Appendix 4

Table of rainfall stations that have been used for modelling.

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Rainfall Station	Station Number	Easting	Northing
Ballinasloe (Derrymullen)	2628	183400	232200
Ballyforan (Bord Na Mona)	2528	179900	243200
Ballygar	2228	178400	252500
Glenamaddy (Gortnagier)	3127	162900	261600
Frenchpark Callow	6129	169600	295500
Lecarrow	4129	196900	254900
Loughglinn	1128	163400	286000
Roscommon (Vocational School II)	5829	186700	264100
Strokestown (Carrowclogher)	6329	192800	278200
Coolavin	4729	166600	298500
Aherlamore	5704	150000	66600
Ballinagree (Mushera)	2904	135700	85500
Banteer Lyre	6306	141500	92500
Cork (Clover Hill)	4204	171100	70400
Cork (Douglas)	5504	170800	69400
Cork Airport	3904	166500	66200
Cork Montenotte	5404	169300	72600
Donoughmore	2804	149200	82100
Inishcarra (Gen.Stn.)	3704	154500	72200
Lombardstown (Drompeach)	6206	146300	94200
Muskerry (Golf Club)	6104	158000	74300
Rathduff G.S.	1504	159800	84800
Enniskerry (Kilmalin)	2324	319800	217700
Ballyedmonduff House	3524	318500	221800
Milltown (Golf Club)	6323	316500	229900
Stillorgan (Vartry Hse.)	2723	320200	226800
Celbridge (Ardrass House)	8123	294300	230900
Timahoe South	3331	278700	229200
Casement Aerodrome	3723	304100	229500
Dublin (Phoenix Park)	1723	310000	236100
Leixlip (Gen.Stn.)	4223	300700	235800
Dunsany (Grange)	3731	288800	252800
Warrenstown	2931	292100	253500
Bangor Erris (Kiltane)	1634	82200	323400
Bangor Erris (Main St.)	1834	86300	323200
Bellacorrick (Moneynierin)	934	98800	319700
Bellacorrick (Shanvolahan)	3535	101900	319700
Bellacorrick (Srahnakilly)	1334	97500	323300
Keenagh Beg	2435	103000	311000
Mulrany (Doughbeg)	1233	80900	294300
Newport (Furnace)	833	96700	298100
Srahmore	1533	97200	304800
Drangan (Moanvurrin)	4112	228500	142200
Fethard (Parsonshill)	7112	223800	140300
Littleton Ii B. Na M.	6712	220400	151100
Mullinahone (Killaghy)	6312	233400	140900

Roscrea (New Road)	6119	214700	190800
New Ross W.W.	5714	272400	128300
Callan (Mallardstown)	4813	244100	142300
Callan (Moonarche)	4113	239400	142700
Coolgreany Castlewarren	5214	259600	162300
Coon	4013	259600	170600
Dungarvan (Castlefield)	5013	259700	148500
Gowran	6514	262900	153200
Kilkenny	3613	249400	157400
Kilkenny (Lavistown House II)	4513	254300	154300
M.Thomastown Forest	9813	266300	142700
Mullinavat (Glendonnell)	6912	257500	123800
Paulstown (Shankill Castle)	5514	266200	160000
Piltown (Kildalton Agr.Coll.)	5912	247700	122400
Thomastown (Mt. Juliet)	4913	254900	141500
Tullaroan (Ballybeagh)	4413	233300	157800
Carlow (Oak Park)	4814	273000	179500
Aughnacross	5113	250300	182200
Clonaslee Waterworks II	3222	231700	210300
Parknahown Cullahill	4213	234300	173900
Portlaoise (Coolnamona)	4614	245600	194900
Portlaoise Esb Training Centre	2614	247100	197400
Slieve Bloom Mtns.(Nealstown)	3513	219900	193600
Derrygreenagh	3431	249300	238200
M.Donadea Forest	9931	274800	249700
Ballivor (Hill Of Down)	2731	264400	254100
Coole (Coolnagun)	1130	238400	270100
Kinnegad (Mullingar Road)	4631	259000	245900
Mullingar II	2922	242300	254300
Rathwire	4331	257000	251300
Foulkesmills (Longraigue)	108	284100	118400
John F. Kennedy Park	4514	272300	118900
Ballincurrig (Peafield)	6204	186300	84200
Bartlemy	7006	181900	87600
Dungourney (Ballyeightragh)	4804	194800	83100
Fermoy (Moore Park)	3606	181900	101400
Killeagh (Monabraher)	4904	201000	80600
Mallow (Sewage Treatment Works)	6606	157600	98000
Watergrasshill (Tinageragh)	5804	176100	84500
Tallow Kilmore	6406	201200	91300
Youghal (Glendine W.W.)	4106	206400	83900
Enniscorthy Brownswood	4015	297800	135400
Kiltealy Askinvillar	4115	284300	145500
Pollmounty Fish Farm	6114	274600	135600
Ballineen	4002	134300	54000
Macroom (Curraleigh)	5204	126300	80700
Rockchapel (Cappaphaudeen)	2410	116000	110800
Gap Of Dunloe	405	88500	81900
Killarney (Muckross Hse.)	3205	97200	86200
Listowel (Grogeen)	2310	101000	132800

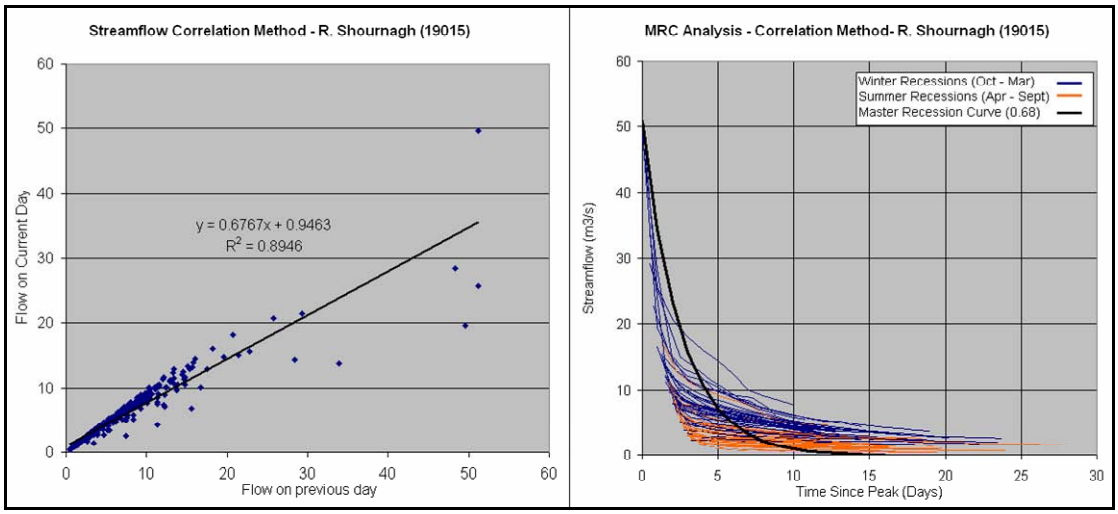
Cahir Park II	6412	204500	122800
Cashel (Ballinamona)	2012	204900	140000
Nenagh (Connolly Park)	5819	187200	180000
Silvermines Mtns.(Curreeny)	4819	190100	164700
Castlemahon W.W.	4911	131500	131200
Meanus	5811	158400	140200
Mount Russell	5306	161300	119800
Murroe G.S.	4319	173100	155300
Carron	1718	127700	198200
Tulla	1218	148900	180100
Gorey (Treatment Works)	1216	315900	158800
Blessington (Hempstown)	8623	299900	217400
Carnew (Cronyhorn)	5015	300500	163900
Moneystown	820	319200	195900
Birr	4919	207400	204400
Curragh Racecourse	5614	277800	213600
Kells (Headfort)	931	276100	276900
Tyrrellspass	3022	240100	235500
Granard Springstown	1830	238100	280900
Gort (Derrybrien II)	2121	159700	201900
Milltown	3027	141000	262800
Ballina (Attymass)	4835	129200	312100
Hollymount G.S.	1527	126200	268500
Aughnasheelan (Miskawn)	3937	208500	315100
Dromahair (Market St.)	1936	180600	331500
Dromod (Ruskey)	1829	205300	286200
Manorhamilton (Amorset)	2236	188200	339800
Cavan (Drumconnick)	4137	239800	305300
Rockcorry	2737	264600	319000
Fintown (Kingarrow)	1742	196500	405600

