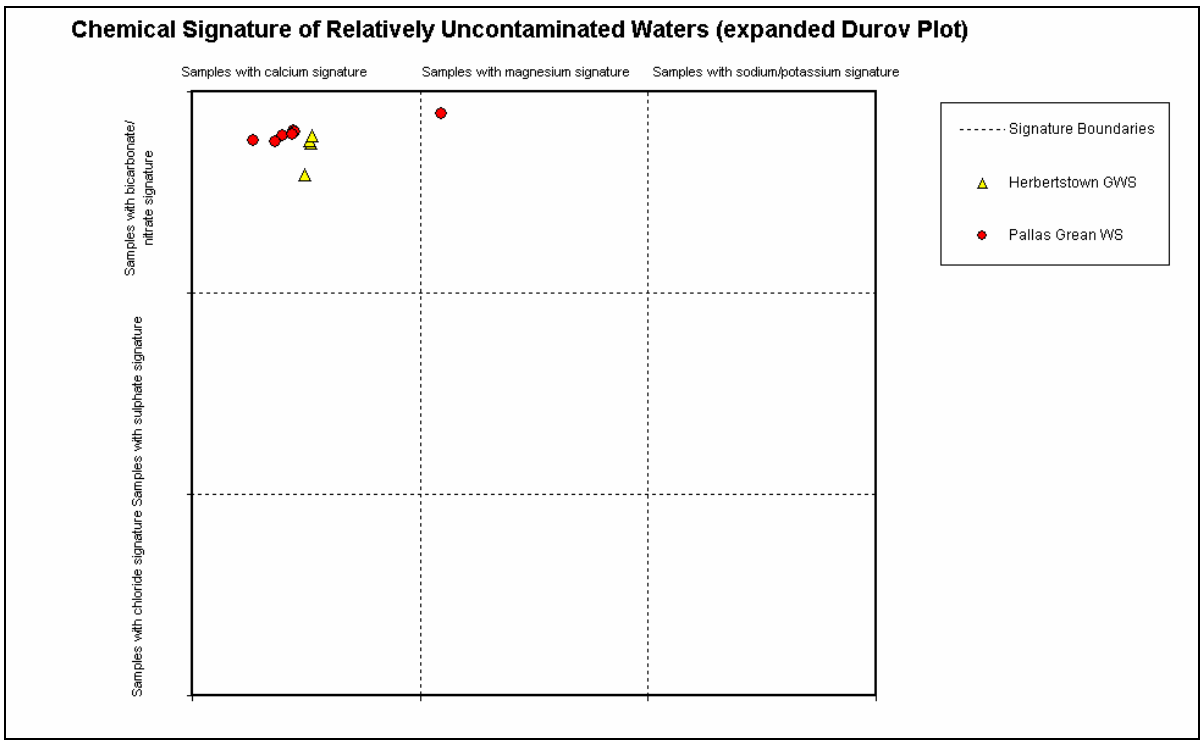
Pallas Grean GWB: Summary of Initial Characterisation.

