Derravaragh GWB: Summary of Initial Characterisation.

Hydrometric Area Local Authority		Associated surface water features	Associated terrestrial ecosystems	Area (km^2)
26 – Inny/Lough Ree Westmeath & Meath Co. Co.'s		**Rivers:** Glore, Yellow, Gaine, Brosna. **Lakes:** Owel; Derravaragh; Ballynagal; Annagh or White; Oldtown; Rushy; Puncan; Bogwood; Doo; Glore; Ballynafid; Patrick; Bishops.	(001814) Lough Naneagh; (001810) White Lough, Ben Loughs and Lough Doo; (000686) Lough Glore; (000684) Lough Derravaragh; (000688) Lough Owel; (000692) Scragh Bog	107
Topography		The topography of this GWB has a northwest to southeast orientation related to the movement of the last ice sheet (Midlandian). The area consists of a series of distinctive isolated hills with a core of cherty limestone. Typically the hills are steep sided although they can be blanketed by till and/or fluvial deposits. Vertical rock faces on the sides of the hills are common, for example on the hill south of Fore and on Knockeyon Hill just south-east of Lough Derravaragh, County Westmeath(Drew, 2002). The hilly areas are separated by a number of parallel northwest-southeast trending valleys containing lakes and rivers. The highest point in the body is at the summit of Knockeyon Hill at 210 mAOD. The lowest ground in the body occurs along the shores of the lakes and along the valleys of the Yellow River and the River Gaine, which flow southeast to northwest across the body. The lowest point is 60 mAOD along the southeastern shoreline of Lough Derravarragh, just northeast of Crookedwood.		
Geology and Aquifers	Aquifer type(s) Main aquifer lithologies	**Lm:** Locally important aquifer which is generally moderately productive Derravaragh Cherts, which are considered to be a part of the Dinantian Upper Impure Limestone Group.		
	Key structures.	On quarry faces within this body, the rock is seen to be well jointed (T. Hunter Williams, pers comm.). Bedding is quite flat lying and no severe folding is observed. At Knockeyon the rocks dip at 80°.The major faults in the surrounding region have a general southwest northeast trend.		
	Key properties	There is no information available on the hydrogeological properties (transmissivity or storativity) specific to this GWB. The Derravaragh Chert is different in character to the surrounding Lucan Formation (also part of the Dinantian Upper Impure Limestone Group) in that it contains far more chert and less shale. Some karstification has been recorded in the Derravaragh Chert in this region including several springs, a swallow hole and a cave. Epikarst has been observed in some locations, but is absent in others (T. Hunter Wiliams, pers comm.). It is also thought that ancient Tertiary karst exists in this area and that some of this palaeokarst may be to some degree being reactivated. The presence of deposits of Tertiary age (determined palynologically) infilling fissures or hollows that are presumed to be karstic in origin, is the main source of evidence for the existence of such ancient karst (Coson and Coxon 1997). A hydrological study which included water tracing by McDonald (1988) demonstrated that flow underground from Lough Lene to a southerly spring at Fore took place with a flow rate of 80 m/h. The spring dries in late summer suggesting a high level connection only between the lake and the spring. The study also discriminated, by analysing the conductivity and temperature of a number of springs in the area, between rapid, low conductivity throughflow and a deeper flow system in which the groundwater contains high dissolved solids. Lough Lene and Lough Owel have no surface inflows and are fed by groundwater indicating the presence of a significant, regional groundwater flow system, which would be required to supply the water to these lakes. It has been suggested that the existence of present day shallow underground drainage and numerous springs may be evidence for a degree of present-day active and probably post-glacial karstic drainage. The presence of large springs with stable flow regimes and apparent long-residence times may be evidence of more mature, ancient, fossil conduit systems that are being reactivated to some degree. The isolated hills may represent residual features of a former mature karst landscape. These however are currently only hypotheses and require compilation of additional evidence before being accepted or rejected (Drew 2003). It is considered that the transmissivity could be high in certain areas where there is a connected fracture network, which contains solutionally enlarged conduits. The storativity, as in most karst aquifers, is expected to be low.		
	Thickness	The thickness of the aquifer is difficult to determine. Most groundwater flow is thought to occur in the upper 30 m of the rock, in a highly weathered layer a couple of metres thick, and a zone of interconnected fissures below this. However deeper water strikes are possible. There is some karstification in the highly weathered upper layer, however this is variable, present in some areas and absent in others.		
Overlying Strata	Lithologies	A Teagasc Parent Material Map is not currently available for County Westmeath. Information from the National Soil Survey, Soils of County Westmeath (An Foras Talúntais 1977) shows that the GWB is overlain predominantly by shale and chert dominated till. In the north east of the body in County Meath (northeast of White Lough), sand and gravel deposits have been recorded (Dromone Sand & Gravel). They are described as clean coarse esker & fan gravels (Woods, 1988) with an estimated thickness of 5-15 m.		

