Soil&Water Management Centre

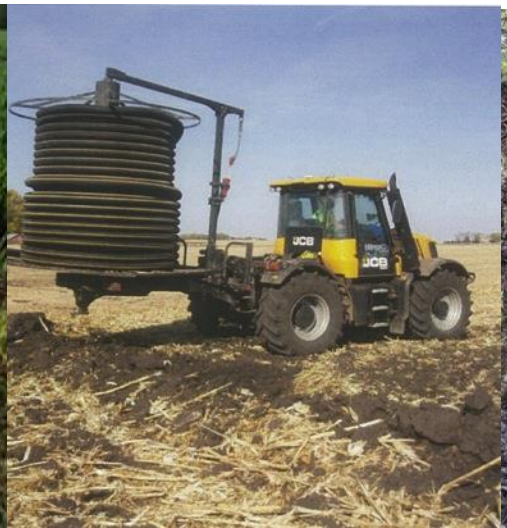
IAgrE 2015

Harper Adams University

Drainage

The Engineering Challenge

Dick Godwin



Outline







- Fundamentals
  - The problem and the penalties/benefits
  - Soil and water relationships
- Actions
  - Short term
  - Medium term
  - Long term
- Concluding remarks

Land drainage and crop yield

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Crop failure – during growth, in this case ~25% loss
Soya beans, Illinois - July 2008

Ontario 38% increase in yield 1979 - 1999
Burtonshaw, Nuffield Scholar



Effect on crop growth – Denchworth Soil
FDEU studies at Drayton 1970 -74 Winter Wheat

Yield	~4.5 t/ha
Drains & Moles	+ 1.0 t/ha
Drains No moles & subsoiling	+ 0.6 t/ha



Studies at Brooksby showed + 0.5t/ha from mole drainage
FDEU Annual Report 1975



Waterlogging in winter wheat 19% reduction in yield,
Lysimeter studies at Letcombe -1978

Birds Eye lost 40% of pea yield in the UK in the summer of 2007 due to poor traffickability

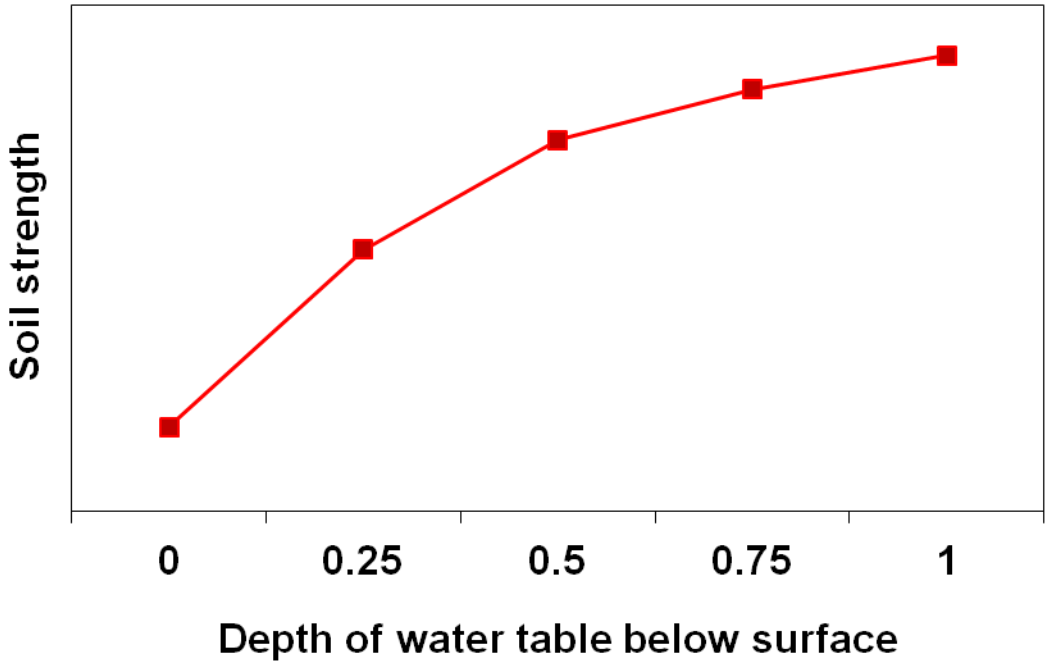
The Role of Drainage on Machinery Operations

Increasing water table depth:

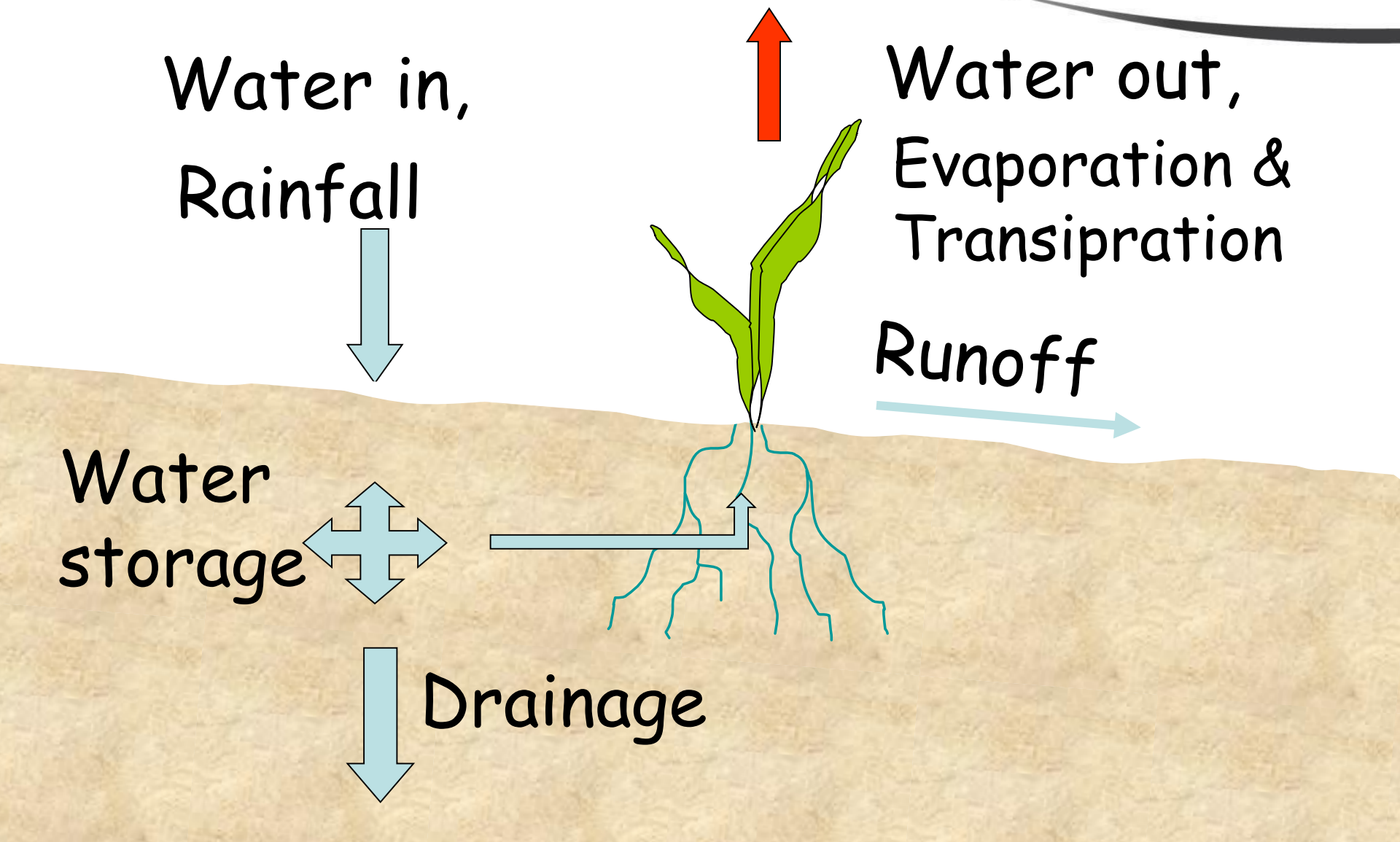
- Increases soil strength & trafficability
- Less soil damage or compaction.
- Easier& more effective field operations.
- Increased number of available work days, improved timeliness and establishment.



