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Ardtully Beg Sand and Gravel Aquifer
Summary of Initial Characterisation

GW3D Project Report TR2023/41
March 2023

Geological Survey Ireland is a division of the Department of the Environment, Climate and Communications

Ardtully Beg Sand and Gravel Aquifer Description March 2023

This sand and gravel report forms part of a series representing the output of a body of work undertaken to re-evaluate previously mapped sand and gravel aquifers and to identify new sand and gravel aquifers. This study resulted in the refinement of existing sand and gravel aquifer mapped extents, the modification of some sand and gravel aquifer categories, and the removal of some previously mapped sand and gravel aquifers, as well as identification of new aquifers. In addition to mapping the extent and depths of the sand and gravel aquifers, the investigations consider the hydraulic properties.

The study, undertaken as part of the GW3D project (2015-2019), comprised three parts:

1) Desk study and fieldwork preparation

Sand and gravel bodies above a minimum size criterion were extracted from the GSI Quaternary Sediments 1:50,000 map. Where it was known that the surface expression of the sands and gravels was only a small portion of the subsurface body, such areas were retained. This process left several hundred sand and gravel bodies remaining as a starting point for field work.

2) Fieldwork including mapping and data collection

Field work included a visit to each of the areas which had the potential to be (at least) a Locally Important Sand and Gravel Aquifer owing to its area. In such areas, gravel pits and sand pits were visited and depth and type of sediment recorded, other exposures into the subsurface were visited and logged, wells (whether Public Supply, Group Scheme or private farm or domestic) were dipped and any information on depths recorded, and data was collected where geological and hydrogeological data existed for the area.

3) Data collation, analysis and reporting.

All field data, and information from earlier reports and studies, were compiled and analysed. Where a sand and gravel body had qualifying aquifer properties (either 10 m depth sand and gravel, or 5 m depth saturated sediments), these areas were digitised in a GIS. The aquifer area was then ascertained and drawn up. Such areas formed the basic building blocks for the sand and gravel aquifer map, which included details on the aquifer name, area, aquifer resource value (Rg or Lg), confidence level, county, and any important aspects to note for each body.

The updated mapped sand and gravel aquifers are found on the Geological Survey Ireland site https://www.gsi.ie/en-ie/data-and-maps/Pages/Groundwater.aspx#Aquifers

The GW3D Mapping Team involved in the current revision of delineated sand and gravel aquifers were:

Geological Survey Ireland staff:

- Dr. Sophie O'Connor, Groundwater Programme / Land Mapping Unit
- Dr. Sarah Blake, Groundwater Programme

Consultant support:

- Dr. Robbie Meehan, Talamh Ireland
- Coran Kelly, Tobin Consulting Engineers
- Damien Doherty, independent Consultant Geologist/ Tobin Consulting Engineers
- Natalie Duncan, independent Consultant Geologist
- Sara Raymond, independent Consultant Geologist
- James McAteer, Gavin and Doherty Geosolutions

Ardtully Beg Sand and Gravel Aquifer Description March 2023

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Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
06 - Newry, Fane, Glyde and Dee Louth County Council	**Rivers:** None **Streams:** Several unnamed, minor streams **Lakes:** Several unnamed lakes and ponds	None	0.5 km^2

