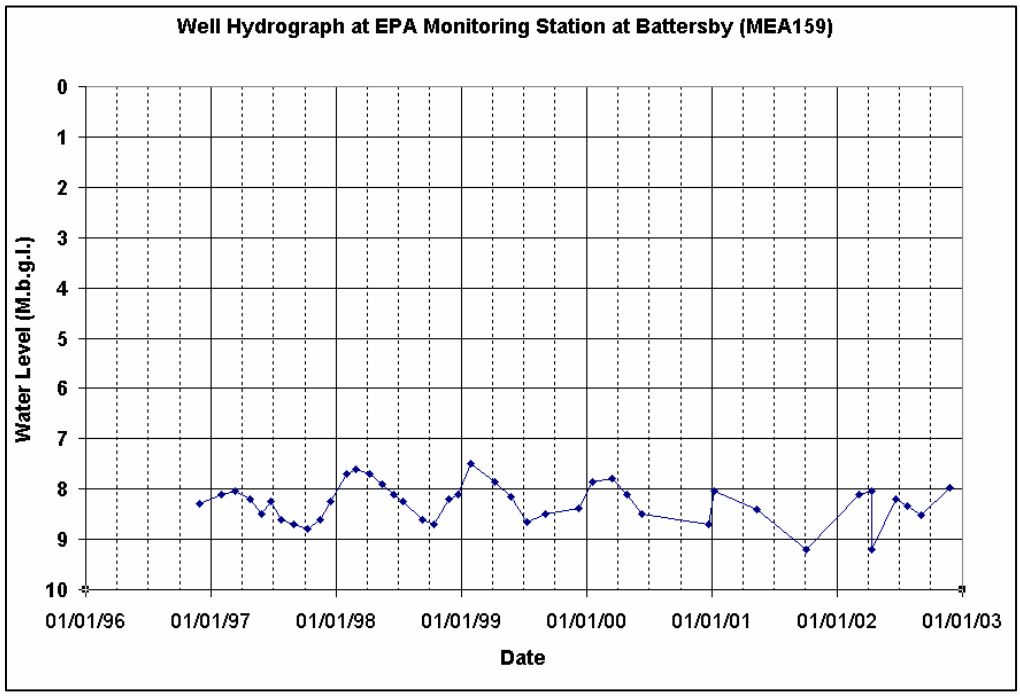
Lusk GWB: Summary of Initial Characterisation.

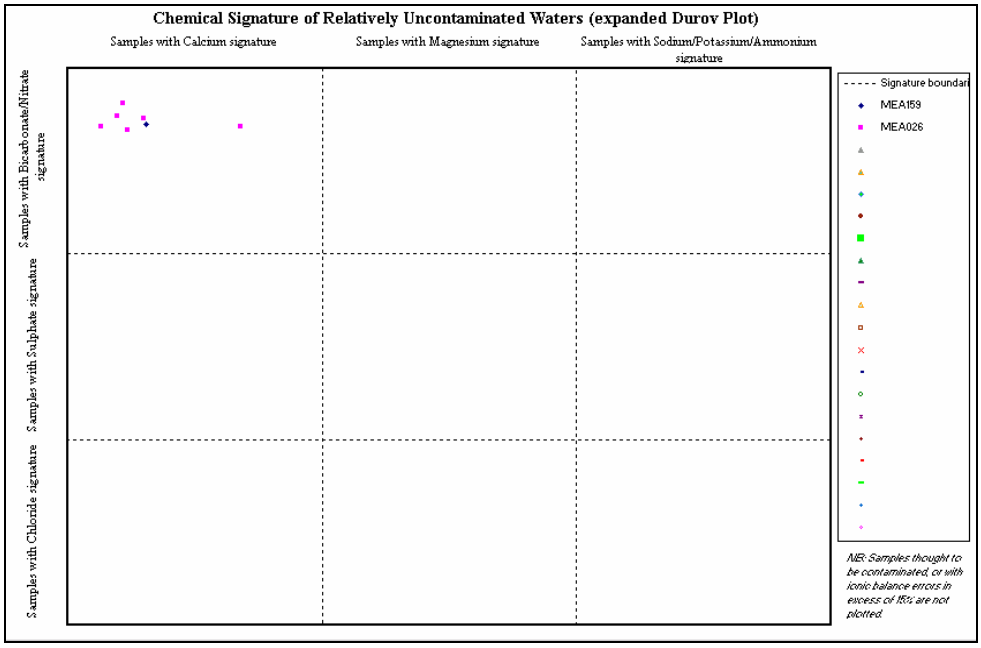
Hydrometric Area Local Authority	Associated surface water bodies	Associated terrestrial ecosystems	Area (km^2)
Dublin Co. Co. Meath Co. Co. Hydrometric Area 08	Ballough Stream, Ballybog Hill, Delvin, Hurley, Broadmeadow, Fairyhouse Stream, Nanny	Bog of the Ring (1204)	209

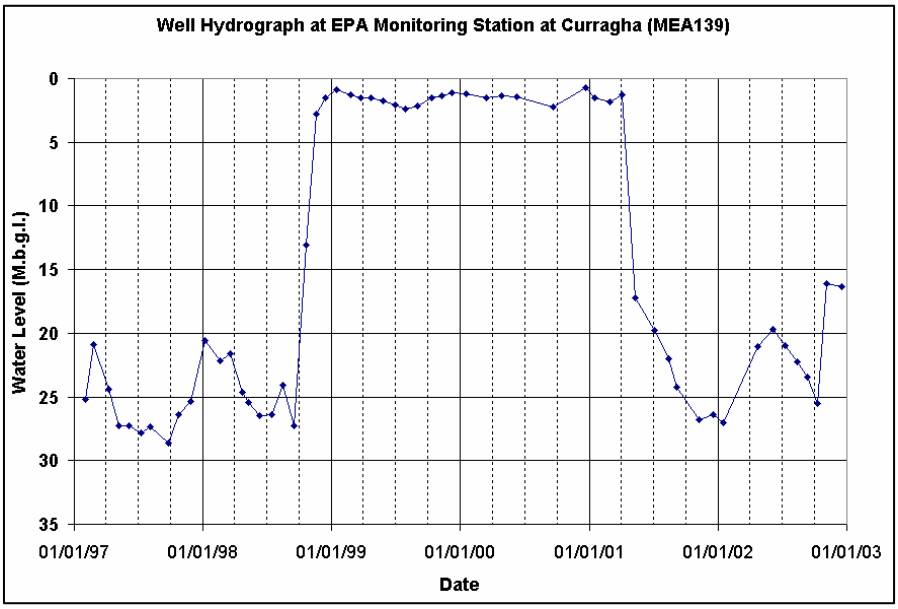
Topography		This GWB extends east from Dunshaughlin in Meath towards the coast of north Dublin. The area is mostly low lying with some areas of higher elevations along the centre of the GWB at Garristown and the Nags Head, Co. Dublin, and also along the western boundary of the GWB, which separates the Boyne catchment from Hydrometric Area 8. The higher elevations are in the order of 160 m OD. Elevation falls off from these hills along the centre of the body to the north and south and also towards the coast.
Geology and Aquifers	Aquifer type(s)	**Lm:** Locally important aquifer which is generally moderately productive Small areas ($12km^2$ ~ 5.7%) of **Rk^d**: Regionally important karstified aquifer dominated by diffuse flow
	Main aquifer lithologies	Dinantian Upper Impure Limestones (Calp Limestones). Smaller areas of Dinantian Pure Bedded Limestones. (5.7%) The limestones in this area tend to be cleaner in nature than the more typical Calp limestones and the faulting and the associated folding result in higher than usual groundwater yields.
	Key structures.	In this area the rocks are intensely folded and faulted. The severe deformation can be seen in the upper impure limestones at Loughshinny beach, where the folds are angular and partially overturned (McConnell *et al.*, 2001). The results of a drilling programme in the area of the Bog of the Ring have shown that the hydrogeology is strongly related to the structural deformation associated with the faulting in that area. Along the northern boundary of the body there is a large fault that runs east-west and separates the Lower Palaeozoic Rocks of the Balbriggan Inlier to the north from the limestones to the south. The faulting has fractured the limestones in the area, making them susceptible to karstification.
