Funshinagh GWB: Summary of Initial Characterisation.

Note: In the southwest of the Funshinagh GWB the body boundary needs to be adjusted by moving it to the east. This is because the catchment boundary on which the body boundary is based needs to be adjusted to take into account the zone of contribution of Tobermore Spring (Killeglan PWS) which lies in the neighbouring Suck GWB. The Funshinagh GWB boundary in this location should be taken to run along the outmost extent of the Killeglan Source Protection Area.

Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
26 – Hind/Lough Ree Roscommon Co. Co.	Rivers: Feorish, Clooneigh, Hind, Cross, Mihanboy. Streams: Curraghroe. Loughs: Loughaun, Ree, Funshinagh, Cup, Williams, Dooloughan, Corkip.	(000440) Lough Ree; (002072) Lisnanarriagh Bog; (000599) Clooncraff/Cloonlarge Bog; (000588) Ballinturly Turlough; (000611) Lough Funshinagh; (000602) Corbo Bog.	354

Topography	The topography of the body is generally flat with some small hills and low ridges. There are low lying areas, where elevations range from 30-50 mAOD. These include the south of the body, a broad area along the west shore of Lough Ree, along the valley of the River Hind which flows east west across the northern part of the body and along the north eastern limb of the body. There are some large areas of bog in these low-lying regions. In the south of the body there is also some hilly and hummocky terrain associated with areas of gravel deposits. Elevations are higher just west of the centre of the body, and in the extreme northwest. There is a low ridge (70-100 mAOD) to the east of Lough Funshinagh. The highest point in the body is 160 mAOD, in an area of high ground to the north west of Lough Funshinagh, close to the boundary of the body, just east of Athleague. Elevations in the northeast range from 50-100 mAOD.	
Geology and Aquifers	**Aquifer categories**	The main aquifer category in this GWB is: **Rk^c:** Regionally important karstified aquifer dominated by conduit flow. A number of small areas occur throughout the body with an aquifer category of: **Ll:** Locally important aquifer which is moderately productive only in local zones. The islands in Lough Ree are formed of karstified limestone similar to the rest of the GWB, however they are not considered large enough to merit the classification of regionally important – a classification code to reflect the karstified nature of these islands as well as their limited size is pending.
	Main aquifer lithologies	This GWB is composed primarily of Dinantian Pure Bedded Limestones. Some of the Pure Bedded Limestones have been dolomitised, but only a small area (4 km^2) is currently mapped as Dinantian Dolomitised Limestones. There are a number of very small areas (generally < 1 km^2) of Dinantian Pure Unbedded Limestone (Visean Mudbanks) within the body.
	Key structures	Few faults are mapped in this area; this may reflect the poor exposure and the lack of major variation in the rock lithology. The dips over the GWB area are generally less than 10^o, except near faults, where steeper dips result from fault drag. The Strokestown Inlier forms part of the northern boundary of the body.
	Key properties	Karstification is widespread in this GWB. As with most karstic systems, permeability and transmissivity are very variable. Transmissivity in karstified aquifers with conduit flow can range from less than 1m^2/d up to a few thousand m^2/d, depending on whether or not the conduit flow system is intersected. As part of an EIS for Ballingard Spring source, individual pumping tests were undertaken on five boreholes between June and September 1994. The estimated transmissivity from the individual pumping tests ranged from 60 m^2/d in the lower permeability rock to 180 m^2/d in the high permeability zones (Jennings O'Donovan & Partners, 1996). The aquifer supports high and intermediate yielding springs. Rapid groundwater flow velocities have been recorded. Tracer tests carried out within this GWB recorded minimum velocities of 24 m/hr in the Ballinagard tracer test (Roscommon County Council, 1991) and 70 m/hr recorded in the Lough Funshinagh to Atteagh Corn Mill Spring tracer test (Drew, D. and Burke, M., 1996). Tracer tests carried out in the adjoining Suck South GWB range from 68 to 107 m/hr between several connections east of Castlerea (Longford and Silver Island Springs multiple tracer test, GSI, 2001), and 70 m/hr and 110 m/hr recorded in the Killeglan Springs tracer test (Roscommon County Council, 1991 and 1994). Rapid velocities recorded for groundwater in these areas imply flow through relatively sizeable conduits. Groundwater gradients calculated in the vicinity of Ballingard Spring source were low, ranging from 0.002-0.007 (Lee *et al.* 2003). In karstified Pure Bedded Limestone, such as that found in this GWB, enlargement of the fracture network by solution, and the generally well connected and widespread fracture systems result in a highly permeable aquifer with rapid groundwater flow. Storativity in this aquifer will be low. Small isolated areas of pure unbedded limestones occur within this GWB. These pure unbedded limestones are considered less susceptible to karstification due to their unbedded nature. The permeability of these rocks is generally low but local zones of enhanced permeability may be present. There are seven Turloughs, eight Enclosed Depressions and seven Swallow Holes currently recorded in the GSI Karst Features Database for this GWB. *(data sources: Rock Unit Group Aquifer Chapters, Roscommon GWPS and Source Reports, see references)*
	Thickness	The Dinantian Pure Bedded Limestones in this region are generally over 100 m thick. Near Castlerea, over 150 m of Dinantian Pure Bedded Limestones are recorded, while depths of 170 m, and 250 m have been recorded in boreholes near Newtown Forbes, and Glebe, County Longford (Morris *et al* 2002). Most groundwater flows in an epikarstic layer a couple of metres thick and in a zone of interconnected solutionally-enlarged fissures and conduits that extends approximately 30 m below this. Deeper inflows can occur in areas associated with faults or dolomitisation. In borehole logs from the vicinity of Ballinagard Spring, fissure zones were located at both shallower (10 – 30 m b.g.l.) and deeper (55 – 60 m b.g.l.) depths.