Topography		This hummocky sand and gravel body centred on Ardtully Beg townland is situated within the broad, coastal lowland area at the base of the southern slopes of the Cooley Mountains. The sand and gravel body rests at elevations between 25 m and 40 m AOD, and represents ice marginal meltwater deposits. The sands and gravels are surrounded by till deposits, some of which may also interfinger with the sands and gravels themselves. Among the hummocks, many of the hollows have surface water ponds at their bases.
Geology and Aquifers	**Aquifer categories**	The Ardtullybeg sand and gravel deposit was highlighted by Robinson (1973) as an investigation area with potential for Public Water Supply. Since, this deposit has been confirmed as greater than 10 m in thickness and have a saturated thickness greater than 5 m. Although the 1 km^2 areal criterion of an aquifer is not met, the deposit body has demonstrated its ability to provide 'Excellent' yields, and therefore is considered to be a **Locally Important Sand and Gravel Aquifer (Lg)** (DELG/EPA/GSI, 1999; GSI, 2017).
	Main aquifer lithologies	The main component of the area of this aquifer is glaciofluvial sands and gravels derived chiefly from Lower Palaeozoic sandstones and shales (GSI, 2023a).
	Key structures	There is a large degree of variability in the sediments recorded from a number of borehole logs at Ardtully Beg. In general, the deposit is proven as well bedded and stratified from these logs and the permeability of these layers varies considerably depending on clast and grain size. The presence of less permeable layers in the deposit, even if thin, can cause the formation of perched water tables locally. The sand and gravel aquifer at Ardtully Beg overlies limestone bedrock, which has been classified as Locally Important Bedrock Aquifer which is Generally Moderately Productive (**Lm**). The granites that form the mountains to the north are classified as a Poor Bedrock Aquifer which is Generally Unproductive except for Local Zones (**Pl**). The gravel deposit is in direct contact with bedrock intermittently as the till deposits beneath the gravel are discontinuous (Cullen and O'Dwyer, 1983).
	Key properties	The composition of the deposit varies from beds of gravelly COBBLES to SAND. The groundwater is considered to be generally unconfined, and in hydraulic continuity with the underlying limestone bedrock (An Forás Forbartha and GSI, 1982); however, where clay layers are present within and above the sand and gravel deposit, the aquifer may be locally confined. Ó'Suilleabhain (2000) found that sands and gravels with a fines content of less than approximately 8% are generally considered to have sufficient permeability for aquifer development. Grain size data are available for samples taken from Ardtullybeg PW 1 by Cullen and O'Dwyer (1983). The particle size distribution curves show that fines make up less than 5% of the material. The slope of water table is expected to be relatively subdued due to the permeable nature of the aquifer. An Forás Forbartha and GSI (1982) estimated groundwater storage in the aquifer body to be 7.5 x 10^5 m^3. This estimate is based on an average thickness of the aquifer (15 m) and an area (0.5 km^2), with an estimated specific yield (0.1). This is considered to be conservative, and somewhat of an underestimation, due to the uncertainty in the subsurface extent of the sand and gravel deposit. The productivity of the abstraction boreholes within the sand and gravel which are recorded as having 'Excellent' yields suggest that the deposit may extend under the surrounding till, as a larger area than mapped is needed to generate the high yields. Cullen and O'Dwyer (1983) completed a 2 day pumping test on the Ardtullybeg PWS and calculated the transmissivity of the aquifer to be in the region of 1,215-1,443 m^2/day. The permeability is estimated to be in the range of 100 m/day. Both boreholes were demonstrated 'Excellent' yields, and sustainable yields were calculated as 818 m^3/day and 1,363 m^3/day.