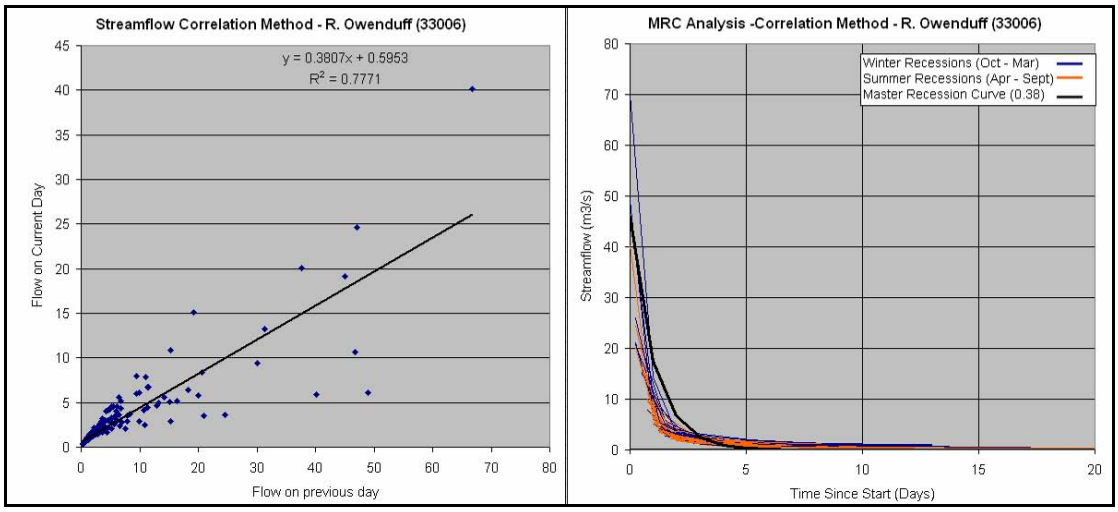
Appendix 5

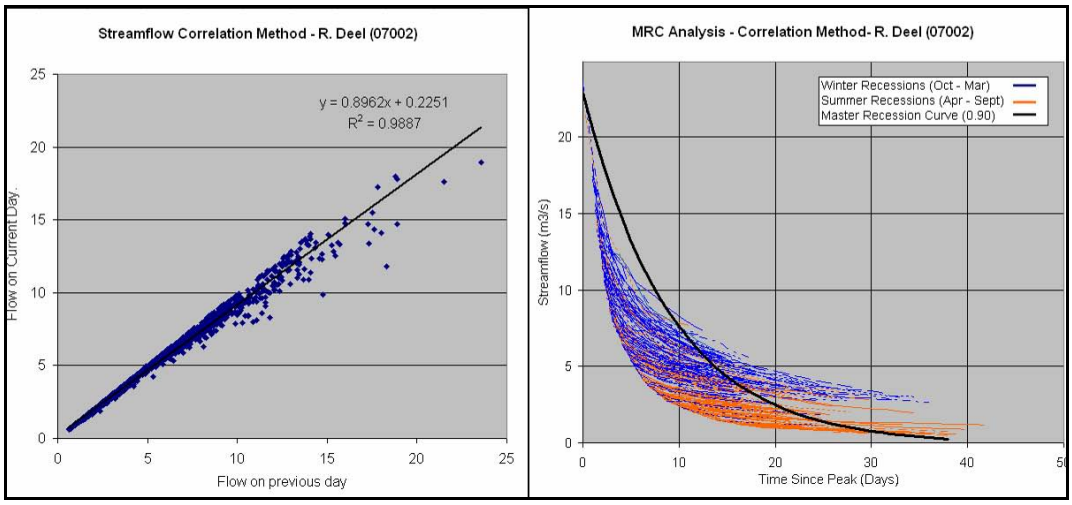
Derivation of the Recession Constant (k)

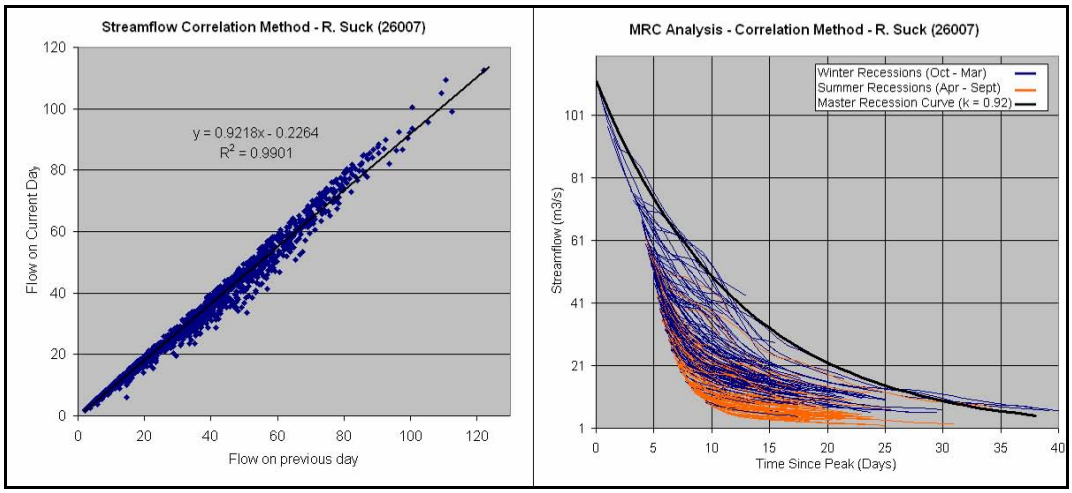
Derivation of the Recession Constant (k)

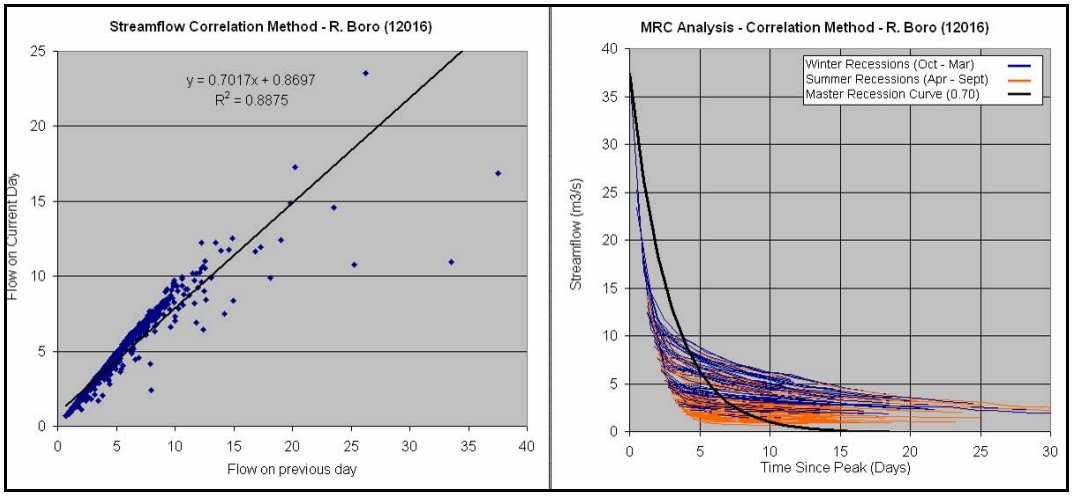
The resulting recession curves based on one exponential coefficient does not match recorded recessions well (shown below) because it suggests that there is only one linear storage for all groundwaters.

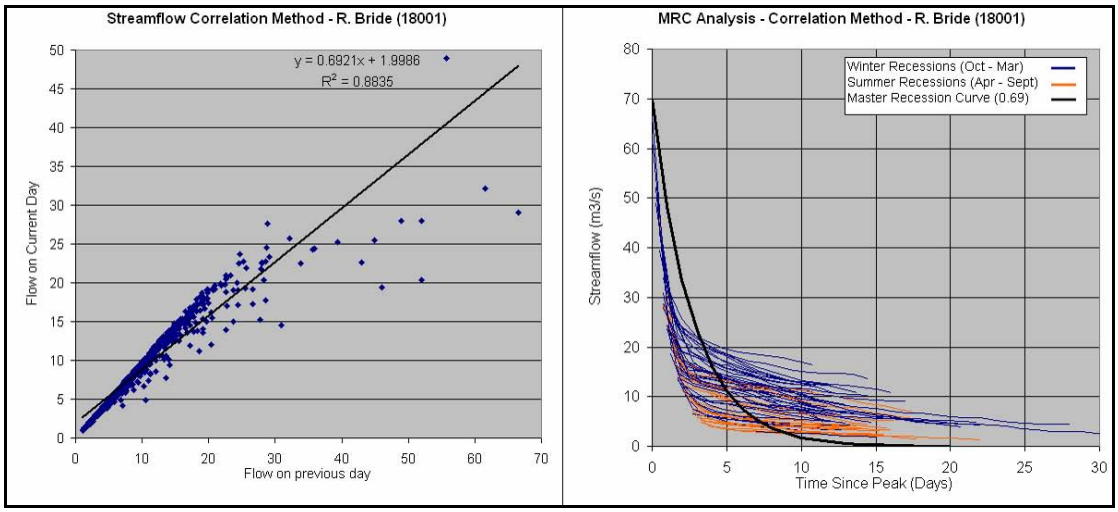





Streamflow Correlation Method - R. Deel (07002)
y = 0.8962x + 0.2251
R² = 0.9887
Flow on Current Day
Flow on previous day
MRC Analysis - Correlation Method- R. Deel (07002)
Winter Recessions (Oct - Mar)
Summer Recessions (Apr - Sept)
Master Recession Curve (0.90)
Streamflow (m3/s)
Time Since Peak (Days)


Streamflow Correlation Method - R. Suck (26007)
y = 0.9218x - 0.2264
R² = 0.9901
Flow on Current Day
Flow on previous day
MRC Analysis - Correlation Method - R. Suck (26007)
Winter Recessions (Oct - Mar)
Summer Recessions (Apr - Sept)
Master Recession Curve (k = 0.92)
Streamflow (m3/s)
Time Since Peak (Days)


Streamflow Correlation Method - R. Boro (12016)
y = 0.7017x + 0.8697
R² = 0.8875
Flow on Current Day
Flow on previous day
MRC Analysis - Correlation Method - R. Boro (12016)
Winter Recessions (Oct - Mar)
Summer Recessions (Apr - Sept)
Master Recession Curve (0.70)
Streamflow (m3/s)
Time Since Peak (Days)


Streamflow Correlation Method - R. Bride (18001)
y = 0.6921x + 1.9986
R² = 0.8835
Flow on Current Day
Flow on previous day
MRC Analysis - Correlation Method - R. Bride (18001)
Winter Recessions (Oct - Mar)
Summer Recessions (Apr - Sept)
Master Recession Curve (0.69)
Streamflow (m3/s)
Time Since Peak (Days)

Appendix 6

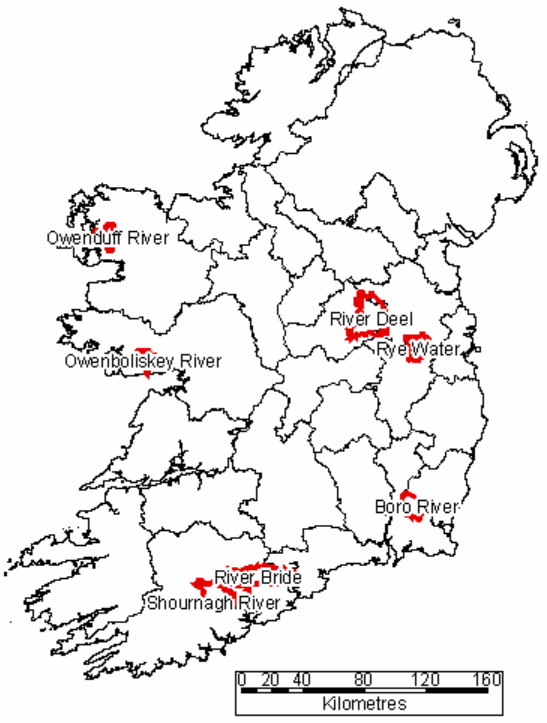
Catchment characterisation for analytical groundwater through-flow parameter derivation

Catchment characterisation for analytical groundwater through-flow parameter derivation

To derive estimate for the unknowns in the Darcy groundwater flow equation, assessments of pilot catchment characteristics were made. GSI databases were interrogated to assess aquifer characteristics for bedrock aquifer types that occur in the pilot catchments.

