Slieve Phelim GWB: Summary of Initial Characterisation.

Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
25 - Mulkear North Tipperary, South Tipperary and Limerick Co. Co.'s	Rivers: Doonane, Newport, Small, Clodiagh, Annagh, Shannon, Bilboa, Kileengarrif, Mulkear, Gortnageragh, Glashacloonaraveela, Dead, Cahernanallia, Clare, Dooglasha, Reask, Aughvaria. Streams: Toem, Cappawhite. Loughs: Voolanaheeva, Duff, Beg.	Clare Glen (930), Derrygarreen Heath (931), Kilbeg Marsh (1848), Phillipston Marsh (1847), Ballyneill Marsh (1846), Ballydonagh Marsh (1844), Bollingbrook Hill (2124), Keeper Hill (1197), Bilboa and Gortnageragh River Valleys (1851), Ballyvorheen Bog (1849), Dromsallagh Bog (1850).	545

Topography	The GWB comprises both upland and lowland areas, ranging in elevation from 30 mAOD along the western edges to 694 mAOD at Keeper Hill, in the north of the GWB. Most of the land is above 80 mAOD. This corresponds to areas underlain by Devonian Old Red Sandstones and Silurian Strata. The flat-lying areas are underlain by impure limestones. The Silurian rocks appear to be more resistant than the younger ORS rocks; there can be a break in slope at the contact between the two, especially in the south of the GWB. The main rivers generally flow in a NE-SW direction, and cut deep valleys into the bedrock, especially in areas higher than 100 mAOD. The tributary streams flow at a high angle to the main drainage channels.	
Geology and Aquifers	Aquifer categories	**Ll**: Locally important bedrock aquifers that are productive in local zones; **Pl**: Generally unproductive bedrock except for local zones.
	Main aquifer lithologies	Silurian Metasediments and Volcanics, Devonian Old Red Sandstones, Dinantian Lower Impure Limestones, Dinantian (early) Sandstones, Shales and Limestones, Basalts & other Volcanic rocks, Granites & other Igneous Intrusive rocks.
	Key structures	The major structure comprises the faulted core of a large anticline. Faults cross-cut the fold axis; fault orientations are predominantly NE-SW, but there are also NW-SE, N-S and E-W major faults. In some cases, the faulting influences the locations of the river valleys. Compression during the folding also caused some fracturing and jointing of the rocks.
	Key properties	The only information available for the Silurian rock unit in the Slieve Felim mountains is the site investigation undertaken for a proposed landfill. In four boreholes, permeabilities in the top 30 m of rock ranged from 3.6 x 10^{-4} to 7.6 x 10^{-1} m/d. A zone of higher permeability (with measured permeabilities in a fifth borehole of 0.9 to 10 m/d), 150-200 m wide, 12-14 m deep and 2.2 km long was delineated on the site. The transmissivity estimated for this zone was 27-82 m^2/d (Deakin, Daly and Coxon, 1998). There are no data for the ORS in this area; transmissivities will be low, but better than in the Silurian rocks, especially toward the top of the ORS succession. Within the Dinantian Lower Impure Limestones, transmissivities are likely to be in the range 2-20 m^2/d, with most values at the lower end of the range. Dinantian (early) Sandstones, Shales and Limestones aquifer properties are less good than this. Within all rock units, storativities are low. Groundwater gradients in the upland areas may be steep (up to 0.15). In low-lying areas, groundwater gradients on the order of 0.02 to 0.05 may be the norm. *(data sources: Rock Unit Group Aquifer Chapters, see references; estimation from maps)*
	Thickness	The Silurian, ORS and Lower Impure Limestone aquifers are more than several hundreds of metres thick. However, the effective flowing thickness of these aquifers is usually ≤15 m, although isolated deeper inflows may occur where faults or significant fractures are intercepted by boreholes. The maximum thickness of Dinantian Sandstones, Shales and Limestones is less than 100 m. Again, groundwater flow is confined to the top 15 m.
