Donegal-Ballintra: Summary of Initial Characterisation.

Hydrometric Area Local Authority		Associated surface water bodies	Associated terrestrial ecosystems	Area (km^2)
Hydrometric Area 37 Donegal Co. Co.		***Rivers:*** Ballintra, Bridgetown, Drumenny, Eske ***Streams:*** Laghy stream, 99 unnamed streams ***Lakes:*** Atlughan, Glen, Birra, Drumhome, Durnesh, Dromoske, Ballynakillew, Trumman.	Donegal Bay (Murvagh), Durnesh Lough and Lough Eske and Ardnamona Wood (O'Riain, 2004).	58
Topography		Elongated along a N-S axis (Figure 1), the northern, eastern and much of the western GWB boundaries comprise a change in aquifer type. The southern boundary is a topograpgic divide (Hydrometric Area 36) and the remaining western boundary is coastline. The landscape is generally low-lying with E-W orientated drumlins. Elevations range from <10 mAOD at the coast to 110 mAOD on the inland drumlin-tops. The drumlins are generally c.30-60 m in height. Surface water flow is westwards to the coast.		
Geology and Aquifers	**Aquifer type(s)**	This GWB has been delineated because it is almost entirely **Rk^d**: Regionally important karst aquifer dominated by diffuse flow.		
	Main aquifer lithologies	The GWB comprises Dinantian Pure Bedded Limestones (90.65%) and Dinantian Shales and Limestones (9.1%). Two small areas of Granite and Other Igneous Intrusive Rocks are mapped towards the north of the GWB (<1%). Refer to Table 1 for details.		
	Key structures.	There are 2 main SW-NE trending faults (e.g. Barnesmore Faults) that split this GWB in to three blocks. Dips in the rock succession are c.10°.		
	Key properties	Four well yields are available: 109, 491, 927 and 1090 m^3/d, and one specific capacity value – 103 $m^3/d/m$. The same aquifer in the Ballyshannon GWB (adjacent to the south) has 5 yields ranging from 120-327 m^3/d (averaging 220 m^3/d) and associated specific capacities of between 4-168 $m^3/d/m$ for 4 of those wells. Nationally, transmissivity values in Rk^d aquifers range from 2-2000 m^2/d. The implied transmissivity values in the Donegal aquifers are at the lower-mid end of this scale, indicating that highly peremable *zones* are present. The variable discharge and rapid response to rainfall in the Parkhill Spring (Ballyshannon GWB) indicates the potential for rapid groundwater flow and low storativity in this type of aquifer. High annual variation in groundwater levels (up to 25 m) have been recorded in a borehole in the Ballyshannon GWB (Figure 2), which *may* also suggest low storativity in these rocks. From the minimal karst work undertaken in Donegal, c.30 karst features have been recorded in this and the adjacent Ballyshannon GWB, and there are likely that there are more unrecorded features. 85% of the 26 groundwater levels are 0-3 m below ground level. The data are inadequate to calculate groundwater gradients although these are often expected to be low as the aquifer can have high a transmissivity values. Overall flow directions are to the west, with groundwater discharging to the sea. *(Minerex Reports; Donegal GWPS; Pure Bedded Limestones Aquifer Chapter)*		
	Thickness	The Dinantian Pure Bedded Limestones are generally over 100 m thick. Most groundwater is thought to flow in an epikarstic layer 2-3 m thick, and in a zone of interconnected, solutionally-enlarged fissures and conduits that extends approximately 30 m below this. There will also be a zone of isolated, poorly connected fissures – typically less than 150 m bgl. Deeper inflows can occur, as suggested by the recorded deeper water strike (73 m). Such flows are often in areas associated with faults or dolomitisation.		
Overlying Strata	**Lithologies**	Till is the predominant subsoil in this GWB (c.77%), with a small proportion of alluvium (9%). Just under 10% of the GWB is recorded as outcrop/shallow rock.		
	Thickness	The available borehole and oucrop data indicate that the till drumlins each represents a thicker deposit, frequently >10 m thick, with rock near the surface of the inter-drumlin areas.		
	% area aquifer near surface	*[Information will be added at a later date]*		
	Vulnerability	From the Donegal GWPS, vulnerability ranges from Extreme where subsoil deposits are thin to Moderate and Low over the thick drumlin deposits.		
Recharge	**Main recharge mechanisms**	Both point and diffuse recharge occur in this GWB. Diffuse recharge occurs via rainfall percolating through thin subsoil and rock outcrops. Point recharge to the underlying aquifer occurs via of swallow holes, dolines and caves. Although recharge along 'losing' sections of streams is also associated with this particular type of aquifer, to date none have been recorded in this GWB. The presence of low permeability, thick till drumlins will promote surface runoff. The runoff may either discharge to the streams in the GWB or be diverted to the inter-drumlin areas, where recharge to the aquifer is more likely to occur. The stream density, which is lower than for the surrounding, lower permeability GWBs, is likely to be influenced by the permeable karst aquifer.		
	Est. recharge rates	*[Information will be added at a later date]*		