From :Profi



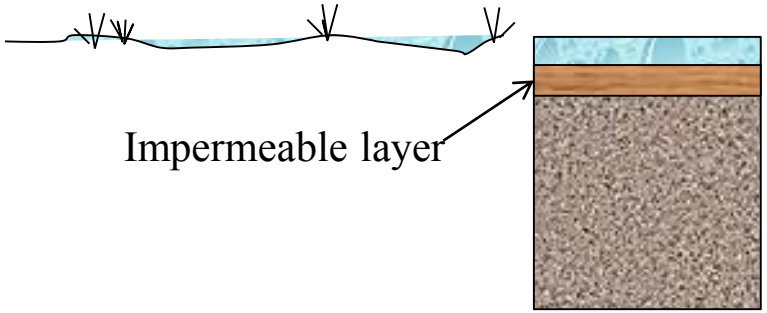
Water budget



2 types of drainage problem

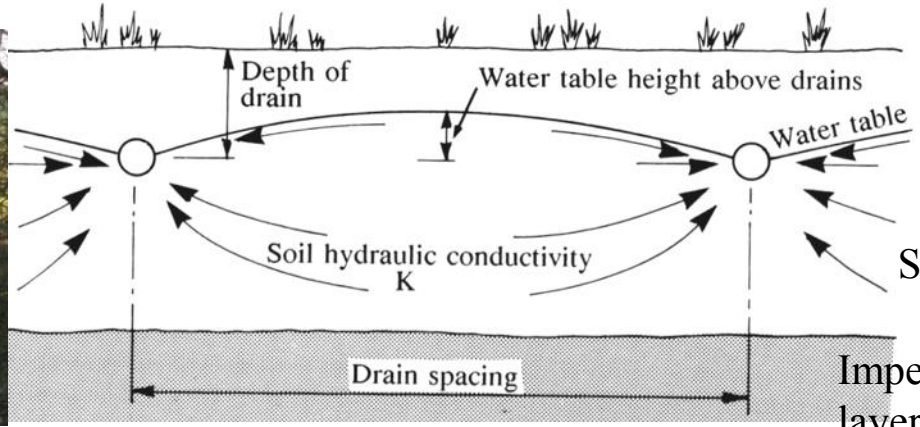
1. Surface water control (top water or perched water table)

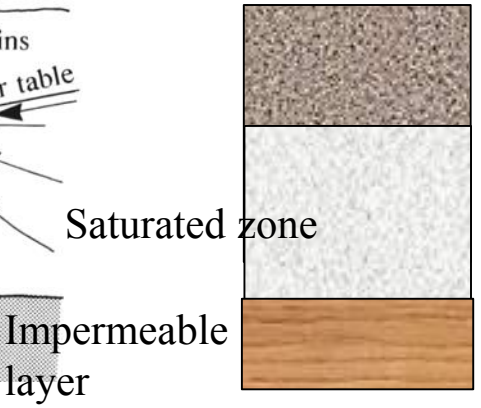




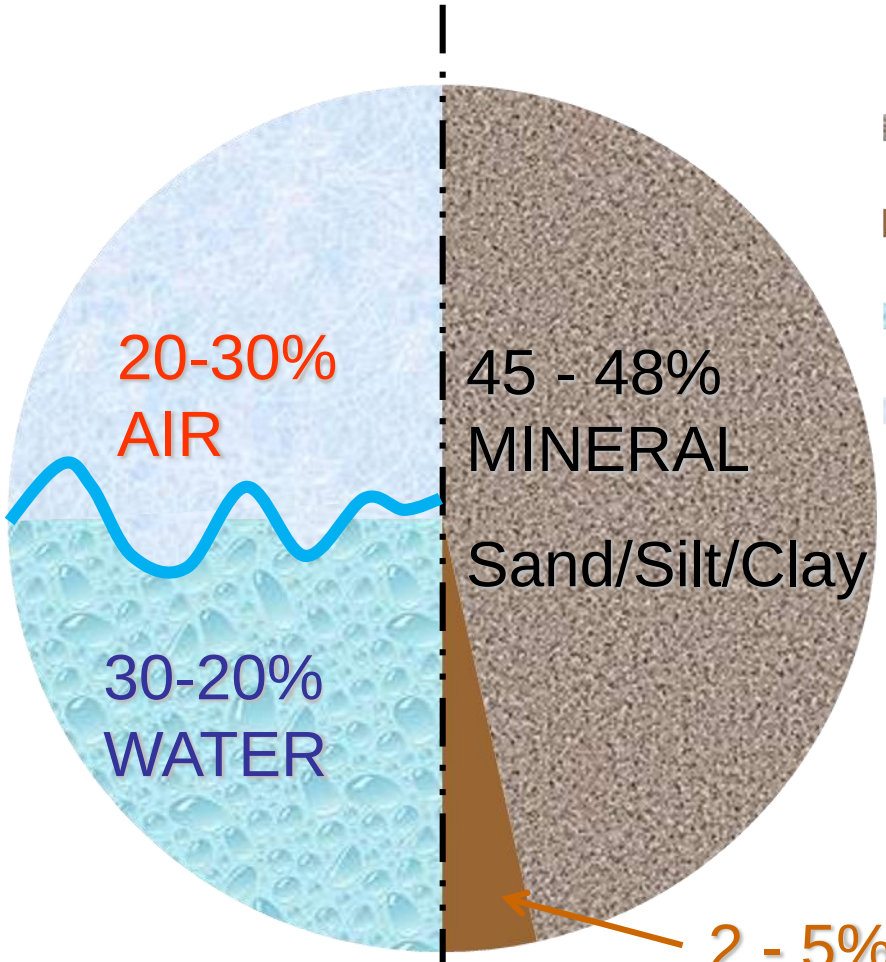
2. Groundwater table control (bottom water)







Soil constituents



- Mineral
- Organic matter
- Water
- Air



Sponge analogy



- **Saturation**
  - All pores are filled with water

↓ *Drainage*

- **Field capacity**
  - Some water has drained due to the forces of gravity

↑ *Plants extracting water + evapotranspiration*

- **Permanent wilting point**
  - There is still some water but plants cannot apply enough suction to get it

Perched water tables and storage capacity



Sand pit

Harper Adams University

Volumetric moisture content, %

0
10
20
30
40
50

Saturation

Field capacity

Permanent wilting point

Drainable porosity

Available water

Field conditions
Rivers Uck and Bourne catchments, 2003

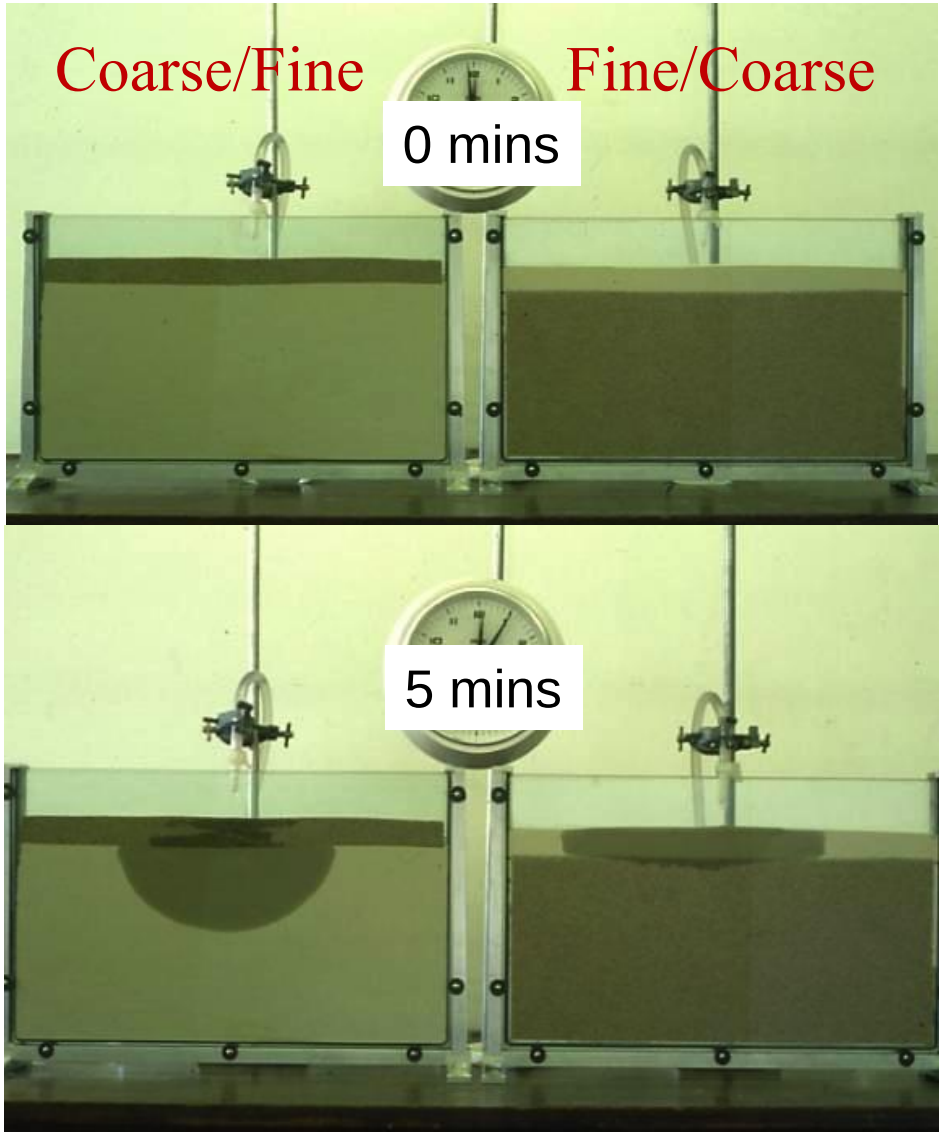
Sand
Loamy sand
Sandy loam
Sandy silt loam
Silt loam
Sandy clay
Clay loam
Silty clay loam
Sandy clay
Silty clay
Clay