	Thickness	The deepest recorded thickness of sand and gravel within the area of the deposit is 29 m, and the average saturated thickness is approximately 15 m (Collins, 2009).
Overlying Strata	**Lithologies**	Fen Peat and pockets of lacustrine clay overlie a number of restricted localities within the area of the sands and gravels, within the hollows between the hummocks.
	Thickness	Where fen peat and lacustrine clays occur they are estimated to be less than 3 m thick.
	% area aquifer near surface	Approximately 90% of the sand and gravel aquifer body is at the surface.
	Vulnerability	Most of the aquifer is at the surface and therefore vulnerable; consequently pollutants can easily infiltrate the aquifer. Sand and gravel aquifers are categorised as having either 'High or 'Extreme' vulnerability (DELG/EPA/GSI, 1999), with the vulnerability classification determined by the depth to the water table from ground level. Measured water levels range from 3.5 m to 13.5 m below ground level; in terms of elevation this range falls between 23 m and 28 m AOD. The influence of pumping decreases the water levels in the vicinity of the PWS from 18.5 m to 19.2 m AOD (Collins, 2009). The seasonal variation in water levels in the Ardtully Beg Public Supply boreholes may be up to 2 m annually (Collins, 2009). Sufficient data are not available to determine whether seasonal water level variations affect the vulnerability classification of areas within the aquifer. In areas where the water table is less than 3 m below ground level the aquifer vulnerability is mapped as 'Extreme'; this accounts for just over 10% of the aquifer area. Where the water table is greater than 3 m below ground level the aquifer vulnerability is mapped as 'High'.
Recharge	**Main recharge mechanisms**	The aquifer receives both direct and indirect recharge. Diffuse recharge occurs by the infiltration of rainfall through the unsaturated sands and gravels. The proportion of the effective rainfall that recharges the aquifer is largely determined by the thickness and permeability of the soil and subsoil, and by the slope (DELG/EPA/GSI, 1999). Typically the proportion of recharge that infiltrates to ground water in sand and gravel is around 85% (Hunter Williams *et al.*, 2011). The presence of less permeable layers in the deposit, even if thin, can create perched water tables and prevent recharge to the true water table. Rejected recharge from the surrounding granite hills increases the amount of available recharge to the aquifer at Ardtully Beg. The aquifer is interpreted as being in hydraulic connectivity with the limestone below it also, based on the groundwater chemistry (Collins, 2009). The hardness of the groundwater suggests that the impure limestone aquifer below may be contributing rejected recharge to the gravel aquifer.
	Est. recharge rates	The rainfall in the area of the Ardtully Beg sands and gravels is 855 mm (Walsh, 2012), and the estimated recharge rate to the aquifer from direct recharge is approximately 560 mm/yr. The minimum direct groundwater throughput in the aquifer is only estimated to be 514 m^3/d, and with rejected recharge this increases to 754 m^3/d; the aquifer has, however, been proven to be able to provide yields of over 2,100 m^3/d.
Discharge	**Large springs and large known abstractions (m^3/d)**	Ardtullybeg Public Water Supply, comprising two boreholes, is located within and abstracts groundwater from this deposit. These have sustainable yields of 818 m^3/day and 1,363 m^3/day and (Cullen and O'Dwyer, 1983).
	Main discharge mechanisms	The main discharge mechanisms are discharge to ponds in the sand and gravel body, and discharge *via* springs.
	Hydrochemical Signature	Daly (1980) recorded that the groundwater at Ardtully Beg has a calcium bicarbonate signature (Figure 1). Louth County Council and EPA monthly water quality monitoring results (1993-2006) were examined by Collins (2009), and it was found that the groundwater is very hard. Chloride can exceed EPA threshold values; this is thought to be due to proximity to the coast. Nitrate and potassium are elevated but do not exceed the drinking water standards.

Ardtully Beg Sand and Gravel Aquifer Description March 2023

Groundwater Flow Paths	The principal groundwater flow direction is north to south. Flow paths are considered to be short due owing to the restricted area of the aquifer. There are not enough hydrogeological data to calculate precise groundwater gradients, but low gradients are expected as these are typical of sands and gravels. The available data suggest that the natural groundwater gradient is in the order of 0.005. The increased drawdown at the public supply will increase the gradient in the vicinity of the boreholes.
Groundwater & Surface water interactions	Hydraulic connection between the groundwater and surface water is expected to be high particularly in the southwestern area of the body. The ponds and marshy land in this area are thought to be fed by groundwater based on their elevation and the natural groundwater levels elsewhere in the locality. Springs at the south are also thought to be generated by groundwater flow from this aquifer body.
Conceptual model	• The Ardtullybeg sand and gravel aquifer is a hummocky, ice marginal sand and gravel deposit. • The surface extent of the sand and gravel deposit is 0.5 km^2 as mapped by GSI (GSI, 2023a), but this map reflects only the top metre of subsoil and there may be sand and gravel at depth around the fringes of the delineated extents. The productivity of the public water supply at Ardtully Beg does suggest that the area of the sand and gravel deposit is much larger at depth. The sediment stratigraphy observed in borehole logs, as well as in sand and gravel pits in surrounding areas, also support this idea. • The maximum thickness of sand and gravel recorded is in the northern portion of the deposit; 29.2m depth of sand and gravel over bedrock, with a saturated thickness of 16 m (GSI, 2023b). • The permeability and porosity of the deposit varies due to variations in clast and grain size. The sand and gravel aquifer generally has high permeability, transmissivity and effective porosity. Well yields are proven as 'Excellent' within the area of this aquifer body. • Monitored well levels showed a gradual variation in water table levels annually, with the largest being 2.17 m across annual cycle (Collins, 2009). Water levels in the aquifer are at depths generally greater than 3 m below ground level. The aquifer is therefore categorised as having 'High' vulnerability across the majority of it's extent. Where groundwater discharges at the surface in the southwest of the deposit, and the water table is much closer to the surface, the vulnerability of the aquifer is mapped as 'Extreme'. • The aquifer is recharged by the infiltration of direct rainfall. Additional recharge reaches the aquifer in the form of rejected recharge from the hills to the north, and as discharge from the underlying limestone aquifer. It is thought the limestone bedrock and overlying sand and gravel aquifers are hydraulically connected based on hydrochemical analysis (Collins, 2009). • The aquifer is generally unconfined, although borehole logs indicate clay layers overlie the sands and gravels intermittently. • Groundwater is thought to flow from north to south, following topography, and discharges largely to springs. • The minimum direct groundwater throughput in the aquifer is only estimated to be 514 m^3/d, and with rejected recharge this increases to 754 m^3/d; the aquifer has, however, been proven to be able to provide yields of over 2,100 m^3/d.
Attachments	Figure 1: Location and extent Figure 2: Cross sections Figure 3: Groundwater vulnerability Figure 4: Piper diagram Figure 5: Water level variations