Hydrometric Area Local Authority		Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
25 - Mulkear catchment Limerick Co. Co.		Rivers: tribuataries to the Mulkear.	None groundwater-dependent.	16
Topography	The GWB has an irregular outline, is elongated WNW-ESE and is slightly curved in plan-view. The largest parts of the GWB are in the NW and NE, with a narrower tail in the SE. Ground elevation ranges from just under 50 mAOD to just over 190 mAOD. The highest ground is found on the east slope of Knockseefin, which is formed of the more resistant volcanic rocks of the Knockseefin-Longstone East GWB; elevations here are >120 mAOD. The lowest elevations are along the NE boundary of the GWB, where small tributaries flow to the Mulkear River. Over most of the GWB, in the west, elevations are around 60-80 mAOD, and the terrain is almost flat. There are local topographic highs, and the ground level decreases northwards and eastwards. Drainage generally is poor, and drainage channels have been excavated in the NW.			
Geology and Aquifers	Aquifer categories	Most of this GWB classified as **Lm:** Locally important aquifers which are generally moderately productive. There is a very small area of Volcanic **Ll:** Locally important aquifer which is moderately productive only in local zones.		
	Main aquifer lithologies	The majority of the GWB comprises Dinantian Pure Bedded Limestones. There is a very small area of Basalts and other Volcanic rocks in the south of the GWB.		
	Key structures	The rocks are on the north and eastern limbs of a large boat-shaped syncline whose axis is orientated ENE-WSW. Strata are tilted to the S, SW and W at angles ranging between 10-33°. NNW-SSE trending major faults cross-cut the fold at about 1 km intervals. There are also ENE-WSW orientated faults. Movements during the folding would also have caused some fracturing and jointing of the rocks. Deakin (1995) considers that fracturing and jointing in the area may provide high transmissivity zones in a north-south direction.		
	Key properties	Transmissivity in the limestone aquifer at Pallas Grean (new) WS was estimated as 26 m^2/d. Transmissivities are likely to be in the range 5-150 m^2/d, with the median value towards the lower-middle end of the range. In the Volcanic rocks, transmissivities will be similar, with median values towards the lower end of the range. Because much of the ground is flat-lying, groundwater gradients will be low (~0.01) over most of the GWB, ranging up to 0.02 in the steeper areas. *(data sources: Rock Unit Group Aquifer Chapters, Limerick GWPS Report, Source Reports, see references; estimation from maps)*		
	Thickness	The Dinantian Pure Bedded Limestones vary laterally in maximum thicknesses from 150 m to up to 500 m. However, most groundwater flow is likely to take place in the top ~30 m, in the zone that comprises a weathered layer of a few metres and a connected fractured layer below this. Deeper groundwater flow occurs along fault zones and large fractures. The driller's log from the original Pallas Grean New borehole describes the geology as limestone to 5.2 m, limestone/sandstone to 30.5 m, broken rock to 45.7 m, fissured limestone to 76 m and finishing in solid limestone to 104 m. It is likely that the sandstones referred to are dolomitic limestones, which are more porous and orange in colour than would be expected of pure limestones.		
Overlying Strata	Lithologies	GSI mapping indicates that the subsoil is predominantly Limestone Till. There are small areas of Gravel, Till with Gravel, and Alluvium.		
	Thickness	There are insufficient data to assess subsoil thicknesses across this GWB.		
	% area aquifer near surface	*[Information to be added at a later date]*		
	Vulnerability	Probable groundwater vulnerability ranges from Extreme to High over most of the GWB. There is a smaller area of Moderate Vulnerability in the west of the GWB. Extreme vulnerability areas occur mainly around the southern margins of the GWB, although there is an Extreme area in a locally elevated area in the NE of the GWB. The remaining areas are predominantly High vulnerability.		
Recharge	Main recharge mechanisms	Diffuse recharge will occur via rainfall percolating through the subsoil or areas of outcropping rock. The proportion of the effective rainfall that will recharge the aquifer is determined by the thickness and permeability of the subsoil, and by the slope. The drainage density indicates the water table is close to the ground surface over much of the GWB. In these areas, groundwater flow paths will be very short and potential recharge may be rejected. Point recharge of waters originating from outside the GWB may occur along the southern edges of the groundwater body, where runoff from the low transmissivity Knockseefin-Longstone East GWB crosses onto this GWB and has caused karstification. Subsurface cross-flow from the adjacent Knockseefin-Longstone East GWB may also occur.		
	Est. recharge rates	*[Information to be added at a later date]*		

