

INFLUENCE OF CATCHMENT HYDROLOGY ON WATER QUALITY RESPONSE

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Introduction

- **Nitrates Directive** (European Council, 1991) 2006
- Limits on stocking rates on farms in terms of the quantity of N from livestock manure that can be applied mechanically or directly deposited by grazing livestock on agricultural land.
- The limit is **170 kg ha⁻¹ year⁻¹** of N from livestock manure.
- November 2006 - derogation from the 170 kg ha⁻¹ year⁻¹ limit on N from livestock manures to allow grassland-based (mostly dairy) farmers to operate at up to **250 kg ha⁻¹ year⁻¹** under the understanding that this derogation will not impinge on meeting the requirements of the Directive.
- With the phasing out of milk quota there is the potential for dairy farmers to intensify production up to **2.94 livestock units (LU) ha⁻¹** from the current average stocking rates on dairy farms of 1.9 LU ha⁻¹.

- As land availability for agriculture decreases, intensification or expansion is probable in certain areas.
- **Paradox** between environmental compliance and agricultural intensification
- **Some areas** will see an **improvement** in environmental quality, **others** will be subject to **increased nutrient loading**.
- Where agricultural intensification occurs on such vulnerable areas **improved nutrient management** will be required to more precisely match nutrient supply with agronomic need in space and time.

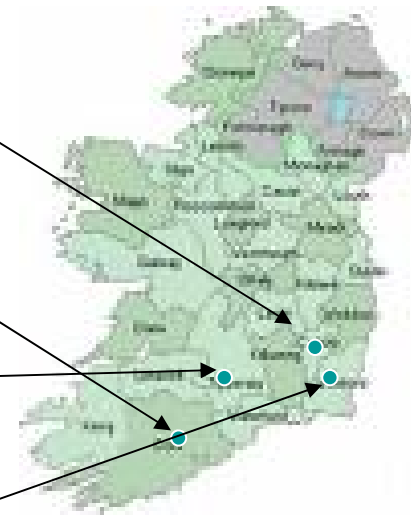
➤ The study sites are:

1. Oak Park, Co. Carlow
(High to extreme vulnerability site)

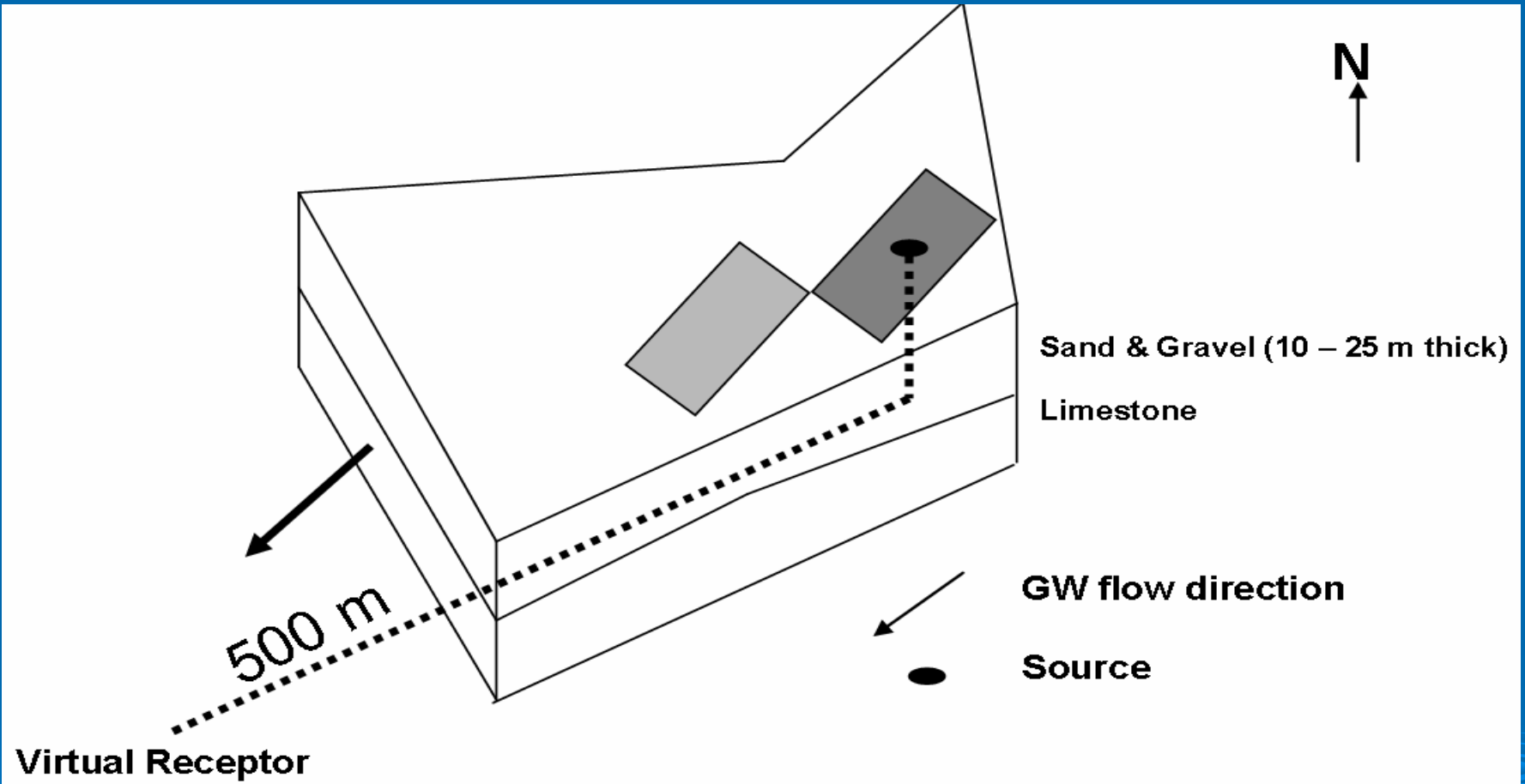
2. Moorepark Farm (Curtin's), Co. Cork
(High to extreme vulnerability site)

