Knockaderry GWB: Summary of Initial Characterisation.

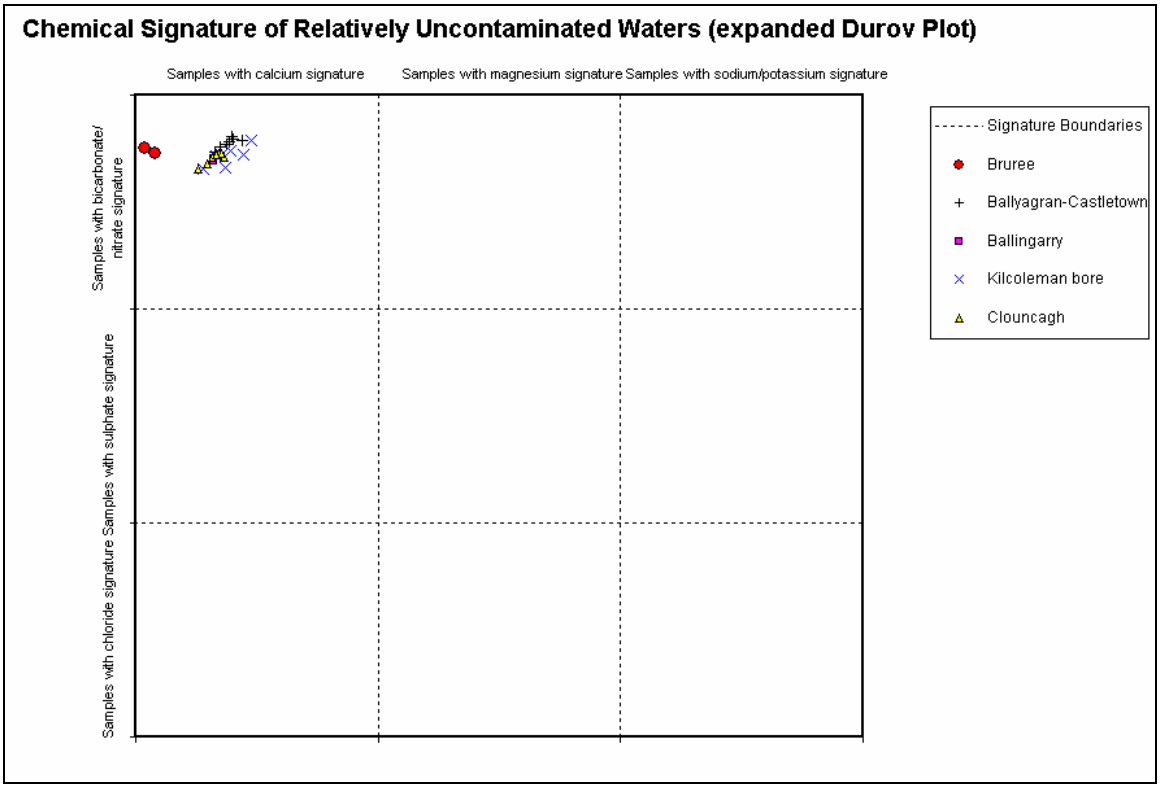
Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
24 - Deel Limerick Co. Co.	Minor streams.	-	10.8

