Cloyne GWB: Summary of Initial Characterisation.

Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
19 Cork Co. Co.	**Rivers:**.None **Lakes:** None	(001076) Rostellan Lough	26.4

Topography	This GWB occupies the floor of an elongate east west trending valley in east Cork. The valley is bounded to the north and south by parallel east-west trending ridges which comprise the Knockadoon and Whitegate GWBs respectively. The valley floor is generally flat to gently undulating. Ground elevations range from sea level to 30 m OD. More than half the body is under 10 m OD, which includes areas near the coast in the west of the body and most of the eastern half of the body. Slightly higher ground occurs just west of the centre of the body (20-30 m OD).	
Geology and Aquifers	**Aquifer categories**	The main aquifer category in this GWB is: **Rkd**: Regionally important karstified aquifer dominated by diffuse flow. A tiny area (0.01 km^2) in the west of the body has an aquifer category of: **Ll:** Locally important aquifer, moderately productive only in local zones
	Main aquifer lithologies	The main aquifer lithology in this GWB is Dinantian Pure Unbedded Limestones (Waulsortian Limestone Formation). Tiny areas of Dinantian Pure Bedded Limestones (0.2 km^2) and Dinantian Mudstones and Sandstones (Cork Group) (0.01 km^2) also occur within the body.
	Key structures	During the Variscan Orogeny, rocks in South Munster were compressed from the south into a series of folds on east west axes. Subsequent erosion stripped the more soluble Carboniferous Limestones from the fold crests or ridges (anticlines) exposing the harder, more resistant sandstones underneath. The Carboniferous Limestones were preserved in the fold troughs (synclines) which today occupy elongate east-west trending valleys separated by the intervening sandstone ridges. This GWB lies in the east of the Cloyne Syncline. Extensive fracturing and faulting accompanied the folding of the rocks. The ridges and valleys are cut by series of shear faults trending approximately north-south and a series of thrust faults with a general east-west trend. The major north-south shear faults are paralleled by a very well developed system of vertical or near-vertical north-south joints which are very evident in exposures in quarries and caves in East Cork. These joints are commonly spaced at intervals of about 0.5 to 2 metres (Wright, 1979).
	Key properties	The pure unbedded limestones of South Munster are highly productive. Faults and joints were enlarged by karstification as groundwater moved through the limestones. There are numerous surface karst features in these limestones, (e.g. swallowholes, collapse features and closed depressions) and extensive cave systems (e.g. Carrigtohill, Midleton and Cloyne). The strong structural influence on the development of karstification is demonstrated by cave plans from southeast Cork (e.g. Poulnahorka Caves, Castlemartyr, Co Cork – Midleton GWB) where the main passages or 'galleries' have developed along north-south joints in the order of 1 to 6 metres apart (Wright 1979). Transmissivity in the pure unbedded limestones can range up to a few thousand m^2/d. Pumping tests in boreholes at Cloyne (Cloyne Aghada WSS) gave a range of transmissivity of 200 to over 2000 m^2/day (Wright 2002). In a borehole in the same rock type near Dungarvan, Co Waterford (Dungarvan GWB, SERBD) a range of transmissivity of 900 - 13,000 m^2/d was recorded (Cronin *et. al*. 1997). Groundwater gradients within the pure unbedded limestones are low, around 0.001-0.002. (Wright & Gately 2002). There are several wells with Excellent yields (>400 m^3/d). Large springs occur in the same rock type in other GWBs in the region. Springs in the pure unbedded limestone range in size from small to large, but have reliable discharges. A tracer test at Shanagarry gave a groundwater velocity of about 100 m/h, while another in the Midleton GWB to the north recorded groundwater flow velocities of 30 m/h between Carrignashinny swallow hole and Dower Spring and 16.5 m/h between Dower Ford swallow hole and Dower Spring (Wright & Gately 2002). Storativity is relatively low in the limestone aquifer, but may be enhanced by overlying sand and gravel deposits which are in continuity with the underlying limestone and provide it with additional storage.