The location of the pilot catchments is shown in the Figure (right). The catchments assessed are those underlain by poorly productive aquifers: the Owenduff, the Shournagh, Deel, Rye Water, and Bride.

Figure: Location of pilot catchments



PRECAMBRIAN – Owenduff Catchment

The Owenduff catchment is dominated by upland areas in the east and flatter plains in the west, towards the catchment outlet. Elevation ranges from sea level to about 500m AOD. The total catchment area is 131.7 km^2. The total length of rivers and streams in the catchment is 273.31 km (this value, which is conservative, derives from the 1:50,000 OSi vector data set augmented with streams marked on 1" to 6 mile maps).

The catchment bedrock geology is dominated by PreCambrian Quartzites and Schists, with minor areas of PreCambrian Marbles and Dinantian Sandstones. The majority of the catchment is classed as a Pl aquifer: "Bedrock which is Generally Unproductive except for Local Zones". Quaternary sediments are dominated by blanket peats. Alluvium is mapped along the larger rivers' valleys. Till derived from metamorphic sediments (TMp, Teagasc 2005) in general separates the areas of shallow rock from the peat. Subsoils thicknesses are not known. Metamorphic till permeability is mapped as Moderate in the Donegal GWPS.

Figure: Catchment topography and river network

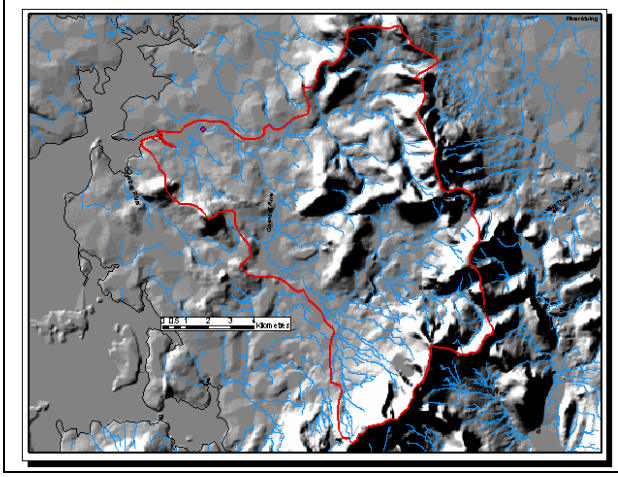


Figure: Catchment topography, river network and subsoils

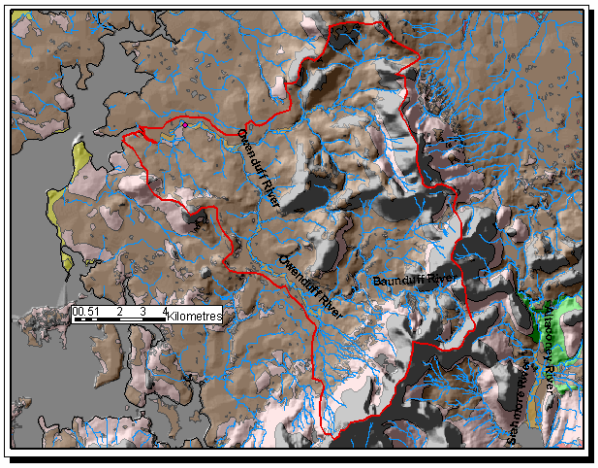


Table: Percentage by area of Quaternary sediments ("subsoils") and lakes in catchment.

Subsoil	% area
Alluvium	0.2%
Blanket peat	90.5%
Lake	0.04%

Subsoil	% area
Rock/ rock close	4.7%
Scree	0.001%
Metamorphic Till	4.5%

To analyse the catchment characteristics, the catchment was subdivided into upland and lowland areas. This was done on the basis of the break-in-slope (i.e., where the rate of change of elevation gradient was greatest). The "upper zone" is predominantly rock/rock close, but does contain areas of Metamorphic Till and Blanket Peat. Subdividing the catchment into two areas based on elevation is also desirable. Unfortunately, the data were unavailable to complete this task.

Figure: Subdivision of catchment into "upper" (purple) and "lower" (green) zones based on break-in-slope.

These zones are used in stream density and stream separation calculations using Hogan's code (2003). The numbered rectangles refer to areas in which stream separation is investigated in more detail.

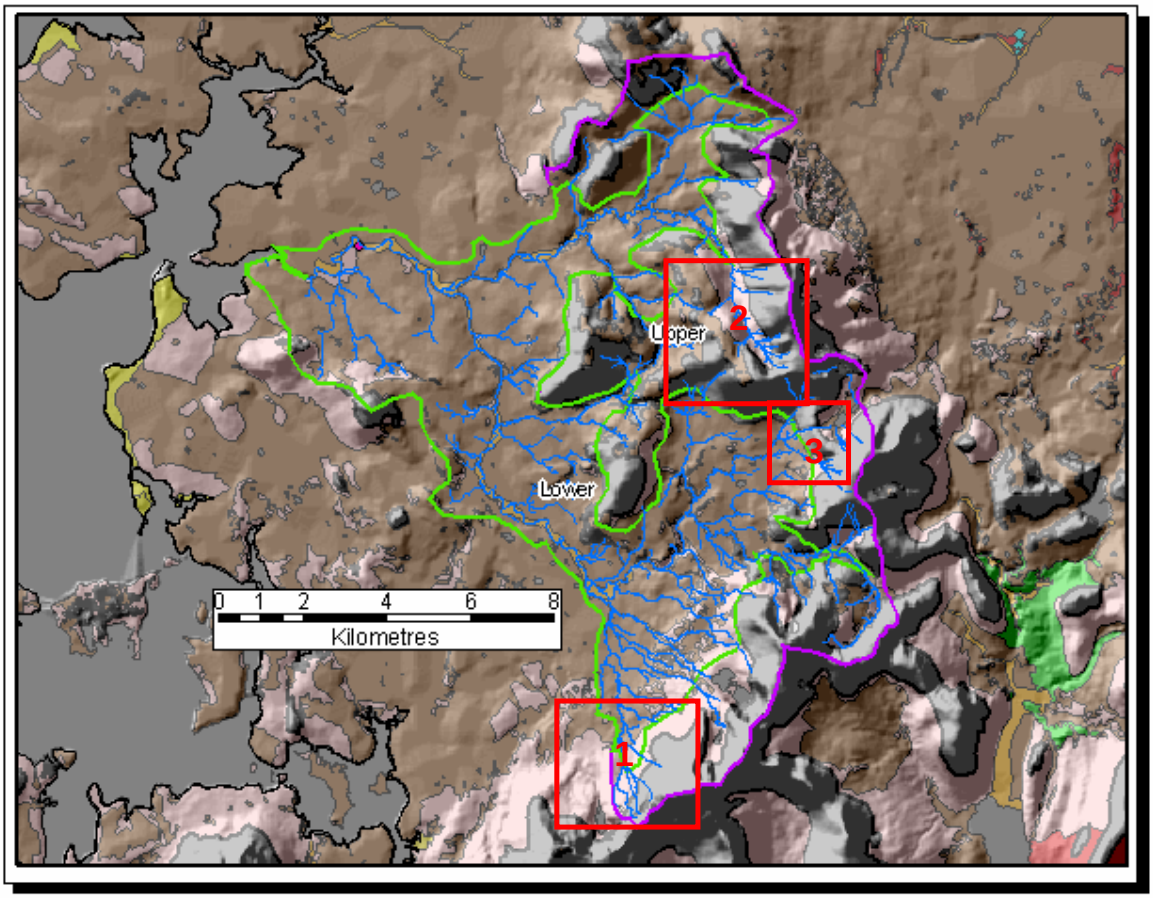


Table: Catchment characteristics

	Whole catchment	Lower zone	Upper zone
River/stream length (km)	273.3	200.8	72.5
Area (km^2)	131.7	75.7	56.0
Drainage Density (km/km^2)	2.076	2.652	1.296
Average Distance (km)	0.216	0.175	0.311

The figures and table above shows that the drainage density is greatest in the lower part of the catchment. As can be seen from the figures above, the greatest number of streams per area occurs in the southern part of the catchment, on the peat. This region was included in the "lower zone" by virtue of it occurring in a flatter area and thus below the 'break-in-slope'. However, if an elevation criterion was used to subdivide the catchment, it would likely be in the "upper zone".

Streams do originate in the area mapped as rock/rock close. However, it appears that factors that strongly influence the location of stream headwaters in this catchment are (i) the boundary between rock/till and peat and (ii) the zone where the ground slope decreases (i.e. break-in-slope).