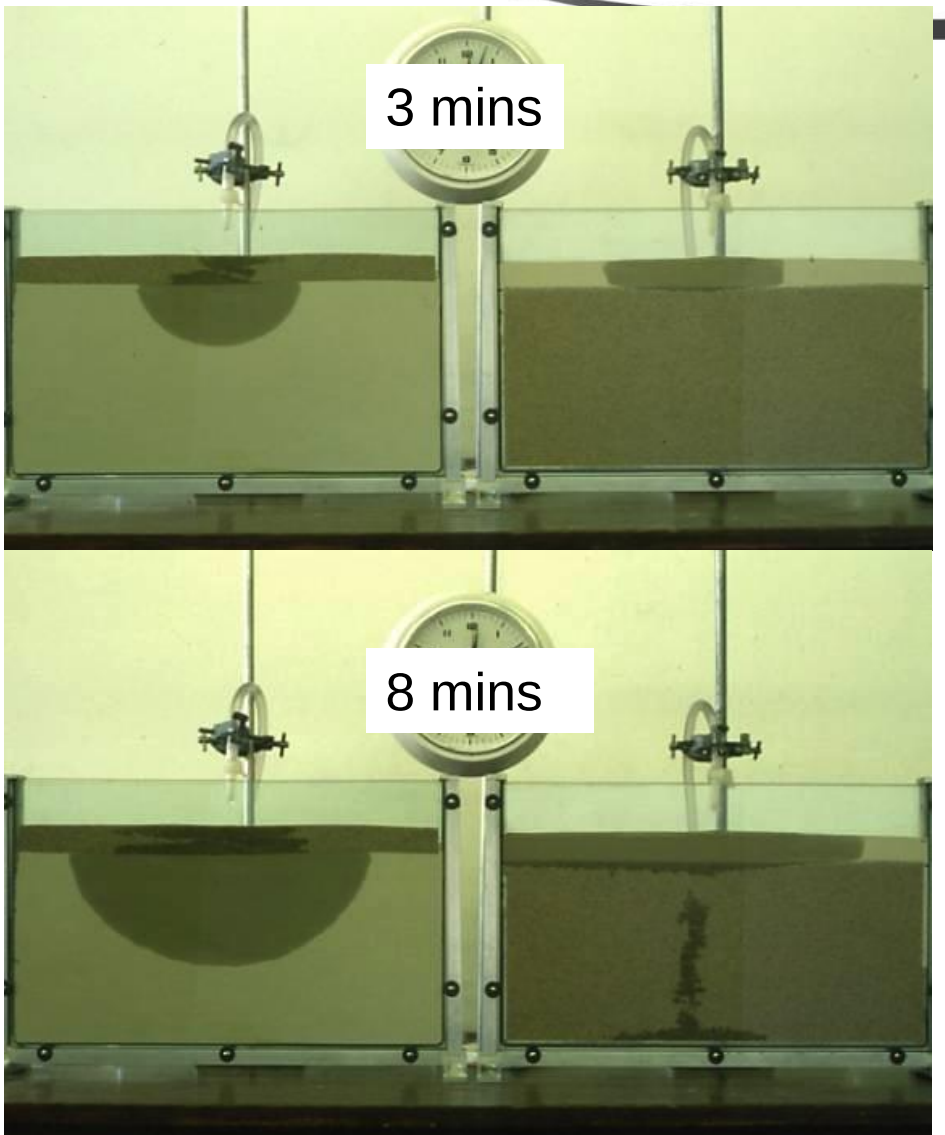
After: Godwin and Dresser, 2003

Infiltration / soil wetting

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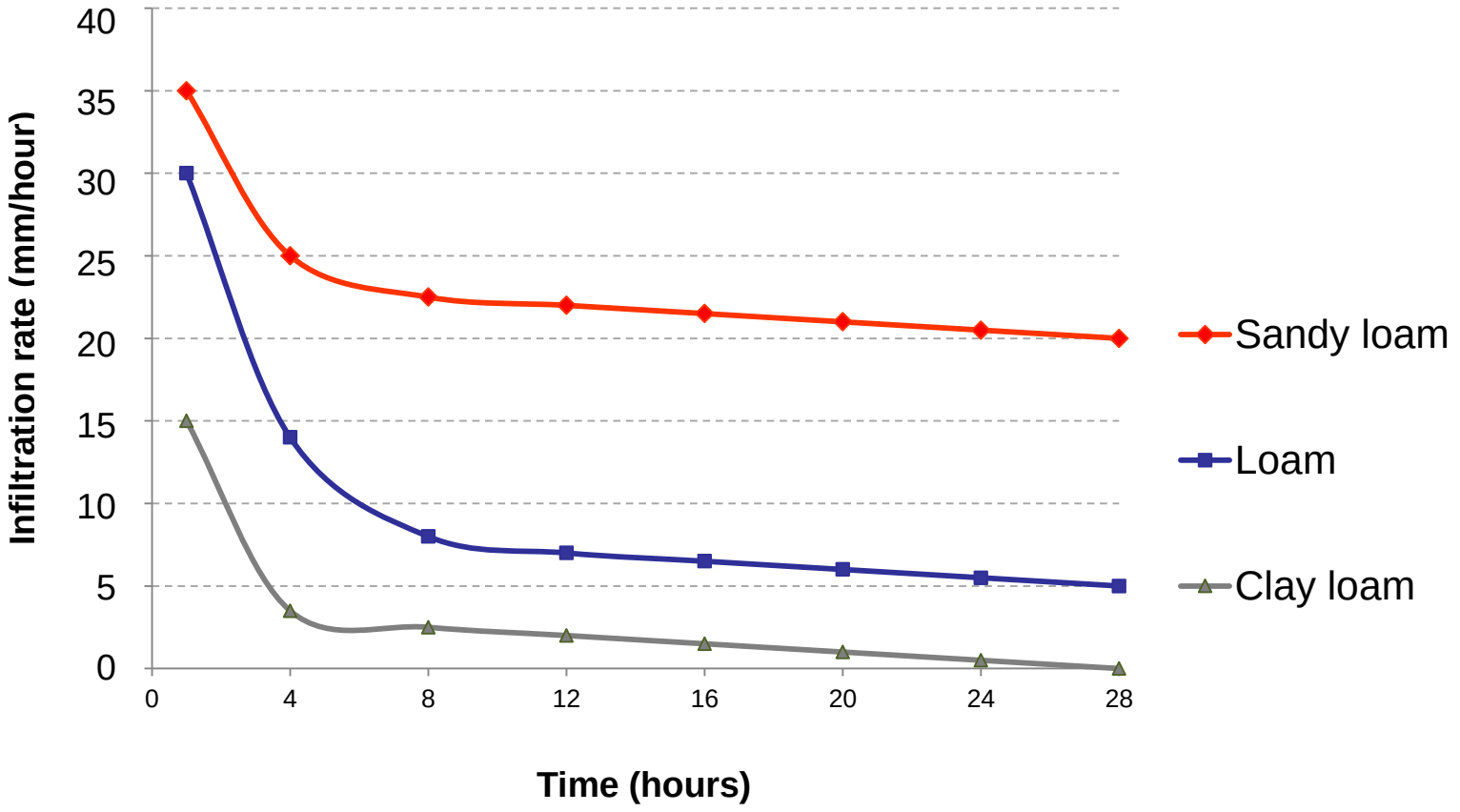