	Thickness	The Dinantian Pure Unbedded Limestones (Waulsortian Limestone) are some 420 m thick in the Cork Syncline (Sleeman & Pracht, 1994). Most groundwater flow may occur 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. However deeper flows can occur. Boreholes in the Waulsortian Limestone intersect major zones of fissuring at depth at Cloyne, where a major zone of fissuring occurs at approximately 41 m below ground level, i.e. approximately 20 m below OD and at Ringaskiddy (Carrigaline GWB), where major water inflows occur down to 40 m below OD (Wright, 1979). In the past sea level is estimated to have been approximately 50-60m below present day OD, the level to which the now infilled channel of the River Lee was eroded (Farrington, 1959) enabling karstification at depth. Today this region is an example of a drowned karst terrain.

Overlying Strata	**Lithologies**	This GWB is primarily covered by glacial till, of varying permeability. West of Cloyne and Lissanly, and in the extreme east of the body around Shanagarry the subsoil permeability is generally 'moderate'. Between these two areas is a zone of 'low' permeability till. Sand and gravel deposits ('high' permeability) also occur in many areas, particularly in the west of the body. Many areas of rock outcrop and shallow rock occur in this GWB, particularly in the west of the body and some isolated areas in the east. *Subsoil Types identified in Cloyne GWB by Teagasc Parent Material Mapping (Draft): Alluvium (A); Sandstone sands and gravels (Devonian) (GDSs); Marine sands and gravels (MGs); Made Ground (Made); Rock outcrop and rock close to surface (Rck); Till – Devonian Sandstone Till (TDSs), Limestone Till (TLs).*
	Thickness	Areas with subsoils of <3m occur around Cloyne and in the west of the GWB. Some areas of <3 subsoil also occur in the east of the body. Elsewhere subsoil depths of 5-10m are frequently recorded. Deep subsoils (10-17 m) have been recorded, although these points are generally isolated and may represent cavities in the limestones. The underlying pure unbedded limestone in this valley is highly karstified and likely to have a very irregular bedrock surface. Subsoil depths in these areas can therefore be highly variable within short distances.
	% area aquifer near surface	
	Vulnerability	This GWB has areas of Extreme Vulnerability around Cloyne and in the west of the GWB, and some more isolated areas of Extreme Vulnerability in the east of the body. The remainder of the body west of Cloyne and an area in the east of the body around Shanagarry is of High Vulnerability. Between Cloyne and Shanagarry is an area of Moderate Vulnerability, coinciding with an area of generally 'low' permeability subsoil of >5 m.
Recharge	**Main recharge mechanisms**	The ridges to the north and south of this GWB (Knockadoon & Whitegate GWBs) provide runoff which recharges the limestone aquifer in the valley. In the GWB itself both point and diffuse recharge will occur. Swallowholes and collapse features provide the means for point recharge to the karstified aquifer. Diffuse recharge will occur over the entire GWB via rainfall percolating through the subsoil. The limited of surface drainage, particularly in the west of the body, indicates that potential recharge readily percolates into the groundwater system. In low-lying areas with a high water table, a proportion of the effective rainfall may be 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 karstified aquifer they provide a permeable pathway for recharge to the underlying aquifer. They can also augment storage in the aquifer. The 'moderate' permeability subsoils in the west and extreme east of the body will not generally restrict percolation of recharge. East of the centre of the body, between Cloyne and Shanagarry, areas of 'low' permeability subsoil occur where recharge may be restricted. However, variability in subsoil depths due to the underlying karstified limestone means that even in areas with lower permeability subsoil, opportunities for recharge to areas of shallower limestone can still occur. A small volume of groundwater may enter as through-flow from the sandstones and mudstones which make up the ridges, into this GWB.
	Est. recharge rates	
Discharge	**Large springs and high yielding wells (m^3/d)**	*Note: The following data need to be checked and updated by RBD Project Consultants.* Data from GSI Well Database: Cloyne Aghada Water Supply Scheme (4 Boreholes): Lissanly BH (1309 m^3/d), Commons East BH (1636 m^3/d) Castlemary BH (1200 m^3/d), Townparks BH (1618 m3/d).
	Main discharge mechanisms	Groundwater discharges to the streams crossing the GWB and to the coast east and west of the body. Rivers overlying the limestones in the South Munster Synclines have relatively high dry weather flows representing contributions from the underlying aquifer. Rostellan Lough as discharge area??