	Key properties	Transmissivity and storativity values in the aquifer appear to be better than is normal for the Calp limestone. Hydrogeological investigations (K.T. Cullen 2000) in the Bog of the Ring area, located along the northern boundary of the GWB, east of Naul, have estimated the transmissivity of the aquifer as very high, in the region of $580m^2/d$. This high transmissivity may be influenced in part by presence of some gravel deposits in the area. At Curragha PWS, Co. Meath, transmissivity values of 60 - $130m^2/d$ have been estimated. Although not in the order of the Bog of the Ring values these are considered to be high values, indicative of a regional flow system. The specific yield of 0.002 was calculated from the pumping test data from the GSI Observation Well No.2 and indicated that the aquifer is unconfined. The pumping tests indicate that a higher permeability zone has been developed close to the surface, and the permeabilities decreases with increasing depth below ground level. During the drilling of the Curragha boreholes major inflows were found at 25 and 30m below ground. The hydrograph at Curragha (MEA139) shows the water table fluctuating at around 25m underground. The levels then rise to 2.5 below ground and fall again two years later. At the lower level the annual fluctuation of the water table is around 8m and at the higher level it is only 2m. This illustrates the increase in storativity when a larger section of the aquifer is saturated. Also the storativity of the upper layers will be higher as the degree of faulting and weathered material increases. The period of recovery, from 25m below ground to about 5m is 2 weeks. A hydrograph from the EPA station MEA159, around one kilometre from the Curragha source, shows the water table situated around 8m below ground with an annual fluctuation of less than 2m, this would suggest there is a significant degree of storativity in the aquifer. This hydrograph shows no influence of the rise in groundwater levels experienced in 1999 & 2000 suggesting the cone of depression of the aquifer is less than the 1.2km separating the boreholes. Analysis of pumping test data at the Kilmoon, Bunnan Bridge borehole indicates the aquifer is semi confined here with a transmissivity of $8.8m^2/d$ and a storativity value of 7×10^{-4}. (Cullen 1983)
	Thickness	The limestone bedrock at the Curragha PWS, located at the center of the GWB, is extensively fissured and highly broken, particularly between 32 to 35 metres b.g.l. which provides large inflows of water. Numerous calcite veins were noted, and their thickness increased with depth, with major fracturing and cavities being encountered below 30 metres. The return water was lost during the drilling from 33m below ground level, which would suggest higher permeabilities occur in this zone, due to the increased fracturing. Drilling in the Bog of the Ring area has shown inflow significant from limestone fissures at depths of 30m, 70m and 90m. Drilling in the area of Kilmoon suggests the total bedrock thickness is thinning out towards the Lower Paleozoic rocks in the area. Two individual boreholes in the area record limestone thickness of 14 and 25m. These were in both cases overlain by very thick tills (~20m) and underlain in the first instance by "red sandstones" and in the second by "green grits and slates of the underlying Lower Paleozoic basement" (Cullen 1983 & 1984). It is also of note that the wells in this area are artesian with overflows up to $200m^3/d$.

Overlying Strata	Lithologies	The dominant subsoil type overlying this GWB is Limestone-derived Till which covers all but the northern and coastal area of the GWB. The thickness of the till is highly variable: in general it is thicker towards the south and thinner towards the north. In the east there are deposits of Irish Sea Till which is a low permeability boulder clay derived from ice sheets which occupied the Irish Sea during the last glaciation. In the north there are areas covered by Till derived from the Lower Paleozoic rock. There are small areas of gravel deposits and also alluvium deposits along some channels. Drilling in the Bog of the Ring area has shown the subsoil layers generally consist of till layers, in some places underlain by thick gravel deposits.
	Thickness	Available borehole information suggests that there is a highly variable thickness of subsoil overlying the aquifer. There are large areas where the subsoil is less than 5 metres thick, whereas other evidence suggests subsoil thickness of up to 40m in places.