Overlying Strata	**Lithologies**	There are large areas of cut peat overlying the body, particularly in the northern limb of the body that extends alongside the River Shannon and also in the south of the body. Much of this cut peat has been reclaimed for grassland. There are gravel deposits in the south of the body west of Athlone. Most of the rest of the body is covered by Limestone Till with some Sandstone Till in the north-eastern limb of the body. Small areas of rock outcrop occur throughout the body, however these are more frequent and extensive in two broad areas east and northwest of Lough Funshinagh. *Subsoil Types identified in Funshinagh GWB by Teagasc Parent Material Mapping: Alluvium (A), Esker (Bas Esker), Cut Peat (Cut), Gravels –Limestone (GLs), Rock outcrop and rock close to surface (Rck), Kartified Limestone outcrop and close to surface (KaRck), Lake sediment (L), Till – Lower Palaeozoic Sandstone and Shale Till (TLPSsS) & Limestone Till (TLs).*
	Thickness	Areas of outcrop occur throughout the GWB, however outcrop is more frequent and extensive in two broad areas east and northwest of Lough Funshinagh. Within these broad areas, and in the vicinity of other areas of outcrop, subsoil depth will be generally < 3 m. Outside of these areas subsoil depths range from 0-10 m. Deeper subsoils of >10 m are encountered south of Brideswell between the areas of shallow subsoils just northwest of Lough Funshinagh, and in the extreme north east of the body.
	% area aquifer near surface	[Information will be added at a later date]
	Vulnerability	There is a sizeable area of Extreme vulnerability east of Lough Funshinagh, where a lot of shallow rock is present. North and northwest of Lough Funshinagh there is another area of Extreme vulnerability with a significant amount of shallow rock. Other more isolated areas of Extreme vulnerability occur throughout the body. Most of the rest of the area of the GWB is of High vulnerability. There are four main areas of Moderate and Low vulnerability. These occur south of Brideswell in the south of the body; an elongate area between areas of Extreme Vulnerability just north west of Lough Funshinagh; between Roscommon town and Lough Ree; and in the extreme north east of the body. *A Groundwater Vulnerability Map has been prepared for County Roscommon as part of a Groundwater Protection Scheme.*
Recharge	**Main recharge mechanisms**	Both point and diffuse recharge occur in this GWB. Swallow holes and collapse features provide the means for point recharge. Diffuse recharge will occur over the entire GWB via rainfall percolating through the subsoil. The lack of surface drainage in several parts of this GWB indicates that potential recharge readily percolates into the groundwater system. Except for the northeast of the body and some areas in the south of the body, the subsoil is primarily of 'moderate' permeability which will generally not restrict percolation of recharge though it. Subsoils of 'high' permeability (gravel deposits) occur in the south of the body and allow easy percolation of recharge. Subsoils of 'low' permeability occur in the northeast of the body and may restrict the percolation of recharge. In this highly permeable aquifer there can be some rejected recharge in low-lying areas with a high water table, where a proportion of the effective rainfall is rejected due to lack of storage space in the aquifer. Groundwater in this body generally shows a rapid response to recharge. Where gravels overlie the karstic aquifer they provide a permeable pathway for recharge to the underlying karstic aquifer. They can also act to augment storage in the karstic aquifer.
	Est. recharge rates	*[Information to be added at a later date]*
Discharge	**Large springs and high yielding wells (m^3/d)**	Ballinagard Spring (2728 m^3/d) – Public Water Supply (GSI Database) Knockcroghery RWS – Carrigeens (ROS29-Spring) (646m^3/d); Lecarrow (ROS30-Spring) (636 m^3/d); Keadew WS (ROS27-Bore) (131 m^3/d) (From EPA Groundwater Sources List (Larger Sources > 100 m^3/d)) *[This information is not complete – further data need to be added]*
	Main discharge mechanisms	The main discharges are to the streams and rivers crossing the body and to the large springs found within the body. In winter groundwater will discharge to the turloughs found in the area.
	Hydrochemical Signature	The hydrochemistry of the carbonate rocks, especially pure limestones, is dominated by calcium and bicarbonate ions. Hardness can vary from slightly hard to very hard (typically ranging between 380–450 mg/l). Spring waters tend to be softer, as throughput is often quicker with less time for the dissolution of minerals into the groundwater. Groundwater alkalinity is variable, but can be high. Alkalinity is generally less than hardness indicating that ion exchange (where calcium or magnesium are replaced by sodium) is not a significant process. These hydrochemical signatures are characteristic of clean limestone and are frequently associated with lime-scale problems. Like hardness and alkalinity, electrical conductivities (EC) can vary greatly. Typical limestone groundwater conductivities are of the order 500–700 µS/cm. Lower values suggest that groundwater residence times are very short. In some springs and boreholes in karst areas, high turbidity occurs after heavy rainfall (e.g. Killeglan PWS in the adjoining Suck South GWB to the west). Microbial pollution of groundwater in karstic aquifers is also a significant problem. Due to the high level of interaction between groundwater and surface water in karstic aquifers, microbial pollution can travel very quickly from the surface into the groundwater system. The normal filtering and protective action of the subsoil is often bypassed in karstic aquifers due to the number of swallow holes, dolines and large areas of shallow rock. The hydrochemical signature of groundwater from a number of public supplies within this body is demonstrated in an expanded Durov plot in Figure 2 below.