	Hydrochemical Signature	The groundwater in this body is dominated by calcium and bicarbonate ions. Hardness ranges from moderately hard to very hard (200 to >400 mg/l (as $CaCO_3$). Spring waters tend to be softer as throughput is quicker and there is less time for the dissolution of minerals into the groundwater. Groundwater alkalinity is high, up to 400 mg/l (as $CaCO_3$). These hydrochemical signatures are characteristic of clean limestone. Like hardness and alkalinity, electrical conductivity (EC) can vary greatly. Typical limestone water conductivities are around 500-700 µS/cm. Lower values suggest that the residence times of some of the sources are very short, for example at the Dower Spring (Midleton GWB) where conductivities average 396 µS/cm, reflecting a karstic system with rapid flow velocities. Chloride levels in groundwater in this body can be elevated near the coast. 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 hydrochemical signatures of groundwater from public supply wells from the Cloyne Aghada WSS are demonstrated in an expanded Durov plot in Figure 2 below.
Groundwater Flow Paths		These rocks are devoid of intergranular permeability. Groundwater flow occurs in the many faults and joints, enlarged by karstification. Past depression of the sea level enabled karstification at depth, which further enhances the permeability of these rocks. Because of the high frequency of fissures in this region, overall groundwater flow is thought to be of a diffuse nature, although solutionally enlarged conduits and cave systems do occur. Groundwater flow occurs in an upper shallow highly karstified weathered zone in which groundwater moves quickly in rapid response to recharge. Below this is a deeper zone where there are two components to groundwater flow. Groundwater flows through interconnected, solutionally enlarged conduits and cave systems that are controlled by structural deformation. In addition there is a more dispersed slow groundwater flow component in smaller fractures and joints outside the larger conduits. The water table is generally within 10 m of the surface, except for the more elevated parts of the limestone aquifers, and the typical annual fluctuation of the water table ranges up to 6 or 7 m (Wright 1979). A hydrograph for a borehole at Castlemary shows an annual fluctuation of water levels in the limestone of about 3-5 metres (Figure 2). Groundwater in this GWB is generally unconfined. The highly permeable aquifer supports a regional scale flow system. Groundwater flow paths can be up to several kilometres long, but may be significantly shorter in areas where the water table is very close to the surface. Regional groundwater flow is towards the streams draining the valley and to the sea at the eastern and western boundaries of the body. The limestones in this body are frequently overlain by small sand and gravel deposits which are in hydraulic continuity with the underlying bedrock. Where present they provide a permeable pathway for recharge to the karstic aquifer and where saturated provide additional storage for the underlying bedrock aquifer
Groundwater & Surface water interactions		The nature of the karstic system leads to rapid interchanges of water between surface and underground. Swallow holes and caves receive surface water, and groundwater is discharged to surface as springs or as baseflow to rivers crossing the groundwater body. (001076) Rostellan Lough

Conceptual model	• This GWB occupies the floor of an elongate east west trending valley in east Cork. The body is generally flat to gently undulating (sea level to 30 mAOD). • The GWB is bounded to the north and south by the contact with the low permeability sandstones and mudstones of the Knockadoon and Whitegate GWBs respectively. It is bounded to the east and by the coast. • The GWB is composed mainly of diffusely karstified, highly permeable pure limestones. To the north and south of the body are ridges of low permeability sandstones and mudstones. • The regional structural deformation that created the characteristic South Munster sandstone ridge-limestone valley topography was accompanied by intense fracturing and frequent jointing (dominantly N-S) within the limestone synclines. Subsequent karstification of these openings has significantly enhanced the permeability of the pure limestones. Karst features are common. Karstification is known to extend well below present sea levels, and is estimated to extend to