	Thickness	In this area subsoil thickness can be very variable. Information on depth to bedrock is limited. Small areas of rock outcrop are mapped throughout the GWB. Several points with depth to bedrock of < 3 m have been recorded just south of Lough Derravaragh in the centre of the body. Thin subsoils and outcrop can be expected on the top and slopes of the isolated hills. Thicker deposits can be present in the valleys and lower ground. In other parts of Westmeath where more data on depth to bedrock are available sand and gravel deposits of greater than 20 m deep have been found along river valleys. One data point recording a depth to bedrock of 64 m has been recorded along the Gaine River in the south of this body.
	% area aquifer near surface	*[Information to be added at a later date]*
	Vulnerability	A Groundwater Vulnerability map is not currently available for County Westmeath. It is probable that areas of Extreme vulnerability are present just south of Lough Derravaragh and in the vicinity of rock outcrop; however categorising the remaining areas of Extreme vulnerability and areas of High, Moderate and Low vulnerability is not possible at this time.
Recharge	Main recharge mechanisms	Both point and diffuse recharge occur in this GWB. In karstified areas swallow holes and collapse features provide the means for point recharge. Some karstification is observed in this GWB and one swallow hole is currently recorded at Martinstown south of the south-eastern end of Lough Derravaragh. Water will also enter the aquifer by diffuse recharge which will occur over the entire GWB via rainfall percolating through the subsoil. The proportion of the effective rainfall that recharges the aquifer is largely determined by the thickness and permeability of the soil and subsoil, and by the slope. The highest amount of diffuse recharge will occur at rock outcrop and where subsoils are thinnest and most permeable. Subsoil permeability has not currently been mapped in detail in County Westmeath. There is evidence that there is recharge to this GWB from across the RBD boundary. Tracing tests have shown an underground connection from sinks in Lough Lene in the Lough Lene GWB in the Eastern RBD to springs located near the town of Fore in this GWB (MacDonald, 1988). The springs and sinks dry up in summer indicating that a high level connection only exists.
	Est. recharge rates	*[Information to be added at a later date]*
Discharge	Large springs and high yielding wells (m^3/d)	No large springs or high yielding wells recorded.
	Main discharge mechanisms	This aquifer will discharge to the surface water features overlying the GWB. There are no major surface inflows to Lough Owel indicating the lake is primarily fed by groundwater. Cold springs are present in the Lough Owel (OCM, 2003) and may in part originate from the Derravaragh Cherts of this GWB. Several small springs occur within this GWB.
	Hydrochemical Signature	Hydrochemical information is available for one point within this GWB at the Multyfarnam GWB. It is not known however whether this source is drawing from bedrock or overlying gravels in the river valley. South along the Gaine River from the Multyfarnam supply a depth to bedrock of 64 m was recorded. Analogy with other limestones would suggest that water drawn from bedrock in this GWB will have be calcium-bicarbonate signature hard waters with high electrical conductivity values. The hydrochemical signature of groundwater from the Multyfarnam GWS is demonstrated in an expanded Durov plot in Figure 1 below
Groundwater Flow Paths		These rocks are generally devoid of intergranular permeability. Groundwater flows through fissures, joints, along bedding planes and conduits. Although a Dinantian Upper Impure Limestone, karstification has been recorded in the bedrock in this GWB. Karstification enlarges the fissures and joints by solution and can significantly enhance the permeability of the rock. It has been suggested that there may be some reactivated fossil karst conduits as well as present-day active post-glacial karstic drainage (Drew, 2002). The traced underground connection between Lough Lene and the springs at Fore at a rate of 80 m/hr demonstrates that rapid groundwater flow can occur within the Derravaragh Cherts of this GWB. The fact that this flow path crosses a catchment and river basin boundary demonstrates that flow in karstic systems does not always follow the surface water catchment. Due to the karstification of the rock, the traced underground connection between Lough Lene and the springs at Fore, and the fact that Lough Owel and Lough Lene appear to be supported primarily by groundwater it appears that the Derravaragh Cherts support some regional groundwater flow. In the northeast of the body (northeast of White Lough) the bedrock is overlain by a potential locally important sand & gravel aquifer. (Woods, 1998). Termed the Dromone Sands and Gravels in the Groundwater Protection Scheme of County Meath, there are no know water supplies currently developed in these deposits and their confirmation as a gravel aquifer must await further investigation. The sand & gravel aquifer is unconfined and is assumed to be in hydraulic continuity with the underlying bedrock aquifer and will provide additional storage for the bedrock aquifer. The deposit is less than 10 km2 and is only potentially locally important.

