Fanad Gravel GWB: Summary of Initial Characterisation.

Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
38 Donegal Co. Co.	**Lakes**: Kinny Lough, Magheradrumman Lough **Rivers**: four unnamed streams, two of which drain loughs	Ballyhoorisky Point to Fanad Head (IE001975)	2.5

Topography	The sand/gravel GWB is situated on the coast and is elongated SW-NE. It is about 4 km long and 1 km wide at its widest point. The location and boundaries of the GWB are shown in Figure 1. Along the centre of the GWB, there is a SW-NE line of undulating, grassed sand dunes (up to 27 mAOD). The dunes are adjacent to a sand beach. South of the dunes, the area is flat and approximately 10 mAOD. South of the southern GWB boundary, the continuing flat area is characterised by lakes (Loughs Shannagh, Magheradrumman, Kinny, Eelburn and Kindrum) which are situated in a northeast-southwest trending band, parallel to the coastline. Moving inland from the lakes, the landscape becomes rocky as it rises up sharply to form Murren Hill, at a maximum of 227 mAOD. Drainage is good, with four streams flowing north or northwest to the sea.	
Geology and Aquifers	**Aquifer categories**	The deposits are classified as **Locally Important Sand and Gravel Aquifers (Lg)** (DELG/EPA/GSI (1999). They overlie a bedrock aquifer that is Generally Unproductive except for Local Zones (Pl).
	Main aquifer lithologies	Teagasc classify the deposits as Windblown sand (Ws) and Granite Till (TGr) (Meehan, 2004). Broadly speaking, the aquifer comprises 4-5 m of sand over 8-9 m of gravel. The public supply borehole in this aquifer encountered 4-5 m of sand overlying roughly 8-9 m of coarse gravel, which is underlain by some 3 m of 'boulder clay' (till). Bedrock was not encountered (Tri-na-Lough (Fanad) WS Source Report). A borehole log for the Fanad Sea Fisheries Limited well (KTC, 1983) records, from the ground surface, 1.8 m of dune sand, roughly 2 m of peat, 4 m of gravel, 1.6 m of shale/gravel, and 1.2 m of gravel with bedrock encountered at around 11 m below ground level. This latter borehole is located about 1.75 km to the northeast of the Tri-a-Lough borehole which suggests that the flat areas of sand underlain by gravel is fairly extensive. The sand/gravel aquifer is smaller than the 4 km^2 required for reporting under the WFD. However, it constitutes a locally important public supply.
	Key structures	N/A.
	Key properties	Transmissivity, estimated from the public supply well using the Logan Method, is in the region of at least 400 m^2/d. Estimated bulk permeability is about 30 m/d. A typical effective porosity for permeable sand and gravel aquifers is 0.20 (20%) (Tri-na-Lough (Fanad) WS Source Report). Groundwater is unconfined. The data are inadequate to calculate groundwater gradients. In the vicinity of the public supply well, the gradient is 0.0058. Along the northern and southern margins of the GWB, groundwater levels are generally within 1.5 m of the ground surface. Along the middle of the GWB, below the higher dunes, the groundwater will be further below the surface.
	Thickness	In broad terms, the aquifer comprises 4-5 m of sand over 8-9 m of gravel.
Overlying Strata	**Lithologies**	N/A.
	Thickness	N/A.
	% area aquifer near surface	*[Information to be added]*
	Vulnerability	The measured water levels in the boreholes (Tri-a-Lough production and trial wells and Fanad Sea Fisheries borehole) indicate that, in the lower-lying flat areas, the unsaturated zone sand and gravel is less than 1.5 m thick. Consequently, the vulnerability of the groundwater in the flat area in the south of the GWB is categorised as 'Extreme'. Sand dunes are located to the north of the boreholes, which provide a greater thickness of unsaturated overlying materials. This increase in the protective capacity of the unsaturated material reduces the vulnerability category to 'High'. The vulnerability of the area to the north of the dunes that is 10 mAOD or lower is classified as 'Extreme'. *[Further Information to be added at a later date – e.g. percentages]*
Recharge	**Main recharge mechanisms**	Good drainage indicates that diffuse recharge occurs via rainfall percolating through the unsaturated sand/gravel. Due to the high permeability of sand/gravel, a high proportion of the available recharge will percolate down to the water table. Recharge may also come from Loughs Kinny and Magheradrumman and, in some areas, from the streams that cross the GWB. Small amounts may come from beneath the lakes and from the bedrock aquifer below ()
	Est. recharge rates	630 mm/yr (Tri-na-Lough (Fanad) WS Source Report).
Discharge	**Large springs and large known abstractions (m^3/d)**	The Tri-a-Lough borehole abstracts an average of 400 m^3/d. The Fanad Sea Fisheries borehole pumps 900 m^3/d.
	Main discharge mechanisms	Depending on relative water levels in the groundwater and surface water features, groundwater discharges to some of the streams that flow across the deposits.