Groundwater Flow Paths	These rocks are generally devoid of intergranular permeability. Groundwater flows through fissures, joints, along bedding planes and conduits. In pure bedded limestones, the fissures and joints are enlarged by karstification which results in the formation of conduits and significantly enhances the permeability of the rock. Dolomitisation will also locally enhance permeability by collapsing the void space and creating cavities. In some instances, an element of intergranular permeability can develop as a result of dolomitisation. Karstification can be accentuated along structural features such as fold axes and faults. Groundwater flow through karst areas is extremely complex and difficult to predict. As flow pathways are often determined by discrete conduits, actual flow directions will not necessarily be perpendicular to the assumed water table contours, as shown by several tracing studies (Drew and Daly, 1993). Flow velocities can be rapid and variable, both spatially and temporally. The rapid groundwater flow velocities recorded in this body indicate that a large proportion of groundwater flow takes place in enlarged conduit systems. The presence of high yielding springs in this body indicates that the permeability of the rock unit is high enough to permit the throughput of significant quantities of groundwater. High yielding springs are indicative of regional-scale flow systems. Flow path lengths can be up to a several kilometres in length. Overall groundwater flow will be towards Lough Ree, but the highly karstified nature of the bedrock means that locally groundwater flow directions can be highly variable. The 'Hind/Lough Ree'-'Shannon Uptream Roosky' surface water catchment boundary, forms part of the northern boundary of the body. The topography is quite subdued at this point and, given the karstified nature of the bedrock it is possible that this surface water catchment boundary does not coincide with a groundwater divide. There may be some groundwater flow between the Carrick on Shannon GWB and the Funshinagh GWB. Water levels in karstified limestone which is dominated by conduit flow, generally show rapid response to rainfall. Water level data from a well within this GWB are shown in Figure 1 attached. As the water levels are not measured continuously, the quicker responses to rainfall may not be reflected adequately in the hydrograph. In the south of the body the bedrock is overlain by gravel deposits. The topography is hilly and hummocky. While the large number of gravel pits indicate that the deposits are relatively clean and worth quarrying, groundwater has generally not been encountered during excavation due to their high relief. No wells are known to be located in these deposits, and there are no data to determine the extent of any saturation. Given the higher relief and absence of existing groundwater abstractions, this unit is not considered to have a saturated thickness adequate to yield significant groundwater supplies. As such, these sand/gravel deposits are not classified as an aquifer. These gravels will however provide a permeable pathway for recharge to the karstic aquifer and where saturated may provide an element of storage for the underlying bedrock.
Groundwater & Surface water interactions	There is a high degree of interconnection between groundwater and surface water in this GWB. Numerous karst features such as turloughs, swallow holes and enclosed depressions are evident. Turloughs are seasonal lakes which are fed by groundwater as the watertable rises in winter. These turloughs support sensitive ecosystems which are highly dependant on groundwater. Lough Funshinagh in the centre of the body is a large turlough which on occasion dries out completely. A water tracing experiment proved a connection between the sink at Lough Funshinagh and a spring at Atteagh Corn Mill which feeds the Cross River near Milltown Pass some 5km south of the lake, with a minimum flow rate of 70 m/hr. Because of the close interaction between surface water and groundwater in karstified aquifers, surface water and groundwater quality are also closely linked. Any contamination of surface water is rapidly transported into the groundwater system, and vice versa.