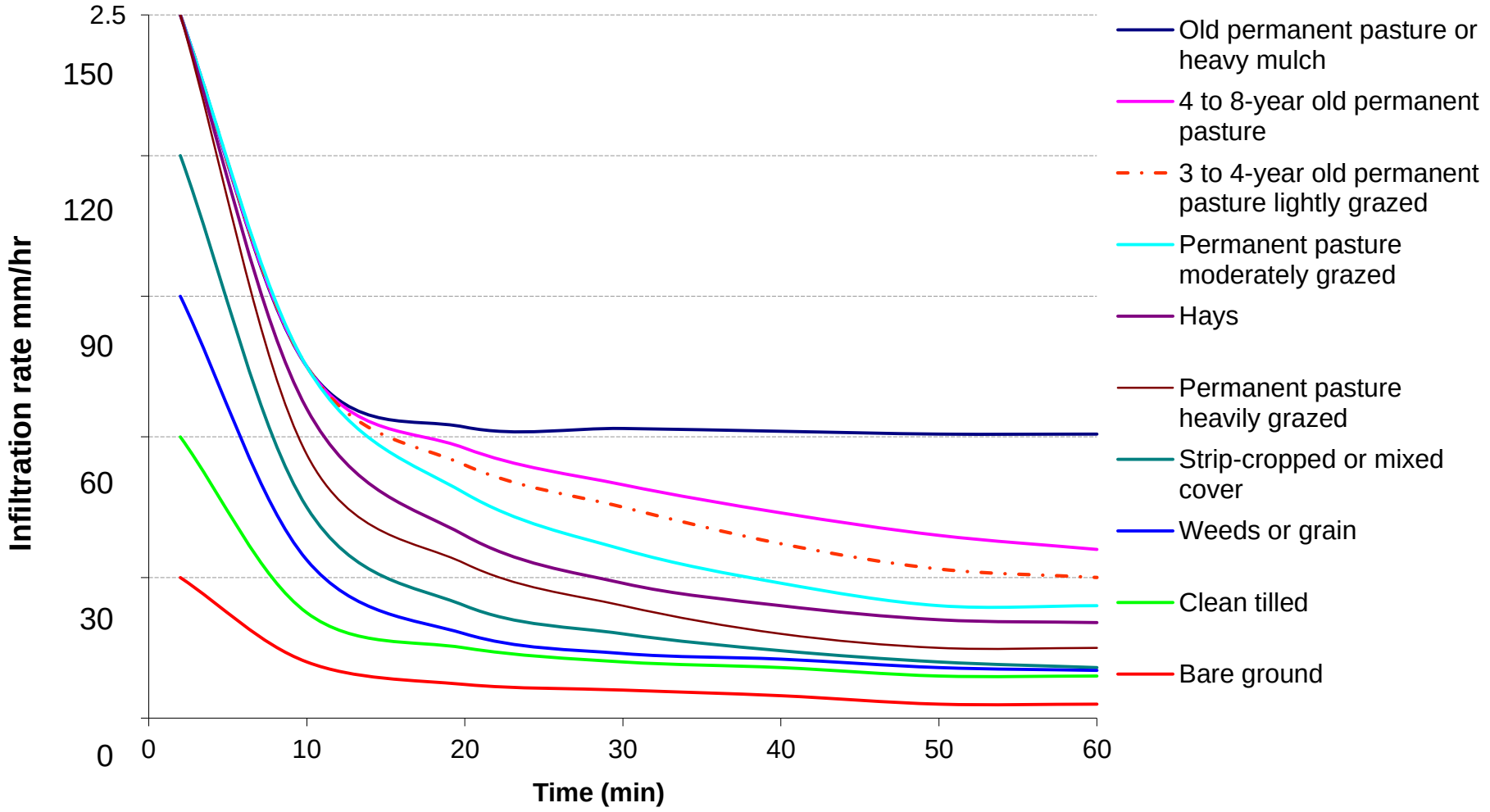
Infiltration ~ soil type

Main factors affecting infiltration

- Soil type
- Vegetation/surface cover



Infiltration ~ surface cover



Compaction and infiltration rate

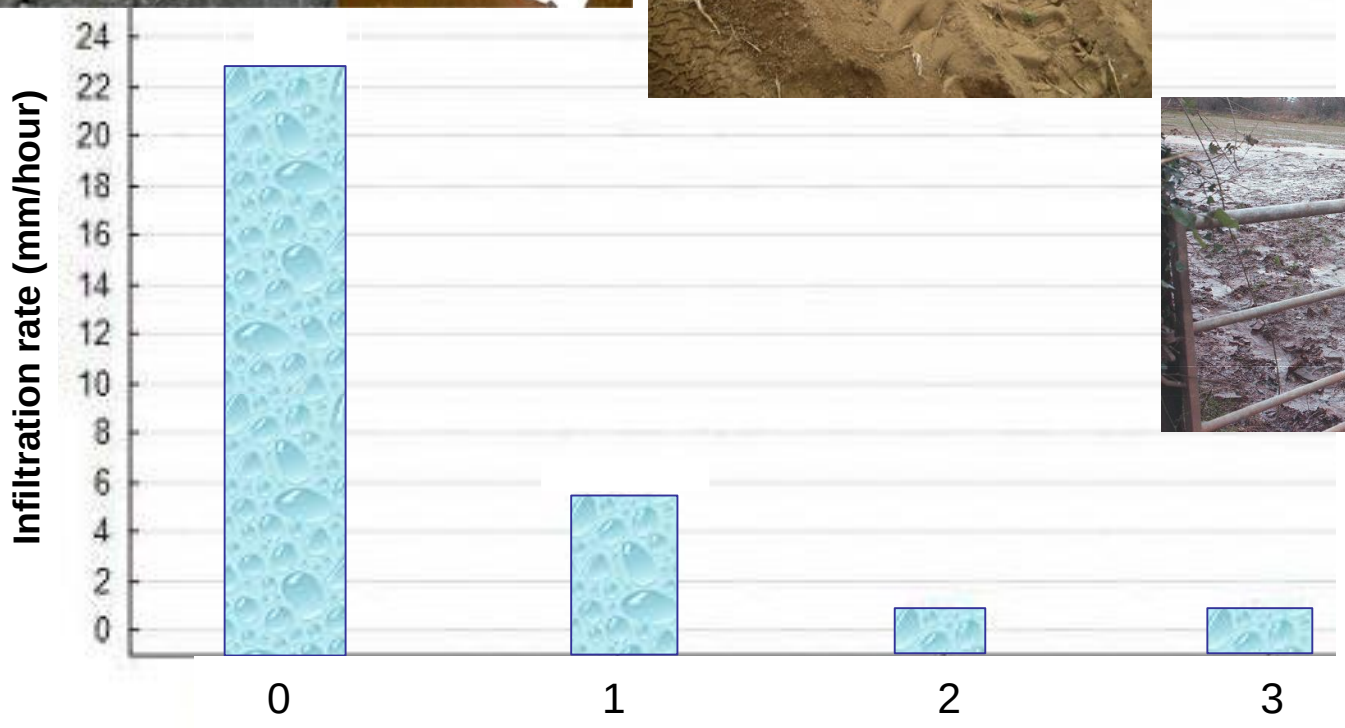
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After: Chyba, 2012

Typical problems



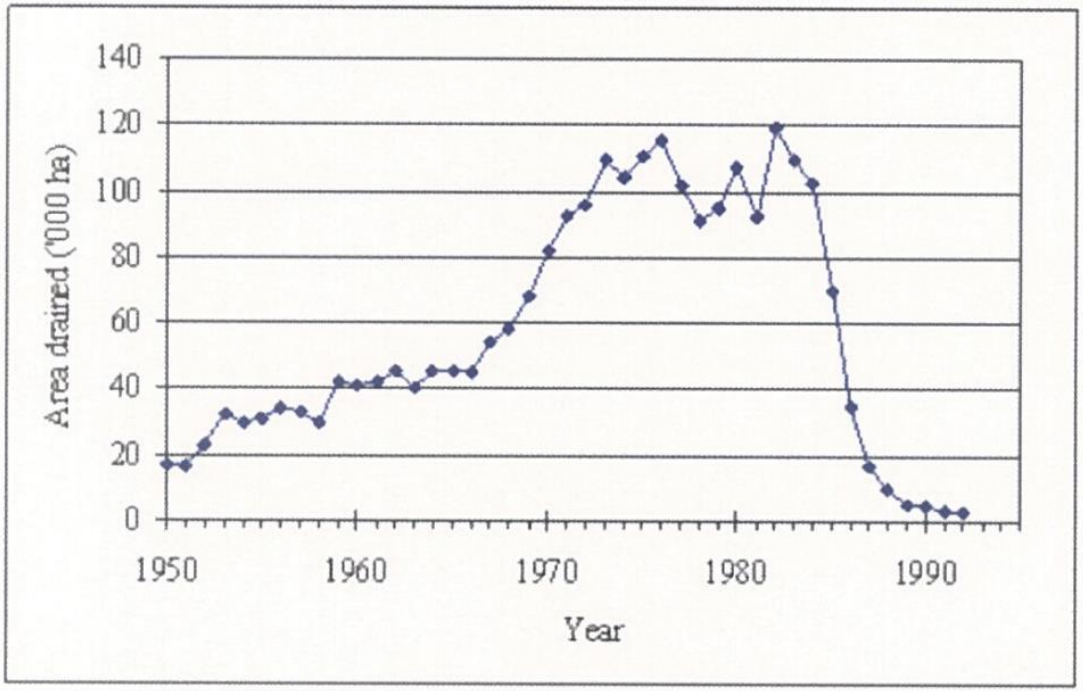




A less common scene

Drain installation Then and now?