	% area aquifer near surface	<5%
	Vulnerability	At the current time GSI groundwater vulnerability mapping has not been carried out for Co. Dublin, therefore only the portion of the GWB in Co. Meath is assessed. In general the groundwater vulnerability is Moderate. Along the western boundary and at isolated hills, where the subsoil covering thins, the vulnerability is Extreme.
Recharge	Main recharge mechanisms	There are two mechanisms for recharge in this GWB, point recharge and diffuse recharge. Diffuse recharge occurs over the majority of the area, it will be higher in the areas where subsoil is thinner and / or more permeable. Due to the Karstic nature of the aquifer it is possible to have point recharge. An example of this is at a swallow hole where a large amount of concentrated recharge occurs over a small area. In areas where the subsoil is not thick, and where the impure limestones occupy lowlands adjacent to Namurian strata, there may be karstification at the boundary between the two rock types, since the relatively corrosive runoff from the Namurian rocks would facilitate solution of the impure limestones
	Est. recharge rates	*[Information will be added at a later date]*
Discharge	Springs and large known abstractions	Curragha PWS (1200) - Fingal County Council: Bog of the Ring PWS 4000 - 5000m^3/d
	Main discharge mechanisms	Groundwater can discharge from this aquifer as baseflow to streams, as springs and as abstractions via wells, for human consumption. The main discharge areas are to the north and southeast. To the east a number of springs are recorded in the GSI Karst Database. There is an absence any major river channels here and it is likely that groundwater is forced to discharge to the surface as the system reaches capacity. The water from these springs forms streams which flow east towards the coast. There will also be groundwater discharge at the geological contact between the limestones and the less permeable Lower Paleozoic rocks to the north and with the less permeable limestones in the south.
	Hydrochemical Signature	The hydrochemical analyses of groundwater indicate a very hard water (355 - 435 mg/l ($CaCO_3$)), with a high alkalinity (310 - 325 mg/l ($CaCO_3$)). Conductivities are also high ranging from 520 - 810 µS/cm. Alkalinity values range from 200 to 350mg/l with the majority of values around 300mg/l. This groundwater can be classed as a calcium bicarbonate water.
Groundwater Flow Paths		The nature of groundwater flow in this aquifer will be determined by the degree of karstification and fracturing and the purity of the limestones. Where there is a highly karstified limestone flow will be concentrated into conduits, which may draw water very deep underground. Where the limestone is not as karstified the flow systems will be shallower and more diffuse. Although groundwater will still flow main along fractures, there will not have been the large-scale dissolution of the rocks to convert these into large conduits and groundwater flow will be less likely to take place at depths below 30m. In most of the area groundwater flow will be unconfined. Exceptions to this will be where there are thick layers of low permeability till and also where the Namuiran strata, which form the hills within the GWB, overlie the limestone.
Groundwater & surface water interactions		Bog of the Ring is a protected ecosystem, which lies to the northeast of the GWB. During pumping tests carried out in that area the water levels in the Bog were measured to asses the reaction of the Bog to local groundwater abstraction. The connection between the Bog and the groundwater system is related to the lithology of the subsoil material underlying the bog. Where the bog is underlain by till there was little or no reduction in water level caused by pumping. In areas where there are gravel deposits there was a direct connection with some monitored locations drying out completely. Groundwater and surface water are more closely linked at certain karst features such as springs and swallow holes. In this area there are a number of springs located in the eastern area of the GWB. At this point Groundwater is directly discharging into the surface water systems.