Instrumentation	**Hydrometric gauges:**	None present
	National Water Monitoring Stations;	
	River:	None present
	Groundwater:	GWIE_NB_G_02421000001 (Ardtullybeg)

Ardtully Beg Sand and Gravel Aquifer Description March 2023

Information Sources	• An Foras Forbatha and Geological Survey Office (1982). Groundwater Resources in the N.E.(R.D.O). Region. March 1982. Volumes 1 to 3. • Collins, F. (2009). Establishment of Groundwater Source Protection Zones: Ardtully Beg Public Water Supply. Report for Groundwater Section, GSI, and Louth County Council, 41pp. • Cullen, K.T. and O'Dwyer, K. (1983). Report on a Water Well Drilling Project at Ardtully Beg, Co. Louth. Report for Louth County Council. • Daly, E.P. (1980). An Interim Report on the Cooley Peninsula Sand and Gravels. Unpublished report, Groundwater Section, Geological Survey of Ireland. • DELG/EPA/GSI (1999). Groundwater Protection Schemes. Department of the Environment and Local Government, Environmental Protection Agency and Geological Survey of Ireland. • EPA map viewer. https://gis.epa.ie/EPAMaps/ • GSI (2017). A description of Irish aquifer categories. 3 pp. Available from: https://www.gsi.ie/documents/GSI%20Aquifer%20Category%20Descriptions.pdf • GSI, 2023a. Geological Survey Ireland Spatial Resources Viewer. https://www.gsi.ie/en-ie/data-and-maps/Pages • GSI, 2023b. Geological Survey Ireland. Internal Groundwater Database. • Hunter Williams, N., Misstear, B., Daly, G., Johnston, P., Lee, M., Cooney, P. and Hickey, C. (2011). National Groundwater Recharge Map for Ireland. Geological Survey Ireland and Department of Civil, Structural and Environmental Engineering, Trinity College Dublin. • NPWS map viewer. http://webgis.npws.ie/npwsviewer/ • Murphy, O. (2012). County Louth Groundwater Protection Scheme. Report to Louth County Council. Geological Survey of Ireland. • Ó'Súilleabháin, C. (2000). Assessing the boundary between high and moderately permeable subsoils. Unpublished MSc., University of Dublin. Department of Civil, Structural and Environmental Engineering, Trinity College Dublin. • Piper, A.M. (1953). A Graphic Procedure in the Geochemical Interpretation of Water Analysis. Washington D.C.: United States Geological Survey. OCLC 37707555. ASIN B0007HRZ36. • Robinson, K.W. (1973). A Resistivity Survey on the Cooley Peninsula Co. Louth. Unpublished MSc. Thesis, Trinity College Dublin. • Walsh S. (2012). A Summary of Climate Averages 1981-2010 for Ireland, Climatological Note No.14, Met Éireann, Dublin. • Wright G.R., Aldwell C.R., Daly, D, and Daly, E.P. (1982). Groundwater resources in the Republic of Ireland, vol 6. In: European community's atlas of groundwater resources, SDG, Hannover, Germany
Disclaimer	Note that all calculation and interpretations presented in this report represent estimations and assumptions based on the information sources described above and established hydrogeological formulae. Figures 4, 5 and 6 are used for illustrative purposes only.

