Trim GWB: Summary of Initial Characterisation.

Hydrometric Area Local Authority	Associated surface water bodies	Associated terrestrial ecosystems	Area (km^2)
Meath Co. Co Louth Co. Co. Kildare Co. Co. Offaly Co. Co.	Athboy, Blackwater, Boycetown, Boyne, Castlejordan, Deel, Glash, Kinnegad, Knightsbrook, Mattock, Rye Water, Skane, Stonyford Yellow (Castlejordan)	Black Castle Bog (570), Carbury Bog, Ballina Bog (039), Boyne Woods, Crewbane Marsh (553). Boyne River (SAC - 2299)	669

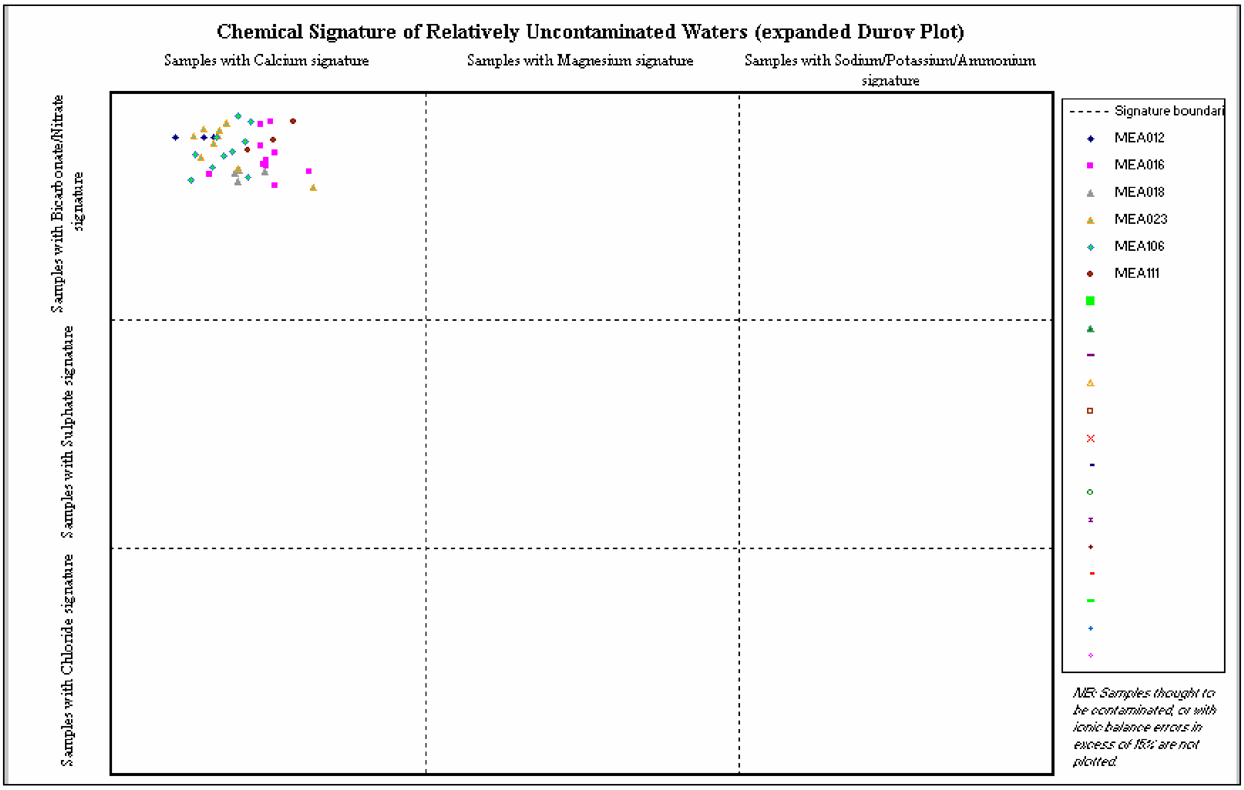
Topography		This GWB occupies an area of mostly undulating low lands in Co. Meath, with some hillier areas located at the GWB boundaries. Elevations range from 120 m OD along the eastern boundary, to 20 m OD at Slane. Only in localized areas where there are isolated hills, and along the eastern boundary, are there significantly steep slopes. The course of the River Boyne is almost completely enclosed in this GWB and elevations fall towards the river from southwest to northeast. In the northeast between Navan and Slane the GWB narrows as it is has hills on both sides, formed to the north by Ordovician Tuff and to the south by Namurian Shales. In this area the hills formed by these harder rocks raise the slope of the land surface on both sides of the Boyne.
Geology and Aquifers	Aquifer type(s)	Mostly – **Lm:** Locally important aquifer which is generally moderately productive (640 km^2) Small Areas of – **Rk^d**: Regionally important karstified aquifer dominated by diffuse flow (<5 km^2) **Ll:** Locally important aquifer which is moderately productive only in local zones (18 km^2) **Pl:** Poor aquifer which is generally unproductive except for local zones (7 km^2)
	Main aquifer lithologies	The majority of the area comprises Dinantian Upper Impure Limestones (Calp limestones), primarily impure limestones and limestones interbedded with calcareous shales. There are smaller areas of Dinantian Pure Bedded Limestones to the northeast at Slane and also to the southwest in Kildare. The Calp limestones around Slane tend to be much purer than the more typical Calp and are also interpreted to be highly folded and faulted, and as a result they tend to give higher than usual groundwater yields.