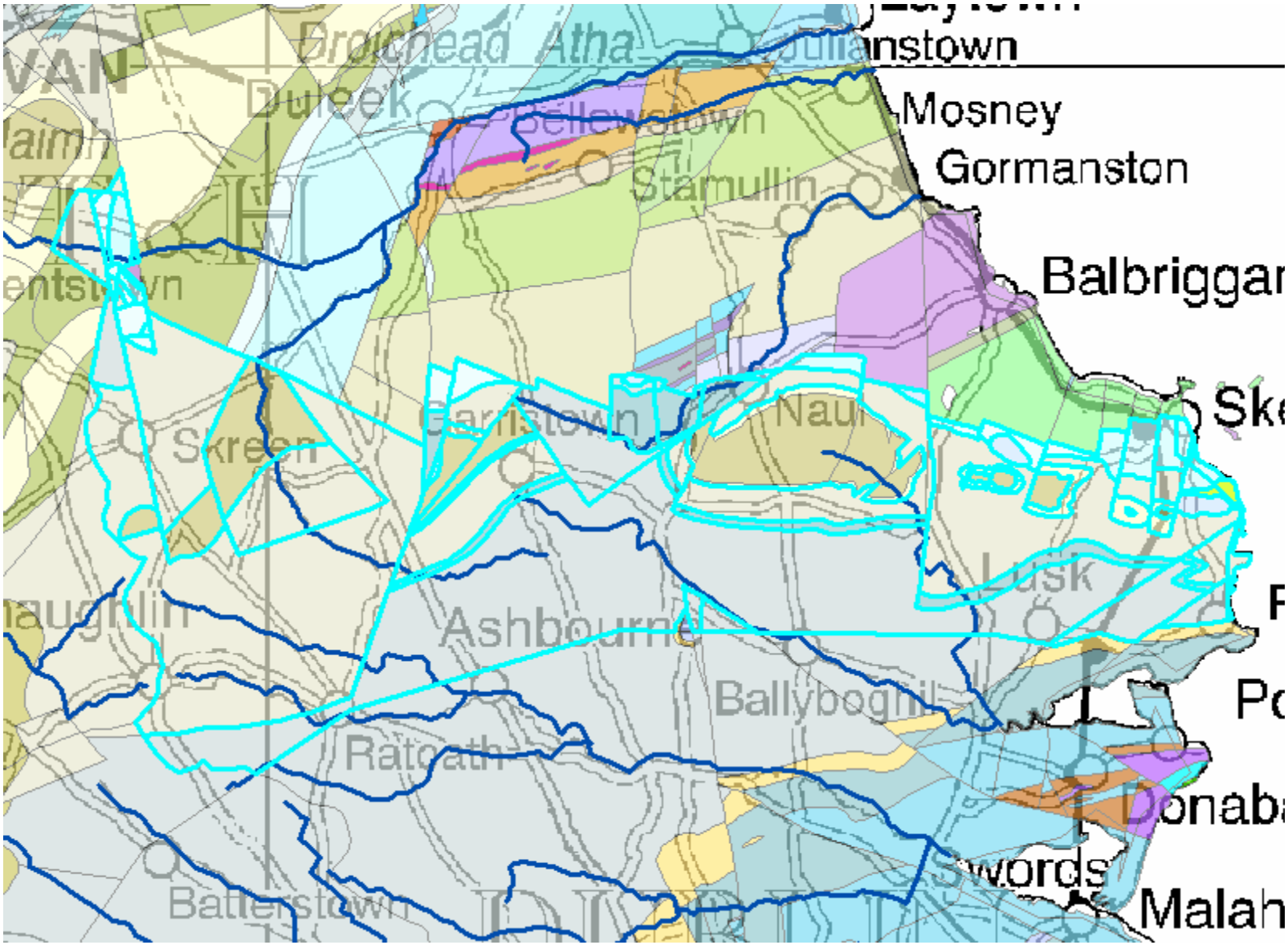
Conceptual model	This GWB is located in the North Dublin – East Meath Area. The area is low lying with higher elevations to the east and some isolated hills along the centre. The GWB is composed of moderate permeability limestone, which in some places is karstified. The extent of the groundwater body is defined to the west by the extent of Hydrometric Area 09, to the North by the contact with the Lower Paleozoic strata and to the south by the extent of the Lm Lucan formation, which in turn is a boundary of a structural region (Dumphy 2003). Very small areas of low permeability impure limestones are incorporated with this GWB, since they are isolated and do not alter significantly the flow system. Karstification of the limestone and increased transmissivity has been found in the north close to the fault, which displaces the Lower Paleozoic rocks alongside the limestone. This area has undergone structural deformation. Groundwater flow occurs along fractures and in place through solutionally enlarged karst conduits. Recharge occurs diffusely through the subsoils and via outcrops. There may be some locations where recharge is more focused i.e. within enclosed depressions, which a common in a Karst landscape. The aquifers within the GWB are generally unconfined, but may become locally confined where the subsoil is thicker and/or lower permeability and where the aquifer is overlain by Namurian Strata. Most flow in this aquifer will occur in a zone near the surface. In general, the majority of groundwater flow occurs in the upper 30 m, comprising a weathered zone of a few metres and a connected fractured zone below this. However, deep-water strikes in more isolated faults/ fractures have been encountered to 90 mbgl in the more structurally deformed area. Flow path lengths are variable, from examining the drainage density it is clear that in some instances groundwater flow paths of up to a couple of kilometres may exist, although distances of a few hundred metres area more likely. The groundwater discharges directly to the Irish Sea in the east and also to the north and south via baseflow to rivers. Analysis of water levels in the area of the Bog of the Ring has shown a direct connection between the bog and the water table in areas where the subsoil is compose of permeable material.