Ardtully Beg Sand and Gravel Aquifer

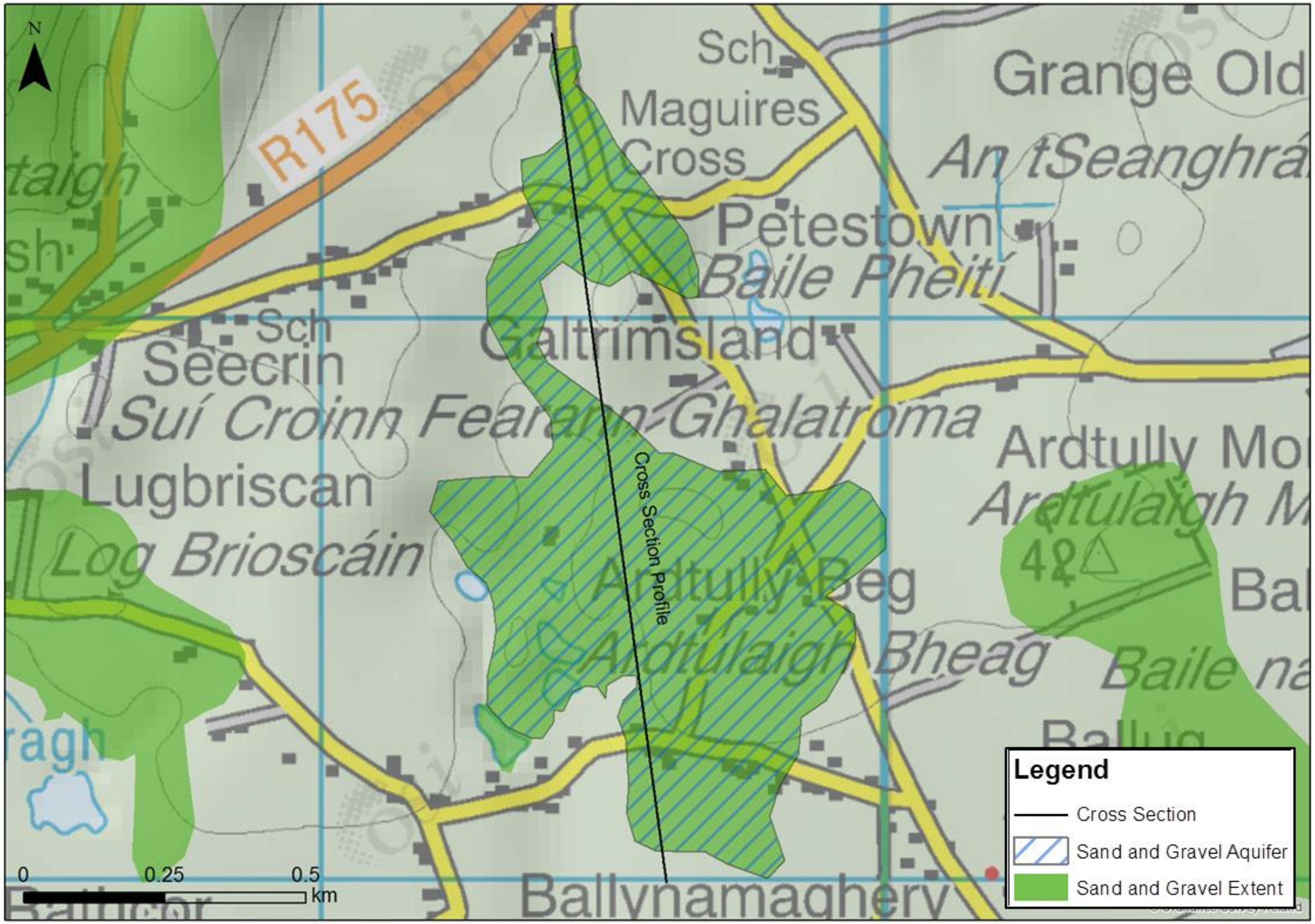