Overlying Strata	Lithologies	*[Information to be added at a later date]*
	Thickness	3 to over 20 m. Generally about 4-10 m above 50 m elevation, and thicker lower down the slopes.
	% area aquifer near surface	*[Information to be added at a later date]*
	Vulnerability	Vulnerability ranges from Extreme to High over most of the groundwater body, with occasional small Moderate vulnerability areas around the western edge of the GWB. Extreme vulnerability areas are mainly encountered in the upland areas between river channels. Extreme vulnerability areas also occur near to the western margin of the GWB, however, in the low-lying areas underlain by impure limestones.
Recharge	Main recharge mechanisms	Diffuse recharge will occur over the entire groundwater body via rainfall soaking through the subsoil. A large percentage of rainfall will not recharge the aquifer, but will runoff to surface water channels, particularly in areas underlain by Silurian and the older ORS rocks due to the high slopes. In the low-lying areas, potential recharge may be rejected due to high water tables.
	Est. recharge rates	*[Information to be added at a later date]*

Discharge	Springs and large known abstractions (m^3/d)	Cappamore Faileen/Bilboa PS (336 m^3/d) – from overlying gravels, (682m^3/d) – from overlying gravelly till, Cappamore Glasha (227 m^3/d), Murroe WS Creamery – Donohill (up to 55 m^3/d), Creamery – Clonbrick (up to 110 m^3/d), Tipperary Co. Co. – Carnahallia (unknown), Doon GWS (unknown), Doon Carrigmore WS (110 m^3/d), Doon Lacka WS (up to 220 m^3/d), Doon Cooga WS (up to 270 m^3/d) *[Doon has combined abstraction of 509 m3/d]*, Kilcommon Creamery (8 m^3/d), Roadstone – Castleconnell (10 m^3/d), Knockfune Creamery (up to 25 m^3/d), Oola WS (336 m^3/d), Tipperary South Co. Co. – Glengar (up to 321 m^3/d), Ashroe (Murroe) GWS (up to 55 m^3/d). *[More Information to be added at a later date]*
	Main discharge mechanisms	The main discharges are to the streams crossing the sandstones, mudstones and impure limestone rock units and to the mainly upland springs.
	Hydrochemical Signature	Groundwaters from all rock unit group aquifers within this groundwater body have a calcium-bicarbonate signature. Groundwaters from the Silurian strata range from slightly hard to hard (90–360 mg/l $CaCO_3$). In association, alkalinities range from 60 to 270 mg/l (as $CaCO_3$) and electrical conductivities from 260–600 µS/cm. pHs are neutral, with lab. pHs in the range 7.12–7.33. The majority of samples in this GWB are at the upper end of the range. Only at Glengar spring, where throughput must be rapid, do groundwaters have limited dissolved solids. There are no data for the ORS aquifers in this GWB. In other areas, alkalinity ranges from approximately 14 to 200 mg/l (as $CaCO_3$) and hardness ranges from approximately 50 to 250 mg/l. Groundwater in the Old Red Sandstone rock units is considered to range from moderately soft to moderately hard water (Kelly and Wright 2000). Groundwater conductivities are relatively low ranging from approximately 150 to 450 µS/cm. A typical range for pH in groundwater from the Old Red Sandstone rock units is 6–7. In the Dinantian (early) Sandstones, Limestones and Shales and the Lower Impure Limestones, groundwaters are Hard to Very Hard (typically ranging between 380–450 mg/l), and high electrical conductivities (650–800 µS/cm) are often observed. Alkalinity is also high, but less than hardness (250-370 mg/l as $CaCO_3$). High iron (Fe) and manganese (Mn) concentrations can occur in groundwater derived from ORS, due to the dissolution of Fe and Mn from the sandstone/shale where reducing conditions occur. It has been demonstrated that at low pumping rates water does not reside long enough in the well for oxidation to occur, thereby resulting in elevated Fe and Mn in small domestic supplies (Applin *et al*, 1989). Within the Impure Limestones, iron and manganese concentrations frequently fluctuate between zero and more than the EU Drinking Water Directive maximum admissible concentrations (MACs). Hydrogen sulphide can often reach unacceptable levels (E.P. Daly, 1982). These components come from the muddy parts of these rock units and reflect both the characteristics of the rock-forming materials and the relatively slow speed of groundwater movement through the fractures in the rock allowing low dissolved oxygen conditions to develop. The bedrock strata of the Old Red Sandstone and Silurian aquifers are **siliceous**. The Dinantian (early) Sandstone, Limestone and Shale and Lower Impure Limestone rock units are **calcareous**.