	Key structures.	In the eastern midlands, around north Dublin and south Meath, the rocks are more folded and faulted than in other areas where these rocks occur. 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). Drilling evidence from Stonyford Bridge, Co. Meath has shown the bedrock to be highly weathered and broken to depths of 35 m. (Cullen 1985)
	Key properties	This GWB comprises a large area of limestone which is extremely heterogeneous. It is therefore impossible to quote a single figure for the hydrogeological properties of the aquifer. Evidence suggests that the degree of karstification throughout the area is highly variable, as is the degree of structural deformation, the occurrence of open fractures in a connected network which will allow groundwater flow, the degree of confinement by impermeable tills, and the additional storage provided by the many gravel deposits overlying the aquifer. All these factors can alter the nature of groundwater flow within the aquifer. Overall the aquifer is classified as a generally moderately productive aquifer based on drilling evidence. Specific data from pumping tests in two different areas illustrate the heterogeneity of this aquifer: Slane WS (PW1), Co. Meath: 70-200 m^2/d. The specific yield of 0.002 was calculated from the early data from the Trial Well No.2 and indicates that the aquifer is **unconfined.** Dunshaughlin WS Co. Meath: 50-60 m^2/d. The specific yield of 0.0004 was calculated from data from Stoke's well and indicates that the aquifer is **confined or is locally confined** in the vicinity of the production well.
	Thickness	The nature of the bedrock is highly variable due to different structural and weathering influences which have been exerted on the rock. In the Dunshaughlin production well, 12.2 m of limestone till overlie a layer of broken limestone to a depth of 21.3 m (Woods 1996). The limestones at Slane are more extensively fissured and highly broken, particularly in the vicinity of the River Boyne. This is expected since the area highly faulted. The logs indicated large inflows of water, particularly around 35 to 37 mbgl. The uppermost 3 m of bedrock were reported to be highly broken and weathered. (Woods 1996) Drilling evidence from Summerhill and Enfield, Co. Meath indicates that in some areas significant cavities occur at depth of 50 m below ground, such cavities are coincident with weathered bedrock and high inflows (Cullen 1985).
Overlying Strata	Lithologies	The most dominant subsoil lithologies overlying this GWB are limestone-derived till and sand/gravel deposits.
	Thickness	Highly variable.
	% area aquifer near surface	~15%
	Vulnerability	*(Groundwater vulnerability in Ireland is highly variable over short distances. In a GWB this size it is not adequate to give a brief description of the nature of the vulnerability of the GWB. Groundwater Vulnerability maps should be consulted for areas of interest.)*

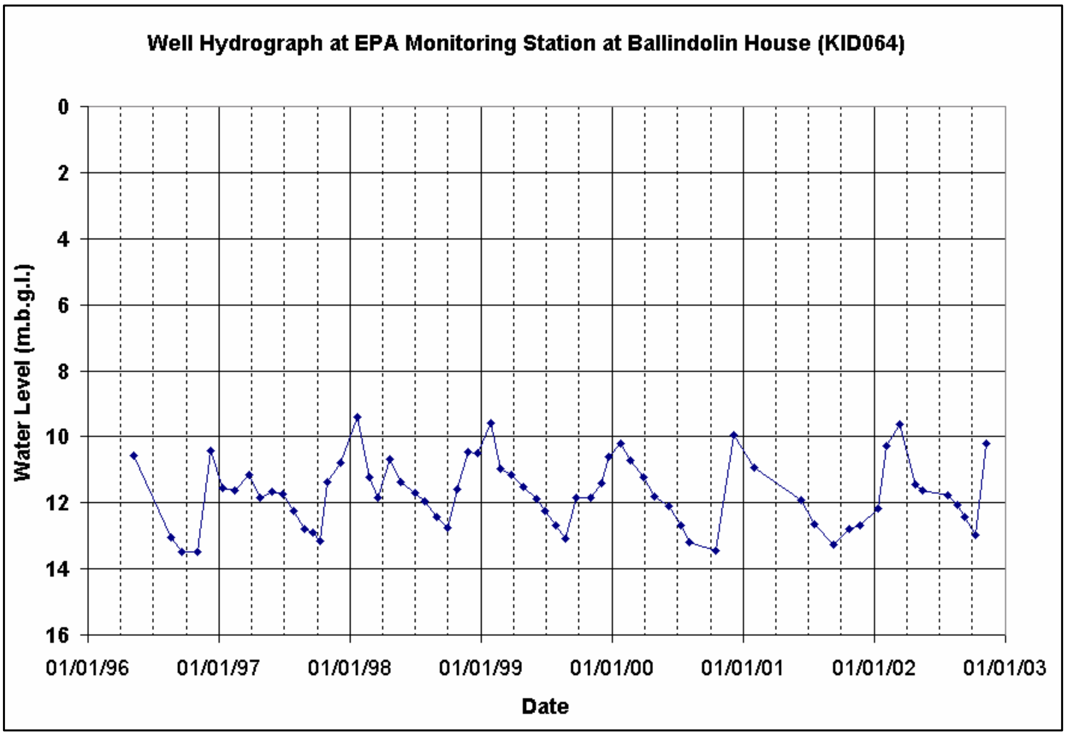
Recharge	Main recharge mechanisms	Two recharge mechanisms occur in this GWB: point recharge and diffuse recharge. Diffuse recharge occurs over the majority of the area, being higher in areas where subsoil is thinner and/or more permeable. Due to the karstic nature of the aquifer it is possible to have point recharge, typically at swallow holes where a large amount of concentrated recharge occurs in a small area. Where the subsoil is not thick, and where the impure limestones occupy lowlands adjacent to Namurian and Lower Paleozoic strata, there may be karstification at the boundary between the two rock types, since the relatively corrosive/acidic runoff from these rocks would facilitate solution of the impure limestones e.g. the swallow hole at Mell, Co. Louth. It is likely that all streams along this contact will lose some portion of their flow, if not entirely sink underground. Note that the number of quarries within the area will facilitate the direct access of rainfall into the bedrock.