Since the focus of this part of the study is the bedrock aquifer component of the hydrological cycle (i.e., not the subsoils), further stream separation statistics were compiled for the areas in parts of the catchment mapped as rock/rock close. These areas are shown on the map above by red rectangles and in the figures below. The key features are summarised in the table below.

Figure: Areas of the catchment where rock/rock close is mapped and where stream separation is investigated in more detail.

Area 1 ***Area 2*** ***Area 3***

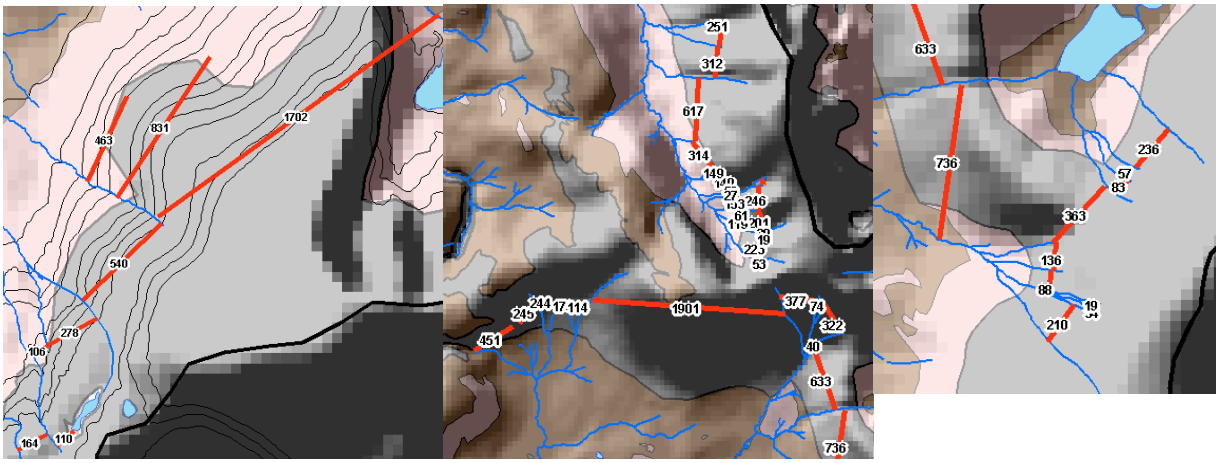
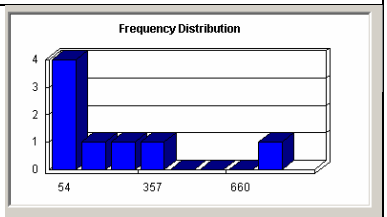
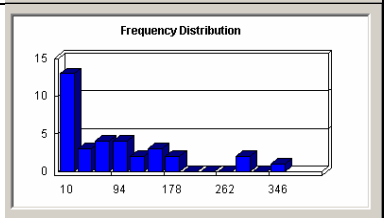
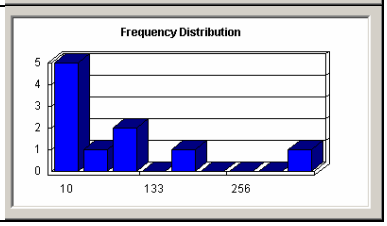
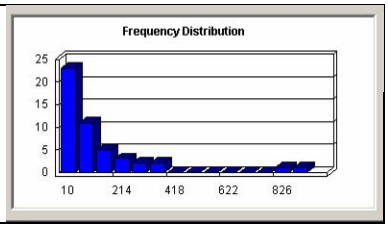


Table: Summary of stream separation and "flow path length" in selected areas

Area	Ground slope		arithmetic average	median	geometric mean	range	
1	0.15	**Stream separation (m)**	524	370	342	107-1702	
		Flow path length (m)	*262*	*185*	*171*	*54-851*	
2	N/A	**Stream separation (m)**	255	165	145	19-1901	
		Flow path length (m)	*127*	*82*	*73*	*10-950*	
3	0.33	**Stream separation (m)**	196	112	117	19-736	
		Flow path length (m)	*98*	*56*	*59*	*10-368*	

All areas	N/A	**Stream separation (m)**	287	170	160	19-1901	
		Flow path length (m)	*144*	*85*	*81*	*10-951*	

The above maps and summary table show that groundwater "flow path lengths" (assumed to be half stream separation) range from 10-950 m. The length appears to be inversely correlated with ground slope, which would be expected. The distributions of the groundwater flow path lengths are skewed strongly to smaller values (they appear to be Poisson distributions rather than log-normal).

For all of the three areas, the median groundwater flow path length is 85 m, the geometric mean (suitable for skewed, log-normal distributions) is 81 m, and the arithmetic average is 144 m. These values compare with an average stream separation in the "upper zone" of 311 m, hence average "groundwater flow path length" of about 156 m.

There are very few analysable pumping tests conducted in the typically low-transmissivity PreCambrian rocks and, more generally, in all Irish aquifers. Therefore, to gain an idea of the transmissivity in this catchment, transmissivity is estimated from available specific capacity data for the PreCambrian aquifer using Logan's rule (T = 1.22 * Q/s) (Logan, 1964). The figures below show histograms of the "Logan transmissivity" on Log and compressed scales (note that the bins on the diagram on the right don't increase linearly).

Figure: Logan transmissivities in PreCambrian aquifers, n=26.

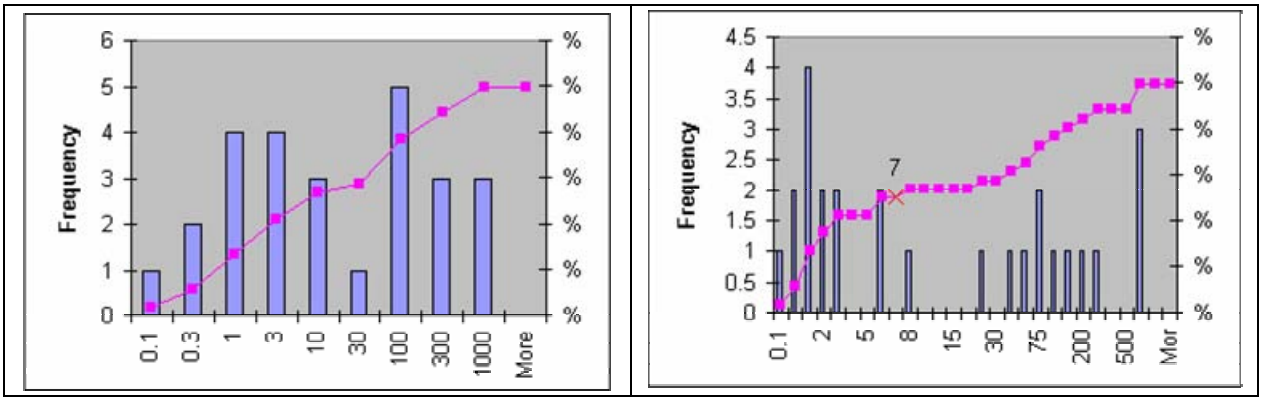
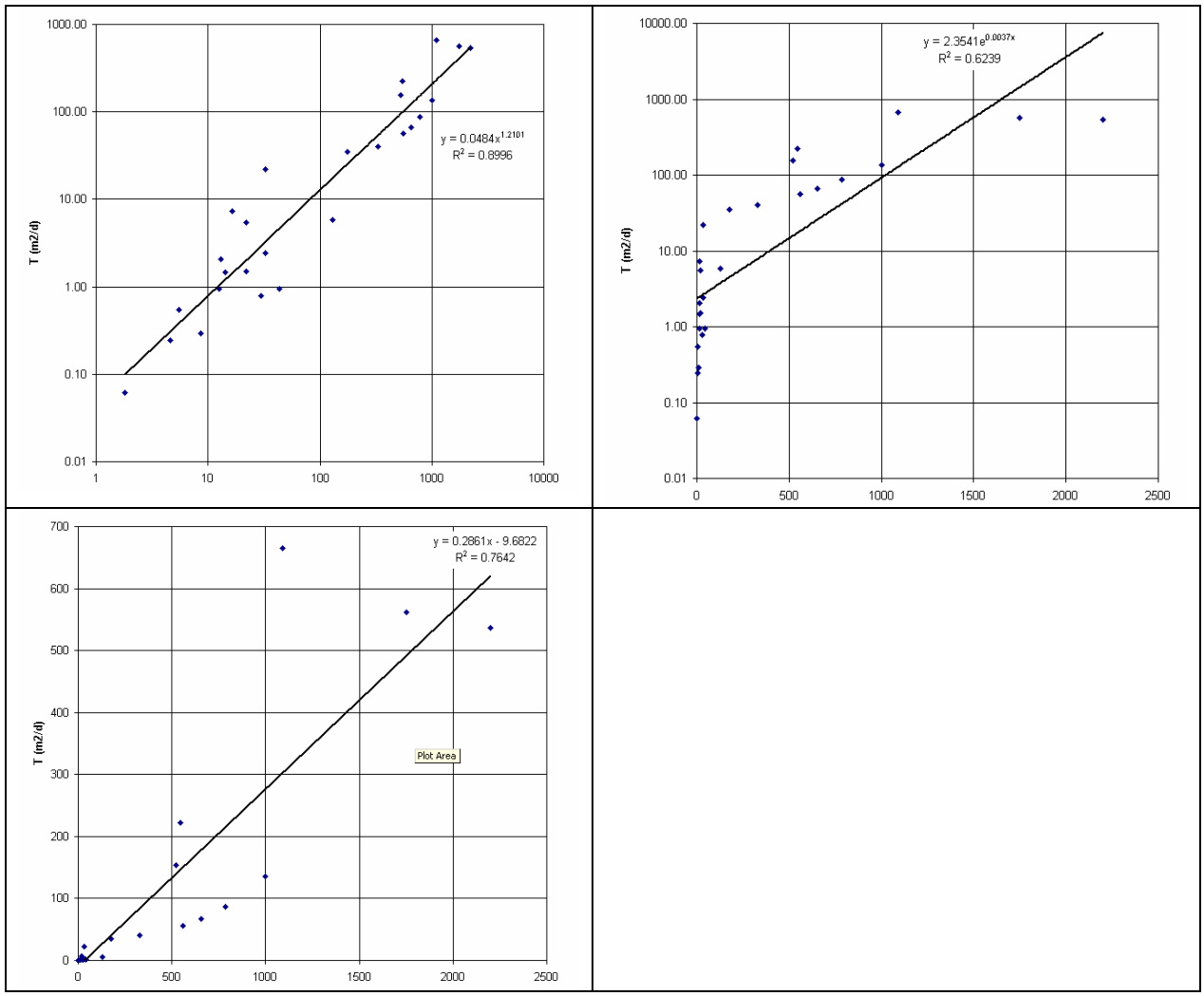


Figure: Logan transmissivities vs. yield/abstraction in PreCambrian aquifers, n=26.