Groundwater Flow Paths		These rocks are devoid of intergranular permeability; groundwater flow occurs in fractures and faults. The rocks are dependent on fracturing and fissuring to enhance their permeability. Where there is localised dolomitisation in the Lower Impure Limestones, groundwater can also flow through the intergranular spaces created by re-crystallisation. Zones of high permeability can be encountered near fault zones and in areas of intensive fracturing. Permeabilities in the upper few metres are often high although they decrease rapidly with depth. In general, groundwater flow is concentrated in the upper 15 m of the aquifer. Evidence of the relatively low permeabilities is provided by the drainage density and flashy runoff response to rainfall in areas underlain by Silurian rocks. Examination of data in the GSI well database shows that water levels in Silurian rocks are shallow, usually less than 15 m below surface. Water levels within the ORS unit are generally less than 15 m below ground surface with an average of approximately 12 m although this varies depending on topography. In the low-lying areas underlain by impure limestones, groundwater levels are between 2 and 10 mbgl. Next to the rivers, water levels will be closer to ground level. Groundwater flow paths are short (30-300 m), with groundwater discharging to small springs, or to the streams and rivers that traverse the aquifer. Flow directions are expected to approximately follow the local surface water catchments. Generally speaking, these rocks are unconfined, except where subsoils are thick and of low permeability. The optimum area for well drilling is likely to be in the vicinity of the boundary with the overlying Mellon House Beds. In the southwest of the GWB around Birdhill, a locally important (Lg) gravel aquifer overlies the bedrock aquifers.
Groundwater & Surface water interactions		The water table is above or close to the base of the subsoils. The streams crossing the aquifer are gaining. Due to the shallow groundwater flow in this aquifer the groundwater and surface waters are closely linked. There are several marshes in the southern part of the GWB, over the ORS. For example, at Philipston Marsh, the southern part is flushed with calcareous groundwater issuing from the base of a gentle slope; this area is very species-rich. In the Southwest of the GWB, there are bogs at the contact between ORS and impure limestone rocks. North of Cappaghmore, dry weather flows in rivers over all aquifer types in this GWB are generally low (0.85-1.08 l/s/km^2), indicating low aquifer storage. However, south of this, there are two high specific dry weather flows recorded: 2.5 and 3.11. These are influenced by the gravelly tills upstream in the river valleys; the gravels have high storage capacities and can maintain summer river flows.

Conceptual model	• The groundwater body is bounded to the north, east and south by surface water catchments, and to the west by the contact between the Lower Impure Limestones of this GWB and the Pure Unbedded Limestones of the adjacent Castleconnell and Ballyneety GWBs. • The groundwater body is comprised primarily of low transmissivity and storativity rocks, although localised zones of enhanced permeability do occur. • Flow occurs along fractures, joints and major faults. Flows in the aquifer are concentrated in a thin zone at the top of the rock. • Recharge occurs particularly in the upland areas where rock outcrops, or subsoils are thin. Much of the potential recharge runs off. Where the water table is close to the surface, potential recharge may be rejected. • Depending upon the local topography, the water table can vary between a few metres up to >10 m below ground surface. Overall, groundwater flow follows topography, flowing generally westwards. Locally, groundwater flows to the surface water bodies. Flow path lengths in the upland areas are short (≤ 300 m). The increased hydraulic gradient, due to the sloping topography, will allow groundwater to flow faster than if it were flowing through a similar rock type in low-lying land. • Groundwater discharges to springs and to the numerous streams and rivers crossing the aquifer. • In the upland river valleys, the presence of gravelly tills contributes storage to the bedrock aquifer and supports summer river flows. • Due to the shallow groundwater flow in this aquifer the groundwater and surface waters are closely linked. There are several ecosystems in the GWB dependent on groundwater. • In the southwest of the GWB around Birdhill, a locally important (Lg) gravel aquifer overlies the bedrock aquifers.
