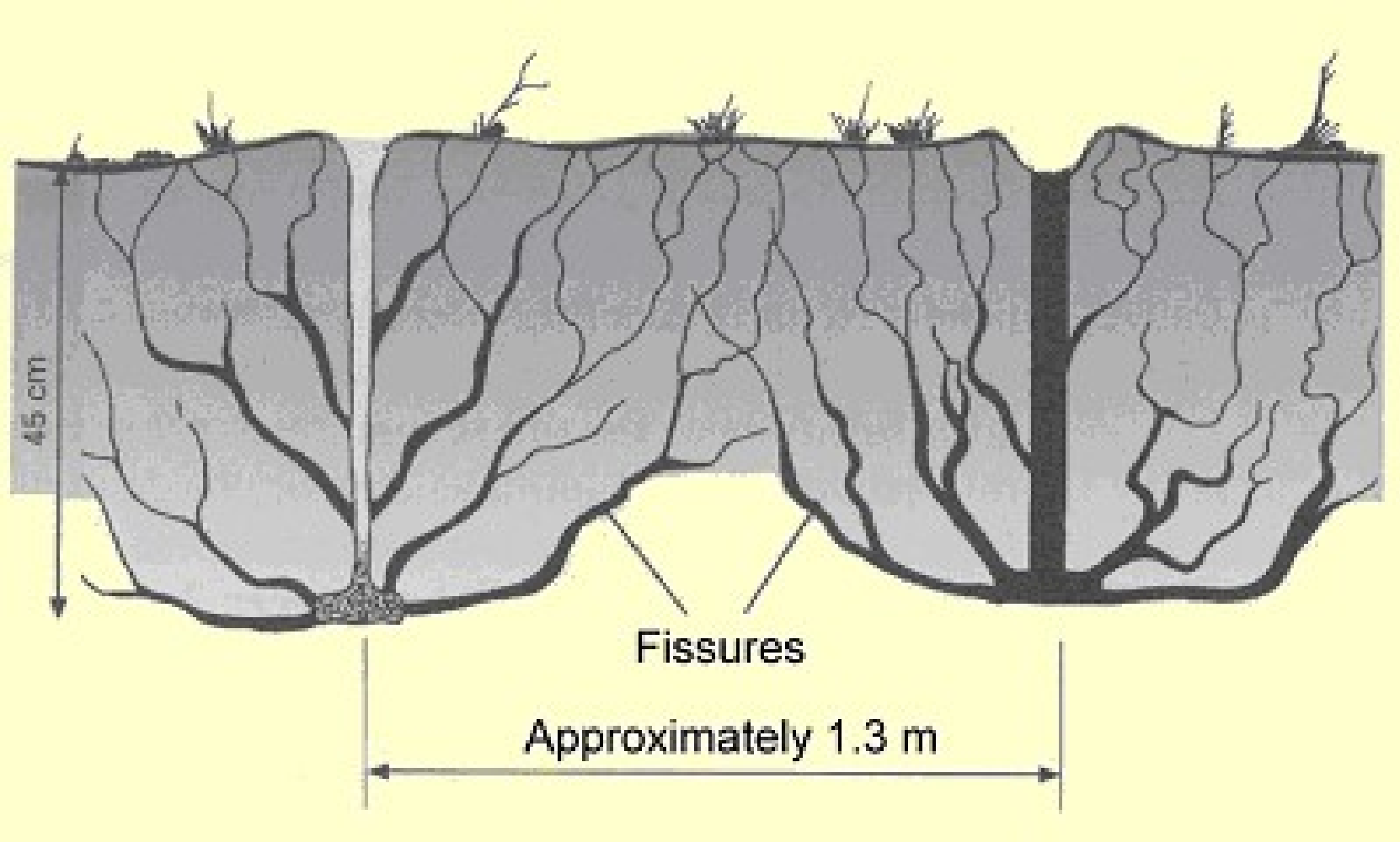


Subsoilers open up the soil

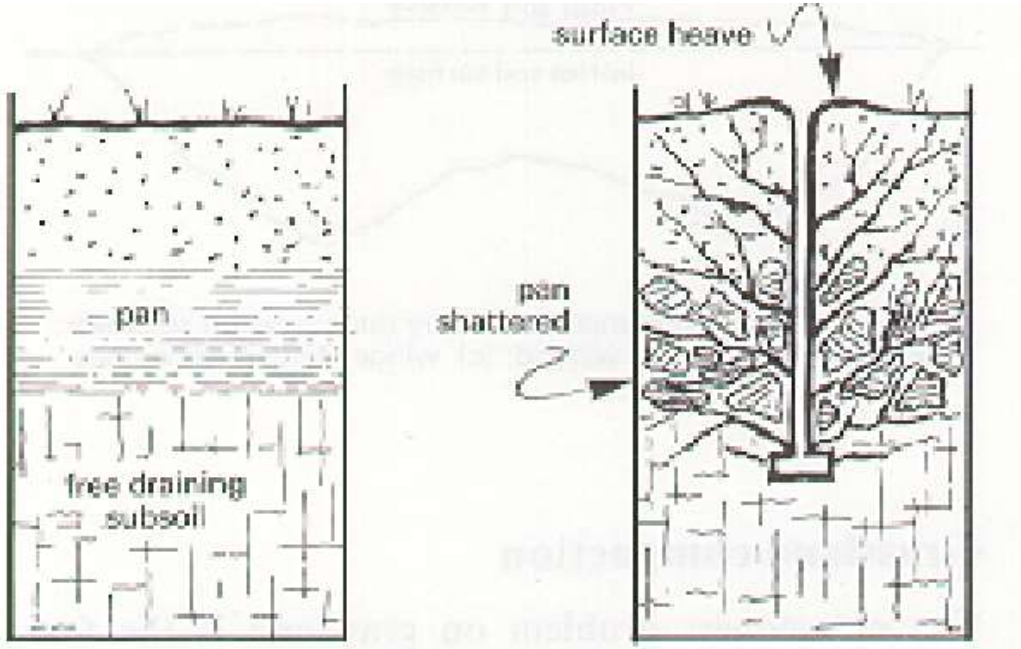


Subsoiling across drains

Subsoil shatter



Subsoilers break up pans



Subsoiling to burst pan, improve drainage and increase rooting depth

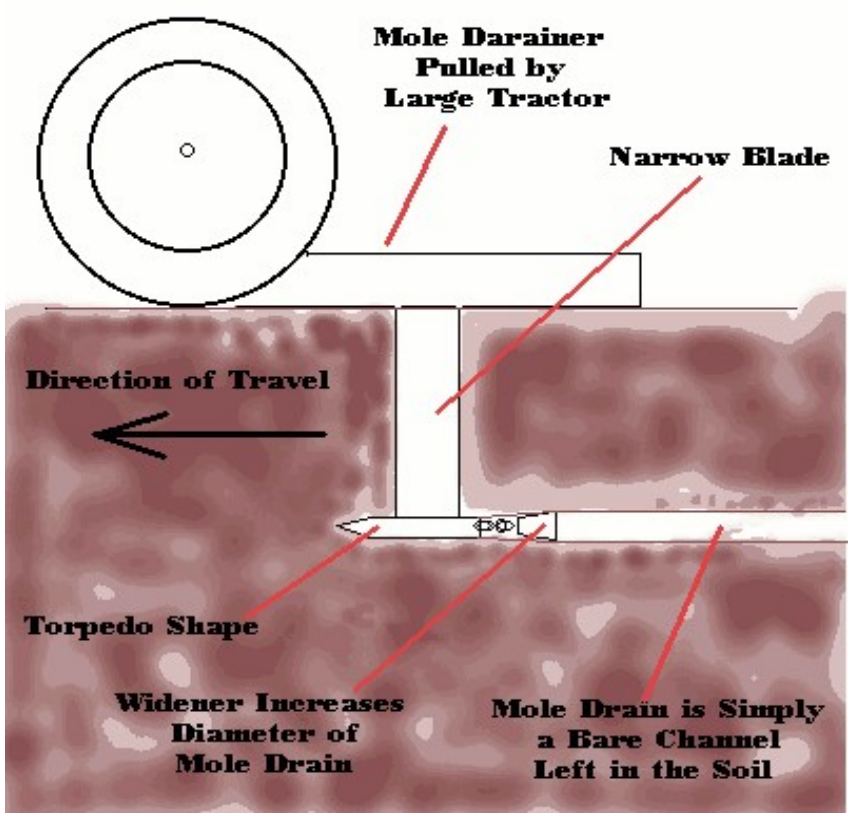
When to subsoil

- Only when necessary - check the subsoil for compaction
- When the subsoil is brittle i.e. not too dry or too wet
- Post Harvest subsoiling is usually best in terms of land access and soil suitability (but not in 2007 or 2008 or 2012)

How to subsoil

- Set the subsoiler below the compact layer if possible or around 16-18”
- Subsoil across the field drains
- Subsoiler should be at least 10cm above the drains
- Check to see if the operation has worked after the first pass
- Use shallow leading tines with the subsoiler
  - if soil above is too compact then shatter does not happen and the result is an inferior ‘mole’ drain

Moling – secondary drainage



- Very closely spaced drains are uneconomic
- Use short lived mole drains to connect permanent drains
- The mole plough has to pass through the permeable fill
- At least 35% clay in the soil and must be **Stone Free**
- The soil should be *plastic* when the mole is pulled

Mole plough

Moling