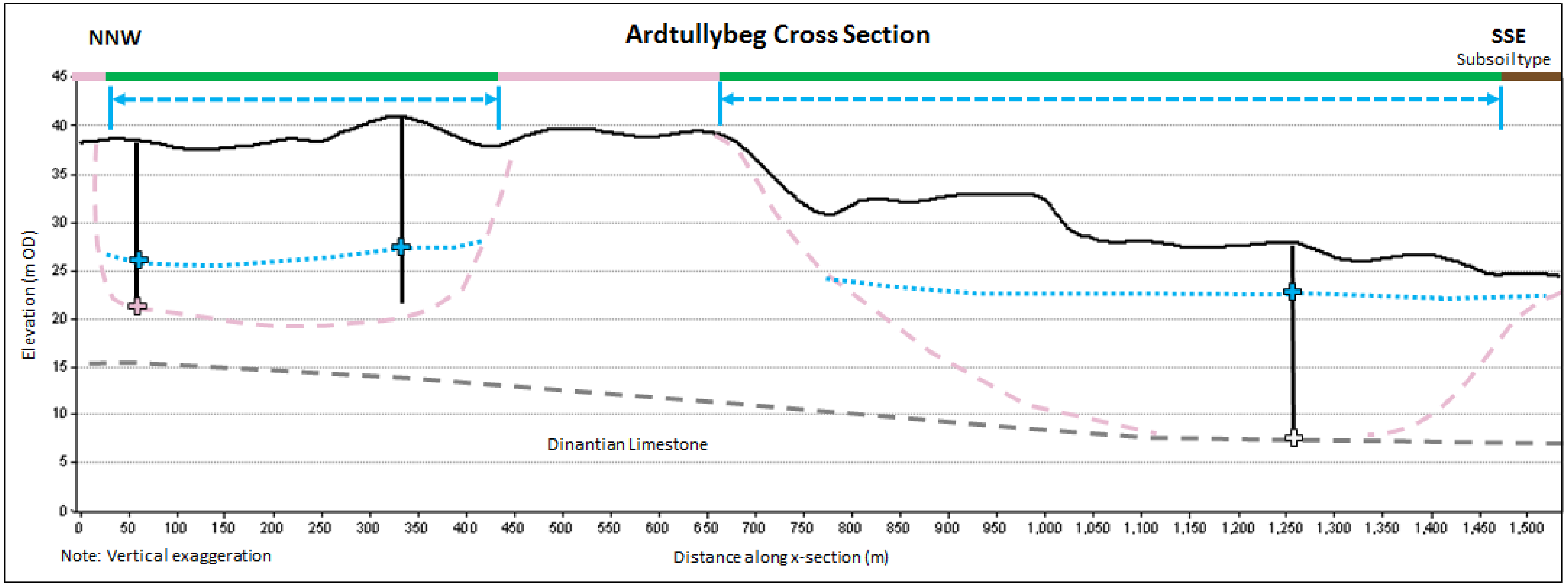