Attachments	Groundwater hydrograph (Figures 1 and 2), Hydrochemical Signature (Figure 3).
Instrumentation	Stream gauges: 25002*, 25003*, 25054*, 25103, 25153, 25155, 25156, 25157*, 25158*, 25205. *(* denotes specific dry weather flow calculated for these stations.)* EPA Water Level Monitoring boreholes: Abbington (LIM081), Glenstall Abbey (LIM240) EPA Representative Monitoring Points: Doon WS (LIM 42), Murroe WS (LIM 82), Kilcommon (TIN 38), Glengar (TIS 49).
Information Sources	Applin, K. R. and N. Zhao (1989) The Kinetics of Fe(11) Oxidation and Well Screen Encrustation. *Ground Water*, Vol 27, No 2. Daly, D., Keegan, M. and Wright, G (2001) *County Tipperary (South Riding) Groundwater Protection Scheme*. Geological Survey of Ireland Report to Tipperary Co. Co., 51pp. Daly, E.P. (1982) *The Groundwater Resources of the Southeast Industrial Development Region*. Unpublished report, Geological Survey of Ireland, 102 pp. Deakin, J. (1995) *Murroe Public Supply,Groundwater Source Protection Zones*. Geological Survey of Ireland Report to Limerick Co. Co., 6pp. Deakin, J. (1995) *Cappamore Faileen/ Bilboa Public Supply, Groundwater Source Protection Zones*. Geological Survey of Ireland Report for Limerick Co. Co., 6pp. Deakin, J., Daly, D. and Coxon, C. (1998) *County Limerick Groundwater Protection Scheme*. Geological Survey of Ireland Report to Limerick Co. Co., 72pp. Hunter Williams, N., Motherway, K. and Wright, G. (2002) *North County Tipperary GWPS (draft)*. Geological Survey of Ireland Report to North Tipperary Co. Co., 58 pp. Kelly, D. and Wright, G. (2000) *An Assessment of Groundwater Quality in County Cork (Southern Division)*. Report to Cork County Council (Northern Division). Geological Survey of Ireland. Aquifer chapters: Silurian Metasediments and Volcanics, Devonian Old Red Sandstones, Dinantian Lower Impure Limestones, Dinantian (early) Sandstones, Shales and Limestones, Basalts & other Volcanic rocks, Granites & other Igneous Intrusive rocks.