3. Solohead, Co. Tipperary
(Low vulnerability site)

4. Johnstown Castle, Co. Wexford
(Low vulnerability site)



Oak Park, Co. Carlow



Research into N transfer to groundwater associated with spring barley cultivation is presently being carried out by Premrov *et al.*, (2008).

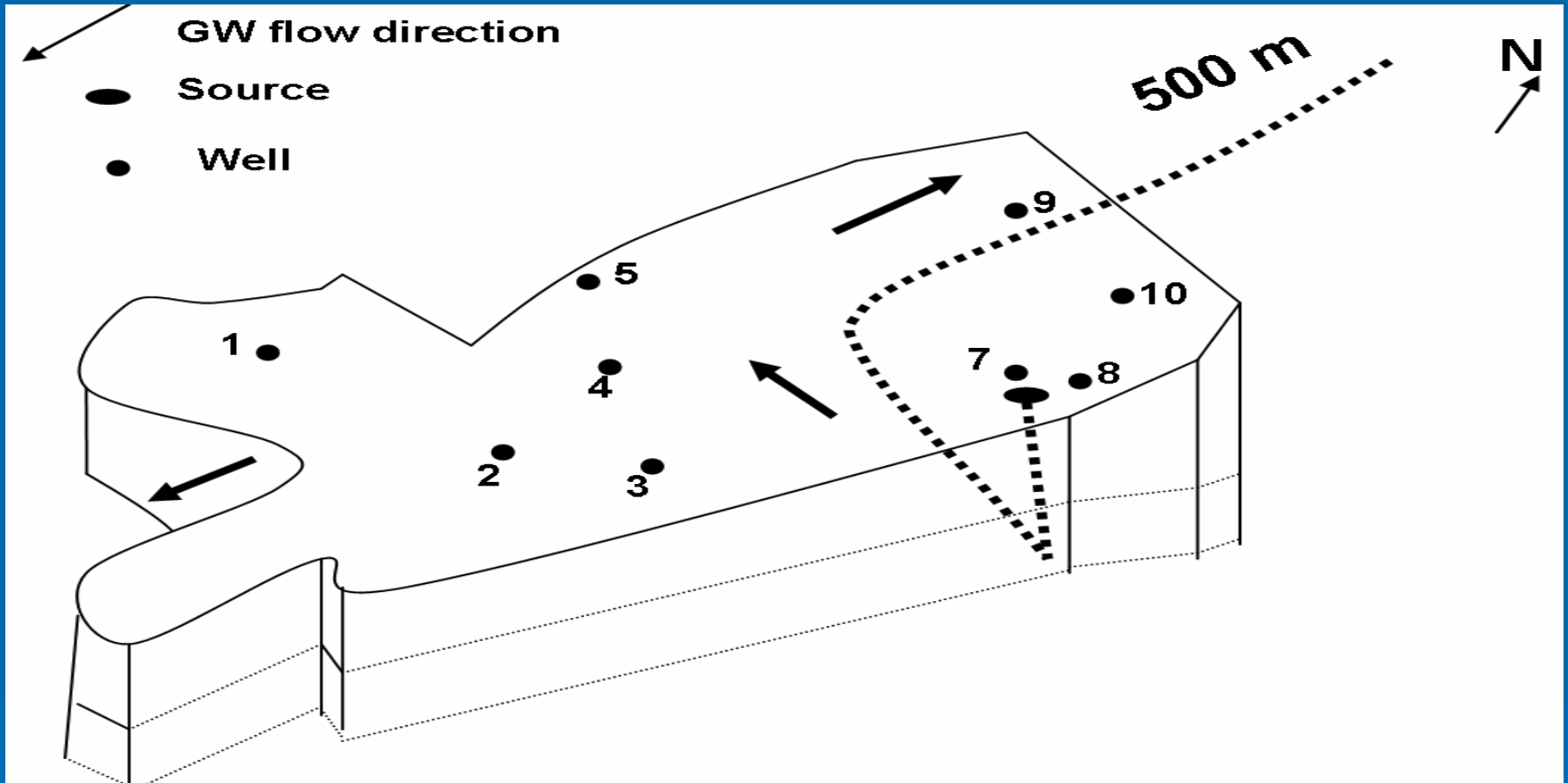
Low attenuation capacity

- Unsaturated zone travel time is based on results from a **bromide tracer** recharge experiment commenced by Hooker *et al.*, 2005.
- Breakthrough of the tracer occurred in the 0.9 m bgl suction cups from **27 to 42 days** after application, giving daily travel times of 0.02 to 0.03 m day⁻¹ (Hooker, 2005).
- Breakthrough of tracer in the groundwater receptor occurred 227 days after application and the peak occurred at **345 days**.
- This vertical travel time of approximately **1 year** corresponds with effective drainage of 300 mm (Premrov *et al.*, 2008).

Oak Park, Co. Carlow

	Linear Velocity	Permeability	Porosity*	Hydraulic Gradient	Travel time
	m day ⁻¹	m day ⁻¹			Year
<i>A</i> <i>(mixed sand & gravel)</i>	0.026	0.534	0.25	0.0122	52.5
	0.244	5	0.25	0.0122	5.6
<i>B (gravel)</i>	4.88	100	0.25	0.0122	0.2
	48.8	1000	0.25	0.0122	0.02