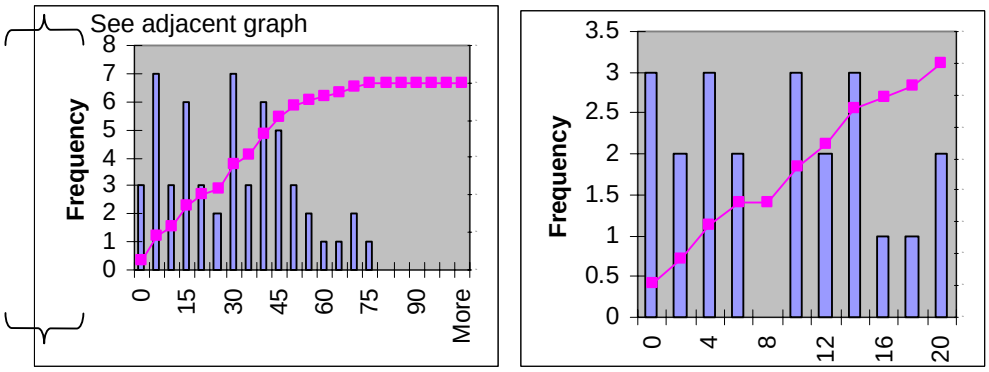


The median transmissivity is 7 m^2/d, with the modal values between 0.1-1 m^2/d. There appears to be a bimodal distribution, with transmissivities ranging from 0.1-8 m^2/d and then about 50-650 m^2/d.

As can be seen from the histograms and the graphs, very high yields/abstractions are achievable from these aquifers. As far as can be ascertained, these high transmissivities are associated with public supplies, which may have targeted fault zones. The fact that there are a relatively large number of these, compared with the lower transmissivities, is very likely to reflect the fact that there is bias in reporting the better-yielding wells, and also bias in collecting the data, since the GSI database contains public water supply scheme information where possible.

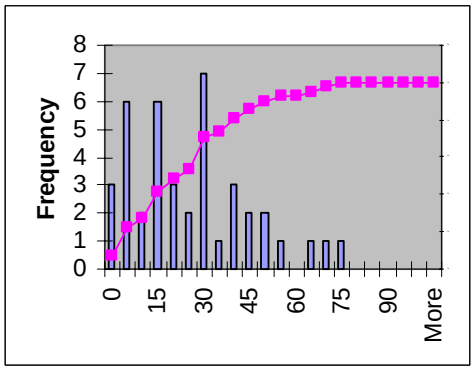
Another aquifer characteristic of interest is the depths at which groundwater inflows are encountered during drilling. The figures below show all recorded inflow intervals in 42 boreholes (left diagram shows all data, right diagram shows a subset of the data on different class divisions. The inflow levels are given as metres below rock head (mbrh).

Figure: Groundwater inflows in boreholes drilled in PreCambrian aquifers, metres below rock head. Number of wells = 42, n=56.



The median inflow level is approximately 27 mbrh. The maximum inflow depth for the first inflow is about 75 mbrh. Second and subsequent inflows are recorded typically at depths of between 30-60 mbrh. The figure below shows a histogram of first recorded inflows. Both the full dataset and 'first inflow' data weakly indicate a bimodal distribution.

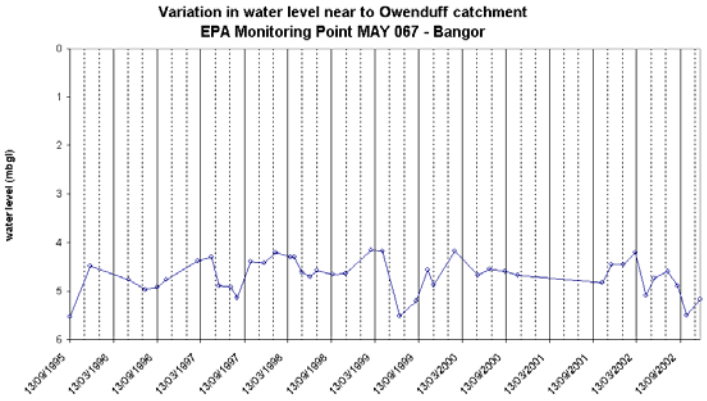
Figure: First groundwater inflows in boreholes drilled in PreCambrian aquifers, metres below rock head. Number of wells = 42, n=42.

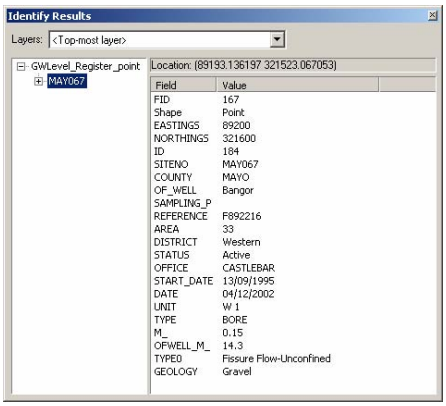


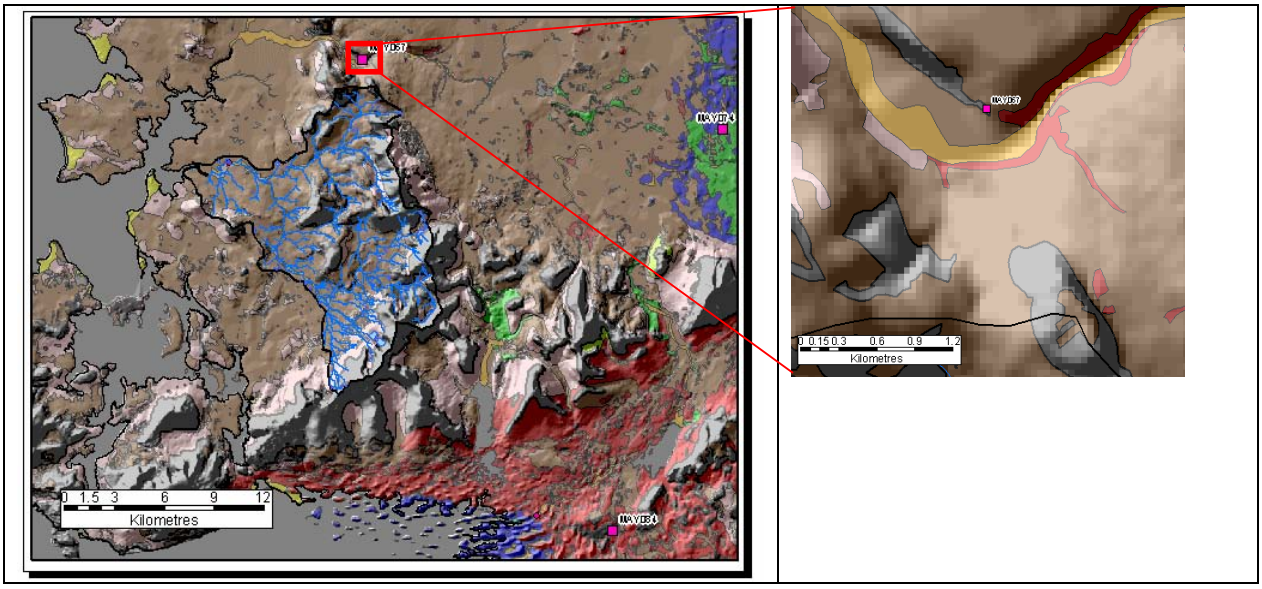
The data shown above is illustrative only, since there is often no indication of the significance of the inflows, most boreholes do not have this information recorded, and the way the inflows are recorded is likely to be influenced by the purpose of the borehole, potentially biasing the dataset. What the data may indicate is that there are "shallow" inflows, to about 20 mbrh, then deeper inflows associated with fissures, occurring between 25-75 mbrh. The (bi)modal inflow depth ranges are 5-10 mbrh and 25-30 mbrh.

There is no known groundwater level monitoring in the catchment. The nearest EPA groundwater level monitoring point is less than 2 km from the northern catchment boundary, thus the monitoring point is in a very similar catchment. It is located near to the bottom of a valley, by a stream. EPA records indicate that it is monitoring 'gravels', although it is also typed as a 'fissure flow unconfined'. The seasonal variation in water level is about 1 m. This is a very small variation for low permeability, low storativity rocks, and is reflective of the position of the monitoring point in or near a groundwater discharge zone and possibly in high storativity gravels.

Figure: Groundwater level variation in nearby EPA monitoring point (MAY 067)







ORS – Shournagh Catchment

In the Shournagh catchment, elevation: ranges from about 10-360 mAOD, most typically 100-200 mAOD. It is 207.7 km^2 in area. The total length of rivers and streams in the catchment is 209.8 km (this value, which is conservative, derives from the 1:50,000 OSi vector data set augmented with streams marked on 1" to 6 mile maps).