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 hydrograph

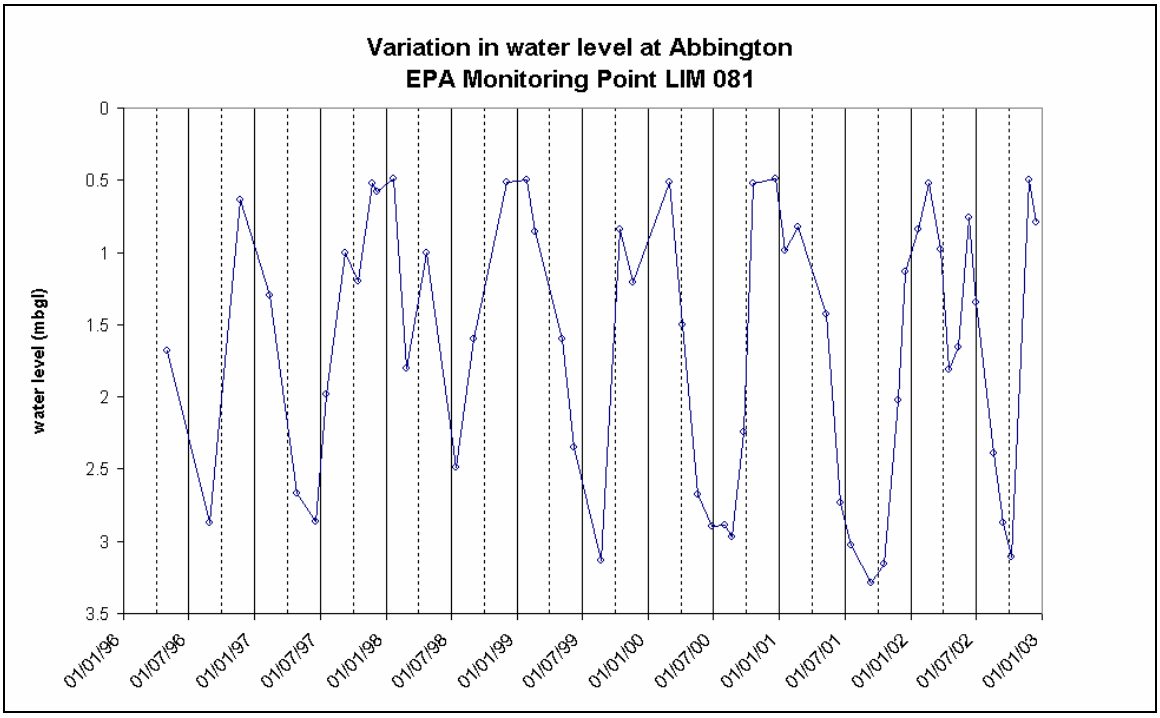


Figure 2: Groundwater hydrograph

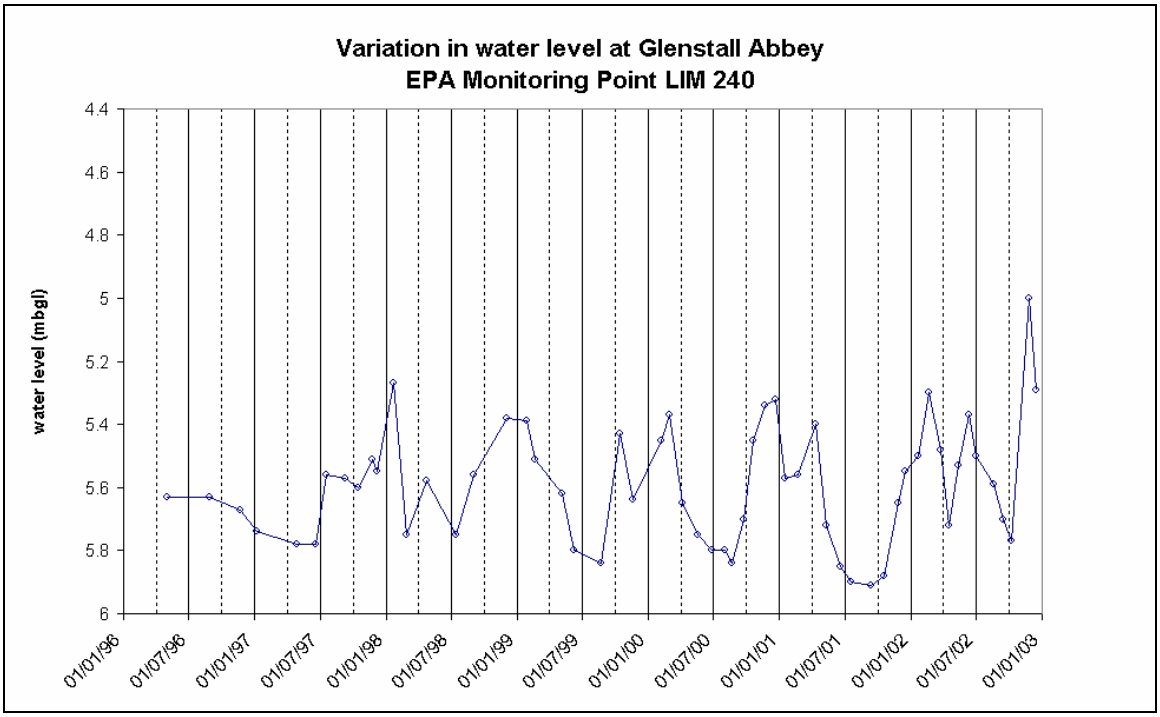
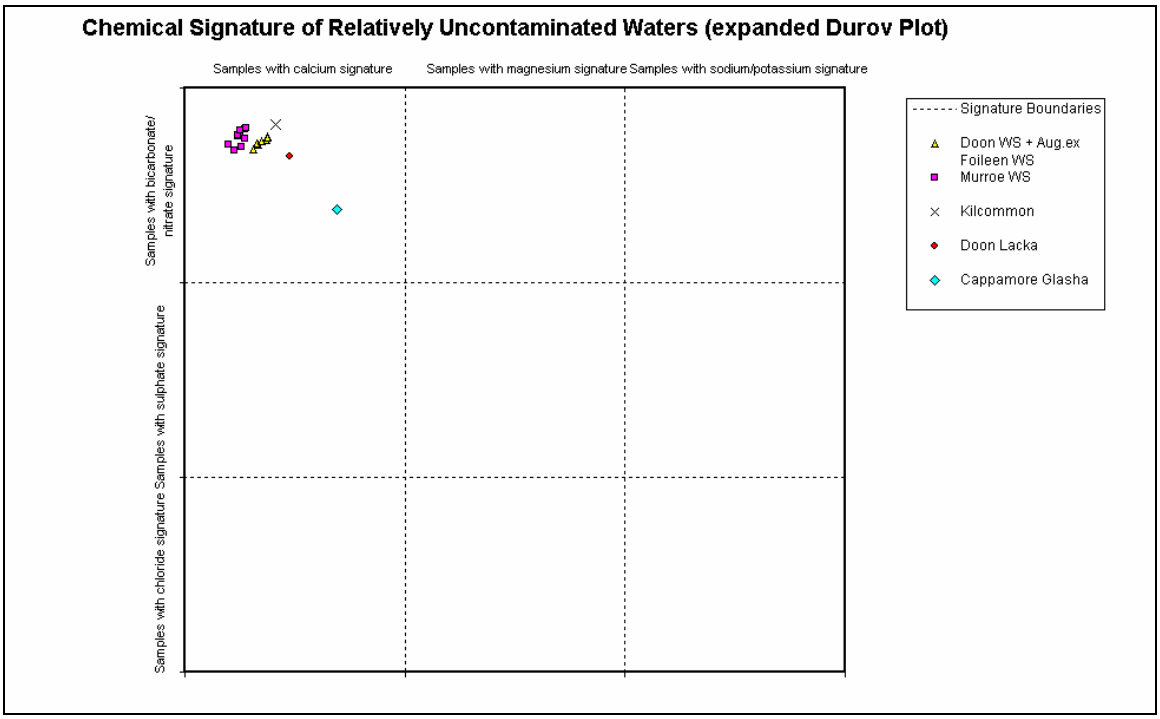
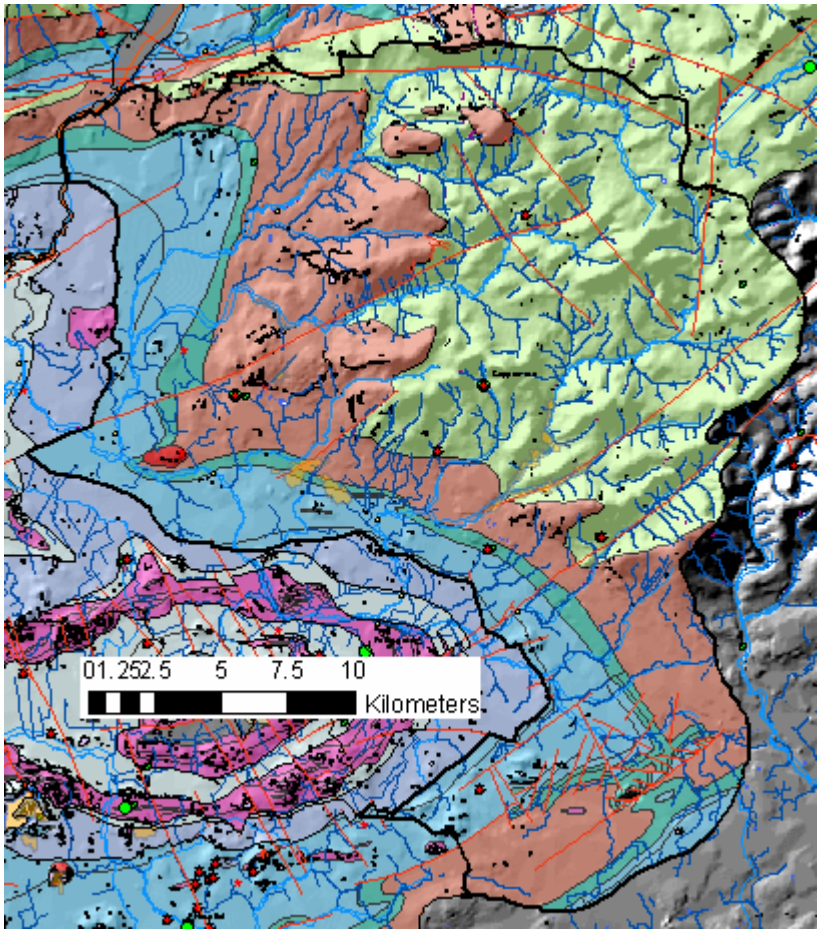


Figure 3: Hydrochemical signature



NB: *Doon WS abstracts water from near the Dinantian (early) Sandstones, Shales and Limestones / Old Red Sandstone boundary. The rest of the supplies abstract groundwater Silurian strata.*



Rock units in GWB

Rock unit name and code	Description	Rock unit group