	Est. recharge rates	*[Information to be added at a later date]*
Discharge	Springs and large known abstractions	**GSI Source Reports –** Slane & Dunsaughlin Public Supply Schemes. **EPA Source Register –** Location (Abstraction (m^3/d)) Slane (1760), Dunsaughlin (810), Ballivor PWS (690), Yellowbatter (475), Edenderry (450), Kilmessan WS (320), Enfield (310), Trim WS (223), Summerhill (160), Longwood (100), Johnstown (Spring) (110), Ballykilleen GWS (70), Kiltale (70), Beauparc GWS (A) (68), Johnstownbridge WS (50), Trim Golf Club (50), Tara Stud (36), Ballindoolin GWS (30), Dunderry Housing (25), Rathmolyon Housing (25), Killeen Castle Estate (18), Newtown/Kilcock WS (17), Boyne Valley Honey (15), Oakstown Concrete (14), S.A.P. Nursery Growers (13), Clonuff Housing WS (12), Clogherinkoe WS (11), Robinstown GWS (8), Lions Den GWS (~5), ESB at Rhode, Edenderry Mart, Edenderry Co-op.
	Main discharge mechanisms	The main discharge mechanism for this aquifer is as baseflow to the River Boyne and its tributaries. Discharge from the aquifer will also occur via springs, many of which are recorded in the GSI Karst database. The variety noted in the structural deformation of the rocks will influence the groundwater flow and hence the nature of the discharge from the aquifer. Where there is a high degree of fracturing, conduit karstic flow is more likely. In these areas groundwater will discharge from the aquifer via springs, the flow from such springs will be highly variable or 'flashy' as there is a low storativity in the aquifer. Where the karstic system is less developed, the occurrence of large springs is less likely as the GWB discharges as baseflow to the overlying rivers.
	Hydrochemical Signature	The Durov Plot for this GWB shows that monitored sources consistently show a Calcium Bicarbonate hydrochemical signature. Values for electrical conductivity through out the GWB range from 500 to 800µS/cm, with moderately hard to very hard waters with alkalinities between 150 to 350mg/l. Spring waters may be softer, as throughput can be quicker with less time for the dissolution of minerals into the groundwater. Like hardness, groundwater alkalinity is variable, but is often high. Typical groundwater electrical conductivities are high, but may be less if there is rapid infiltration of surface water and then quick throughput to a spring.
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. In highly karstified limestone flow will be concentrated into conduits, which may draw water very deep underground. During the drilling of Production Well No.1 at Slane major inflow of groundwater was recorded in fissured limestone between 27 and 38 metres below ground level (-9.75 and -20.75 m O.D) with a cavernous fissure from 35 to 37 metres. The specific yield of 0.002 was calculated from the early data from the Trial Well No.2 and indicates that the aquifer is **unconfined**. Where the limestone is less karstified the flow systems will be shallower and more diffuse. Although groundwater will still flow mainly along fractures, there will not have been the large-scale dissolution of the rocks to convert these into large conduits that concentrate flow deep underground. An example of this can be seen at Dunshaughlin where a 300 metre deep well was drilled for the Council adjacent to the Tower in Dunshaughlin and encountered 296 metres of dark gray to black limestones, intermittently shaly. Calcite veining occurred through the sequence and the abundance of shale and veining increased with depth. The rock was competent indicating no significant fracturing in this area. There is evidence of confined groundwater flow in the eastern area of the GWB around Basketstown, Co. Meath. Hydrogeological investigation of the area indicates the limestone is overlain by a thick layer of clay which itself is overlain by a gravel deposit. Measurements of the water level in both aquifers showed the piezometric surface in the bedrock aquifer to be above the top of the rock and at a similar elevation to the water table in the gravel deposits above (Cullen 1993). Investigations carried out for Tara Mines Ltd (1.5 km east of Navan) involving exploratory drilling and permeability testing revealed that the limestone was karstified in some places at between 25 and 73 metres below ground but that the cavities were filled with a variety of unconsolidated material. (Minerex 1983). This material did not necessarily prevent groundwater movement and analyses of some infilling material revealed a proportion of medium sized gravel (up to 20 mm) and results from some falling head tests revealed high permeabilities (86.4 m/d) The fault system discharges groundwater at a rate of about 4200 m^3/d to the mine sump but this is at a depth of 250 m below ground level. Joint planes also transmit groundwater within the mine but to a lesser extent than the faults. It should be noted that there will be some drawdown towards the mines as dewatering pumping causes a cone of depression surrounding the site.