Bedrock geology: Old Red Sandstone, Ll aquifer class.
Subsoils: Predominantly Devonian Old Red Sandstone Till (TDSs). Small areas of peat, rock/rock close, alluvium, made ground. Permeability of TDSs in South Cork = Moderate.

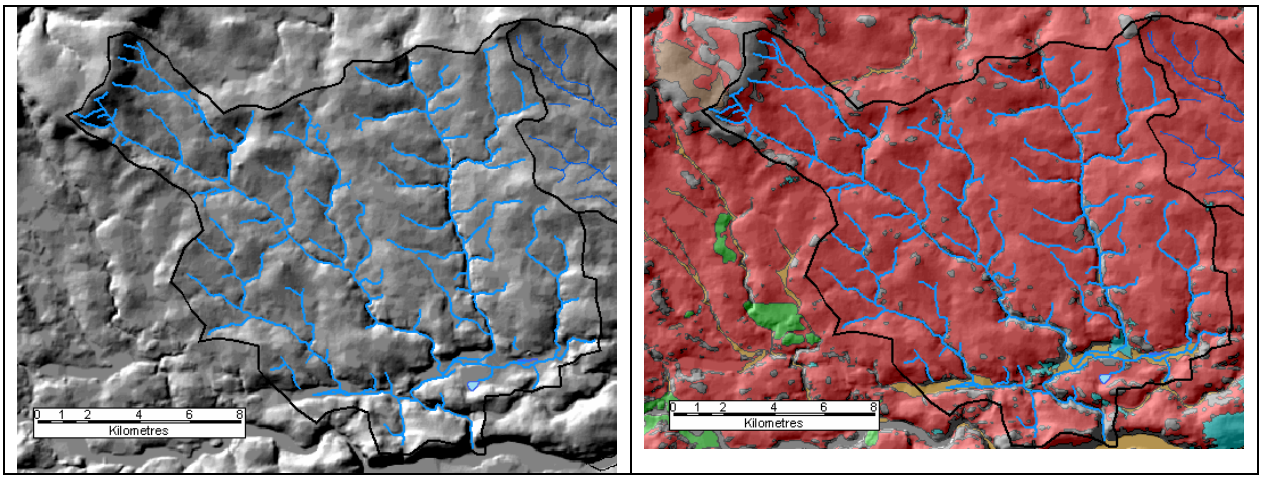


Table: Percentage by area of Quaternary sediments ("subsoils") and lakes in catchment.

Subsoil	% area
Alluvium	0.1%
Blanket peat	0.02%
Lake	0.001%

Subsoil	% area
Made ground	0.01%
Rock/rock close	0.2%
Devonian Sst Till	99.7%

Table: Catchment characteristics

	Whole catchment
River/stream length (km)	209.8
Area (km^2)	207.7
Drainage Density (km/km^2)	1.01
Average Distance (km)	0.41

	Typical ground slopes	**representative of what area**
Upper catchment (NW)	0.065	Small – regions around northern perimeter
Mid-catchment	0.028-0.056 'average' value around 0.04	Majority of catchment. Slopes tend to be lower on east of catchment.
Lower catchment (S)	As for upper	Area along the W-E flowing Blarney/Shournagh river

The average distance between rivers/streams is 410 m, indicating average groundwater flow path lengths of 205 m.

Figure: Logan transmissivities in Devonian ORS aquifers, total n=326 (Ll: 278, Pl: 48).

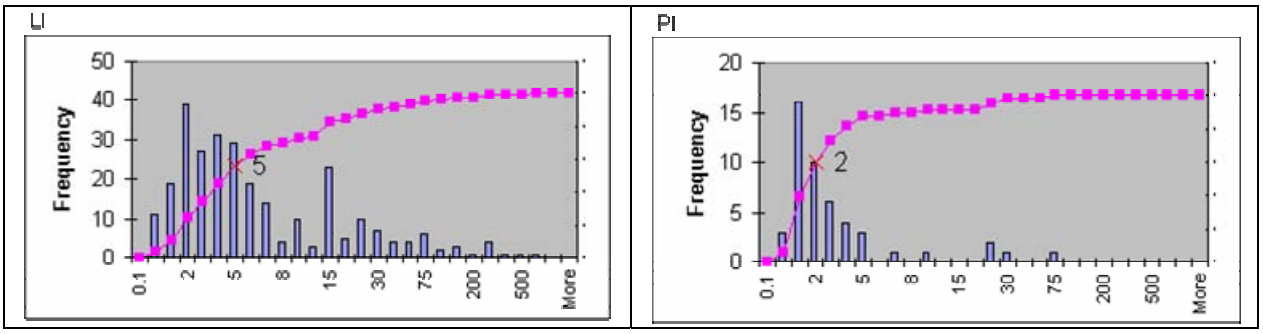
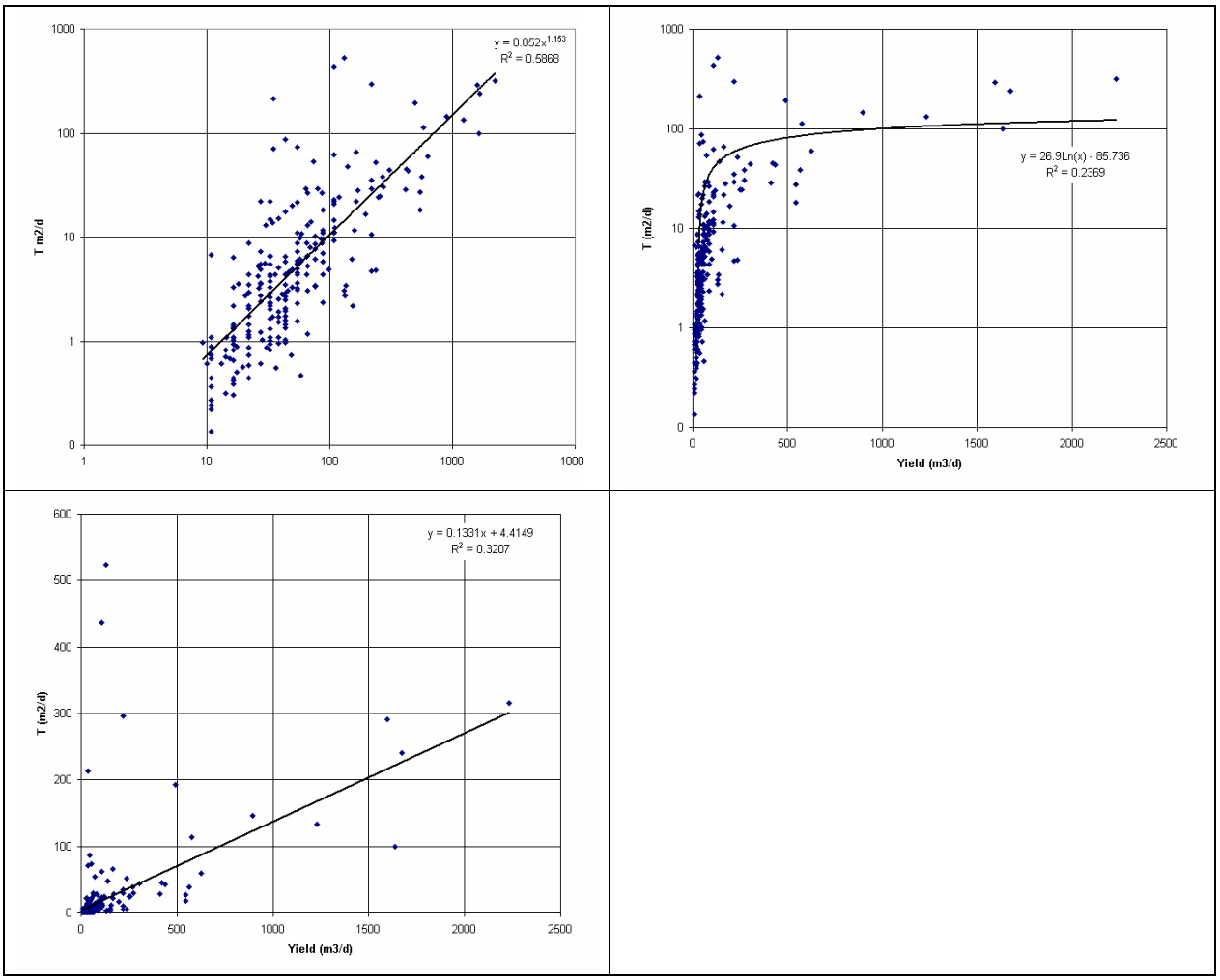
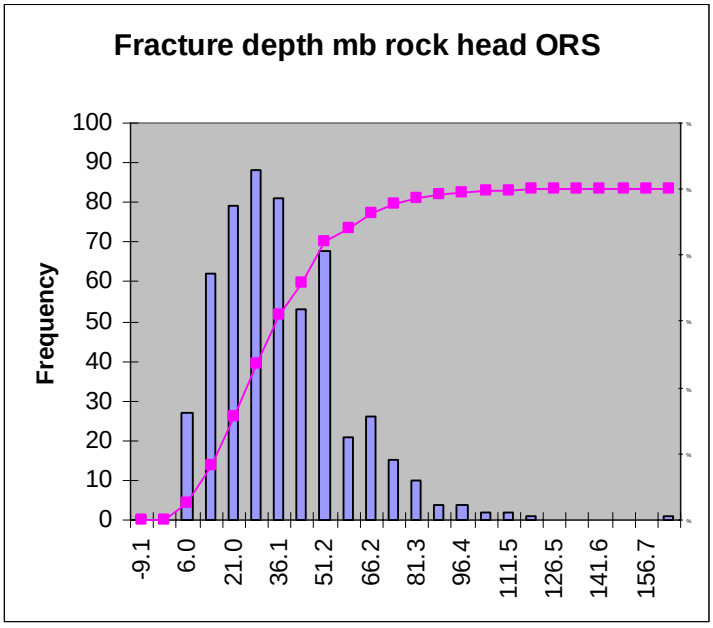


Figure: Logan transmissivities vs. yield/abstraction in Devonian ORS aquifers, n=326.