Topography	This groundwater body is elongated in an E-W direction along a slightly elevated ridge. It is the western extension of the northern ridge of the Ballingarry GWB. The highest point of the GWB (183 mAOD) is on the eastern boundary, which is a surface water divide. The ground elevation decreases to 60 mAOD away from the central ridge underlain by more resistant sandstone towards the margins of the GWB. The drainage in the area is variable with topography. In the higher regions, there are no surface streams and the land is very well drained. Moving downhill onto the lower-lying flatter areas, surface streams are abundant, drainage ditches are present, and the overall drainage is generally poor. The streams drain in northwesterly and southwesterly directions into the River Deel or its tributary, the Owenskaw.	
Geology and Aquifers	Aquifer categories	The majority of the GWB comprises **Rf**: Regionally important fissured bedrock aquifer. There are small areas along the ridges underlain by Devonian Old Red Sandstone that are **Ll**: Locally important bedrock aquifer which is moderately productive only in local zones.
	Main aquifer lithologies	Devonian Kiltorcan-type Sandstones underlie most of the middle of the GWB; the Devonian Old Red Sandstone in small areas along the ridges is harder and less fractured than in the bulk of the GWB. Dinantian (early) Sandstones, Limestones and Shales underlie the outer margins of most of the GWB (except the east).
	Key structures	The ridge is part of the core of an anticlinal fold that is oriented ENE-WSW. The younger rocks of the Dinantian (early) Sandstones, Limestones and Shales occupy the lower ground around the northern, western and southern edges of the GWB. Major faults trending N-S and NE-SW cross-cut and displace the fold axes and disrupt the continuity of the rock units. Deformation during the folding caused fracturing and jointing of the rocks, especially in the sandstone layers.
	Key properties	The transmissivity in this rock unit group generally ranges from 40 to 100 m^2/d. At Kilcolman WS, a pumping test on the borehole provided transmissivities in the range 111–197 m^2/d with 154 m^2/d being the best estimate. At Clouncagh WS, also in Knockaderry GWB, analysis of the pumping test data gave a range of transmissivity values from 42–150 m^2/d, with a best estimate of 68 m^2/d. In these rocks, the specific yield is normally about 2%, but near the surface it can be as high as 5%. Groundwater gradients from the higher areas to the river valley are estimated to be approximately 0.04. *(data sources: Rock Unit Group Aquifer Chapters, Limerick GWPS and Source Reports, see references; estimation from maps)*
	Thickness	The effective thickness of this aquifer is up to 200 m (i.e. the entire thickness of the rock unit groups forming the GWB). The upper 10 m may be more weathered and transmissive than the bulk of the aquifer. It becomes confined where it passes underneath the Ballysteen Formation (Dinantian Lower Impure Limestones).
Overlying Strata	Lithologies	Limestone tills predominate; sand and gravel deposits and till-with-gravel occur in certain areas. Clayey till with silt tends to occupy the lower-lying areas. Near the areas of outcrop along the ridge, the covering is a thin deposit with a sandy matrix, some clay and many sub-angular clasts. *[More information to be added at a later date]*
	Thickness	The subsoil varies in thickness from about 4 m to almost 30 m. The thinner subsoils are found in the higher areas, where there are also small scattered outcrops. Deeper subsoils occur around the edges of the GWB, in the lower-lying areas.
	% area aquifer near surface	*[Information to be added at a later date]*
	Vulnerability	*[Information to be added at a later date]*
Recharge	Main recharge mechanisms	Diffuse recharge will occur over the entire groundwater body via rainfall soaking through the subsoil and directly into outcropping rock. It will occur most readily where rock is close to surface. A percentage of rainfall will not recharge the aquifer, but will runoff. Gravel lenses in the subsoils may contribute flow and storage to the aquifer.
	Est. recharge rates	*[Information to be added at a later date]*
Discharge	Springs and large known abstractions (m^3/d)	Clouncagh (590 m^3/d); Kilcolman (1840 m^3/d). *[More information to be added at a later date]*
	Main discharge mechanisms	Groundwater discharges to springs and the streams crossing the GWB, which will be gaining (although some of the stream flow may come from perched water tables in the higher permeability subsoils).