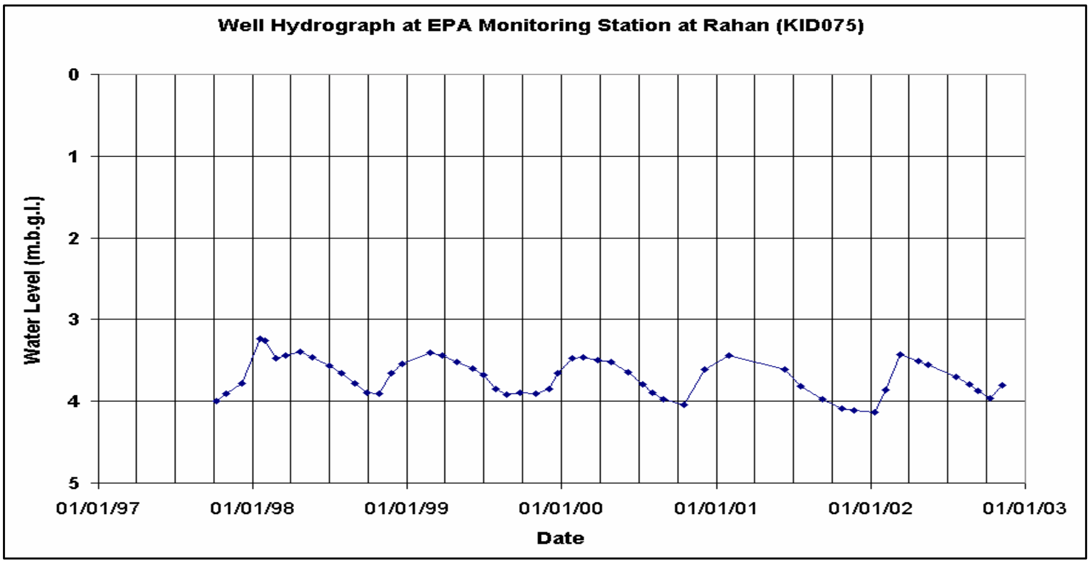
Groundwater & surface water interactions	Groundwater and surface water are more closely linked at certain karst features such as springs and swallow holes. In this GWB these features are concentrated in the highly fractured area between Slane and Navan. Also in the northeast the presence of the Crewbane Marsh is an area where groundwater interaction with surface water has a key influence on the sustainability of an ecosystem. A drop in water levels caused by over abstracting near this site could have a detrimental effect ecological balance of this National Heritage Area. This small site contains one of the last remaining examples of floodplain marsh on the banks of the Boyne. There are very few Dry Weather Flow values available for this area (considering its size). The available values are lower than expected (DWF Values – 07039 (0.55l/s/km^2), 07009 (0.64 l/s/km^2), 07021 (0.51 l/s/km^2)). The hydrograph at EPA Monitoring station OFF058 shows an overflowing well during certain times of the year. The remaining monitored wells in that area show groundwater located between 3 and 12 m below the ground surface. They hydrographs also show the water level's annual fluctuation is only in the region of 2 m, suggesting a high storativity in the aquifer. The karstification of the limestone along the boundary with the Lower Paleozoic and Namurian rocks has significance for groundwater and surface water interactions in this aquifer. Water flowing from these rocks will be slightly acidic and therefore likely to dissolve the limestone and create solution features. It is along this boundary that surface water will enter the groundwater system of this GWB with little attenuation. (Minerex 1983)
Conceptual model	This GWB is extends from northeast Offaly through Meath and narrows towards Navan and Slane. The area is generally low-lying with some hillier areas to the southeast. The aquifers are classified as Lm and there are small areas of Rkd, Ll and Pl aquifers. The Lm aquifer is comprised of the Edenderry Oolite and the Lucan formation. The boundaries of the GWB are defined by the extent of the Calp, which is classified as Lm, which is in turn determined by the location of a region of higher structural deformation (Dumphy 1993). The variety in the structural deformation of the rock increases the complexity of the conceptual model for the area. Firstly the area northeast of Navan including the highly fractured Lucan formation will have a different groundwater flow system than the low-lying aquifer, which comprises the remainder of the GWB. This difference in geological structure can be seen in all aspects of the conceptual model i.e. recharge, groundwater flow and discharge. The intense structural deformation in the northeast of the GWB has given rise to the development of karstic groundwater flow systems. Although karst features can be expected throughout the GWB, it is in the northeast with the more fractured bedrock where karstification will be greatest. Both point and diffuse recharge occur over the area of this GWB. Point recharge is known to occur at the contact between the non-calcareous rocks and the limestones. This form of recharge is most likely to occur over the more clean and fractured limestones. Diffuse recharge is a more widespread process occurring over the entire area of the GWB. This will be the main recharge process in the large lowland areas of this GWB. Groundwater flow will be from local areas of high recharge e.g. areas of thin subsoils in the uplands, to the main surface water bodies overlying the aquifer, such as the Boyne. Where overlying quaternary deposits consist of thick limestone tills, they can act as a confining layer, thus producing artesian supplies. This occurs, for example at Kilmoon, Dunshaughlin and Longwood public water supplies in County Meath. Discharge from the aquifer is also varied. Water will leave the aquifer in a diffuse nature as baseflow along riverbeds and also as point source at springs. The development of a karstic groundwater system has a key influence on the transportation of pollutants to receptors. Groundwater flow will be faster and more concentrated along karstic conduits.