Discharge	**Important springs and high yielding wells**	Sources: None identified. Springs: None identified. Excellent Wells: Ballynacarrick (1090 m^3/d); Tullywee (927 m^3/d); Laghy (491 m^3/d). Good Wells: Ballymagrorty (109 m^3/d).
	Main discharge mechanisms	The main groundwater discharges are to the streams, rivers, lakes and any springs found within the body. Given the permeable nature associated with Rk^d aquifers, the baseflow proportion of the total streamflow is expected to be higher in this GWB than for the adjacent Pl/Pu GWB, especially where the subsoil is thinner i.e. in the inter-drumlin areas.
	Hydrochemical Signature	***National classification:*** Dinantian Pure Bedded Limestones Calcareous. Generally $CaHCO_3$ signature. Alkalinity (mg/l as $CaCO_3$): range of 10-990; mean of 283 (2454 data points) Total Hardness (mg/l): range of 10-1940; mean of 339 (2146 'non limestone subsoils' data points) Conductivity (μS/cm): range of 76-2999; mean of 691 (2663 'non limestone subsoils' data points) *(Calcareous/Non calcareous classification of bedrock in the Republic of Ireland report)*
Groundwater Flow Paths		As these rocks are generally devoid of inter-granular permeability, groundwater flows through fissures, faults, joints and bedding planes. In pure bedded limestones, these openings are frequently enlarged by karstification resulting in significantly enhanced rock permeability. Karstification can be also accentuated along structural features such as fold axes and faults. An epikarst layer in the upper few metres of the rock is likely to be present on top of the diffusely karstified aquifer. The majority of the available groundwater levels are 0-3 mbgl, suggesting that shallow groundwater flow is prevalent. The observed deeper water strike (73 m) indicates that there is a component of deep groundwater flow, however shallow groundwater flow is dominant. The flow regimes in diffusely karstified aquifers are likely to be hydraulically connected, resulting in continuous water tables that reflect topography. As the groundwater flow is thought to be mainly unconfined, surface water is also likely to be in hydraulic continuity with the aquifer, espcially where subsoil deposits are thin and/or permeable. Flow in highly permeable karstified limestones is of a regional scale – flow path lengths of several kilometres are not unusual although are likely to be shorter in discharge areas (c.100-300 m), e.g. towards the southwest. Overall, groundwater flow will be westwards, towards the coastline. However, where the rock is significantly karstified, locally groundwater flow directions can be highly variable.
Groundwater & surface water interactions		There is a high degree of interconnection between groundwater and surface water in karstified limestone areas such as in this GWB. Swallow holes, dolines, caves, turloughs, springs, and 'losing' and 'gaining' streams all provide a direct route between surface water and groundwater systems. This rapid interchange between surface water and groundwater is often reflected in their similar water quality as contamination is also rapidly transported between the two systems.

