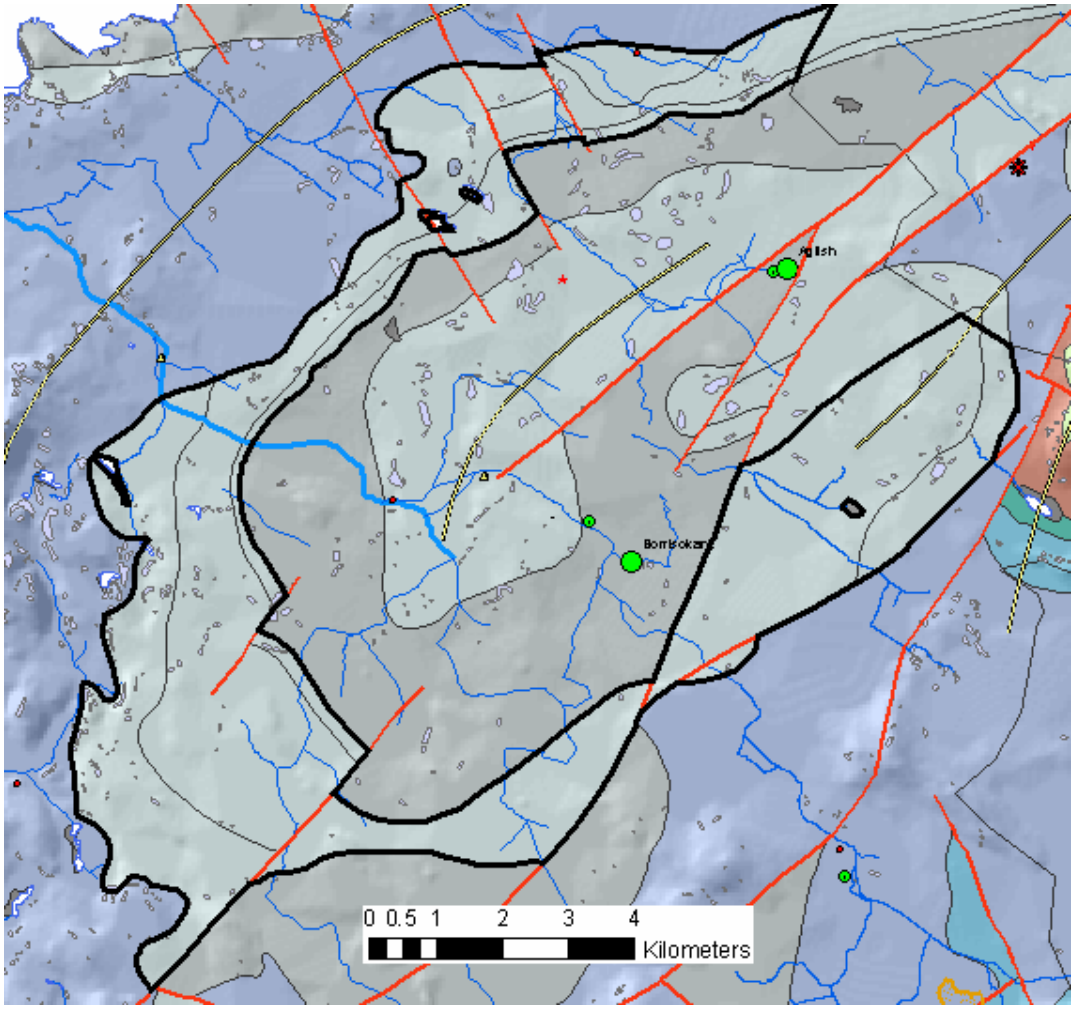
Lismaline GWB: Summary of Initial Characterisation.

Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
25 - Lough Derg catchment North Tipperary Co. Co.	Rivers: Ballyfinboy, Carrigahorrig. Streams: Ardcrony. Loughs: Aran, Cornnaling, Sopwell.	Arragh More Bog (000640), Kilcarren - Firville Bog (000647), Spring Park Wetlands (000941), Lough Avan (001995), Clareen Lough (000929).	53

Topography	The GWB is arcuate in shape, with the open ends pointing to the NE. Much of the GWB is flat-lying to gently undulating, with elevations typically in the range 50-70 mAOD. Elevations reach just over 90 m in the NE of the GWB and fall to just under 40 mAOD in the SW. The area is generally well-drained, except in very flat-lying areas. Surface drainage is generally SE to NW, with streams and rivers very gently incising into the substrate.	