Groundwater & surface water interactions	Groundwater and surface water are closely linked in this GWB. The presence of swallow-holes and springs, the lack of surface water input to Lough Owel and Lough Lene, and the groundwater tracing showing a connection between Lough Lene and the springs at Fore demonstrate that there is a direct link between the surface water and groundwater in this GWB. Any contamination of surface water can be rapidly transported into the groundwater system, and vice versa. There are important protected ecological areas e.g. fens and wet woodlands, surrounding the lakes in this GWB, which are considered to be dependant on groundwater. The lakes themselves, which are highly calcareous, support a rare range of aquatic lower plant (Charophyte) species.

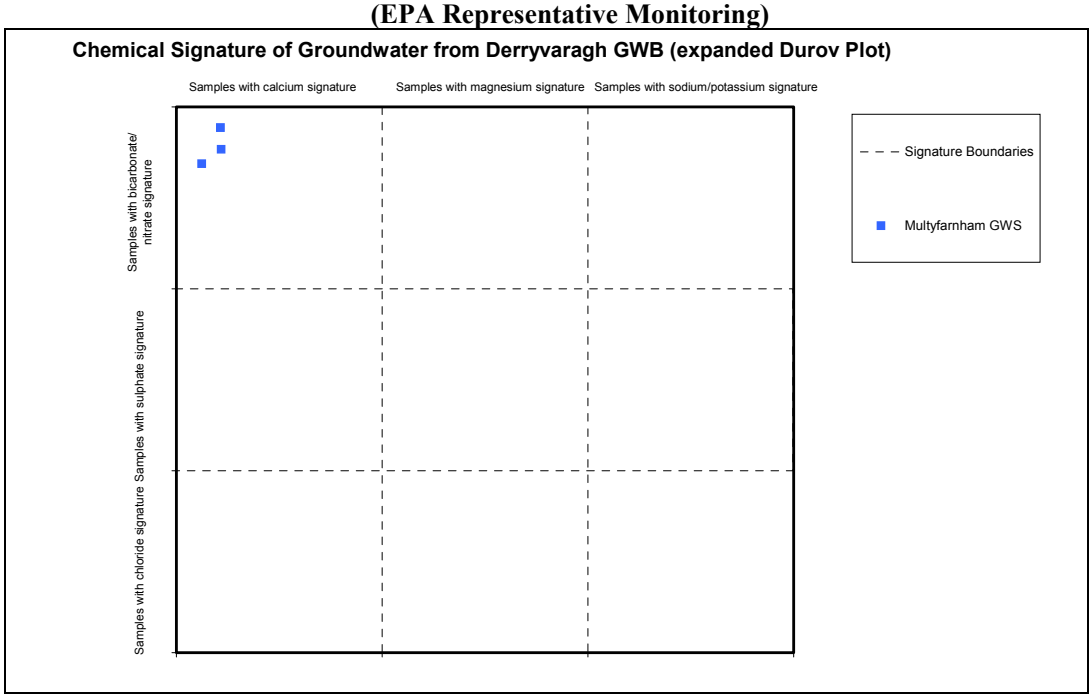
Conceptual model

- This GWB occupies a roughly rectangular northeast southwest trending area in the north east of the Shannon RBD. It is bounded to the south, west and north by the contact with the low permeability Dinantian Upper Impure Limestones (Lucan Formation) of the Inny GWB. It is bounded to the east by the surface water catchment boundary between the Inny (Shannon) and Deel (Boyne) catchments, however groundwater flow occurs across this boundary from Lough Lene to springs at Fore in winter months.
- The topography of the body is has a northwest to southeast orientation. There are a series of distinctive isolated often steep sided hills, with a core of cherty limestone. The hilly areas are separated by a number of parallel northwest-southeast trending valleys containing lakes and rivers.
- This GWB is composed of Derravaragh Chert, a cherty limestone which contains less shale than the surrounding Lucan Formation which is thought to make it more susceptible to karstification. Karst features including springs, a swallow hole, a cave and variable epikarst have been observed in this GWB. Groundwater flows along interconnected fractures, joints, faults and bedding planes, some of which have been enlarged by solution. Where karstification occurs, flow can be concentrated in solutionally enlarged conduits, with a high degree of interconnection, enabling rapid groundwater flow over flow paths of up to a few kilometres in length. Groundwater flow velocities of 80 m/hr (Lough Lene to Fore Springs) have been recorded by groundwater tracing through the Derravarragh Cherts. There are no major surface inflows to Lough Lene and Lough Owel indicating that they are largely fed by groundwater which implies that the Derravaragh Cherts can support regional scale groundwater flow. In karstic systems the groundwater catchments can sometimes differ from the surface water catchments. In this GWB groundwater tracing has demonstrated that groundwater flows across a surface water catchment boundary from the Lough Lene in the Lough Lene GWB in the Eastern RBD to springs at Fore within this body. This is believed to be a high level connection only as the springs dry in late summer. Based primarily on the known karstification and the evidence of a regional groundwater flow system, the aquifer classification for the Derravaragh Cherts is a **"locally important aquifer which is generally moderately productive" (Lm)**.
- Recharge to this GWB is both point, though swallow holes and diffuse via rainfall percolating through the subsoil. Groundwater has been shown to recharge to this GWB in the winter months from the Lough Lene GWB in the Eastern RBD. This aquifer will discharge to the surface water features overlying the GWB. Lough Owel, which occurs on the southwestern boundary of this GWB, has no major surface inflow and is thought to be supported primarily by groundwater flow from the surrounding Inny and Derravarragh GWBs.