Attachments	Durov Plot of Hydrochemical signature. EPA Hydrographs for wells KID064, KID068, KID075, LOU097, OFF058 & OFF076. List of geological formations in the Trim GWB
Instrumentation	**Stream gauge**: 07001, 07003, 07005, 07007, 07009, 07010, 07013, 07016, 07018, 07021, 07022, 07026, 07027, 07037, 07038, 07039, 07040, 07041, 07042, 07046, 07048, 07053, 07054, 07055, 07056, 07057, 07061, 07103 **Borehole Hydrograph**: Ballindolin House (KID064), Duffy's Cross Roads (KID068), Rahan (KID075), Townrath (Drummonds) (LOU097), Edenderry Co-Op (OFF058) ***(Artesian at times)***, Mount Wilson (OFF076) **EPA Representative Monitoring boreholes**: Newtown / Kilcock WS (KID022), Clogherinkoe WS (KID040), Boyne Valley Honey (LOU023), McCloskey (LOU040), Yellowbatter (LOU056), Enfield GWS (MEA012), Kilmessan WS (MEA016), Longwood WS (MEA018), Rathmolyon Housing (MEA021), Slane (MEA023), Mick Byrne (MEA106), Trim Golf Club (MEA111), Edenderry (OFF029)

Information Sources	Cullen K T 1985. *Preliminary Hydrogeological Report of South County Meath*. Consultants report to Meath Co. Co. Cullen K T 1993. *Hydrogeological Study at Basketstown Landfill, Co. Meath.* 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, Meath*. Geological Survey of Ireland. 77 p. McConnell B, Philcox M, Sleeman A G, Stanley G, Flegg A M, Daly E. P & Warren W P, 1994. *A Geological description to accompany the Bedrock Geology 1:100,000 Scale Map Series, Sheet 16, Kildare-Wicklow*. Geological Survey of Ireland, 70 pp. Minerex 1983. *The hydrogeology of Co. Meath. A Preliminary Assessment of Groundwater Potential.* Report to Meath County Council. Woods L, Meehan R & Wright G R, 1998. *County Meath Groundwater Protection Scheme*. Report to Meath County Council. Geological Survey of Ireland. 54 p. Kelly C. & Fitzsimons V 2002. *County Kildare Groundwater Protection Scheme*. Report to Kildare County Council. Geological Survey of Ireland 55pp Daly D, Cronin C, Coxon C & Burns S J 1998. *County Offaly Groundwater Protection Scheme*. Report to Offaly County Council. Geological Survey of Ireland, 57pp. Woods L 1996. *Slane Public Supply, Groundwater Source Protection Zones*. Report to Meath County Council. Geological Survey of Ireland. Woods L 1996. *Dunshaughlin Public Supply, Groundwater Source Protection Zones*. Report to Meath County Council. Geological Survey of Ireland.
Disclaimer	Note that all calculation and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae

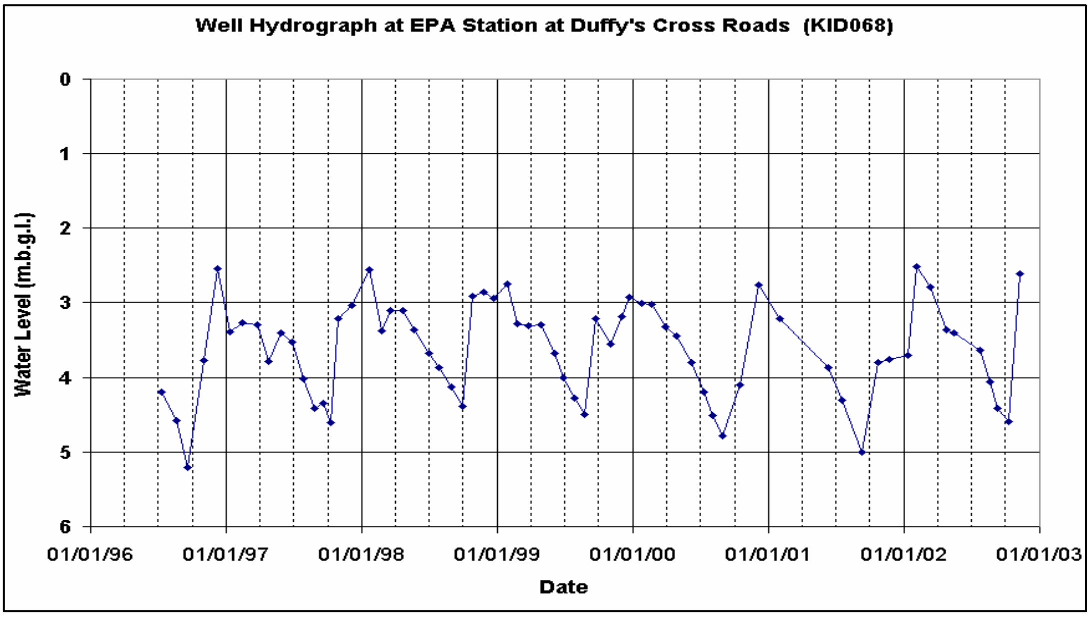
Formation Name	**Code**	**Description**	**Rock Unit Group**	**Aquifer Classification**
Allenwood Formation	AW	Thick-bedded limestone, locally peloidal	Dinantian Pure Bedded Limestones	Rkd
Ardmulchan Member	BXam	Argillaceous limestone, shale, chert	Dinantian Upper Impure Limestones	Lm
Ballyadams Formation	BM	Crinoidal wackestone/packstone limestone	Dinantian Pure Bedded Limestones	Rkd