Figure 1. Ardtully Beg Sand and Gravel Aquifer extent with cross section location.



Elevation		Aquifer		Borehole/Trial Pit	
Groundwater level		Presumed Groundwater Level		Sand and gravel	
Top of till		Presumed Top of Till		Till	
Top of bedrock		Presumed Top of Bedrock		Peat	

Figure 2. Cross section through the Ardtully Beg Sand and Gravel Aquifer body.

Ardtully Beg Sand and Gravel Aquifer Vulnerability

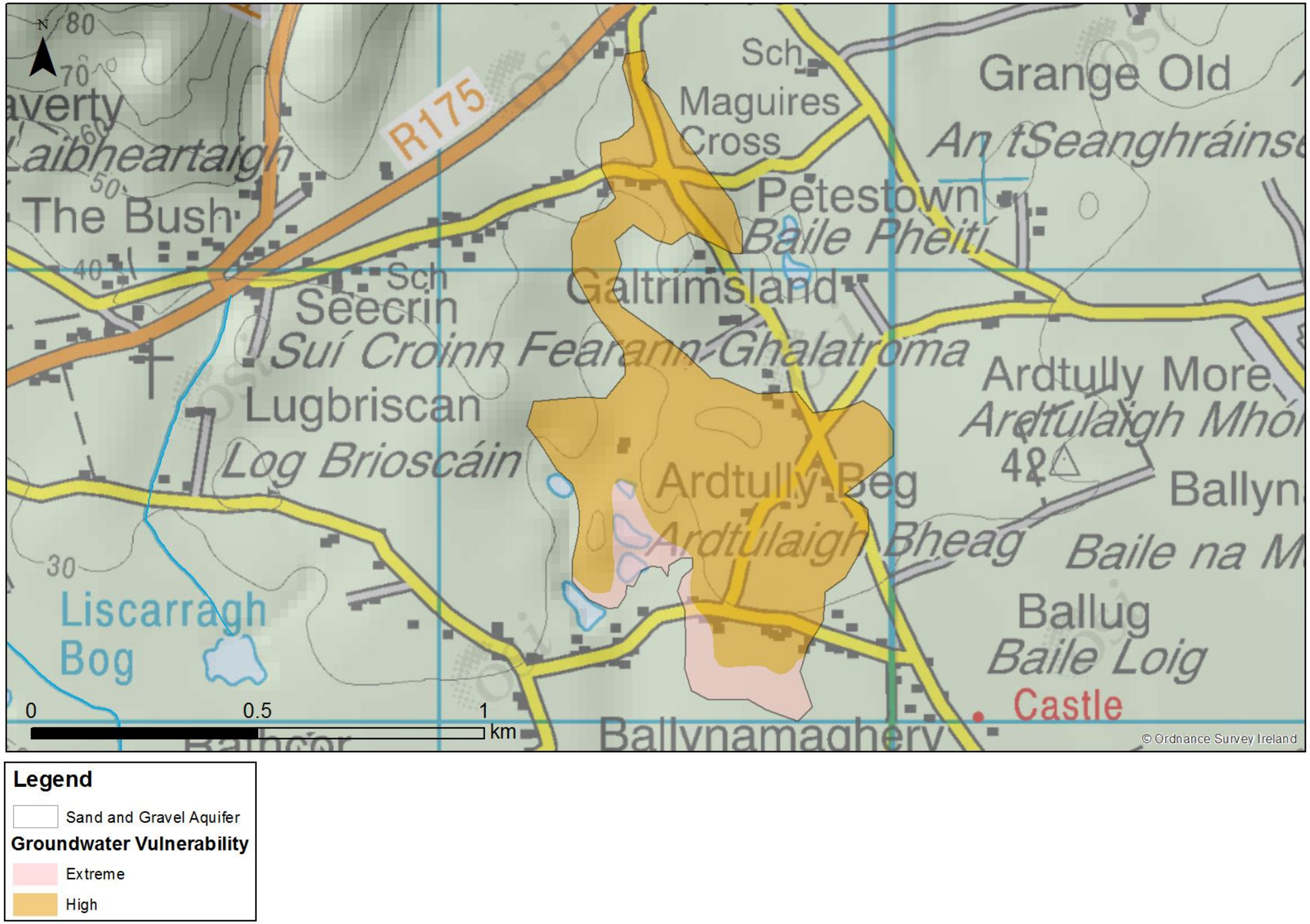


Figure 3. Groundwater vulnerability across the Ardtully Beg Sand and Gravel Aquifer.