- Some areas in this GWB are of extremely vulnerable due to the thin nature of the subsoil, as well as the frequency of karst features. Groundwater storage in karstified bedrock is low and the potential for contaminant attenuation in such aquifers is limited.
- Most groundwater flow is thought to occur in the upper 30 m of the rock, in a highly weathered layer a couple of metres thick, and a zone of interconnected fissures below this. However deeper water strikes are possible. There is some karstification in the highly weathered upper layer in this GWB, however this is variable, present in some areas and absent in others. It has been suggested that there may be both a present-day active karst system and an ancient fossil conduit system that has been reactivated to some degree present in this area (Drew 2003).
- There is a high degree of interaction between surface water and groundwater in this GWB. Groundwater supports calcareous lakes which contain rare plant species and themselves support sensitive terrestrial ecosystems near the lake shore.
- Further research is required to identify: the full extent of the karstification of the Derravaragh Cherts in this GWB; more detailed understanding of groundwater contributions to surface water lakes and to obtain information on the aquifer properties of the Derravarragh Cherts within this GWB.
- In the northeast of the body the bedrock is overlain by a potentially locally important sand & gravel aquifer. The gravels have been described as clean coarse esker & fan gravels of 5-15 m thick and are assumed to be in hydraulic continuity with the underlying bedrock. They will provide additional storage for the underlying bedrock aquifer. These gravels may be identified as a separate gravel GWB (no name at present).

Attachments	Figure 1 Hydrochemical Signature
Instrumentation	Stream gauges: 25118, 26044, 26126, 26127, 26128, 26252. EPA Water Level Monitoring boreholes: None EPA Representative Monitoring points: Multyfarnham GWS (WES 12).

Information Sources	An Foras Talúntais. Soils of Co. Westmeath. National Soil Survey of Ireland, 1977. Coxon, P. and Coxon, C. 1997 A pre-Pliocene or Pliocene land surface in County Galway, Ireland. Pp37-55 in Widdowson, M. (ed.) *Palaeosurfaces: Recognition, Reconstruction and Palaeoenvironmental Interpretation.* Geological Society Special Publication No. 120. Drew, D., 2002. Day2 IAH Fieldtrip: Landforms and Hydrology of the County Westmeath 'Lakeland' Area. From International Association of Hydrogeologists (Irish Group), Karst Field Trip 2002. Lowland Karst of North Roscommon and Westmeath 5-6th October 2002. McConnell, B., Philcox, M. and Geraghty, M., 2001. *Geology of Meath: A geological description to accompany the bedrock geology 1:100,000 scale map series, Sheet 13, Meath*. With contributions from J. Morris, W. Cox, G. Wright, and R. Meehan. Geological Survey of Ireland. 77 p. McDonald, D. (1988) *Aspects of hydrology in and around Fore*. Unpublished Moderatorship dissertation, Geography Department, Trinity College Dublin, 88 pp. Morris J.H., Somerville I.D. and MacDermot C.V. (2002). *Geology of Longford-Roscommon. A Geological Description to Accompany the Bedrock Geology 1:100,000 Bedrock Series Sheet 12*. With contributions by D.G. Smith, M. Geraghty, B. McConnell, K. Carlingbold, W. Cox, D. Daly. Geological Survey of Ireland, 121pp. (Publication Pending) OCM 2003. Assessment of Groundwater Vulnerability in the Lough Owel Catchment. Prepared for Westmeath County Council, County Buildings, Mullingar, Co. Westmeath by O'Callaghan Moran & Associates, Granary House, Rutland Street, Cork. Hunter Williams T. Hydrogeologist, Groundwater Section, Geological Survey of Ireland. Woods, L., Meehan, R. and Wright, G. R., 1998. *County Meath Groundwater Protection Scheme*. Main report. Final report to Meath County Council. Geological Survey of Ireland. 54 p.
Disclaimer	Note that all calculation and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae

Figure 1: Hydrochemical Signature
(EPA Representative Monitoring)



Extract from "Notes on Delineation of RBD boundaries where there are Groundwater/Surface Water interaction issues. 2nd July 2003. Drafted by M. Keegan, EPA"

2. Lough Lene, Co. Westmeath

A paper by D. Drew for an IAH Fieldtrip: Landforms and Hydrology of the County Westmeath 'Lakeland' Area, indicates that L.Lene straddles the water shed between the Shannon and Boyne catchments. Work by Piers, 1682, Vallancy, 1771 suggested that L. Lene drains via a surface channel eastward to the River Deel and underground via sinkholes to (it was assumed) springs in the settlement at Fore' which is in the Shannon catchment, therefore it flowed to both catchments.

Water tracing carried out by McDonald, 1988 demonstrated flow underground from L. Lene to the springs at Fore. The fieldtrip paper refers to 'mean outflow from the sinks and at the spring of 100l/sec compared to a surface outflow rate of 80 l/sec'. However, it states that 'the sinks and springs dry up in later summer suggesting a high level connection only, the floor of the lake presumably being impermeable'.

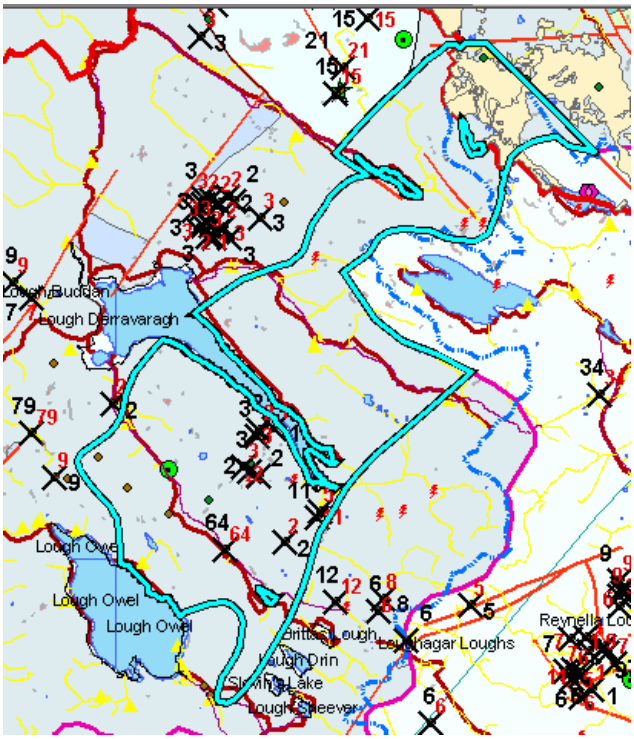
The nearby L.Bane has no surface water inflow or outflow but has been traced to the springs at Fore, which is in the Shannon RBD. It is currently included in the Eastern RBD.

Recommendations

Based on the seasonal flow (only high level connection) from L. Lene into the Shannon TBD catchment and the continuous surface water flow in to the Eastern RBD, it is recommended that L. Lene remain in the Eastern RBD with measures put in place to protect the surface water and thereby protecting the groundwater, some of which will end up in the adjacent Shannon RBD. Similarly, L. Bane should remain in the Eastern RBD and surface water protection measures should be put in place thus ensuring that the groundwater element, which flows to the adjacent Shannon RBD is also protected.

Approved by the GW Working Group 25 September 2003

Derryvarragh GWB (For Reference)



Rock units in Derryvarragh GWB

Rock unit name and code	Description	Rock unit group
Derravaragh Cherts (DV)	Cherty limestone, minor shale	Dinantian Upper Impure Limestones