Balrickard Formation	BC	Coarse sandstone, shale	Namurian Undifferentiated	Pl
Beauparc Member	BXbc	Oolitic peloidal calcarenite	Dinantian Upper Impure Limestones	Lm
Boston Hill Formation	BN	Nodular & muddy limestone & shale	Dinantian Lower Impure Limestones	Ll
Boulder Conglomerate	LUbr	Limestone conglomerate	Dinantian Upper Impure Limestones	Lm
Boyne Formation	BX	Dark limestone & shale (`Calp)	Dinantian Upper Impure Limestones	Lm
Calp	CD	Dark-grey to black limestone & shale	Dinantian Upper Impure Limestones	Ll
Donore Formation	DR	Shale, sandstone, limestone	Namurian Undifferentiated	Pl
Edenderry Oolite Member	AWed	Oolitic limestone	Dinantian Pure Bedded Limestones	Lm
Fennor Formation	FN	Limestone breccia, peloidal calcarenite	Dinantian Pure Bedded Limestones	Rkd
Kiln Hill Member	BXkh	Crinoidal calcarenite, shale	Dinantian Upper Impure Limestones	Lm
Loughshinny Formation	LO	Dark micrite & calcarenite, shale	Dinantian Upper Impure Limestones	Lm
Lucan Formation	LU	Dark limestone & shale (`Calp)	Dinantian Upper Impure Limestones	Lm
Mattock Member	LOmt	Calcarenite & limestone conglomerate	Dinantian Upper Impure Limestones	Lm
Meath Formation (`Pale Beds)	ME	Pale grainstone	Dinantian (early) Sandstones, Shales and Limestones	Ll
Mooretown Formation	MR	Crinoidal wackestone-packstone	Dinantian Pure Bedded Limestones	Rkd
Mullaghfin Formation	MF	Pale peloidal calcarenite	Dinantian Pure Bedded Limestones	Rkd
Namurian (undifferentiated)	NAM	Shale & sandstone	Namurian Undifferentiated	Pl
Navan Group (undifferentiated)	NAV	Limestone, mudstone and sandstone	Dinantian (early) Sandstones, Shales and Limestones	Ll
Slane Castle Formation	SL	Argillaceous bioclastic limestone, shale	Dinantian Lower Impure Limestones	Ll
Volcanics (in Carboniferous)	V	Lm	Basalts & other Volcanic rocks	Lm
Walshestown Formation	WL	Shale, sandstone, limestone	Namurian Undifferentiated	Pl
Waulsortian Limestones	WA	Massive unbedded fine-grained limestone	Dinantian Pure Unbedded Limestones	Ll


Chemical Signature of Relatively Uncontaminated Waters (expanded Durov Plot)
Samples with Calcium signature
Samples with Magnesium signature
Samples with Sodium/Potassium/Ammonium signature
Samples with Bicarbonate/Nitrate signature
Samples with Sulphate signature
Samples with Chloride signature
Signature boundari
MEA012
MEA016
MEA018
MEA023
MEA106
MEA111
NB: Samples thought to be contaminated, or with ionic balance errors in excess of 15% are not plotted


Well Hydrograph at EPA Monitoring Station at Ballindolin House (KID064)
Water Level (m.b.g.l.)
0
2
4
6
8
10
12
14
16
01/01/96
01/01/97
01/01/98
01/01/99
01/01/00
01/01/01
01/01/02
01/01/03
Date



Well Hydrograph at EPA Monitoring Station at Rahan (KID075)
Water Level (m.b.g.l.)
0
1
2
3
4
5
01/01/97
01/01/98
01/01/99
01/01/00
01/01/01
01/01/02
01/01/03
Date



Well Hydrograph at EPA Station at Duffy's Cross Roads (KID068)
Water Level (m.b.g.l.)