Discharge	Springs and large known abstractions (m^3/d)	Ballyclough Co-Op (27 m^3/d – EPA database), Caherline/ Newtown GWS (145 m^3/d – GSI database), Pallas Grean New WS (160-180 m^3/d – GSI database), Pallas Grean (Moymore/ Keating's Well) WS (409 m^3/d – GSI database; 430 m^3/d – EPA database. This spring/ dug well is sited just within the volcanic rocks of the Knockroe East GWB, but the groundwater originates in this GWB.) Caherline Caherconlish GWS (163 m^3/d – EPA database) falls within the Maigue catchment used as the western boundary of the GWB (and eastern boundary of the adjoining Herbertstown GWB) but, from topographic considerations, would appear to be on the east of the catchment divide and part of this GWB. *[More information may be added at a later date]*
	Main discharge mechanisms	The rivers, streams and drainage ditches crossing the GWB are gaining. Groundwater also discharges to springs.
	Hydrochemical Signature	Groundwater generally has a calcium-bicarbonate signature, although a sometimes Ca-Mg-HCO_3 signature in the Pallas Grean (Moymore) WS and high Mg:Ca ratios in the and Pallas Grean New WS indicates some influence of dolomitisation. Groundwater is typically Hard to Very Hard (240–370 mg/l as $CaCO_3$) with corresponding high alkalinities (230–315 mg/l as $CaCO_3$) and conductivities (530-670 µS/cm), and pHs in the range 7.2-7.85. In the adjacent Herbertstown GWB, there is a chalybeate (iron rich) spring near a NNW trending fault; the composition of the spring water indicates that the groundwater has originated in the Namurian rocks 1 km to the south, and travelled along the fault zone. This phenomenon has not been recorded in this GWB, but may occur. In this GWB, background chloride concentrations will be higher than in the Midlands, due to proximity to the sea.
Groundwater Flow Paths		Groundwater flows through fractures and faults. A limited amount of dissolution along fractures and bedding planes may have further increased permeability in some areas. Dolomitisation has further increased local permeability, and dolomitised regions in the subsurface are considered by Deakin (1995) to be the main groundwater-transmitting zones to the Pallas Grean New WS borehole. Water entry to the public supply borehole, as recorded in the driller's report, occurs primarily in two main fractures, above and below a broken rock band (30.5 m and 45.7 m respectively), although a 30 m zone of fissured limestone beneath this is also reported to give small quantities of water. In general, permeabilities decrease quite rapidly with depth. Groundwater flow is concentrated in the upper part of the aquifer; this zone comprises a weathered layer, with a dolomitised and connected fractured zone below this, below which is a generally poorly fractured zone, although deeper inflows from along faults or connected fractures can be encountered. It is considered that the productivity of the aquifer will depend on encountering one of these dolomitised zones. This is likely to be the reason for the number of dry boreholes in the area, in particular the dry well that was drilled adjacent to the Co. Co. well. Karstification has occurred at the boundary between the non-carbonate rocks of the Knockseefin-Longstone East GWB and the limestones within this GWB (Strogen, 1988). Transmissivities will be enhanced in this area, and point recharge is likely to occur. There is likely to be a reasonably good hydraulic connection between the volcanics of the Knockroe East GWB and the productive zone in the limestones. Groundwater is considered to be in hydraulic continuity with the rivers and streams. The drainage pattern and database records show that the water table is very close to the surface (0-3 mbgl) over much of the GWB. The small variation in water level at Ballyclough Co-Op (Dromkeen) reflects the location in a groundwater discharge zone of the well. Dug wells are a common means of abstracting groundwater in this area. However, in the elevated areas at the southern and western edges of the GWB, and a local topographic high near Deerpark, deep wells intersect the water table at between 12-22 mbgl. Groundwater flow paths are typically relatively short in the low-lying waterlogged areas, with groundwater discharging locally to the streams, ditches and small springs. Longer flow paths will occur in more elevated areas where the water table is further below ground level. Local topographic variation and the locations of streams will determine the groundwater flow direction.
Groundwater & Surface water interactions		The very shallow nature of the flow system (due to the generally high water table) leads to rapid interchanges of water between surface and underground. At the boundary between the non-carbonate Knockseefin-Longstone East GWB and this limestone aquifer, swallow holes and karstic features receive surface water. Groundwater is discharged to surface as springs or as baseflow to rivers and streams crossing the GWB.