Conceptual model		• The northern, eastern and majority of the western boundary comprise differing aquifer types. The southern boundary is a topographic divide (Hydrometric Area 36) and the remainder of the western boundary comprises coastline. The topography is generally low-lying and is dominated by E-W orientated drumlins.
		• The main rock type in this GWB is a karstified limestone that is dominated by diffuse groundwater flow (aquifer category **Rk^d**).
		• Most of the groundwater flux is expected to be in the uppermost 30 m of the aquifer, comprising an epikarst zone of c.3 m in thickness and a zone of interconnected, karstified (solutionally enlarged) joints, fissures, fractures and faults. Deeper groundwater flow can occur along permeable fault or fracture zones, which is highlighted be deeper water strikes.
		• Transmissivity values and well yields are variable, reflecting zones of higher and lower permeability. Rapid response of springs to rainfall events indicates that there is the potential for high groundwater flow velocities through this rock, and the potential for low storativity.
		• In general, the degree of interconnection in karstic systems is high and they support regional scale flow systems. Long flow paths (kilometres in length) can be expected although are likely to be shorter in discharge areas (100-300 m).
		• Groundwater flow is generally unconfined and there is likely to be a high degree of hydraulic continuity with rivers, streams and lakes, especially where the subsoil is thinner and/or permeable.
		• Recharge occurs by:
		  • diffuse means – through rock outcrops and thin subsoil, although may be limited by thicker, low permeability subsoil, and
		  • point mechanisms; swallow holes, dolines, caves and along lengths of losing streams – mainly occurring where subsoil is thin.
		• Due to the combination of point recharge and rapid flow through solutionally enlarged joint/fissure/fracture zones, there is minimal potential for contaminant attenuation in this aquifer.
		• The main discharges are to the rivers and springs within the GWB. Overall, the flow direction is to the west, as determined by the topography.
		• There is a high degree of interaction between surface water and groundwater in the GWB.

Attachments	Figure 1. Figure 2. Table 1.
Instrumentation	**Stream gauges:** 37002, 37008, 37009 **EPA Water Level Monitoring boreholes:** None identified. **EPA Representative Monitoring points:** None identified.
Information Sources	Lee M. and Fitzsimons V. (2004). *County Donegal Groundwater Protection Scheme.* Main Report. Draft Report to Donegal County Council. Geological Survey of Ireland 58pp. Long, C.B. and McConnell (1999) *Geology of South Donegal: A geological description, to accompany bedrock geology 1:100,000 scale map, Sheet 3, South Donegal*. With contributions by G.I. Alsop, P. O'Connor, K. Carlingford and C. Cronin. Geological Survey of Ireland, 116pp. Minerex Environmental Ltd. (2003). *Ballyshannon and Rossnowlagh Water Supply Scheme – Groundwater Supply. BH1, BH2, BH3, BH4 and Spring 2 pumping test supervision, monitoring, interpretation an reporting.* MEL Doc.Ref.:1492-103 (First draft). O' Riain, 2004. *Water Dependent Ecosystems and Subtypes (Draft)*. Compass Informatics in association with National Parks and Wildlife (DEHLG). WFD support projects.
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. Location and Boundaries of GWB.

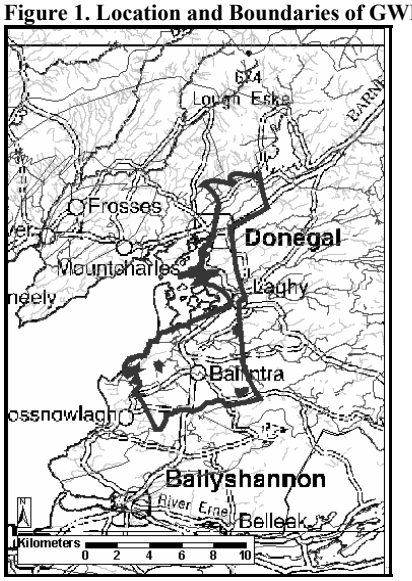

Table 1. List of Rock units in Donegal-Ballintra GWB

Rock Unit Name	Code	Description	Rock Unit Group	Aquifer Class.	% Area
Ballyshannon Limestone Formation	BS	Pale grey calcarenite limestone	Dinantian Pure Bedded Limestones	Rk	90.65%
Bundoran Shale Formation	BN	Dark shale, minor fine-grained limestone	Dinantian Shales and Limestones	Ll	9.10%
Dolerite	D	basalt and gabbro	Granites & other Igneous Intrusive rocks	Pl	0.25%

Figure 2: Groundwater hydrographs (EPA Groundwater Level Monitoring): Ballyshannon GWB