Conceptual model	• This GWB occupies an elongate north south trending area along the west side of Lough Ree and the River Shannon. It is bounded to the west by a groundwater divide and topographic high which coincides with the surface water catchment boundary with the Suck catchment. It is bounded to the east by Lough Ree and the River Shannon. It is bounded to the south by the contact with the lower permeability Dinantian Pure Unbedded Limestones of the Athlone West GWB. The northern boundary is in part formed by the contact with the lower permeability rocks of the Curraghroe GWB and in part by the Hind/Lough Ree-Shannon Upstream Roosky surface water catchment boundary. However the topography is quite subdued at this point and it is possible that this surface water catchment boundary does not coincide with a groundwater divide. There may be some groundwater flow between Carrick on Shannon GWB and the Funshinagh GWB. • The topography of the body is generally flat with some small hills and low ridges. There are low-lying areas in the south of the body, along the west shore of Lough Ree, in the vicinity of the River Hind and along the north eastern limb of the body. Elevations are higher just west of the centre of the body, in the extreme northwest and along a low ridge to the east of Lough Funshinagh. • The GWB is composed primarily of high transmissivity karstified limestone. Groundwater flows through a network of solutionally enlarged fissures and conduits. Karst features such as dolines, swallow holes and turloughs occur within the body. Small areas of pure unbedded limestones are incorporated with this GWB, but these are isolated and are not considered to significantly alter the flow system. • Groundwater flows along interconnected fractures, joints, faults and bedding planes, many of which have been enlarged by solution. Much of the groundwater flow is concentrated in conduits. Rapid groundwater flow velocities have been recorded through groundwater tracing. • Recharge to this GWB is both point, though swallow holes and collapse features, and diffuse via rainfall percolating through the subsoil. The lack of surface drainage in several parts of this GWB indicates that potential recharge readily percolates into the groundwater system. Groundwater in this body generally shows a rapid response to recharge. • The groundwater in this body is generally unconfined. Most of the groundwater flow will be concentrated in the upper epikarstic layer and in a zone of interconnected fissures, enlarged by karstification, generally extending to a depth of 30 m. Deep water strikes in more isolated faults/fractures can be encountered. • In general in karstic aquifers, the degree of interconnection between fractures zones is high and they support regional scale flow systems. Flow paths can potentially be several kilometres in length. • 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. • Groundwater discharges to the streams and rivers crossing the body and to large high yielding springs, some of which are used for water supply. • There is a high degree of interaction between surface water and groundwater in this GWB. Groundwater supports turloughs, sensitive terrestrial ecosystems, which are highly dependant on groundwater. • Overlying gravels provide a permeable pathway for recharge to the karstic aquifer and where saturated may provide an element of storage for the underlying bedrock.
Attachments	Groundwater hydrographs (Figure 1); Hydrochemical Signature (Figure 2)
Instrumentation	Stream gauges: 26016, 26041, 26047, 26051, 26110, 26147, 26150, 26154, 26156, 26157, 26158, 26204, 26210, 26211, 26235, 26236, 26243, 26244, 26245, 26312. EPA Water Level Monitoring boreholes: Ballymartin (ROS 080). EPA Representative Monitoring points: Keadew WS (ROS 27), Knockcroghery RWS (ROS 29), Lecarrow (ROS 30), Termonbarry WS (ROS 44), Whitehall WS (ROS 45).
Information Sources	Drew, D. and Burke, M. (1996) The Disappearance of Lough Funshinagh. Groundwater Newsletter No. 30, November 1996. Lee, M. and Kelly, C. (2003) Roscommon Central Regional Water Supply Scheme (Ballinagard Spring and Proposed Production Boreholes) Groundwater Source Protection Zones. Geological Survey of Ireland Report to Roscommon Co. Co., 14 pp. Lee, M. & Daly D. (2003) *County Roscommon Groundwater Protection Scheme*. Main Report. Roscommon County Council & Geological Survey of Ireland, 54pp. Drew D.P. and Daly D. (1993) *Groundwater and Karstification in Mid-Galway, South Mayo and North Clare.* A Joint Report: Department of Geography, Trinity College Dublin and Groundwater Section, Geological Survey of Ireland. Geological Survey of Ireland Report Series 93/3 (Groundwater), 86 pp Doak, M. (1995) *The Vulnerability to Pollution and Hydrochemical Variation of Eleven Springs (Catchments) in the Karst Lowlands of the West of Ireland*. Unpublished M.Sc. thesis, Sligo Regional McGrath R. (2001). *Microgravity on Roscommon Karst*. Unpublished GSI Report. 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) Gately, S., Sommervill, I., Morris, J.H., Sleeman, A.G. and Emo, G., 2003. *Geology of Galway-Offaly. 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.* With contributions from W. Cox (Minerals), T.Hunter-Williams (Groundwater) and R. van den Berg and E. Sweeney (Carboniferous Volcanics), edited by A.G. Sleeman. (Publication Pending) K.T. Cullen & Co., 1999. *Report on the Drilling and Testing of Two Trial Wells at Ballinlough, Co. Roscommon.* Report for Roscommon County Council. Jennings O' Donovan & Partners, 1996. *Environmental Impact Statement. Roscommon Central Regional Water Supply Scheme*. A report prepared for the Department of Environment.