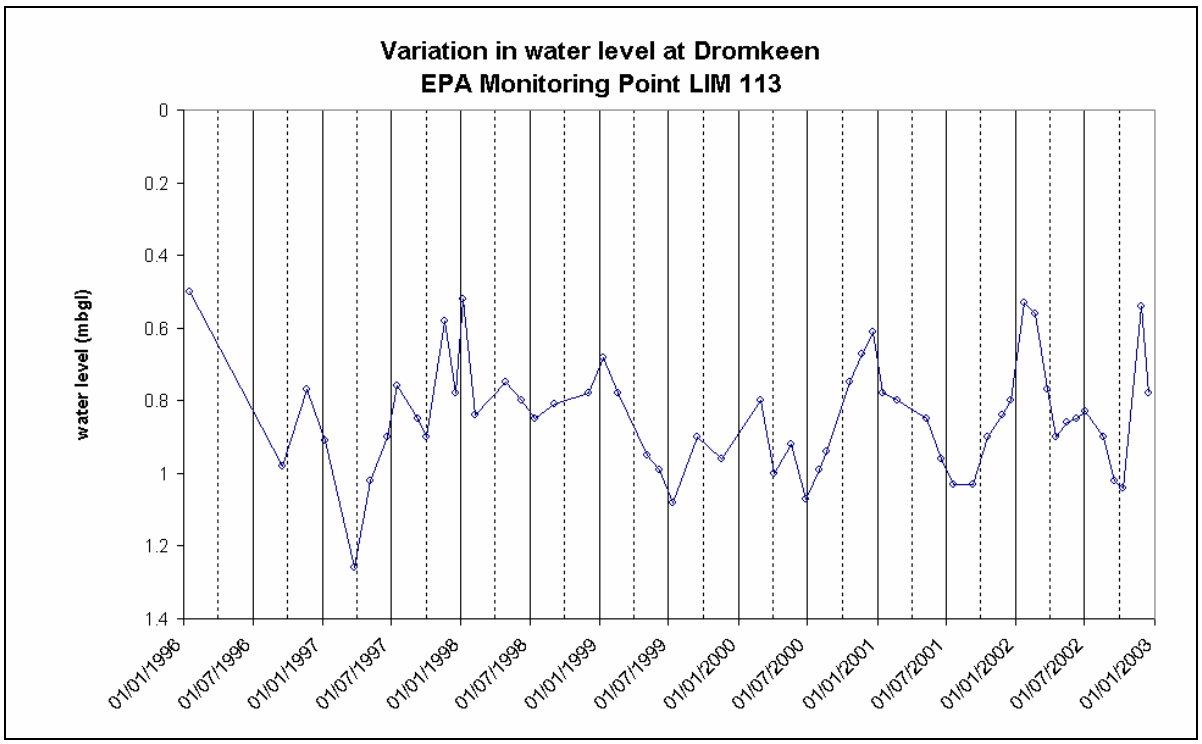
Conceptual model	• The GWB is irregular in shape. It is elongated WNW-ESE, and is slightly curved in plan-view. The largest parts of the GWB are in the NW and NE, with a narrower tail in the SE. The northern, eastern and SE boundaries are formed by the contact with the lower transmissivity volcanic rocks of the Knockroe East GWB. The western boundary and part of the southern boundary are coincident with a surface water catchment boundary and implied groundwater high. The southern and western boundaries are formed by the contacts with the volcanic and Namurian rocks of the Knockseefin-Longstone East GWB The area is generally flat-lying, except around parts of the southern and western margins, and in the centre and SE. • The GWB comprises moderately transmissive rocks that have low storativity. There are dolomitised zones that are higher permeability and porosity than the surrounding unaltered limestones, but these are localised. Localised zones of enhanced permeability also occur along the NNW-SSE orientated fault zones and fracture system. The small areas of gravelly tills and alluvium may contribute storage to the bedrock aquifer. • Diffuse recharge occurs where subsoil thickness and permeability permit. The factor limiting diffuse recharge is the generally high water table, which will cause effective rainfall to be rejected or flow quickly to surface water features via very short flow paths. However, local internal drainage basins probably exist, ponding the potential recharge. Point recharge is likely to occur of runoff from the non-carbonate low transmissivity rocks of the Knockseefin-Longstone East GWB. • The aquifer is probably generally unconfined. The water table follows topography and is typically 0-3 m below ground level in the flat-lying areas, although in elevated areas, unsaturated zones of 10-20 m exist. Groundwater flows in dolomitised zones, and also along fractures, joints and major faults. Overall, most groundwater flows near the surface in a zone comprising a weathered zone of a few metres and a connected fractured zone below this. Deeper inflow levels will occur where isolated fractures/faults or jointed zones are intercepted. Flow path lengths in general are relatively short, particularly in areas where the water table is near to the surface. However, the NNW-SSE fracturing and faulting is known in the adjacent Herbertstown GWB to create high-permeability pathways where groundwater flows significant distances (>1000 m), and has probably caused transmissivity anisotropy. • Groundwater discharges to the streams crossing the aquifer and to small springs. Unconfined groundwater flow directions are controlled by local topography and drainage patterns. • There is probably cross-flow from the adjacent Herbertstown GWB to this GWB, taking the surface catchment divide used to define the boundary between the two as it is currently drawn. • Because the water table is very close to the surface over much of the GWB, the very shallow nature of the flow system leads to rapid interchanges of water between surface and underground.
Attachments	Hydrochemical signature (Figure 1).
Instrumentation	Stream gauges: 25206. EPA Water Level Monitoring boreholes: Dromkeen (LIM 113). EPA Representative Monitoring boreholes: Pallas Grean (Moymore) WS (LIM 89) (note that EPA location is different from GSI and EPA Pallas Grean (Moymore/ Keating's Well) WS location)
Information Sources	Ball, D.M. (2000) *Pallas Grean, Doon and Oola – The exploration and development of additional sustainable groundwater sources*. Report by David Ball (Hydrogeological Consultant) to Limerick County Council, Annacotty Area Office, 28 pp. Deakin, J. (1995) *Pallas Grean Public Supply, Groundwater Source Protection Zones*. Geological Survey of Ireland Report to Limerick Co. Co., 6 pp. Deakin, J., Daly, D. and Coxon, C. (1998) *County Limerick Groundwater Protection Scheme*. Geological Survey of Ireland Report to Limerick Co. Co., 72 pp. Strogen, P. (1988). The Carboniferous lithostratigraphy of southeast Co. Limerick, Ireland, and the origin of the Shannon Trough. *Geol. J.,* Vol. 23, pp. 121–137. Aquifer chapters: Dinantian Pure Unbedded Limestones, Basalts and other Volcanic rocks.
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: Hydrochemical signature