The median transmissivity in Ll aquifers is 5 m^2/d and in Pl aquifers is 2 m^2/d. Corresponding modal transmissivities are between 2-4 m^2/d (Ll) and 0.1-2 m^2/d (Pl). There appears to be a weak bimodal distribution in the Ll aquifers, with transmissivities ranging from 0.1-10 m^2/d and then about 15-500 m^2/d.

Figure: Groundwater inflows in boreholes drilled in Devonian ORS aquifers, metres below rock head. Number of wells = 271, n=545.



UPPER IMPURE LIMESTONE – Deel River/Rye Water

Deel:

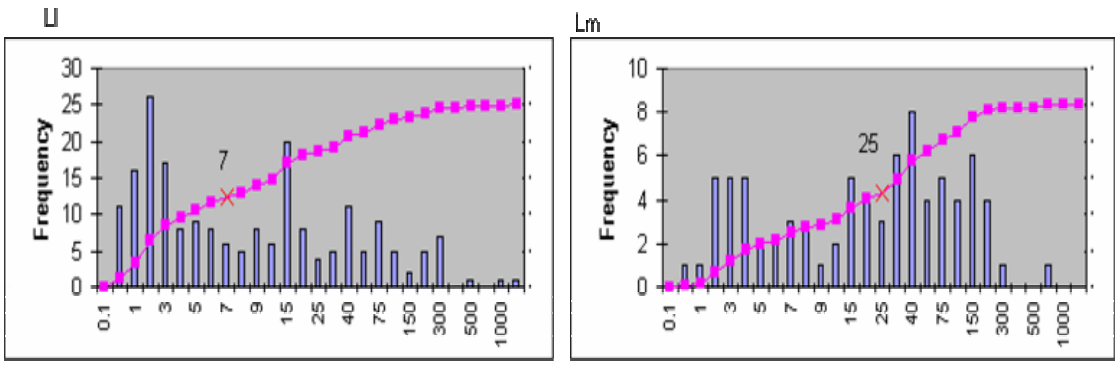
Big underestimate – many streams/ditches not on 1:50K map.

	Whole catchment
River/stream length (km)	371.3
Area (km^2)	471.8
Drainage Density (km/km^2)	0.79
Average Distance (km)	0.52

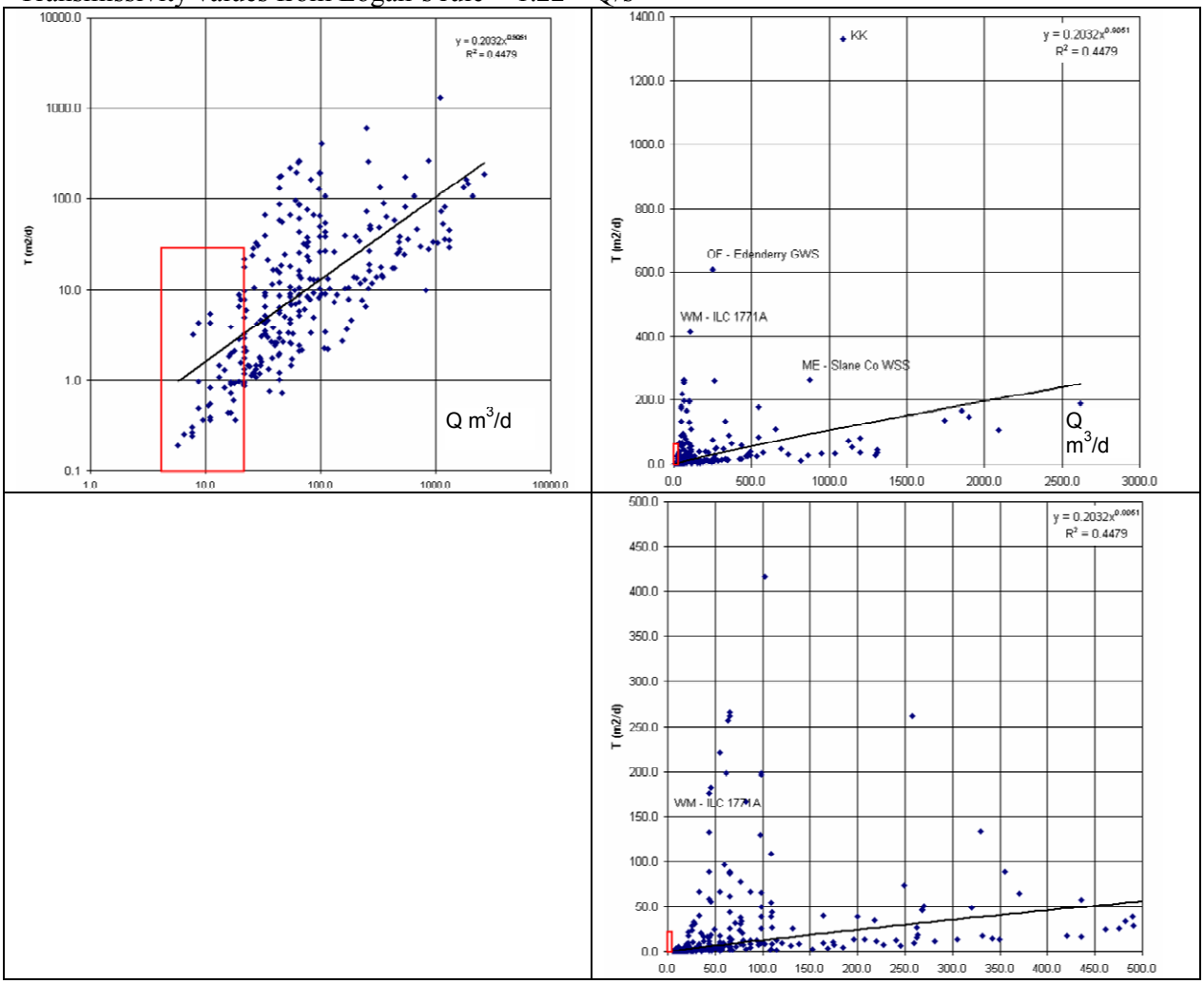
Rye Water:

Big underestimate – many streams/ditches not on 1:50K map.

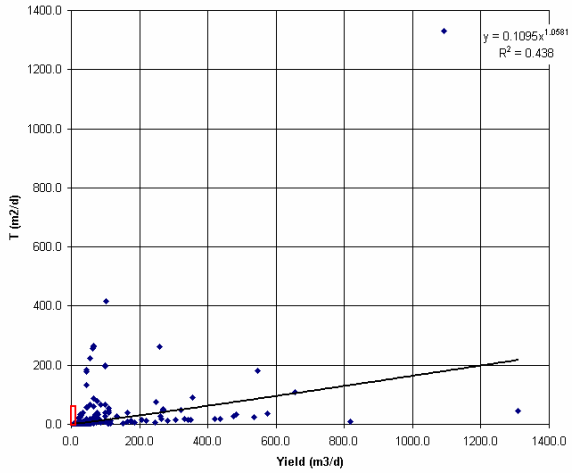
	Whole catchment
River/stream length (km)	196.3
Area (km^2)	204.6
Drainage Density (km/km^2)	0.96
Average Distance (km)	0.45



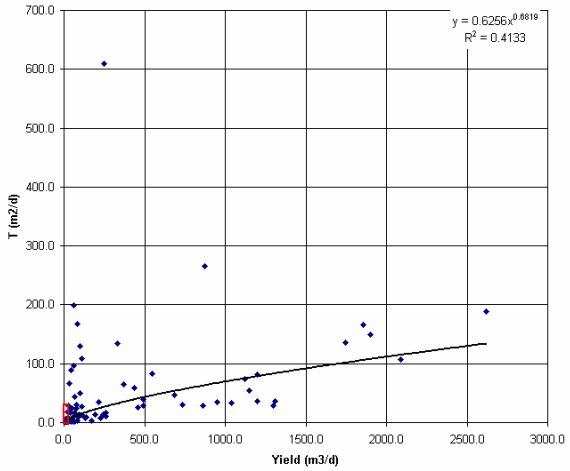
Transmissivity values from Logan's rule - 1.22 * Q/s



Ll calp



Lm calp



UPPER IMPURE LIMESTONE

Gollierstown	**K (m/d)**	
4-5 m	2.75	(average, but up to 15 m/d)
5-10m	0.1-0.8	
>10m	0.04	

Naul	**K (m/d)**
2m	0.75 - 1
3m	0.025-0.25
6-8m	0.015-0.15

Walkinstown	**K (m/d)**
	0.0023-0.69

LOWER IMPURE LIMESTONE

4 boreholes in Ballysteen Lst from Ballaghvenny landfill, Co. Tipperary:

name	interval	m/s	m/d
RC1	14-17.25m	2.00E-07	0.017
RC2	14-18m	5.00E-07	0.043
RC3	20-21.8m	5.00E-08	0.004
RC4	11.5-13.1m	7.00E-07	0.060

Summary: at 6-7m below rockhead, k ranged from 0.017 to 0.006 m/d.

ORS/WAULSORTIAN – River Bride

River Bride – OSi data only

	Whole Upper catchment	ORS catchment	Waulsortian catchment
River/stream length (km)	285.0	244.6	40.5
Area (km^2)	333.7	291.6	42.0
Drainage Density (km/km^2)	0.85	0.84	0.96
Average Distance (km)	0.46	0.46	0.41

River Bride – 6" and OSi data

	Whole Upper catchment	ORS catchment	Waulsortian catchment
River/stream length (km)	635.1	577.1	58.1
Area (km^2)	333.7	291.6	42.0
Drainage Density (km/km^2)	1.90	1.98	1.38
Average Distance (km)	0.24	0.23	0.33

References

Hogan, M. 2003. Design and Implementation of a GIS Toolbox for Hydrogeological Applications. MSc thesis, University of Edinburgh, 40 pp. plus appendices.