Moorepark, Co. Cork

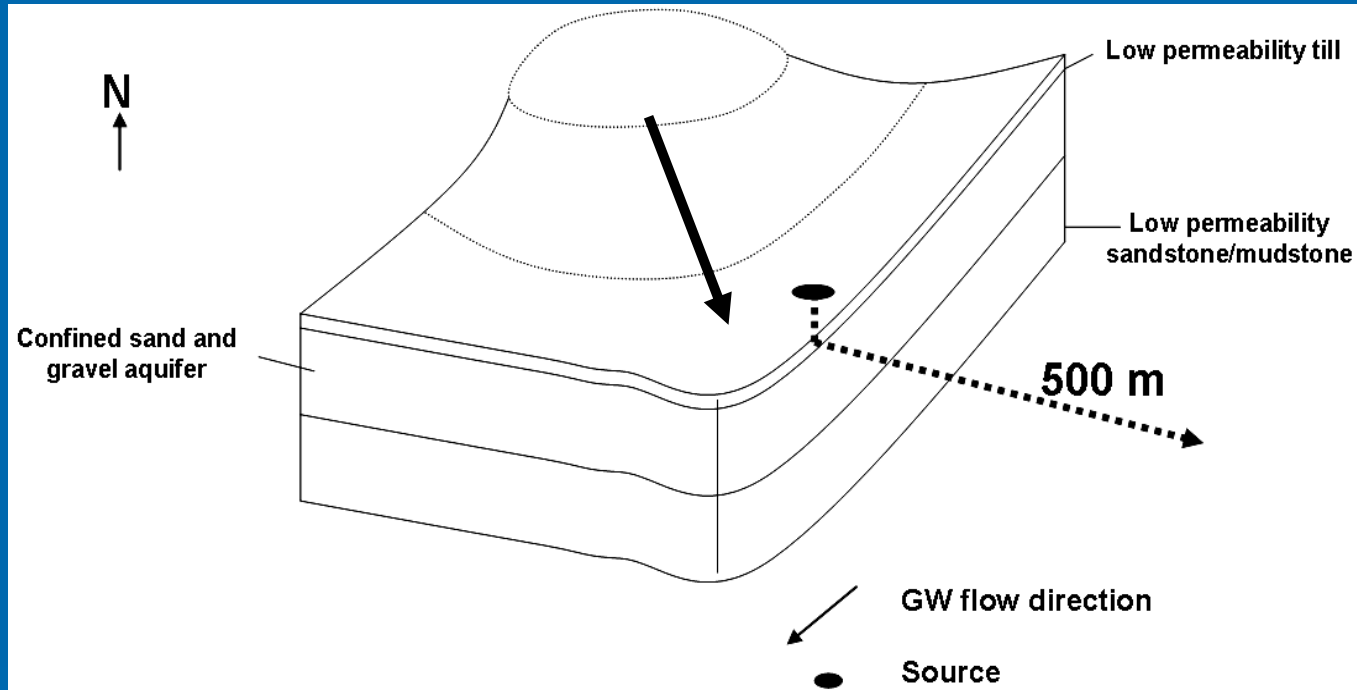


Moorepark research facility at Teagasc Moorepark is within a lowland limestone area and evaluates alternate management systems for spring calving pasture-based milk production.

Low attenuation capacity

- Travel times of approximately **44 days** exist to groundwater based on observed data from a bromide tracer migration to ceramic cups (1 m bgl) and borehole (BH) 7.
- From slug tests bedrock has a K_{sat} range depends on fracture orientation 2.6 - 27 m day⁻¹.
- Travel time therefore weeks to months (< 1 yr)
- Remember Oak Park = < 1 - 50 yr

Solohead, Co Tipperary



Quantities of mineral N in a clay loam soil (25% sand and 42 % clay) and NO_3^- -N in shallow groundwater (1 m bgl) under four dairy grassland based systems from 2001 – 2002 were examined by Humphreys *et al.*, (2008).

Losses of NO_3^- -N were low with all shallow mean groundwater NO_3^- -N concentrations at 1 m bgl $< 3.03 \text{ mg L}^{-1}$.