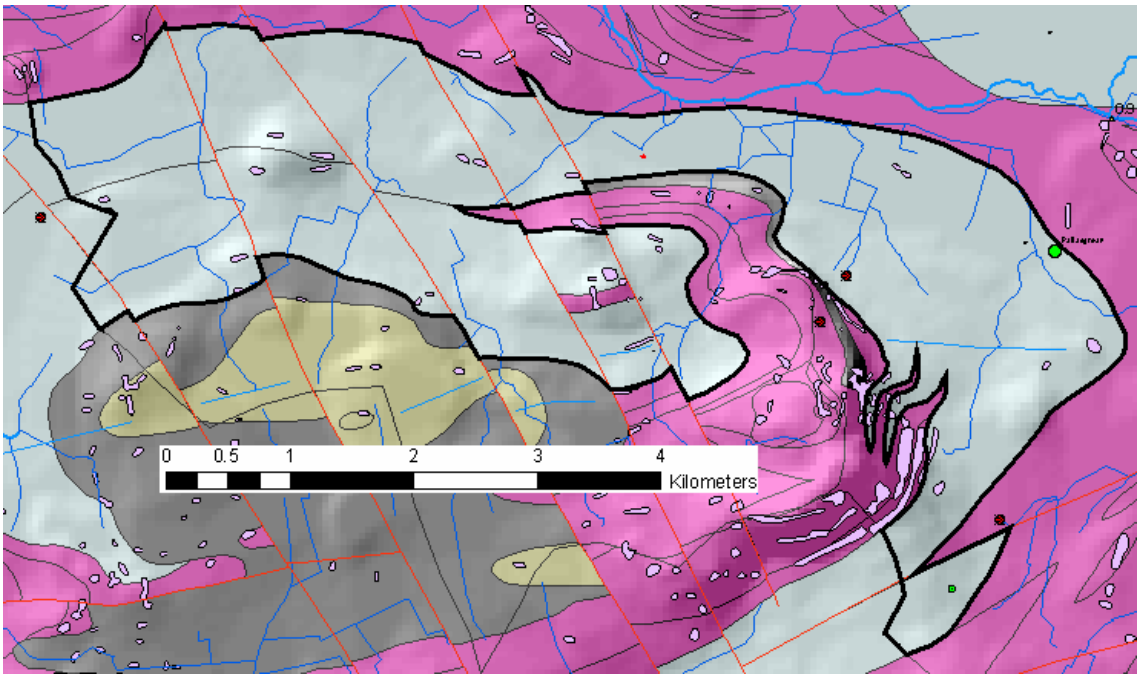


NB: this plot also contains data from the adjacent Herbertstown GWB.

Figure 2: Groundwater hydrograph



NB: this monitoring location is at the Ballyclough Co-Op (Dromkeen)



Rock units in GWB

Rock unit name and code	Description	Rock unit group
Herbertstown Limestone Formation (HE)	Blue-grey limestone and interbedded ash	Dinantian Pure Bedded Limestone
Dromkeen Limestone Formation (DR)	Pale thick-bedded bioclastic limestone	Dinantian Pure Bedded Limestone
Trachyte (T)		Basalts and other Volcanic rocks