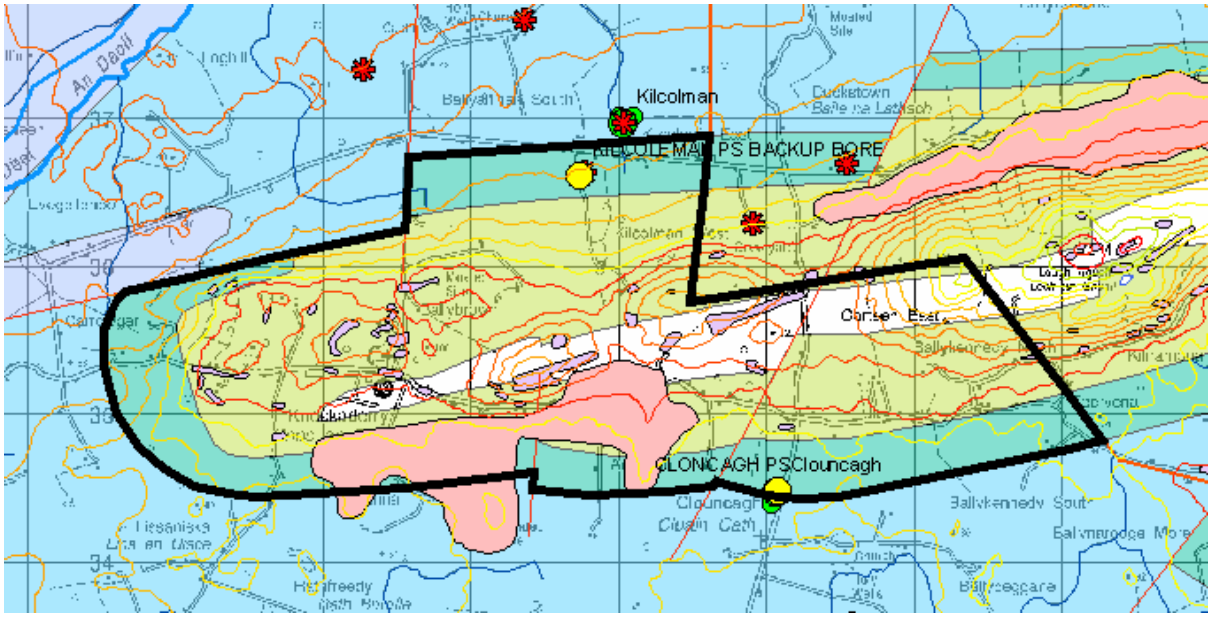
	Hydrochemical Signature	Groundwater from the borehole at Clouncagh is indicative of a hard water (279–293 mg/l $CaCO_3$), with moderately high alkalinity (270 mg/l $CaCO_3$). At the Kilcolman source, which comprises two springs and a summer backup borehole, the hydrochemical analyses of groundwater at the sources are indicative of a moderately hard to hard water (244–292 mg/l; $CaCO_3$), with moderate alkalinity (224–261 mg/l; $CaCO_3$). The conductivities are variable although generally range from 500–700 µS/cm. It is probable that there are some localised flows to the springs in gravelly lenses/layers in the till. At Ballyagran WS in the nearby Bruree GWB, the mean conductivity is 650 µS/cm, and the hardness is in the region of 335 mg/l (as $CaCO_3$) while the alkalinity is approximately 310 mg/l (as $CaCO_3$). pHs are neutral. Background chloride concentrations will be higher than in the Midlands, due to proximity to the sea. Iron can be a problem in the sandstone aquifers. All analyses are indicative of a calcium-bicarbonate type water which is more typical of a limestone aquifer in which carbonate dissolution is the dominant chemical process. This is may be due to the carbonate cement or limestone bands within the formation, or may be a reflection of the presence of limestone-dominated subsoils through which recharge is infiltrating. (Where the aquifer is significantly confined, ion exchange may have taken place, altering the hydrochemical signature towards sodium-bicarbonate.) Where there is mixing with surface water, these parameters have lower values. The bedrock strata of the Old Red Sandstone aquifer are **siliceous**, although they may have some carbonate cementing the sand grains. The Lower Limestone Shale rock unit (part of the Dinantian (early) Sandstones, Limestones and Shales rock unit group) is **calcareous**.
Groundwater Flow Paths		The rocks are devoid of intergranular permeability; groundwater flow occurs in fractures and faults. The fissuring associated with faults results in higher transmissivities, specific capacities and yields for some wells. The sandier units (at the top of the ORS and the base of the Lower Limestone Shales) are more prone to fracturing. In certain areas the rock cement has been dissolved and so the rock is crumbly and easily weathered. Here it may have intergranular permeability - a feature that is very unusual in Irish bedrock. The folding of the rock units renders the aquifer both confined and unconfined; groundwater flow is initially unconfined but, as it travels below thickening subsoils and then underneath the Dinantian Lower Impure Limestones (the Ballysteen Formation), it becomes confined. Water levels vary depending on topography, ranging from near-surface to depths of over 20 m. Artesian supplies may be obtained where boreholes penetrate the aquifer through the confining shaley beds of the overlying formations, or where subsoils are particularly thick and of low permeability. Confined groundwater circulating at depth may discharge to the surface via large faults, such as at Kilcolman. Impermeable fault zones may also retard circulation, however, by isolating all or part of an aquifer block from another, or by isolating the recharge area from the deepest parts of the formation. The general groundwater flow direction is naturally downhill radiating outwards north-, south- and westwards from the high ground along the ridges.
Groundwater & Surface water interactions		Groundwater discharges to the surface at the Kilcolman springs. Springs occurring on the hills slopes drain into the local streams. The larger streams crossing the GWB are considered to be in at least partial hydraulic continuity with the aquifer and gaining baseflow from the aquifer. Deakin (1995) considers that many of the small springs, rises and isolated ponds in the area are likely to be sourced from perched groundwater meaning that, in these areas, interaction between surface and groundwaters will be rapid.
Conceptual model		• The groundwater body is elongated E-W, along a slightly elevated ridge. The eastern boundary is a surface water catchment divide. It is bounded on the north, west and south by the contact with the surrounding Dinantian Lower Impure Limestone (Ballysteen Limestone), under which the aquifer becomes confined. The upper units of the LLS (the Ringmoylan Shales - unmapped as a separate unit in this area) also confine the aquifer. The terrain is slightly hilly; ground elevation decreases outwards from the ridges and also westwards. • The groundwater body is predominantly comprised of high transmissivity fissured bedrock. The topmost unit of the Lower Limestone Shales (the Ringmoylan Shales) is shaley and low permeability. Specific yields in the sandstone are higher than most Irish bedrock aquifers. • Flow occurs along fractures, joints and major faults. In certain areas the rock cement has been dissolved and so the rock is crumbly and easily weathered. Here it may have intergranular permeability. The major faults may compartmentalise the aquifer in certain situations. • Recharge occurs particularly in the upland areas where rock outcrops or subsoils are thin. Gravel lenses in the subsoils may contribute flow and storage to the aquifer. • Depending upon topography, the water table can vary between a few metres up to 20 m below ground surface. The aquifer becomes confined where it passes under the Lower Impure Limestones rock unit group, or under thick low permeability tills; here, wells are artesian. Groundwater flow follows topography, radiating outwards mainly to the north and south from the central ridge. Flow path lengths in the unconfined areas may be up to 1000's metres but, depending upon the topography, may be much shorter. Confined flow path lengths can be considerably long, and groundwater flow will be slow. There is evidence of some perching of groundwater. • Groundwater discharges to the rivers and streams crossing the aquifer, which are gaining, and near the contact with the overlying Lower Impure Limestones. Groundwater also discharges from depth, by flowing upwards along fault zones, as at Kilcolman. Perched groundwater may feed small springs and streams emerging mid-way down the slopes. • The Knockaderry Gravel GWB overlies this bedrock GWB in the southern part of the body.
Attachments		Hydrochemical signature (Figure 1).
Instrumentation		EPA Representative Monitoring boreholes: Rathkeale (Kilcolman) WS (LIM62), Clouncagh WS (LIM105).