Volcanics (undifferentiated) (V)		Basalts & other Volcanic rocks
Cappagh White Sandstone Formation (CA)	Red & white sandstone, conglomerate	Devonian Old Red Sandstones
Keeper Hill Formation (KH)	Pale & red sandstone, grit & claystone	Devonian Old Red Sandstones
Old Red Sandstone (undifferentiated) (ORS)	Red conglomerate, sandstone, mudstone	Devonian Old Red Sandstones
Lower Limestone Shale (LLS)	Sandstone, mudstone & thin limestone	Dinantian (early) Sandstones, Shales and Limestones
Ringmoylan Formation (RM)	Calcareous shale & crinoidal limestone	Dinantian (early) Sandstones, Shales and Limestones
Transition Beds (TB)	Sandstone, limestone, calcareous shale	Dinantian (early) Sandstones, Shales and Limestones
Ballysteen Formation (BA)	Fossiliferous dark-grey muddy limestone	Dinantian Lower Impure Limestones
Ballynash Member (BAbn)	Wavy-bedded cherty limestone, thin shale	Dinantian Lower Impure Limestones
Ballymartin Formation (BM)	Limestone & dark-grey calcareous shale	Dinantian Lower Impure Limestones
Syenite (S)		Granites & other Igneous Intrusive rocks
Hollyford Formation (HF)	Greywacke, siltstone & grit	Silurian Metasediments and Volcanics