depths of 50 to 60 m below OD. • Groundwater flows through the many faults and joints formed by deformation that were subsequently enlarged by karstification. Most groundwater flow occurs in an upper shallow highly karstified weathered zone of a few metres thick in which groundwater moves quickly in rapid response to recharge. Below this is a deeper zone with two components of groundwater flow: interconnected, solutionally enlarged conduits and cave systems controlled by structural deformation (N-S jointing), and a more dispersed network of smaller fractures and joints outside the larger conduits. Generally this connected fracture zone extends to about 30 m bgl in pure limestones, but in South Munster, deep inflows from major zones of fissuring have been encountered to 40-50 mbgl. • Groundwater is unconfined. The water table is generally less than 10 metres below surface with average annual fluctuation up to 6 metres. Groundwater gradients are very flat (0.001-0.002). The highly permeable aquifer can support regional scale flow systems. Groundwater flow paths can be up to several kilometres long, but may be significantly shorter in areas where the water table is very close to the surface. Overall groundwater flow is to the streams draining the valley and to the sea at the eastern and western boundaries of the body. • Recharge is both point and diffuse. Runoff from the ridges to the north and south (Knockadoon & Whitegate GWBs) recharges the limestone aquifer in the valley. Swallowholes, collapse features and sinking streams allow point recharge to the karstified aquifer. Diffuse recharge will occur over the entire GWB through the subsoil. The lack of surface drainage in much of this GWB indicates that recharge readily percolates into the groundwater system. Some areas of low permeability subsoil in the east of the body may restrict recharge where they are sufficiently thick. A relatively small volume of groundwater may enter as through-flow from the adjacent low transmissivity GWBs. • Areas of Extreme Vulnerability occur around Cloyne and the west of the GWB, and in some more isolated areas in the east of the body. The remainder of the body west of Cloyne and around Shanagarry is of High Vulnerability. Between Cloyne and Shanagarry there is an area of Moderate Vulnerability, coinciding with an area of generally 'low' permeability subsoil of >5 m. In a highly karstified aquifer such as this GWB the underlying limestone will have a very irregular surface. Subsoil depths in this GWB can therefore be highly variable within short distances. • This body is frequently overlain by small sand and gravel deposits which are in hydraulic continuity with the underlying bedrock. Where present they provide a permeable pathway for recharge to the karstic aquifer and where saturated provide additional storage for the underlying bedrock aquifer. • There is a high degree of interaction between surface water and groundwater. Swallowholes and caves receive surface water, and groundwater discharges as springs or as baseflow to rivers crossing the groundwater body.
Attachments	Hydrochemical Signature (Figure 1); Groundwater Hydrograph (Figure 2)
Instrumentation	**Stream gauges:** None **EPA Water Level Monitoring boreholes:** None **EPA Representative Monitoring points:** Cloyne/Aghada WS (COS 21)
Information Sources	Cronin C, Daly D, Meehan R, Johnston P (1997) Dungarvan Public Supply Groundwater Source Protection Zones. Farrington A (1959). The Lee Basin Part one: glaciation. Proc. R. Ir. Acad. 60B (3), 135-166. Kelly D, Leader U, Wright G (2002) *South Cork Groundwater Protection Scheme*. Report to Cork County Council (South). Geological Survey of Ireland. Sleeman AG, Pracht M (1994) *Geology of South Cork. A geological description of South Cork to accompany the Bedrock Geology 1:100,000 Map Series, Sheet 25*, Geological Survey of Ireland, 59pp Wright G, Gately C (2002) *Whitegate Regional WaterSupply Scheme (Dower Spring)*. Groundwater Source Protection Zones. Geological Survey of Ireland Report, 19pp. Wright G (1979) Groundwater in the South Munster Synclines. In: Hydrogeology in Ireland, Proceedings of a Hydrogeological Meeting and associated Field Trips held in the Republic of Ireland from 22 to 27 May, 1979. Published by the Irish National Committee of the International Hydrological Programme. Wright G (2002) *Cloyne/Aghada Water Supply Scheme.* Groundwater Source Protection Zones. Geological Survey of Ireland report, 15pp.