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: Groundwater hydrographs (EPA Groundwater Level Monitoring)

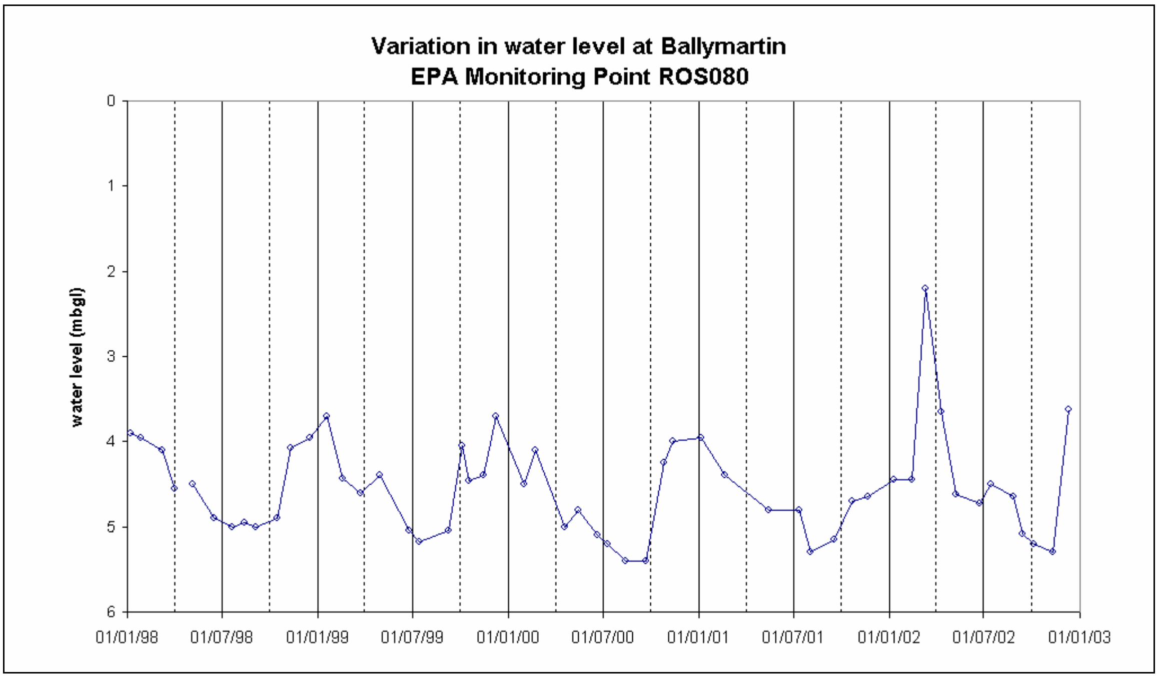
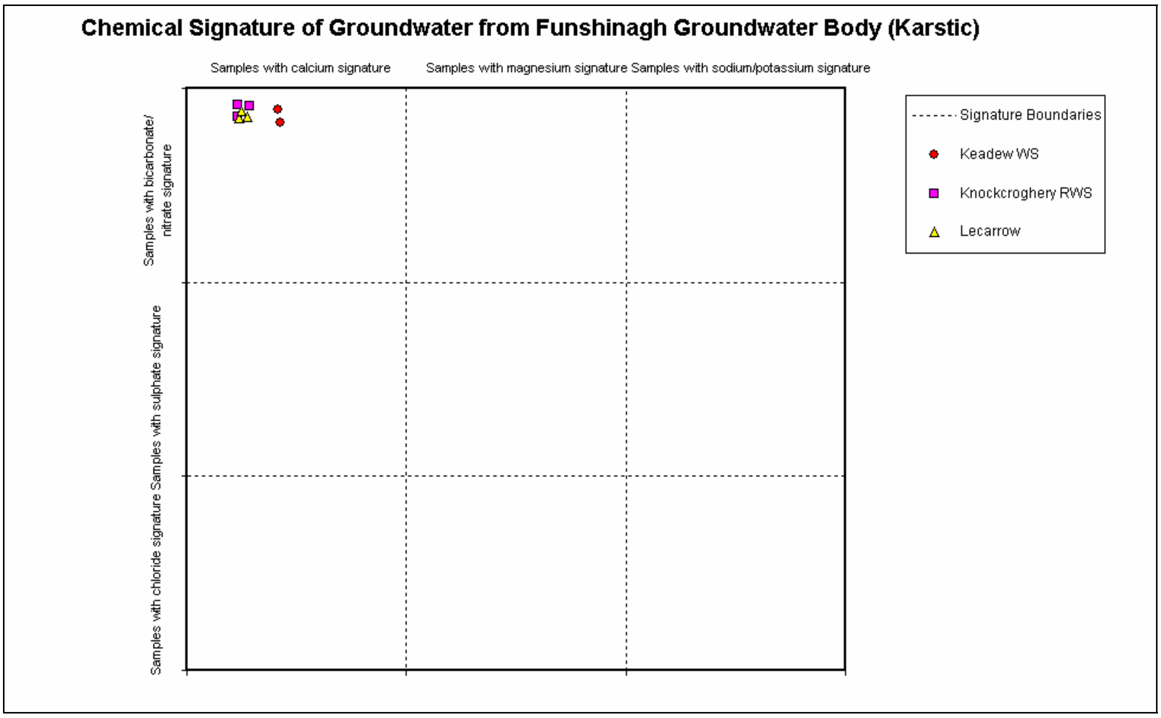
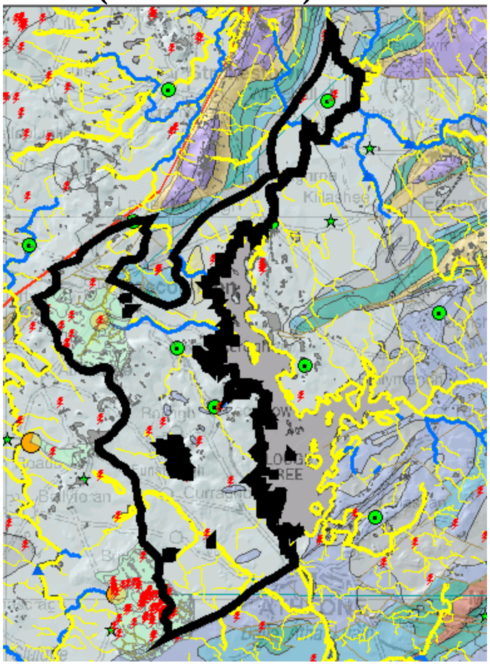