Logan, J. 1964. Estimating transmissibility from routine production tests of water wells. *Ground Water*, **2**, No. 1, 35-37.

Subsoil permeability assessment from Donegal GWPS:

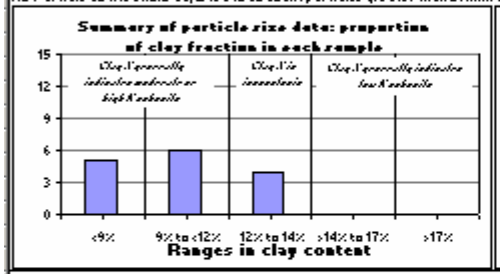
Description of unit location:	Central-Eastern Area: mainly SE and E of Letterkenny. Stretching from Rathmelton/Kilmacrenan to south of Castlefinn, and over as far as Muff.
Why is this a single K unit?	Uniform till, topsoil and land use. Similar bedrock types. Relatively uniform topography.

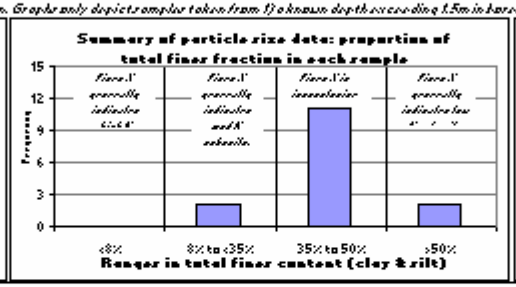
1. General Permeability Indicators and Region Characteristics

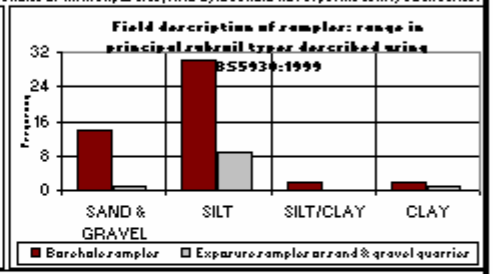
Rock type	Precambrian Marbles (DG, DGmb, DGlv) and Precambrian Quartzites, Gneisses & Schists (BO, LC, LE, LFS, LM. MF, TE). Aquifers are lower permeability ranging from Pl t
Depth to bedrock	Higher areas are generally shallow (0-3m), with some outcrop. Increases to >10m along the low-lying valley areas.
Subsoil type	Mainly glacial till (described as Metamorphic till) although there is alluvial material along the base of the valleys.
Soil type	Brown Podzolics are the predominant topsoil type. Gley underlie some of the western portion of this unit.
Vegetation and land use	Grazing and the highest proportion of tillage in County Donegal. This unit is generally quite free draining.
Artificial drainage density	Low
Natural drainage density	Moderate to Low
Topography and altitude	Upland areas with series of parallel, east-west trending valleys. Highest area to the west (c250m), falling to <10m around Loughs Swilly (north) and Foy
Ave. effective rainfall (mm)	500

2. Summary of Particle Size Analysis and Field Descriptions of Subsoil Samples.

NB Particle distributions adjusted to discount particles greater than 2.0mm. Graphs only depict samples taken from 1) a known depth exceeding 1.5m in boreholes or 1m in exposures, AND 2) locations not at permeability boundaries.







3. Data from Permeability Tests.

T* tests: min/25mm	# Results	# Tests T<1	# Tests T>50	Variable head tests (m/sec):	# Results	Range Values	Typical value	Slug tests (m/sec):	# Results	Range Values	Typical value	Pump tests (m/sec):	# Results	Range Values	Typical value

4. Summary and Analysis

Criteria	Comments	ions of each criterion for assessment of subsoil per	
Quaternary / subsoil origin	Generally till (predominantly described as limestone) with a silty matrix.	>>>	moderate
Particle size data	<12% clay in 12 of 16 available PSDs. <50% fines in 14 of 16 PSDs.	>>>	moderate-high
Field description data	Borehole samples	>>>	moderate-high
	Exposure samples	>>>	moderate
Soil type	Brown Podzolics	>>>	moderate
Artificial drainage density	Few drainage ditches	>>>	moderate
Natural drainage density	Relatively low density compared to other parts of Donegal	>>>	moderate
Permeability test data	No data	>>>	-
Rock type	Marbles, quartzites, gneisses and schists. Marbles maybe influencing till	>>>	moderate-low
Land use	Tillage and grazing. Quite free-draining	>>>	moderate
	Overall conclusion	>>>	**MODERATE**

5. COMMENTS: Majority of available data suggest a moderate permeability subsoil. There are also a number of samples with a high proportion of sand and gravel. These samples are likely to be influenced by the underlying quartzites and other coarse grained metamorphic rocks. This is the most commonly tilled area in County Donegal.

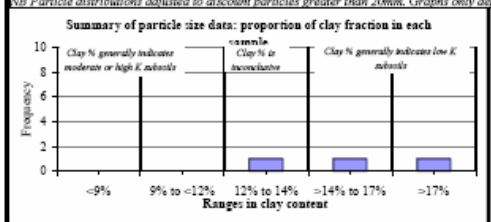
Subsoil permeability assessment from South Cork GWPS:

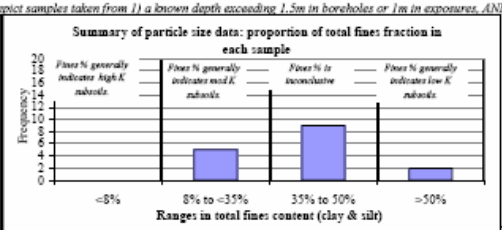
Summary of Permeability Data and Analyses for Permeability Unit 5a. Northern ORS Unit .

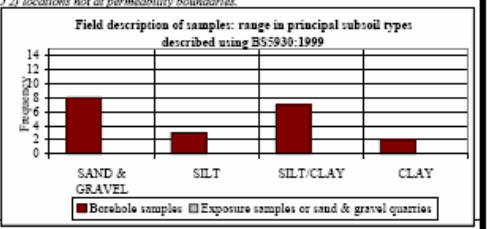
Description of unit location:	Old Red Sandstone ridge running from east to west across the northern part of the South Cork region. This area is bounded to the south by Lee valley and a change in bedrock type and extends to the north, to the boundary of South Cork, and to the west, as far as the Awboy River. There is a gradual transition to poorer land when moving west across the region which is accompanied by a higher average effective rainfall and a greater percentage of shallow subsoils.
Why is this a single K unit?	Same bedrock and till type, similar topography and land use
1. General Permeability Indicators and Region Characteristics	
Rock type	Old Red Sandstone Fmns; Ballytrasna Fmn - mudstones with subordinate fine to medium grained sandstones and Gyleen Fmn - dominated by cross bedded sandstones; Aquifer category L1
Depth to bedrock	Variable 0-10m, frequent rck close particularly near stream gullies
Subsoil type	Mapped as Sandstone till with sandy texture
Soil type	Not mapped
Vegetation and land use	Good grassland (less grain than in south) & forestry, some beet, mostly cattle & dairy
Artificial drainage density	Low. Field drains rarely observed
Natural drainage density	Intermediate
Topography and altitude	Elevation range 40-230m OD
Ave. effective rainfall (mm)	Range for South Cork 400-1900mm/yr lowest in the east and highest in the western uplands

2. Summary of Particle Size Analysis and Field Descriptions of Subsoil Samples.

NB Particle distributions adjusted to discount particles greater than 20mm. Graphs only depict samples taken from 1) a known depth exceeding 1.5m in boreholes or 1m in exposures, AND 2) locations not at permeability boundaries.







3. Data from Permeability Tests.

T' tests: # Results	# Tests T<1 min/25mm	# Tests T>50	Variable head tests: # Results	Range Values (m/sec):	Typical value	Pump tests # Results	Range Values (m/sec):	Typical value	Lab tests # Results	Range Values (m/sec):	Typical value

4. Summary and Analysis

Criteria	Comments	Implications of each criterion for assessment of subsoil permeability	
Rock type	Sandstones - a source of sand size grains, while mudstones provide a source finer clay size particles	>>>	Moderate to Low
Quaternary / subsoil origin	Mapped as sandy tills	>>>	Moderate
Soil type	Not mapped	>>>	-
Land use	Good grassland, some areas of poorer grassland and foresetry, especially towards the north and west	>>>	Moderate to Low
Artificial drainage density	Low	>>>	Moderate
Natural drainage density	Inermediate	>>>	Moderate
Particle size data	Grain size analyses were only carried out on borederline samples - hence the particle size data are skewed towards the low permeability end of scale. Of 4 samples analysed 2 had grain size distributions that indicated low k	>>>	Moderate occasionally Low
Field description data	Majority of samples are SAND, SILT and sandy SILT/CLAY.	>>>	Moderate
Permeability test data		>>>	-
		Overall conclusion >>>	**Moderate**

5. COMMENTS: This region generally consists of good quality farmland with field drains rarely observed. The underlying Old Red Sandstone rock contributes to the sandy nature of the tills while the mudstone elements contribute a proportion of finer grained material. Subsoil descriptions are primarily of SAND, SILT and sandy SILT/CLAY. Subsoils described as 'CLAY' are occasionally recorded with grain size data indicative of low permeability material, however, these were found to be isolated occurrences and not characteristic of the region as a whole. There was not sufficient supporting evidence from vegetation and/or drainage characteristics to merit identifying these points as individual low permeability regions. The general weight of evidence suggests the overall permeability of the subsoils in this region should be classified as 'moderate'