High attenuation capacity

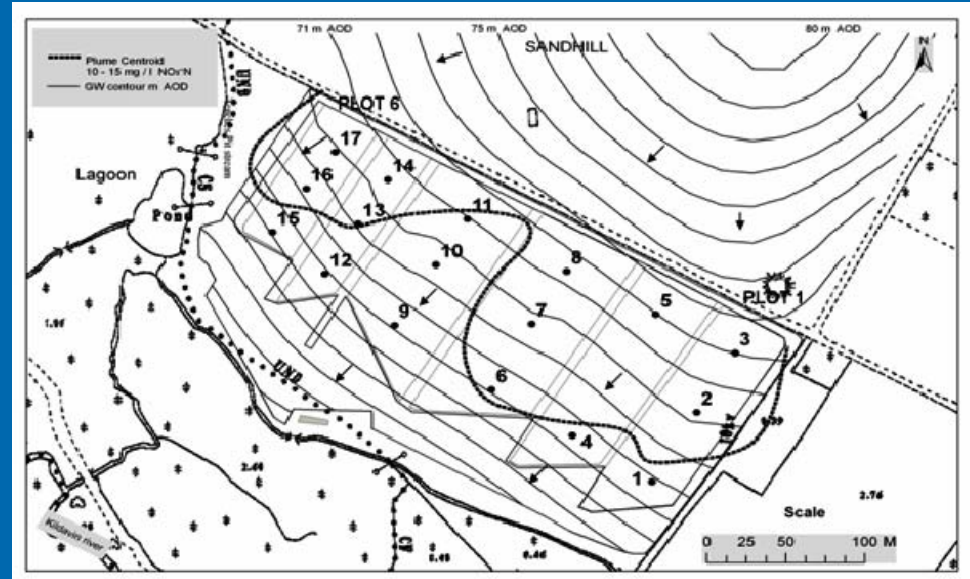
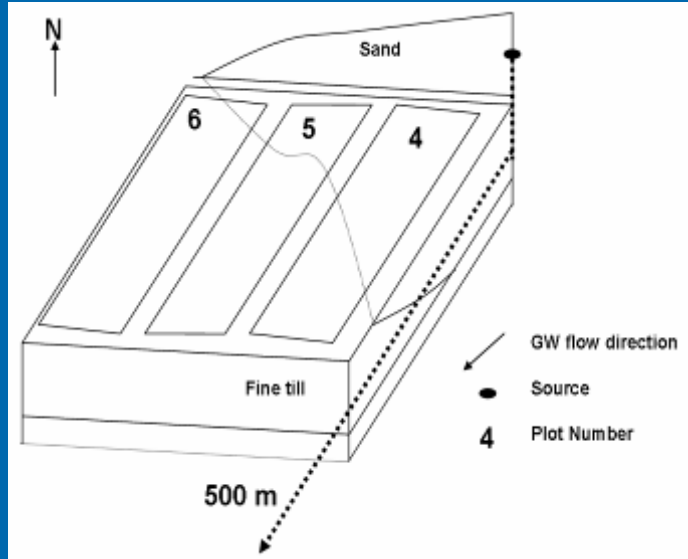
- Annual effective drainage on site is approx. **554.2** mm, which corresponds to 118 days of recharge.
- This gives an average pore velocity of 4.69 mm day⁻¹ and a corresponding infiltration depth of **0.5 m**.
- Therefore travel time to the perched water table **is not achievable** within one drainage season (winter 2001-2002, 424 mm effective drainage = 0.4 m infiltration).
- K_{sat} parameters are taken from borehole investigations at a neighbouring site (Daly & Teillard, 2001).

	Linear Velocity	K_{sat}	Porosity	Hydraulic Gradient	Travel time
	m day ⁻¹	m day ⁻¹			Year
A (Till)	0.0004	0.01**	0.1*	0.004	3424
B (sand & gravel)	0.00896	0.224**	0.1*	0.004	152

Remember

Oak Park = <1 – 50 yr, Moorepark = weeks to months

Johnstown Castle, Co. Wexford



Heterogeneous glacial deposits on a 4.2 ha gently sloping (2%) study site, comprising six study plots on a beef farm in SE Ireland. The overburden varies in thickness from 1-20 m. Underlain by impervious shale. Shallow GW monitored.