Geology and Aquifers	Aquifer categories	Just over half of the GWB comprises an **Lm:** Locally important aquifer which is generally moderately productive, and just under half of the GWB comprises an **Rk^d**: Regionally important karstified aquifer dominated by diffuse flow. The **Lm** aquifer occurs in a discontinuous band on the outer side of the arc, whilst the **Rk^d** aquifer occupies the inner part of the arc. There is a very small area (< 0.1 km^2) of **Ll:** Locally important aquifer which is moderately productive only in local zones.
	Main aquifer lithologies	Dinantian Pure Bedded Limestone is the major rock unit group in the GWB. The bedded limestones that occur on the outer side of the GWB are cherty (Oldcourt Cherty limestones), whilst the bedded limestones on the inner edge of the GWB are mainly composed of coarse-grained limestone (Terryglass Formation). In the north of the GWB, there is a very small area (< 0.1 km^2) of Dinantian Pure Unbedded Limestone (Waulsortian Limestones). On the very inner margin of the GWB, a fine-grained limestone (Lismaline Micrite) occurs. It is an **Lm** aquifer.
	Key structures	The rocks occur in the limbs of a large syncline ('Borrisokane syncline'), whose axis plunges to the WSW. Strata dip towards the centre of the syncline at angles ranging between 5^o and 50^o (i.e., to the NW, E and SE). Minor folds associated with the major structure are present. Significant faults cross-cut the limbs of the fold, and are orientated NW-SE and SW-NE. A major SE-NW fault that extends from east Co. Clare to West Co. Offaly (the Knockshigowna Fault) almost dissects the aquifers in the SE of the GWB. Deformation associated with the folding will have caused fracturing, in addition to deformation caused by the faulting. Joints and fractures may be more open on the axes of the minor anticlines.
	Key properties	Transmissivities in the diffusely karstified aquifer that comprises about 45% of the GWB (the Terryglass Calcarenites) are in the range 20–1000 m^2/d. In this area of the country, the median value will probably be towards the lower-middle end of the range. In a very similar rock unit about 25 km to the ENE, modelled transmissivities were 140 m^2/d and 650 m^2/d respectively (Tully and Hollimshill WSs, Cronin, 1998 & 1999). Field transmissivities of 52-530 m^2/d have been recorded at Hollimshill and 13 m^2/d at Tully. Modelled permeability was 4.5 m/d at Tully and 13 m/d at Hollimshill. At Agall Spring, also in the Tullamore GWB to the ENE, porosity is taken to be about 0.02 (Kelly, 2001). Groundwater gradients within the karstic aquifer are low, ranging from approximately 0.005 to 0.01. This is due to the high transmissivity of the aquifer combined with the very subdued topography. Within the limestones that are less prone to karstification (Oldcourt Cherty Limestones, Lismaline Micrites), transmissivities will tend to be lower, in the range 10-100 m^2/d. Because they are lower permeability, groundwater gradients in these aquifers may be a little steeper than in the karstified limestones but, due to the very low topographic gradients, will still be low. High permeability zones caused by fissuring in the vicinity of faults may be present across the area and may cause local changes to the hydraulic gradient. Storativity in all aquifers will be low (approximately 0.015-0.03). *(data sources: Rock Unit Group Aquifer Chapters, GWPS Reports, Source Reports, see references; estimation from maps)*
	Thickness	The rock units within the Dinantian Pure Bedded Limestone group in this GWB have different thicknesses. They also vary laterally in thickness. The Oldcourt cherty limestone reaches a maximum thickness of 180 m (Gatley *et al.*, in press). The coarse-grained Terryglass Formation pinches out laterally from a maximum of 200 m. The Lismaline Micrite is about 40 m thick in most places. Notwithstanding the considerable combined thickness of the units, most groundwater flow is likely to take place in the top ~30 m, in the zone that comprises a weathered layer of 1-2 metres (epikarst) and a connected fractured (Oldcourt and Lismaline Formations) or diffusely karstified (Terryglass Formation) layer below this. Deeper groundwater flow occurs along fault zones and large fractures.
Overlying Strata	Lithologies	*[Information to be added at a later date]*
	Thickness	Subsoil thickness data are sparse. Available data indicate thickness in the range 1-5 m. There is outcropping rock and probably 'rock close' across much of the GWB.