Information Sources	Deakin, J., Daly, D. and Coxon, C. (1998) *County Limerick Groundwater Protection Scheme*. Geological Survey of Ireland Report to Limerick Co. Co., 72 pp. Deakin, J. (1995) *Clouncagh PS: Groundwater Source Protection Zones*, GSI Report to Limerick Co. Co., 6 pp. Deakin, J. (1995) *Ballingarry PS: Groundwater Source Protection Zones*, GSI Report to Limerick Co. Co., 6 pp. Deakin, J. (1995) *Kilcolman PS: Groundwater Source Protection Zones*, GSI Report to Limerick Co. Co., 7 pp. KT Aquifer chapter LLS Aquifer chapter Basalts/Volcanics chapter
Disclaimer	Note that all calculations and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae

Figure 1: Hydrochemical signature



NB: data used to generate this plot are from Bruree, Ballingarry and Knockaderry GWBs.



Rock units in GWB

Rock unit name and code	Description	Rock unit group
Old Red Sandstone (undifferentiated) (ORS)	Red conglomerate, sandstone and mudstone	Devonian Kiltorcan-type Sandstones AND Devonian Old Red Sandstones
Lower Limestone Shales (LLS)	Sandstone, mudstone and thin limestone	Dinantian (early) Sandstones, Limestones and Shales