Figure 2: Hydrochemical signature



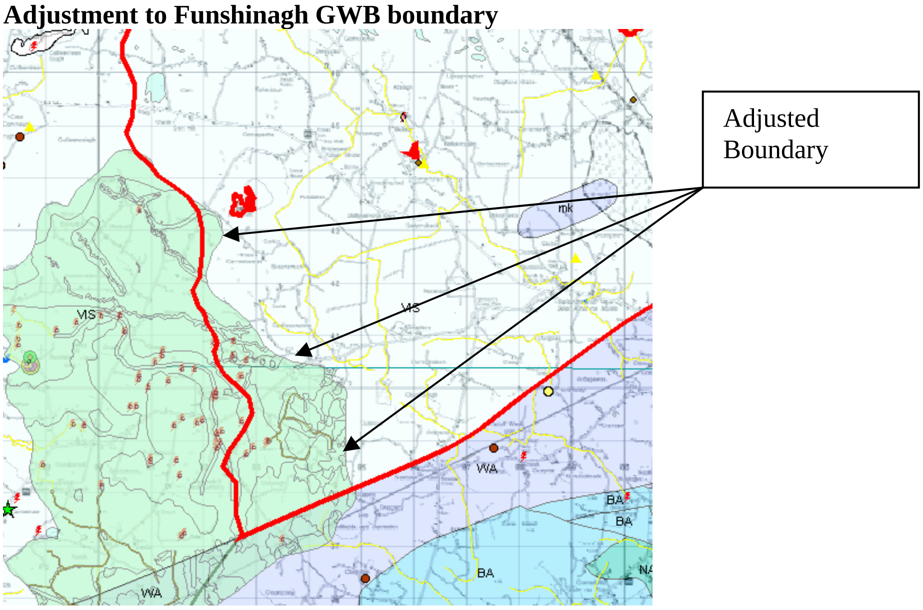
GWB (For Reference)



List of Rock units in Funshinagh GWB

Rock unit name and code	Description	Rock unit group
Visean Limestones (undifferentiated) (VIS)	Undifferentiated limestone	Dinantian Pure Bedded Limestones
Visean Limestones (undiff) & Dolomitised limestone (doVIS)	Undifferentiated limestone	Dinantian Dolomitised Limestones
Mudbank Limestones (mk)	Massive grey micritic limestone	Dinantian Pure Unbedded Limestones

Adjustment to Funshinagh GWB boundary



THE DISAPPEARANCE OF LOUGH FUNSHINAGH, CO. ROSCOMMON, SEPTEMBER 1996. Drew & Burke

Lough Funshinagh is located to the west of Lough Ree, some 11km north-west of Athlone. The lake when full, is some 2.5km^2 in area with a maximum length (north-south) of some 3.2km. Normal water level is 70m O.D.

Lough Funshinagh is an intermittent turlough, the lake becoming nearly dry every three or four years. At longer intervals the lake dries completely with the exception of a few pools, the last expanse of water commonly disappearing within a short time period. J.C. Coleman (1965) remarks:

" In November 1955, the tenth time in the last fifty years, the waters of the lake vanished down a swallow hole, leaving hundreds of fish stranded on its muddy bottom. In July 1964 I visited the site and grass was growing over most of the lake bed. Like Lough Nasool in south Co. Sligo it appears that collapse of the plugged material in swallow holes causes these sudden disappearances"

In 1984 the lake vanished for six months and in late August of 1996 the lake again completely emptied, refilling only with the heavy rains of mid and late October.

The opportunity was taken to visit the site and the surrounding area on several occasions between early September and early November 1996 and the report that follows is based on these visits and conversation with local Wildlife Rangers.

The lake is flat floored and shallow (2m maximum depth) and is filled by two small streams, little more than drainage ditches, entering from the north-west. The lake has no surface outflow, the only outlet being a sinkhole, considerably enlarged by man, in the extreme southeastern corner. During the early part of the summer of 1996 water levels remained high in the lake but levels began to drop rapidly after August 19th and by September 1st only a small body of water some 30cm deep remained in the southern part of the lake, the water draining into the sinkhole. A few days later the only water remaining in the lake was in isolated pools, some of them old peat cuttings, into which those fish that were rescued in time were placed. The large numbers of fish that were left stranded on the dry lake bed emphasises the relative infrequency of the complete loss of water compared with the annual drying out of normal turloughs.