	Hydrochemical Signature	Groundwater is moderately hard, with total hardness ranging from 180-300 mg/l. The hydrochemical signature is calcium bicarbonate. Chloride levels since September 2000 (seven samples) range from 85-145 mg/l. These are above the guideline threshold of 30 mg/l;. This parameter is often used as an indicator of the presence of organic waste and these results would confirm the inferences made from the elevated ammonia concentrations. However, elevated chloride levels may also be due to the influence of seawater; Ballyhiernan Bay is located less than 700 m away. Alkalinity averages 280 mg/l $CaCO_3$ (n=3), ranging from 264-298 mg/l $CaCO_3$. Conductivity averages 863 µS/cm (n=3), ranging from 765-1017 µS/cm.
Groundwater Flow Paths		At a regional scale in the area to the north of Murren Hill, surface water flow is generally northwards to Ballyhiernan Bay. It is assumed that generally, the surface and groundwater flow directions coincide. Flow in the vicinity of the borehole will be influenced by pumping. In a high permeability sand and gravel aquifer in a flat topographic setting, flows will be drawn from some distance in all directions. The length of flow paths depend on the size of the sand/gravel deposit. In general, locally important sand/gravel aquifers are expected to have relatively short flow paths, i.e., up to several hundreds of metres and regionally important sand/gravel aquifers are likely to have longer flow paths, perhaps up to several kilometres. Generally the drainage density is low over sand/gravel areas.
Groundwater & Surface water interactions		Low-lying wet areas occur where the sandy soils have eroded down to below the water table. These marshy areas are characterised by Bog Pimpernel (*Anagallis tenella*), Water Mint (*Mentha aquatica*) and Ragged-Robin (*Lychnis flos-cuculi*). Much of the machair is in a degraded state due to overgrazing and amenity pressure. Significant flow and recharge from Lough Kinny and other lakes is unlikely given that lower permeability deposits are mapped underneath the lake. This is supported by the fact that the lakes are at least 10 m above sea level but the coastline is only 850 m away. The steep gradient between the two infers minimal hydraulic continuity between the lakes and the sea. In general groundwater from sand/gravel deposits located in river valleys discharges to the streams/rivers flowing through the valley. Hydraulic connection between the groundwater in the aquifer and the stream is expected to be high, thus water will be able move into and out of the aquifer depending on the river stage.
Conceptual model		• The GWB comprises sand/gravel deposits that are elongated along the coast and are located between Rinboy and Pullacheany Points. • The deposits are located in a relatively low-lying flat area, situated between 60-100 m OAD. The surface drainage is largely to the southwest. • The aquifers comprise glaciofluvial sand/gravel deposits and alluvial sand/gravel deposits. • Transmissivity is expected to range from 200 to 1500 m^2/d. • The sand/gravel aquifers are generally greater than 10 m thick. • Outcrop and borehole data indicate that the sand and gravel aquifer is within a bedrock trough. The permeable nature of the aquifer together with the water level data from the production and trial wells suggest that the northern lip of the bedrock trough is at a higher elevation than then outcrop recorded at the coastline i.e. possibly somewhere within the higher sand dune area. This lip provides an impediment to groundwater flowing directly to sea, thus creating a significant height difference between the groundwater in the boreholes and at sea level. • The anticipated groundwater flow direction is approximately east to west, along the long axis of the assumed bedrock trough, as indicated by the surface water flow direction through the lakes. • It is assumed that Loughs Kinny and Magheradrumman are in hydraulic continuity with the sand and gravel aquifer. Based on this assumption, water from any part of the lakes' catchment area may end up being abstracted. • Recharge to the well is expected to occur primarily via rainfall over the sand and gravel aquifer and also from Loughs Kinny and Magheradrumman. Small amounts may come from beneath the lakes and from the bedrock aquifer below. Over the area of aquifer, the vegetation and lack of artificial drainage infer that the soil and subsoil is free draining and thus diffuse recharge is occurring. The amount of effective rainfall recharging the sand and gravel aquifer is likely to be in the order of 630 mm/yr. • Given the thin overlying, free-draining subsoil in the vicinity of the borehole, the aquifer is considered to be unconfined. Furthermore, the shallow water-table around the borehole results in a groundwater vulnerability classification of 'extreme'. Where the overlying unsaturated sand is thicker, the vulnerability is reduced to a 'high' category. • • • The data are inadequate to calculate groundwater gradients, but these are expected to be generally greater than 0.001. • Diffuse recharge occurs via rainfall percolating through the unsaturated sand/gravel. • Groundwater discharges to small and large springs, rivers/streams that flow through the deposits. • The groundwater has a calcium bicarbonate signature. • The length of the flow paths is variable – depending on the extent of the sand/gravel aquifers; ranging from several hundred metres to over 1 km.

Comment [V1]: I personally believe all flow in a high K deposit this close to the sea will be seawards. I think surface topo will be less influential, tho there may be a small component south westwards. Is the trough really there (elevations outcrop at sea vs base of trough) see V6. Not so much topo controlled as trough controlled!

Attachments	Figure 1.
Instrumentation	Stream gauges: none EPA Water Level Monitoring boreholes: none EPA Representative Monitoring points: DON26 (this may be lake water or combined lake and groundwater).
Information Sources	DELG/EPA/GSI (1999) *Groundwater Protection Schemes.* Department of the Environment and Local Government, Environmental Protection Agency and Geological Survey of Ireland. Kevin T. Cullen & Co. Ltd., May 1998. Groundwater Resources of the Fanad Peninsula. Lee, M. and Fitzsimons, V. (2004) *County Donegal Groundwater Protection Scheme*. Volume 1 Main Report, Draft, July 2004. 58 pp. Geological Survey of Ireland. Lee, M. and Fitzsimons, V. (2004) *Tri-na-Lough (Fanad) WS Source Report*, Draft, 17 pp. Geological Survey of Ireland. O' Riain, G., (2004). *Water Dependent Ecosystems and Subtypes Draft Report.* WFD Support Projects. Compass Informatics in association with National Wildlife and Parks Service (DEHLG). Meehan, R.T., (2004) *Subsoils Map for County Donegal*. Map produced as part of EPA Soil and Subsoil Mapping Project (formerly FIPS-IFS). Teagasc, Kinsealy.
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 Location and extent of Fanad Gravel