0
1
2
3
4
5
6
01/01/96
01/01/97
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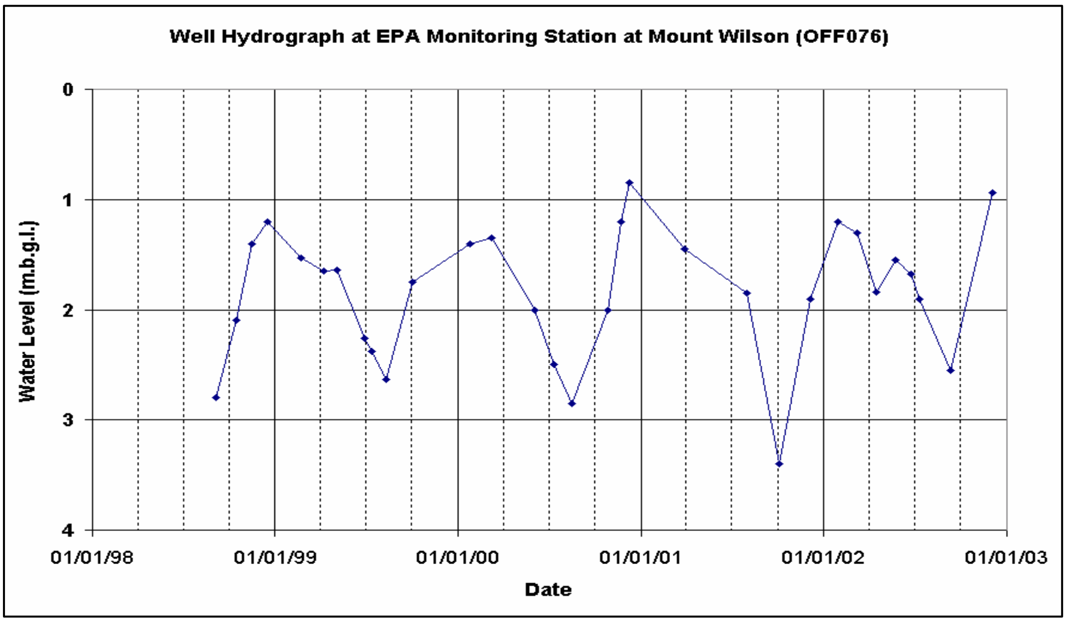
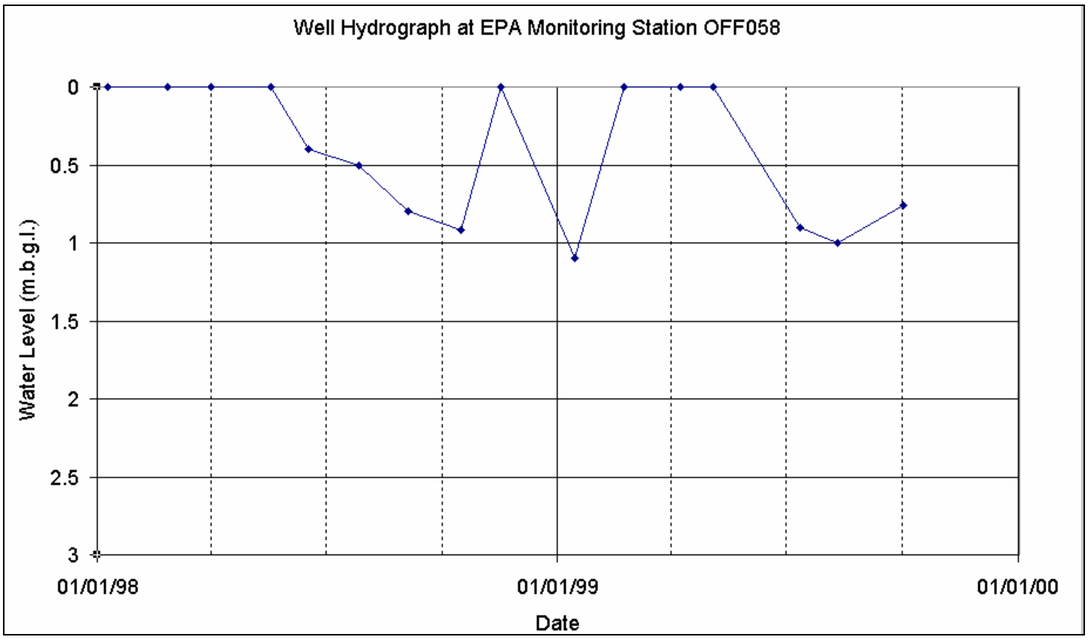
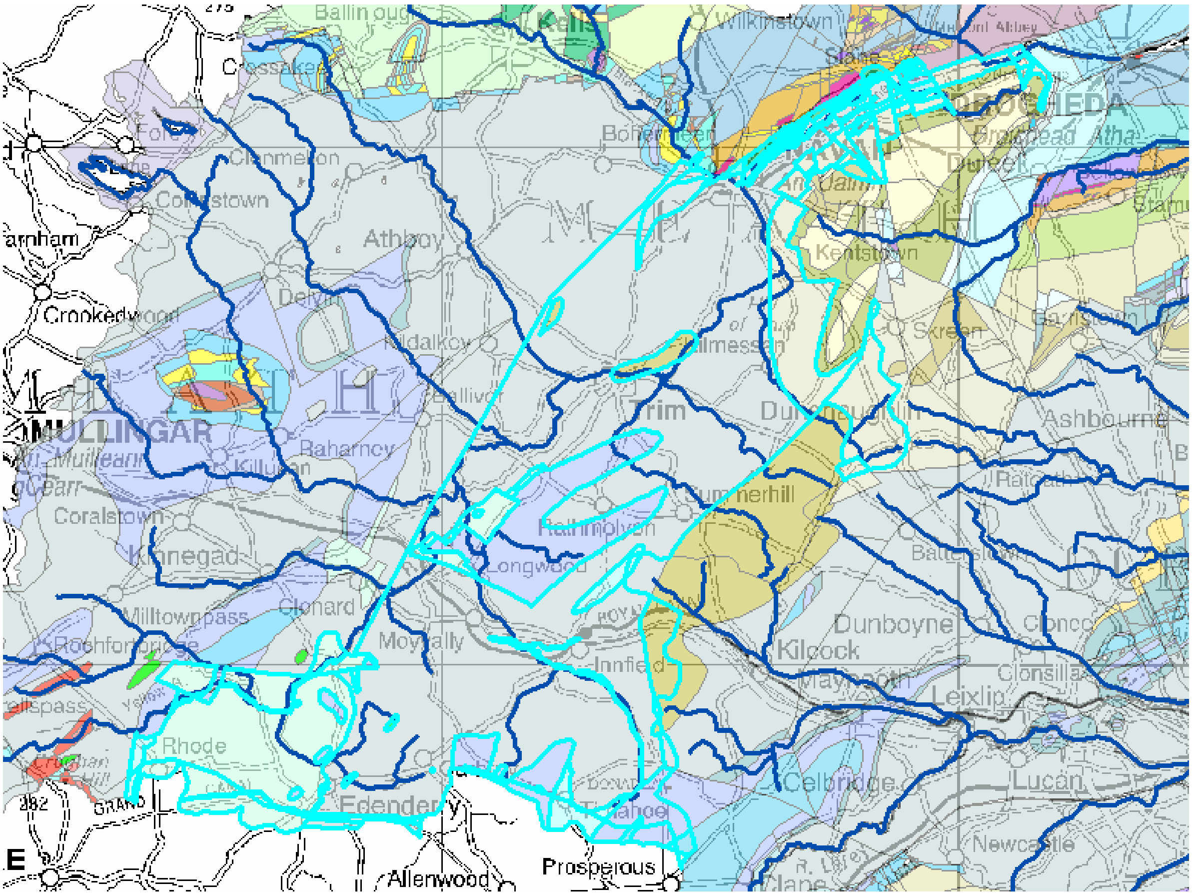
01/01/02
01/01/03
Date



Well Hydrograph at EPA Monitoring Station at Mount Wilson (OFF076)
Water Level (m.b.g.l.)
0
1
2
3
4
01/01/98
01/01/99
01/01/00
01/01/01
01/01/02
01/01/03
Date

Unit Name	**Code**	**Description**
Allenwood Formation	(AW)	Thick-bedded limestone, locally peloidal
Edenderry Oolite Member	(AWed)	Oolitic limestone
Balrickard Formation	(BC)	Coarse sandstone, shale
Ballyadams Formation	(BM)	Crinoidal wackestone/packstone limestone
Brittstown Formation	(BW)	Coarse- to fine-grained tuff
Boyne Formation	(BX)	Dark limestone & shale (`Calp)
Ardmulchan Member	(BXam)	Argillaceous limestone, shale, chert
Beauparc Member	(BXbc)	Oolitic peloidal calcarenite
Kiln Hill Member	(BXkh)	Crinoidal calcarenite, shale
Calp	(CD)	Dark-grey to black limestone & shale
Clonlusk Formation	(CJ)	Pale crinoidal peloidal grain- rudstone
Fennor Formation	(FN)	Limestone breccia, peloidal calcarenite