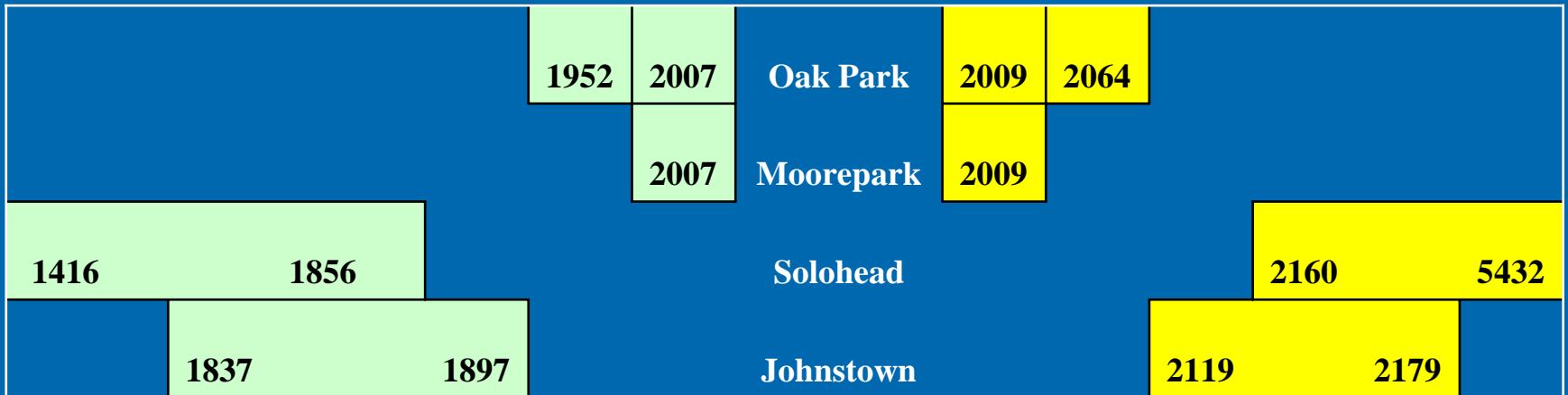
•Travel time to groundwater is based on mean precipitation of 1046 mm, of which **553 mm drainage over 178 days** through the root zone gives an average recharge rate of 3.11 mm d⁻¹. The mean soil total porosity was 32.2±4.9%. The average pore velocity was estimated to be 9.7 mm d⁻¹, giving an approximate **mean travel depth of 1.7 m** in a moderately-drained soil over the study duration.

The depth to the **median watertable** during this period was **1.01m** (Fenton *et al.*, in press).

•Mean saturated **K_{sat} parameters** for each plot are based on slug tests

Parameters	Area of beef farm					
	1	2	3	4	5	6
Area (ha)	0.78	0.75	1.01	0.94	0.41	0.41
Width of plot (m)	50.00	50.00	55.00	55.00	30.00	30.00
Mean velocity v (m day ⁻¹)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Hydraulic conductivity K (m day⁻¹)	0.0090	0.0083	0.0117	0.0117	0.0123	0.0080
Transmissivity T (m ² day ⁻¹)	0.07	0.07	0.09	0.09	0.10	0.06
Mean hydraulic head (Top) (m AOD)	67.13	68.65	70.13	69.92	69.53	69.30
Mean hydraulic head (Bottom) (m AOD)	63.31	66.21	66.80	66.40	66.50	66.28
Mean Travel Distance in 1 year	3.29	3.01	4.26	4.26	4.50	2.92
Mean time (year) to 500 m	151	166	117	117	111	171
Q	m ³ day ⁻¹					
Top Control Plane Nodes	0.15	0.15	0.15	0.15	0.12	0.09
Middle Control Plane Nodes	0.15	-	0.15	0.20	0.11	0.07
Bottom Control Plane Nodes	0.11	0.01	0.22	0.19	0.04	0.01
Contaminant Mass Flux	g NO ₃ -N m ³ day ⁻¹					
Top Control Plane Nodes	0.0009	0.0017	0.0016	0.0009	0.0015	0.0008
Middle Control Plane Nodes	0.0018	-	0.0011	0.0001	0.0010	0.0004
Bottom Control Plane Nodes	0.00074	0.00001	0.0003	0.0000	0.0004	0.0001

EFFECT ON WATER QUALITY



PAST MANAGEMENT

WQ

2008

Assumption: no other source or influence from other sectors in the system, and we must also factor in the **memory** of the systems

Conclusion

- **EU legislation does not discriminate for differences in hydrological travel time distributions that will result in different water quality response times.**
- **Lag time between introducing protection measures and first improvements in water quality will occur at different rates in different catchments.**
- **This variable response time must be considered by policy makers and farmers when assessing the efficacy of the introduced measures.**
- **Lag time may be discouraging for farmers – as limits become more stringent**
- **The unsaturated zone and shallow groundwater should be monitored to look for water quality changes due to management changes – these could be picked up in all sites within the 3 year period**