	% area aquifer near surface	*[Information to be added at a later date]*
	Vulnerability	The majority of the GWB has 'High-Low' groundwater vulnerability. Extreme vulnerability occurs in large, non-contiguous areas over the remainder of the GWB.

Recharge	Main recharge mechanisms	Diffuse recharge will occur over most of the groundwater body via rainfall soaking through the subsoil and directly to the aquifer via outcrop. The well-drained appearance of the area indicates that recharge is readily accepted. However, where the water table is very close to ground surface, recharge may be rejected. Point recharge occurs at swallow holes.
	Est. recharge rates	*[Information will be added at a later date]*
Discharge	Important springs and high yielding wells (m^3/d)	There are no Excellent yielding boreholes (> 400 m^3/d) or significant springs known in the GWB. Frolic GWS abstracts 40 m^3/d (EPA database) from a spring. The spring's yield is not known.
	Main discharge mechanisms	The main discharges are to the streams and rivers crossing the GWB, and to the lakes, which in many cases have no surface inlets or outlets. In the west of the GWB, springs and streams emerge at or near the contact with the lower transmissivity pure unbedded limestones of the Nenagh GWB.
	Hydrochemical Signature	No relevant hydrochemical data are available to assess the hydrochemistry in this GWB. By analogy with other pure limestone aquifers, the groundwater is likely to be Hard to Very Hard, with corresponding high alkalinity and conductivity, and a neutral pH. It will have a calcium–bicarbonate signature.
Groundwater Flow Paths		These rocks are devoid of intergranular permeability; in the cherty and fine-grained limestones (Oldcourt and Lismaline Formations respectively), groundwater flows through an epikarstic layer a few metres thick, and along fault, fracture and joint planes in the zone below the epikarst in which the fractures are more dense and open. In the coarse-grained pure limestone aquifer (Terryglass Formation), groundwater flows through a diffuse network of solutionally-enlarged fissures and small conduits, and along faults. An epikarstic layer is also present at the top of this diffusely karstified aquifer. In all cases, the epikarst is thought to be relatively modern, being formed after the last ice age. Overall, groundwater flux is thought to be concentrated in the top 30 m or so of the aquifers. The groundwater flow regimes in the epikarst and fractured/ diffusely karstified zones will be hydraulically connected, with the degree of interconnection depending on the faults and joints associated with the structural deformation. The GWB is considered to be unconfined, with the rivers and streams in hydraulic continuity with the aquifer, which therefore represent the water table elevation. In these diffusely karstified and fractured aquifers, a continuous water table is considered to exist. The water table will follow the topography. In this generally flat-lying area, groundwater levels are generally shallow, ranging from near ground level near streams and rivers, up to more than 10 mbgl away from surface water bodies under local topographic highs. Local groundwater flow will be from the higher ground between surface water bodies to the rivers and streams, where it discharges. Regional groundwater flow directions are generally northwestwards, following the general decrease in elevation towards Lough Derg. Groundwater flow path lengths are on the order of 500–1500 m over the bulk of the GWB, depending upon position and the plan-view geometry of the aquifer. In discharge zones, flow paths will be much shorter, at around 100–300 m.
Groundwater & Surface water interactions		Groundwater sustains flows in the gaining rivers and streams crossing the GWB. The nature of the karstic system leads to rapid interchanges of water between surface and underground. The epikarst redistributes diffuse recharge in the subsurface, and swallow holes accept surface water at discrete points. There are several ecosystems that are dependent on groundwater. At Arragh More and Kilcarren – Firville Bogs, there are areas flushed with mineral rich water. At Spring Park Wetlands, the western area has extensive Reedbeds; the eastern area is occupied by a turlough. Lough Avan and Clareen Lough are wetland and lake systems with wet grassland and marshy areas.