Loughshinny Formation	(LO)	Dark micrite & calcarenite, shale
Mattock Member	(LOmt)	Calcarenite & limestone conglomerate
Lucan Formation	(LU)	Dark limestone & shale (`Calp)
Boulder Conglomerate	(LUbr)	Limestone conglomerate
Mullaghfin Formation	(MF)	Pale peloidal calcarenite
Mooretown Formation	(MR)	Crinoidal wackestone-packstone
Mornington Formation	(MT)	Dark limestone & calcareous shale
Namurian (undiff)	(NAM)	Shale & sandstone
Platin Formation	(PT)	Crinoidal peloidal grainstone-packstone
Tullyallen Formation	(TA)	Pale micritised grainstone-wackestone
Volcanics (Carboniferous)	(V)	
Waulsortian Limestones	(WA)	Massive unbedded fine-grained limestone





Crossakeel
Clonmellon
Collinstown
Athboy
Crookedwood
Delvin
Kildalkey
Ballivor
Trim
MULLINGAR
Killucan
Coralstown
Kinnegad
Milltownpass
Clonard
Rochfortbridge
Moyvalley
Longwood
Rathmolyon
Summerhill
Dunboyne
Kilcock
Maynooth
Leixlip
Celbridge
Lucan
Newcastle
Clane
Prosperous
Allenwood
Edenderry
Rhode
Innfield
Timahoe
Wilkinstown
Slane
Bohermeen
Kentstown
Skreen
Duleek
Ashbourne
Ratoath
Batterstown
Clonsilla
Garristown