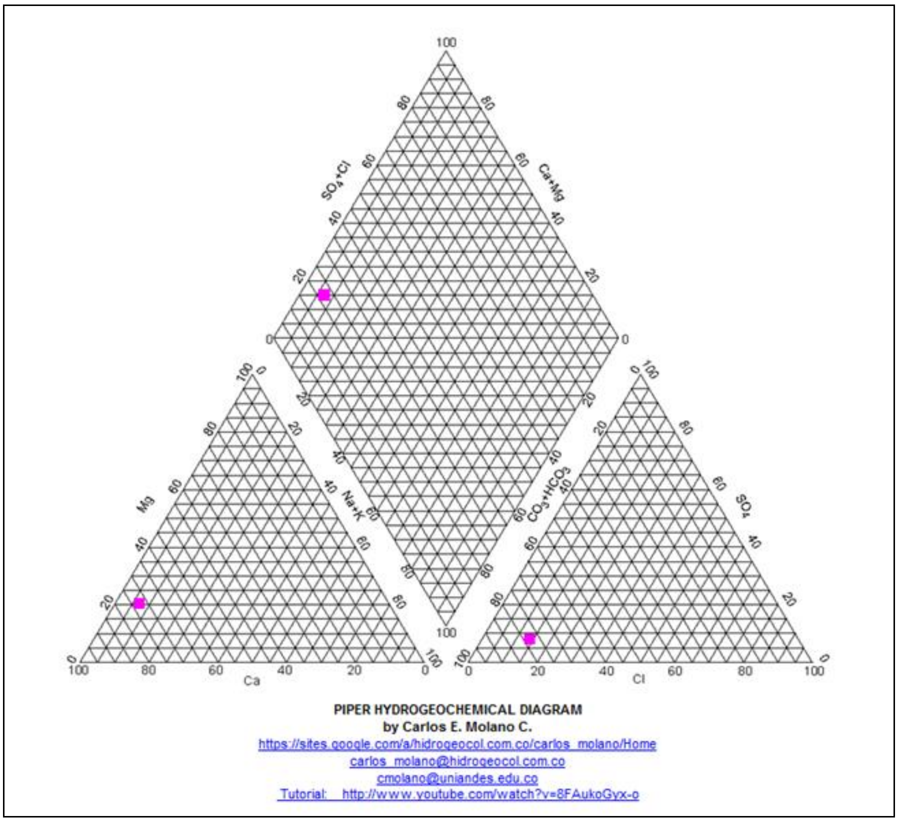


Figure 4. Piper Diagram displaying calcium bicarbonate hydrochemical signature of groundwater at Ardtully Beg (Hydrochemical analysis from Daly, 1980).

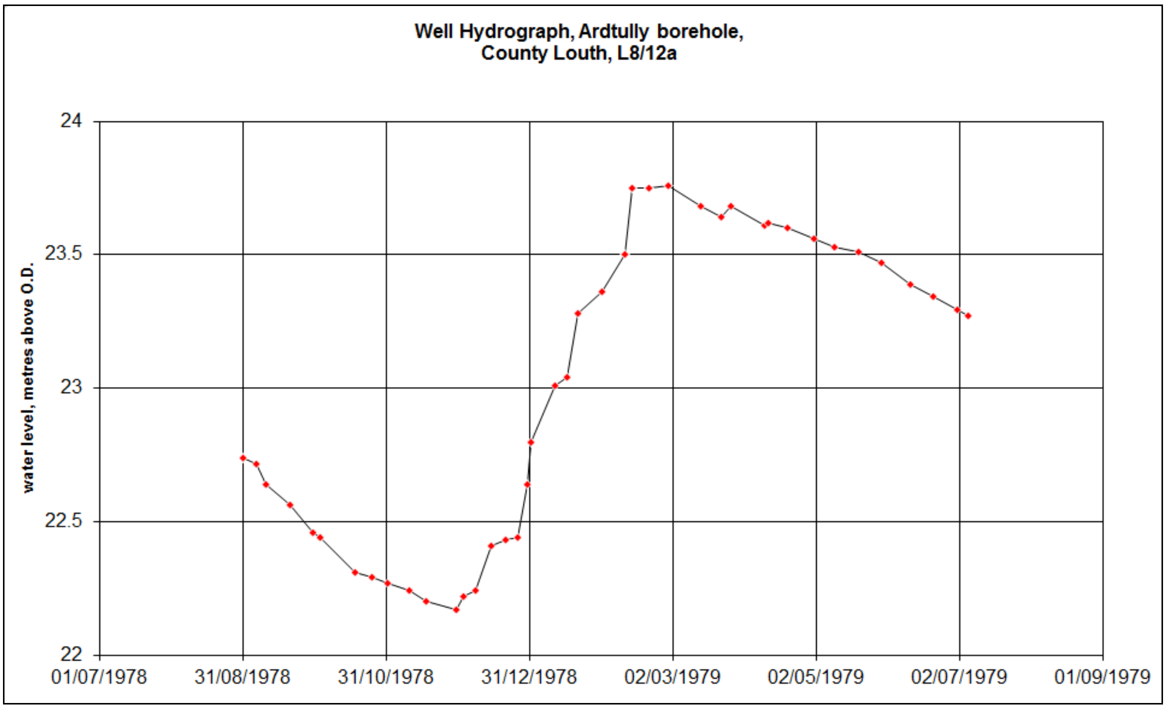


Figure 5. Annual water level variations at Ardtully Beg PWS (after Collins, 2009).