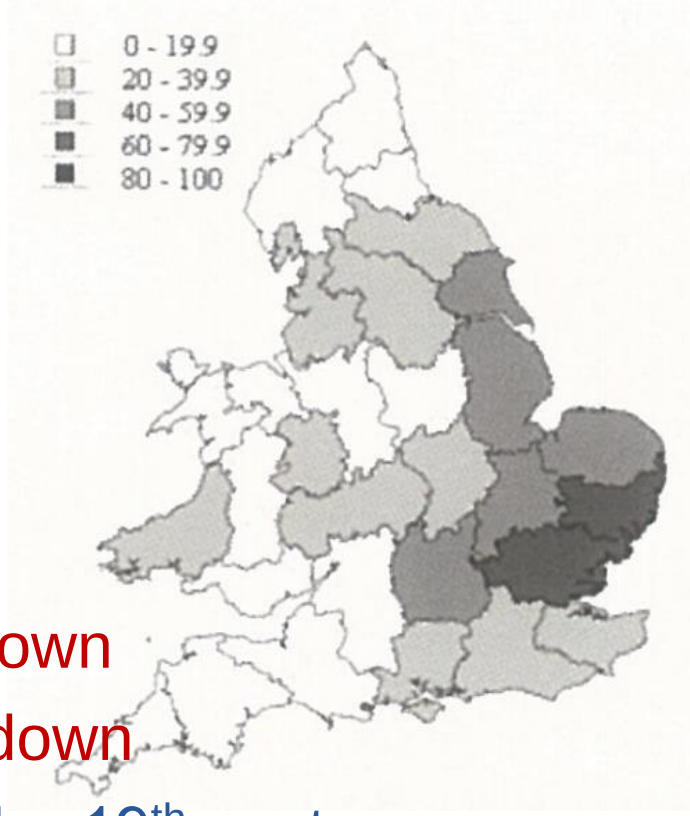


- 1850 – 1880 - 2 million ha was drained through grant aided scheme
- £12 million lent to farmers to drain (£12 billion today)

After: Rob Burtonshaw: Drainage Contractor & Nuffield Scholar

Drainage infrastructure

% of agricultural land area in each old MAFF Division that is drained by pipe drains installed in the period 1950 – 1992 by grant aid



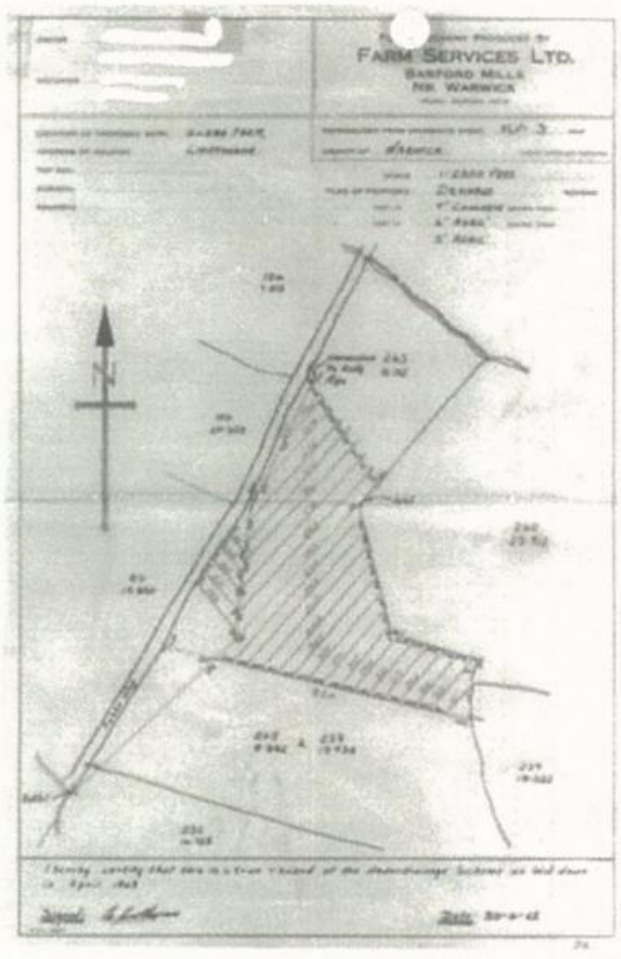
Drain failure

- 20% in South East England breaking down
- 70% in the North of England breaking down
- We're relying on schemes installed in the 19th century
- 1987 Chris Stansfield estimated that 50,000ha of drainage was ceasing to function each year
- 50% down to poor maintenance

Short term measures

- Study “Old Drainage Plans”
- Walk ditch drains
- Check that tile drains, plastic pipes and mole drains are flowing
- Clean blocked ditch and open drains
- Flush pipe drains
- Ensure outfall/arterial drains are functioning
- Install “short term” mole/ditch/furrow drains if appropriate
- Broadcast seed to establish cover and “pump out water”
- Map damaged areas for repair later in the season/next opportunity

Completion plans





- Existing infrastructure, make sure it works
- Can anything be added?

Clean ditches

Ensure there is an outfall





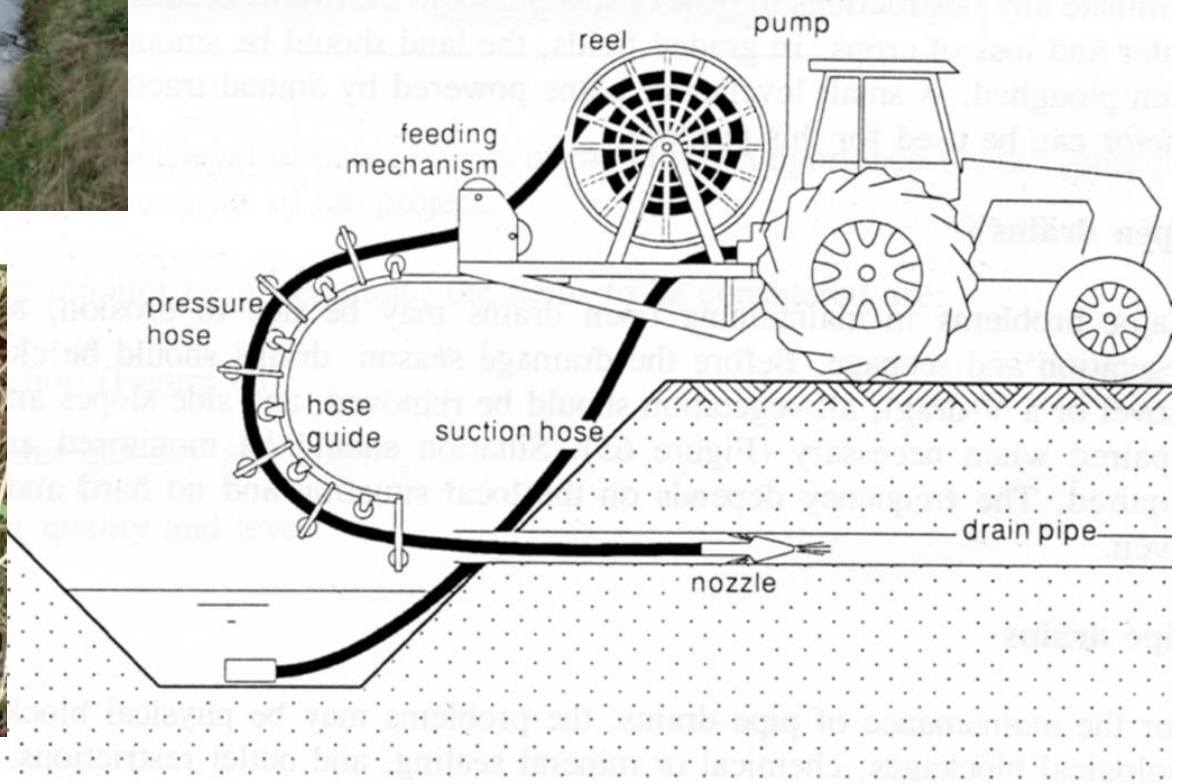
c. £300/day to hire machine and man

Drainage Maintenance:

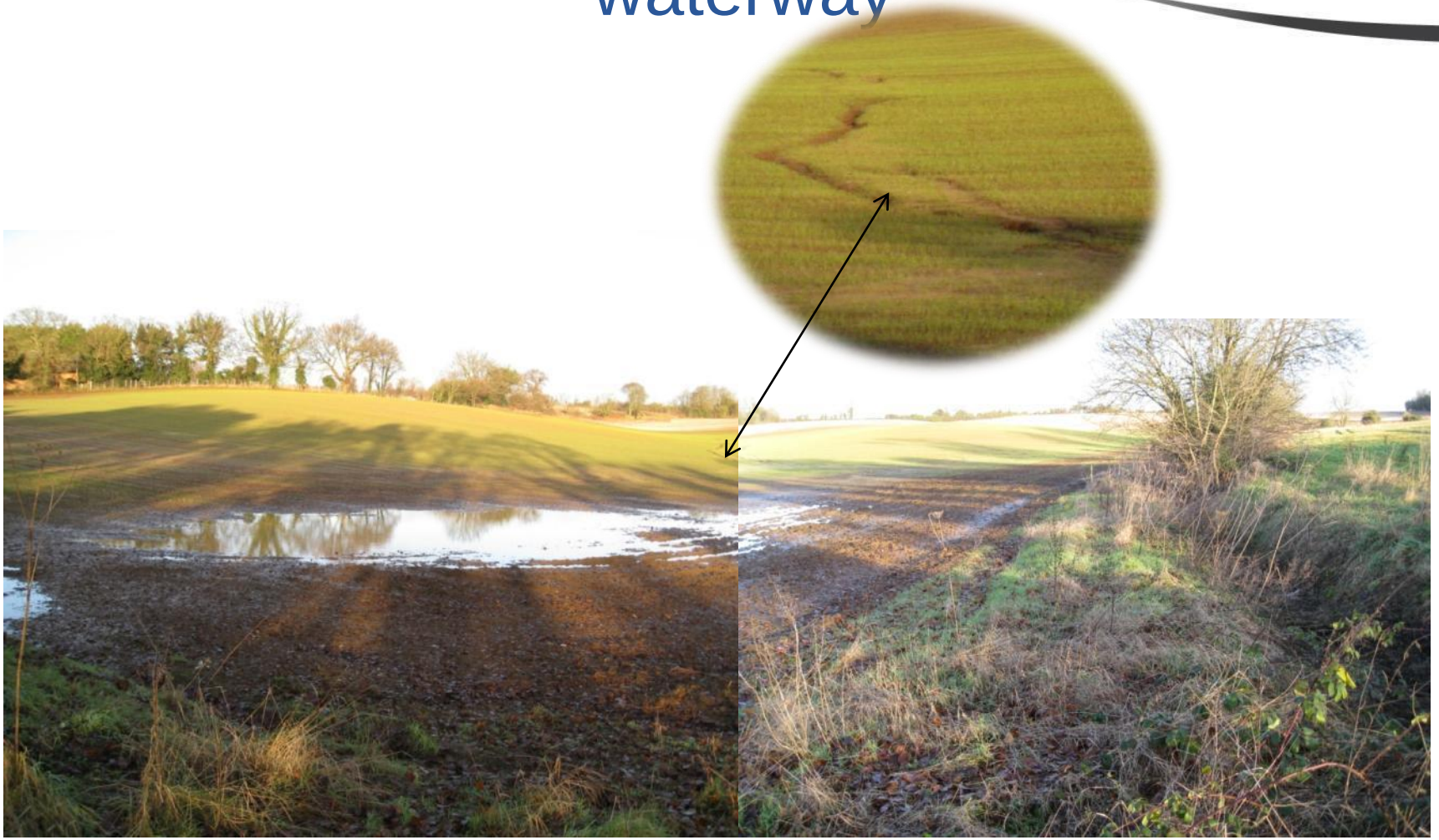
Pipe Jetting for Blockages







Potential site for a short drain, ditch cleaning and grass waterway



Medium term

- Mole drain clay soils with perched water tables to connect with gravel backfill of existing tile/plastic drains
- Subsoil damaged areas after next harvest





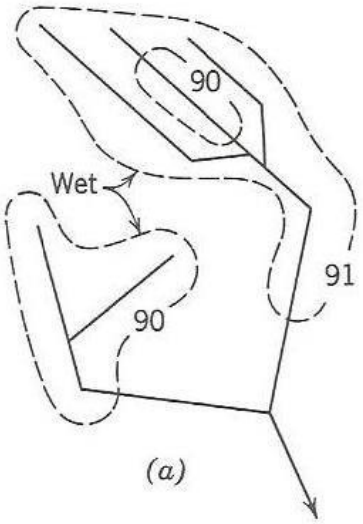


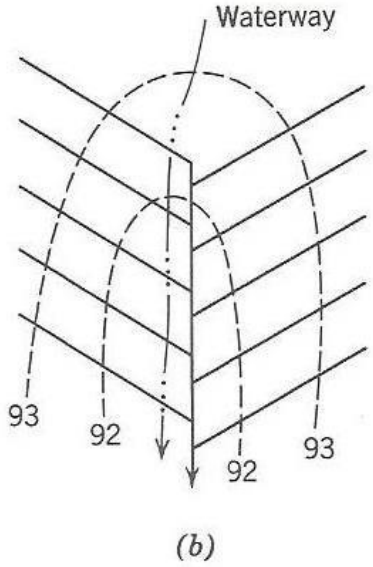
Long term measures

- Install pipe/ditch drains (probably natural (“random”) - drain the problem not the field!)
- Mole drain clay soils with perched water tables to connect with gravel backfill
- Subsoil compacted areas
- Install grass waterways
- Grade low spots in flat lands
- Improve arterial drains
- Reduce surface compaction by reducing traffic density and intensity (CTF and LGP)
- Improve soil organic matter content (a very long term effect)

Common types of pipe drainage systems

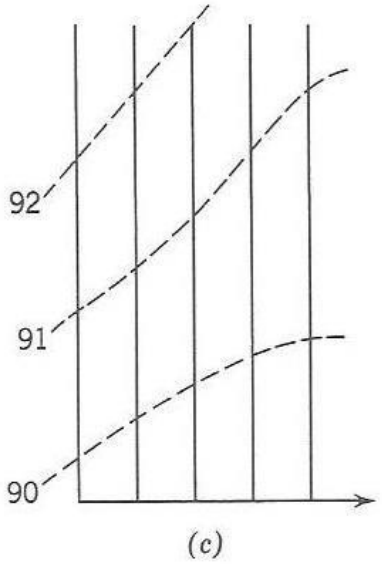
a. Natural

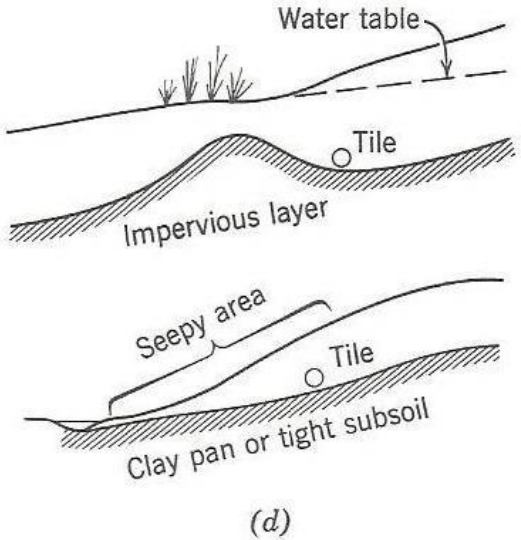




b. Herring bone

c. Regular

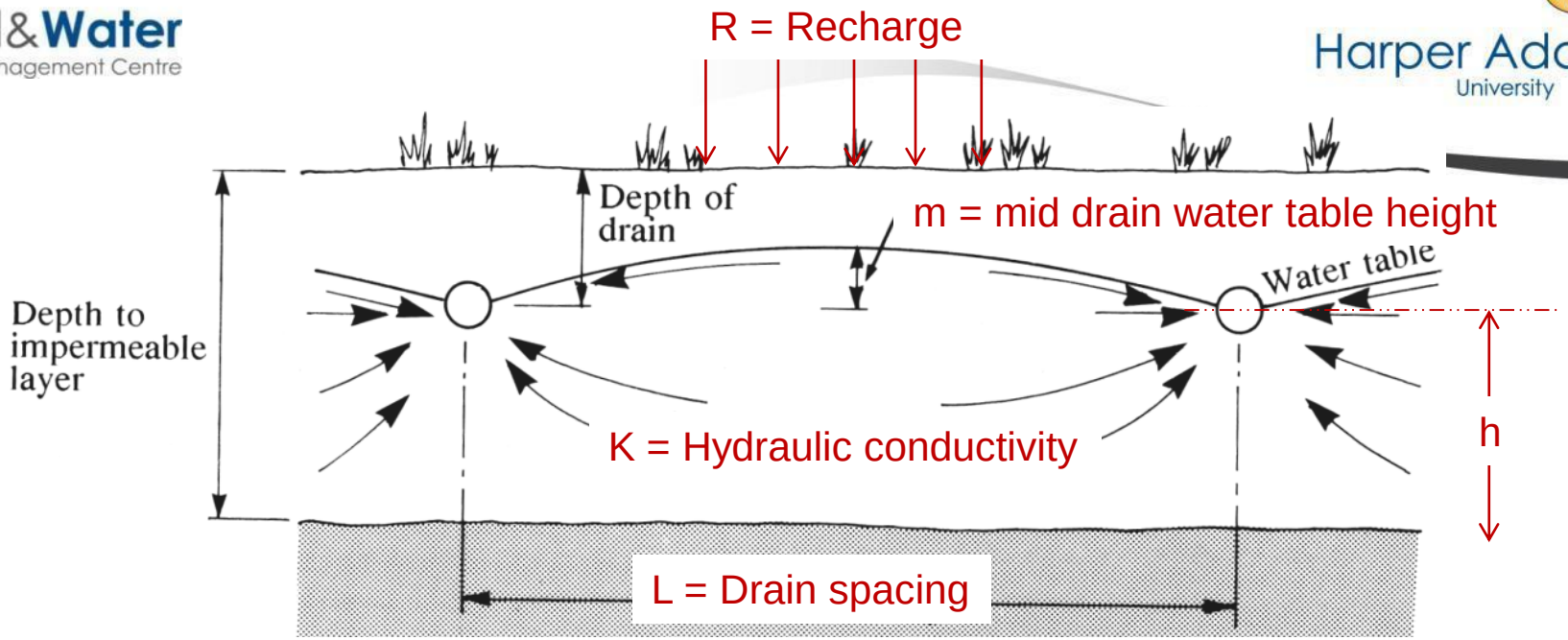




d. Cutoff or Interceptor

After: Schwab et al 1993

Drain spacing



Steady state ground water table control (*Hooghoudt Equation*)