Attachments	
Instrumentation	Stream gauge: 08013, 08010, 08002 Borehole Hydrograph: Battersby (MEA159), Curragha (MEA139) EPA Representative Monitoring boreholes: Battersby (MEA159), Curragha (MEA026), Hayestown, Rush (DUB004)
Information Sources	Cullen KT (1983) *Report on the Drilling and Testing of Trial and Production Water Wells at Kilmoon, Co. Meath*. Report to Meath Co. Co. Cullen KT (1984) *Report on the Drilling and Testing of Water Well No. 3 at Kilmoon, Co. Meath*. Report to Meath Co. Co. K T Cullen & Co Ltd (2000) Bog of the Ring Groundwater Development Drilling and Testing Programme. Woods L, Meehan R, Wright GR (1998) *County Meath Groundwater Protection Scheme*. Report to Meath County Council. Geological Survey of Ireland. 54 p. McConnell B, Philcox M, Geraghty M (2001) *Geology of Meath: A geological description to accompany the bedrock geology 1:100,000 scale map series, Sheet 13*. Geological Survey of Ireland. 77 p. O'Connor Sutton Cronin (2003) Environmental Assessment of Proposed Loughbarn Landfill Facility.
Disclaimer	Note that all calculation and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae







Formation Name	Code	Description	Rock Unit Group	Aquifer Classification
Balrickard Formation	BC	Coarse sandstone, shale	Namurian Undifferentiated	Pl
Crufty Formation	CU	Peloidal wackestone-grainstone, shale	Dinantian Pure Bedded Limestones	Rkd
Holmpatrick Formation	HO	Grainstone-packstone, micrite	Dinantian Pure Bedded Limestones	Rkd
Lane Formation	LE	Argillaceous biocastic limestone, oolite	Dinantian Lower Impure Limestones	Ll
Loughshinny Formation	LO	Dark micrite & calcarenite, shale	Dinantian Upper Impure Limestones	Lm
Lucan Formation	LU	Dark limestone & shale (`Calp)	Dinantian Upper Impure Limestones	Lm
Lucan Formation & Mudbank Limestones	mkLU	Dark limestone & shale (`Calp)	Dinantian Upper Impure Limestones	Lm
Mudbank Limestones	mk	Massive grey micritic limestone	Dinantian Pure Unbedded Limestones	Ll
Mullaghfin Formation	MF	Pale peloidal calcarenite	Dinantian Pure Bedded Limestones	Rkd
Naul Formation	NA	Calcarenite & calcisiltite	Dinantian Upper Impure Limestones	Lm
Platin Formation	PT	Crinoidal peloidal grainstone-packstone	Dinantian Pure Bedded Limestones	Rkd
Smugglers Cave Formation	SR	Conglomerate & lithic sandstone	Dinantian Sandstones	Lm
Walshestown Formation	WL	Shale, sandstone, limestone	Namurian Undifferentiated	Pl


Drinnead
Atha
Duleek
Bellewstown
Stamullin
Mosney
Gormanston
Balbriggan
Skerries
Garristown
Naul
Skreen
Lusk
Ashbourne
Ballyboghil
Ratoath
Donabate
Swords
Malahide
Battlestown