Drainage Cost

Drainage Cost									
							£/acre		
	60mm Pipe		270	m @	45	p/m	122		
	100mm Leader		30	m @	102	p/m	31		
	225mm Twinwall Leader		20	m @	700	p/m	140		
	Junctions						15		
	Pea- Gravel	aver 375mm trench	120	t @	15	/ton	1800		
		(trenchless	25	t					375
	Trenching-excavate (a)		320	m @	32	/hr	102		
	Labour handling pipe (b)		5	hr @	15	/hr	75		
	Labour handling gravel ©		2	hr @	30	/hr	60		
	Backfilling		1.5	hr @	32	/hr	48		
	Consultancy Design						20		
	Mapping						10		
					15	Metres	2423		998
					20	Metres	1615		665
a)	14t tracked digger 30-32 " trench with				15" aver draining bucket				
	assume		100	metres/hr					
b)	skilled man		15	/hr					
c)	man/wagon		30	/hr					
								d	
d)	assume		200	metres/hr					

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Drainage Cost

	Backactor	Trenchless
• 15m Spacing	£2400/ac	£1200/acre??
• 20m Spacing	£1600/ac	£800/acre??

(In 1983 –aver cost of all schemes in Scotland before grant was £400/acre---but for comparable scheme £800/acre)

Summary

- Don’t rush in – pick the right field
- Assess the REAL problem
- Is a totally new scheme needed ?
- Design it right –spacing/gravel need/other problems
- What will the cost /benefit be ???
- Use a Drainage Contractor
- Seek (Independent) Advice