$$L^2 = \frac{8Kdm}{R} + \frac{4Km^2}{R}$$

d = equivalent depth and is related to h
(After: Van Beers)

e.g. R = 9mm/day Drain Depth = 0.9m K = 1m/day m = 0.4m h = 2.1m

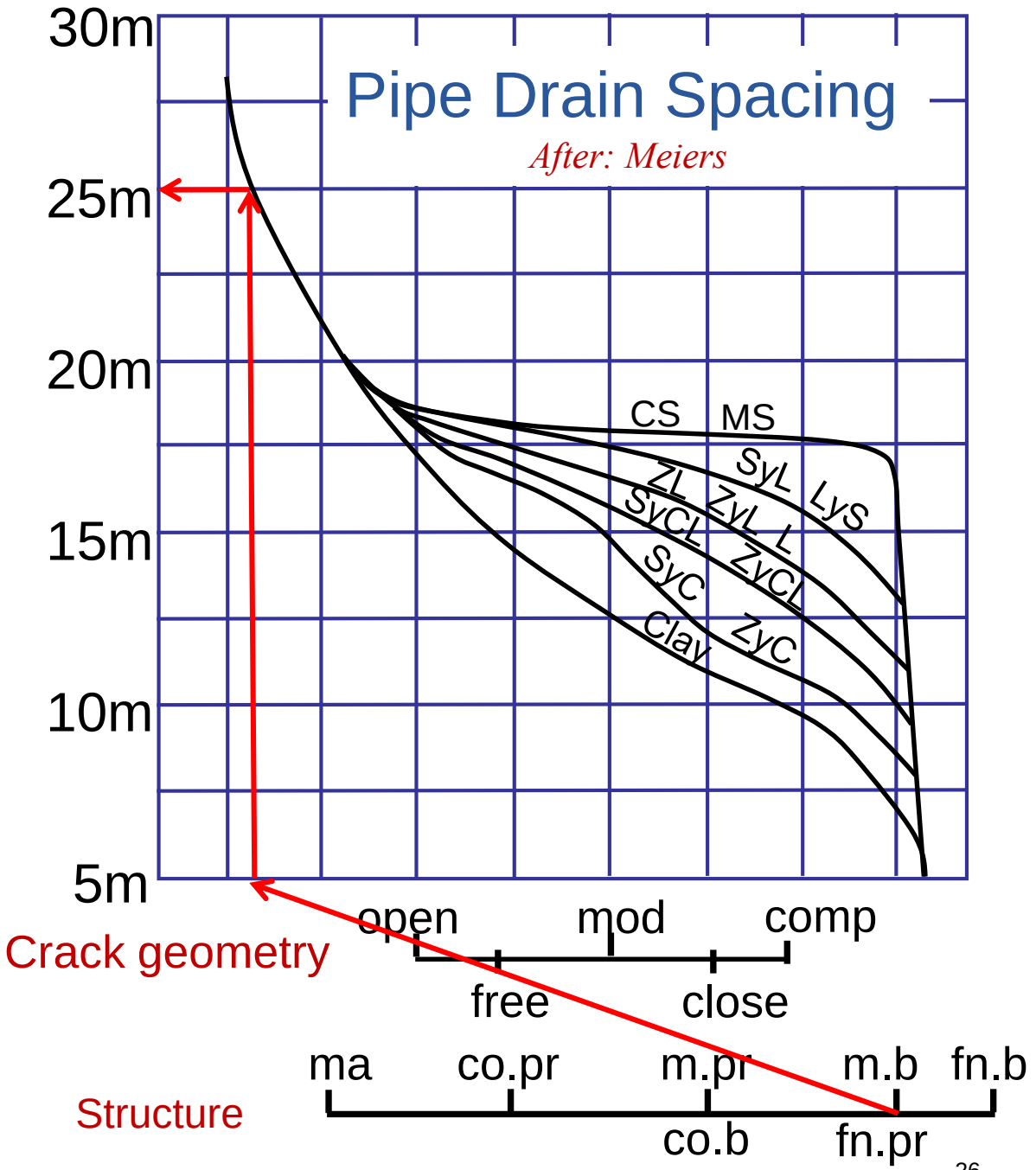
L = 25m

After: Spoor 1984

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Management Centre

CS=course sand
SyL=sandy loam
LyS=loamy sand
ZL=silt loam
L=loam
SyCL=sandy clay loam
ZyCL=silty clay loam
SyC=sandy clay
ZyC=silty clay
C=clay

ma=massive
co.pr=course prismatic
co.b=course blocky
m.pr=medium prismatic
m.b=medium blocky
fn.pr=fine prismatic
fn.b=fine blocky

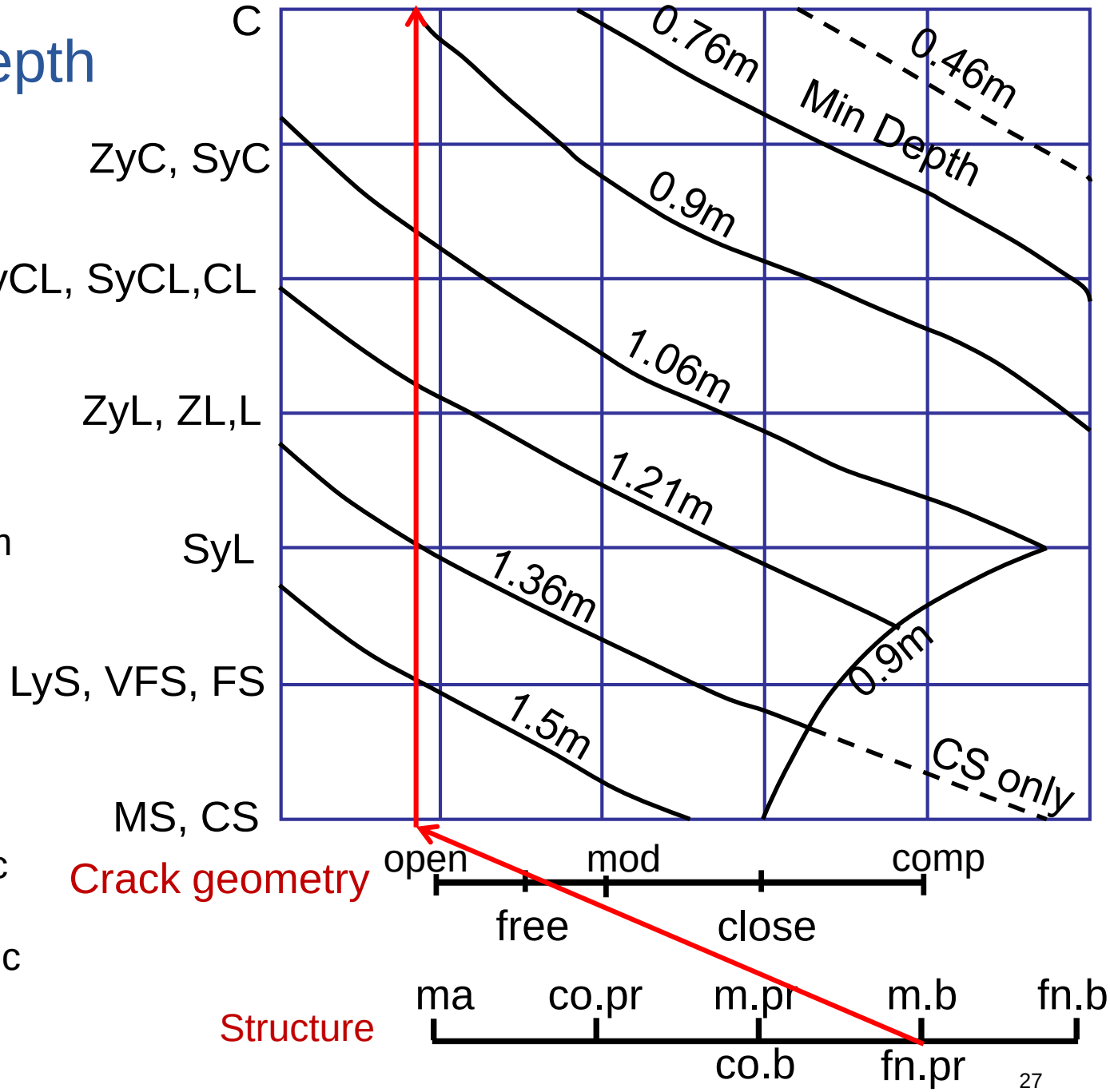


Pipe Drain Depth

After: Meiers

CS=course sand
FS=fine sand
VFS=very fine sand
LyS=loamy sand
SyL=sandy loam
ZL=silt loam
L=loam
SyCL=sandy clay loam
ZyCL=silty clay loam
SyC=sandy clay
ZyC=silty clay
C=clay

ma=massive
co.pr=course prismatic
co.b=course blocky
m.pr=medium prismatic
m.b=medium blocky
fn.pr=fine prismatic
fn.b=fine blocky