Locally it is considered that the turlough drains to Lough Ree to the east and Coleman (1965) also states that this is the case. However, Lough Funshinagh is separated from Lough Ree by a limestone ridge with an elevation some 70m higher than the lake and it seems improbable that a direct underground flow route through the ridge exists given the generally shallow nature of karstic groundwater flow in the western lowlands. To the south of the lake is an extensive area of hummocky till, kame-like in places, drained by the Cross River. Although the Cross River rises to the west of Lough Funshinagh, at the watershed with the River Suck drainage a series of strong springs augment flow in the Cross River near Milltown Pass some 5km south of Lake Funshinagh. A water tracing experiment using optical brightener proved a connection between the sink at Lough Funshinagh and the spring at Atteagh Corn Mill (Td Mullagh). The spring had a discharge of c. 10 litres/sec when the test was undertaken. All other sites monitored in the Milltown Pass area gave negative results. The height difference between the input and output sites is 15m (compared with 25m between Lough Funshinagh and Lough Ree) and the tracer reached the spring within 72 hours, a minimum flow rate of 70m/hour.

The emptying of Lough Funshinagh does not seem to have been as dramatic as indicated in the media, though the disappearance of the last extensive sheet of water was very rapid. The reason for the complete drying out is far from clear, but the regularity of the five to ten year recurrence interval is remarkable. It does not seem as though a plug hole in the sink ruptured as Coleman (op cit.) suggests happens; neither was the late summer especially dry. However, further west in north-east and south Galway water levels in several lakes-cum-turloughs were reported to have fallen to the lowest levels on record during the late summer - significantly lower than those achieved in the preceding exceptionally dry summer of 1995.

Reference: Coleman, J.C. 1965 The Caves of Ireland p. 68, Anvil books, Tral

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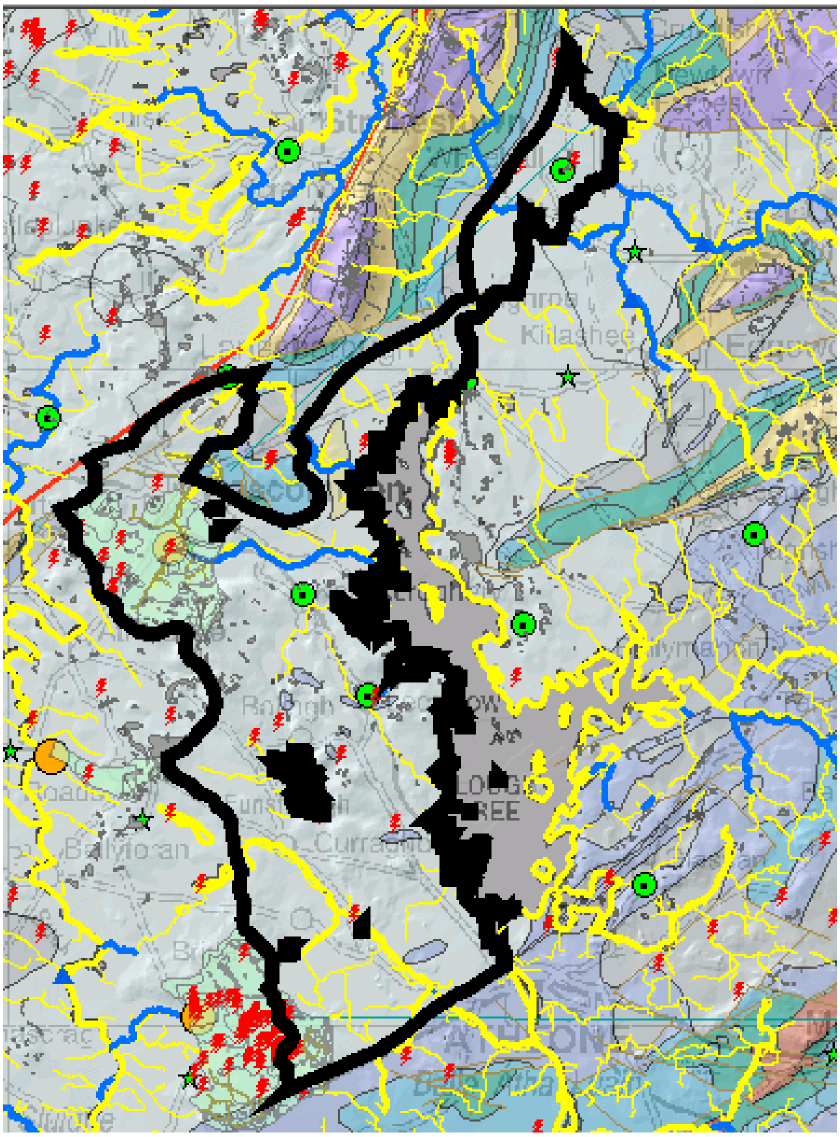

Adjustment to Funshinagh GWB boundary