Conceptual model	• The GWB is arcuate, with the open ends pointing NE. It is bounded on the outer edge by the contact with the lower transmissivity Pure Unbedded Limestones of the Nenagh GWB, and on the inner edge by the contact with the lower transmissivity Upper Impure Limestones of the Ballinderry GWB. In the NE and SE of the GWB, surface water catchment divides, which are implied groundwater divides, bound the GWB along short parts of its perimeter. The terrain is generally flat-lying to gently undulating. • The aquifers within this GWB are transmissive karstified or fractured limestones. The aquifers have low storativities. • In the **Rk^{d}** aquifer (coarse-grained pure limestones), groundwater flows through a network of diffusely karstified fractures and joints and small conduits. Within the **Lm** (cherty limestones) and **Ll** aquifers (unbedded pure limestones), groundwater flow occurs along fractures, joints and faults. There is likely to be an epikarstic layer of 1-2 m at the top of all of the limestone aquifers, which acts to redistribute recharge in the subsurface and, in high water table conditions, is a very high transmissivity layer. • Recharge occurs diffusely through the subsoils and at outcrop. Potential recharge may be rejected in areas where the water table is very close to the surface. Point recharge enters the aquifer at swallow holes. A relatively small volume of groundwater will flow from the upstream lower transmissivity GWB. • Groundwater flux in the limestone aquifer will be concentrated in an approximately 30 m zone at the top of the bedrock. This zone comprises an epikarstic layer of a few metres, below which is a network of joints, fractures and faults that are karstified to differing degrees, depending upon the rock composition. Deeper groundwater flow can occur along permeable fault zones or deeper fractures. • The aquifers are probably unconfined over most of the GWB. Beneath bogs, the aquifer may be confined. Near rivers and streams, the water table is close to the surface. Beneath higher ground, significant unsaturated zones may exist. Depending upon topography and aquifer transmissivity, the water table can range from around 2 mbgl up to more than 10 mbgl. Water table fluctuations in discharge areas will be relatively low (on the order of 1-2 m) whereas, in the high ground underlain by karstified limestones, the water table elevation may vary considerably. • Flow path lengths are generally long (up to 1500 m). In discharge zones, flow paths will be much shorter, at around 100–300 m. On a local scale, groundwater discharges to the streams and smaller rivers crossing the aquifer. Local groundwater flow directions are determined by topography and local drainage patterns. Over most of the GWB, regional groundwater flow directions are mainly E-W, parallel to the GWB margins to roughly NW in the west of the GWB. • Groundwater discharges to the gaining rivers and streams crossing the GWB. • At the western (outer) edge of the GWB, the contrast in transmissivity between the aquifers in this GWB and the lower transmissivity pure unbedded limestones of the Nenagh GWB can be seen in the emergence of springs and streams at or near the contact. Some cross-flow from this aquifer to the lower transmissivity GWB downstream may occur, however. • Several types of ecosystem within the GWB are groundwater-dependent, i.e. mineral flushes in raised bogs, wetlands and loughs. • A large part of the Source Protection Area to the Borrisokane WS is situated in the NE of this GWB, although the spring point is in the adjacent Ballinderry GWB.
Attachments	None.
Instrumentation	Stream gauges: 25323
Information Sources	Cronin C., Daly, D., and R. Flynn, 1999. *Hollimshill Public Supply. Groundwater Source Protection Zones.* Geological Survey of Ireland Report, 12 pp. Cronin C., Daly, D., and R. Flynn, 1998. *Tully Public Supply. Groundwater Source Protection Zones.* Geological Survey of Ireland Report, 18 pp. Kelly, C. 2001. Agall Water Supply Scheme. Groundwater Source Protection Zones. Geological Survey of Ireland Report. Gatley, S. I. Somerville, J.H. Morris, A.G. Sleeman, and G.Emo, with contributions by W. Cox (Minerals), T. Hunter-Williams (Groundwater), and R. van den Berg and E. Sweeney (Carboniferous Volcanics), edited by A.G. Sleeman. A Geological description of Galway - Offaly, and adjacent parts of Westmeath, Tipperary, Laois, Clare and Roscommon to accompany the Bedrock Geology 1:100,000 Scale Map Series, Sheet 15, Galway - Offaly. Hunter Williams, N., Motherway, K. and Wright, G. (2002) *North County Tipperary Groundwater Protection Scheme (draft)*. Geological Survey of Ireland Report to North Tipperary Co. Co., 58 pp. Aquifer Chapters: Dinantian Pure Bedded Limestones, Dinantian Pure Unbedded Limestones.
Disclaimer	Note that all calculations and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae



Rock units in GWB

Rock unit name and code	Description	Rock unit group
Lismaline Micrite Formation (LM)	Medium-grey micritic limestone	Pure Bedded Limestones
Oldcourt Cherty Limestone Formation (OC)	Grey limestone and dark chert	Pure Bedded Limestones
Terryglass Formation (TS)	Grey calcarenitic & oolitic limestone	Pure Bedded Limestones
Waulsortian Limestone (WA)	Massive unbedded lime-mudstone	Pure Unbedded Limestones