Options for compaction reduction

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Controlled traffic





After: Tullberg et al. 2003

Source: CTF Europe

Reduced pressure/axle weight and central tyre inflation pressure control systems







Lower Ground Pressure: Tyres and Rubber Tracks

+ Simple

+ Cheap

+ Less working time and improved fuel economy, trafficability and manoeuvrability

- Pressure is applied (but lower)







Extra costs tyres

Tractor - 280 hp : Ultraflex tyres extra = £1/ha

Combine: Ultraflex = £0.50/ha

Price offset by fuel savings (c.20%)

Personal communication: Mozziconacci, Michelin

Extra costs tracks

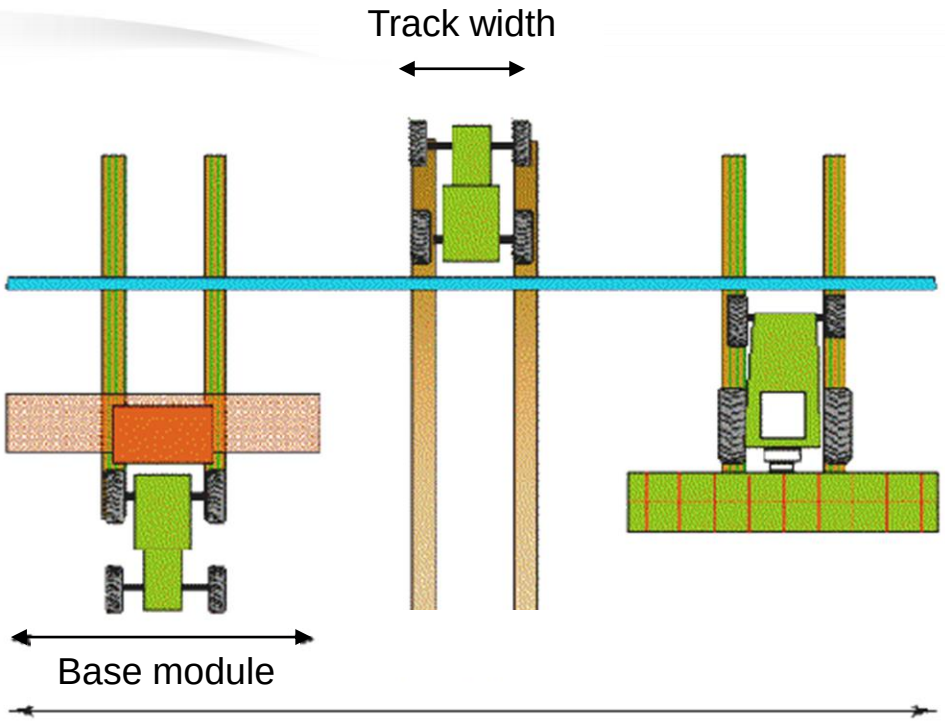
Combine: + £4 to £5/ha for 5 - 7 year life

Price offset by improved trafficability, narrower operating widths & operating up and down hills

Personal communication: Tyrell, Claas UK



Controlled Traffic Farming



- ✓ **Simple** concept
- ✓ **Soil** structure
  - ✓ Infiltration *+ 400%*
- ✓ Crop **yields**
  "CTF (+LGP) = +10 to 15% yield"
- ✓ **Fuel**, **time** and machinery **cost savings**
  "70% reduction between trafficked & untrafficked"
- ✓ **GPS guidance** and steering
- x **Track width** and **harvester width** matching

Source: CTF Europe

Subsoiling & Tramline Management

Soil&Water Management Centre

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Plain tine

Wide point, high lift wing





Narrow point, low lift wing

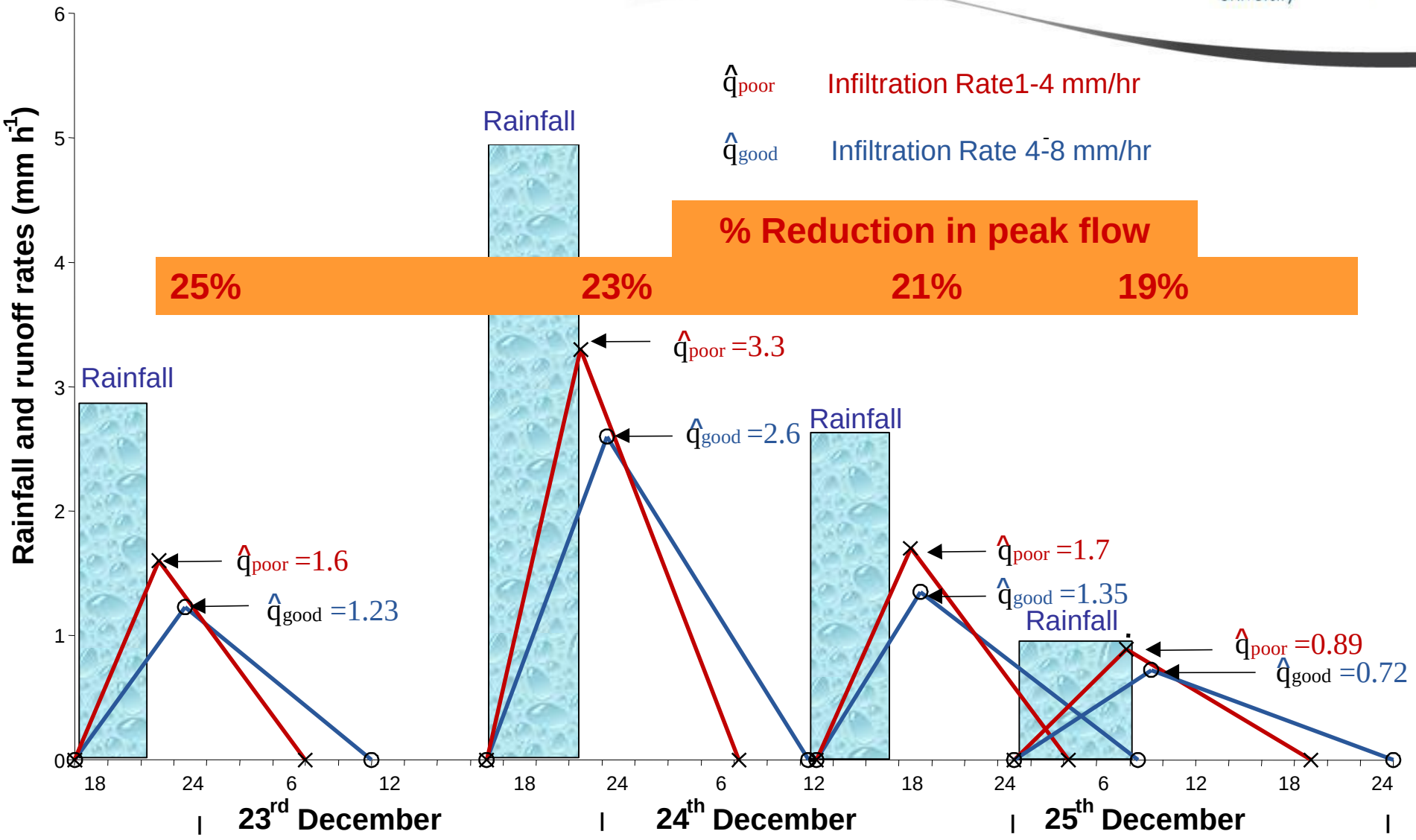
After: Spoor and Godwin, 1978

Effect of infiltration rate on runoff

Parrett and Tone Catchment, Dorset/Somerset @ Haselbury Plucknet/Chiselborough

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After: Godwin and Dresser, 2003 *From: Schwab et al., 1993*

Concluding remarks

- Improved soil and water management is achieved by:
  - Reducing traffic intensity & contact pressure
  - Checking, maintaining and improving drainage infrastructure
  - Considering the short, medium and longer term actions listed above
  - Ensure the outfall and arterial drainage system
- Remember prevention is better than cure

Regular inspections of drainage systems are needed.

Restoration of an old system is cheaper than a new system.