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: Hydrochemical signature
(GSI Monitoring as part of Source Protection Report & EPA Representative Monitoring)

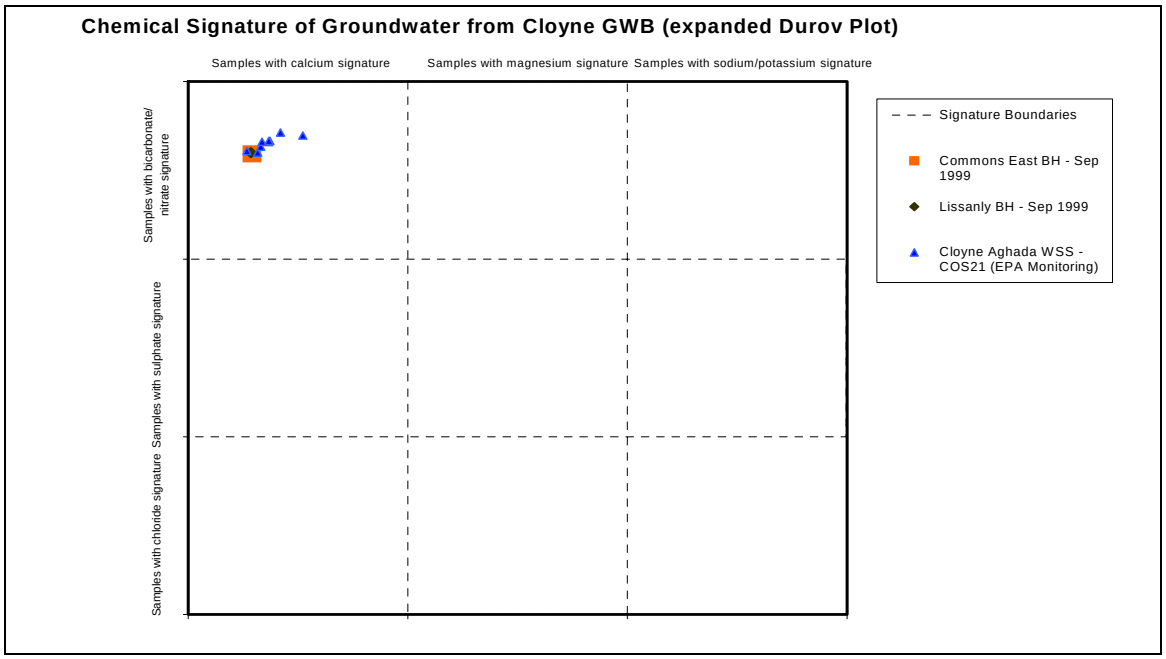
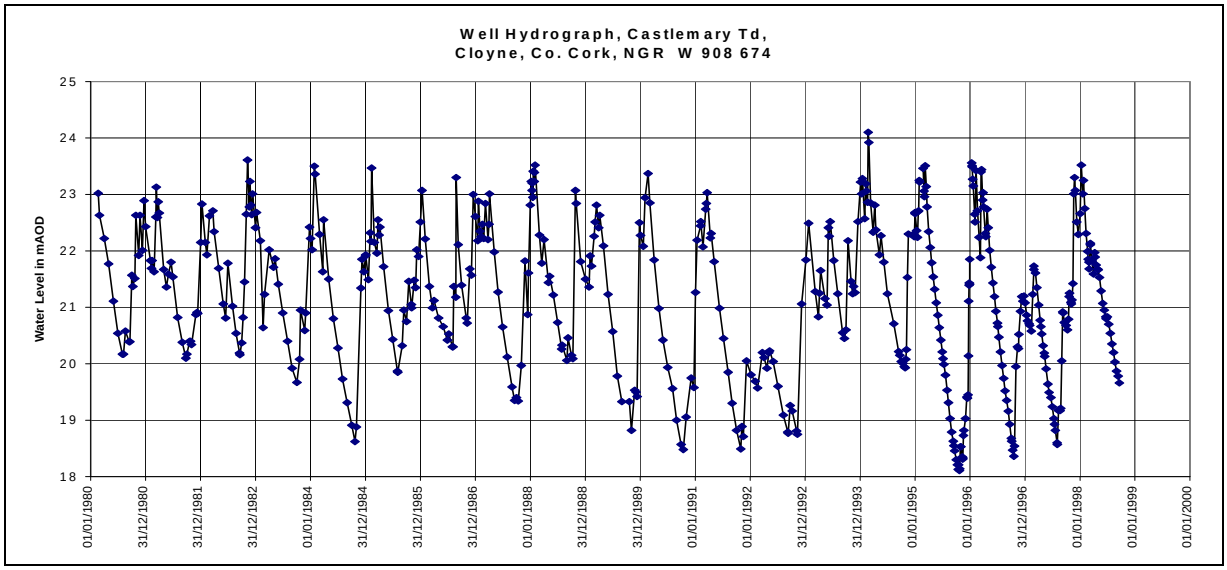
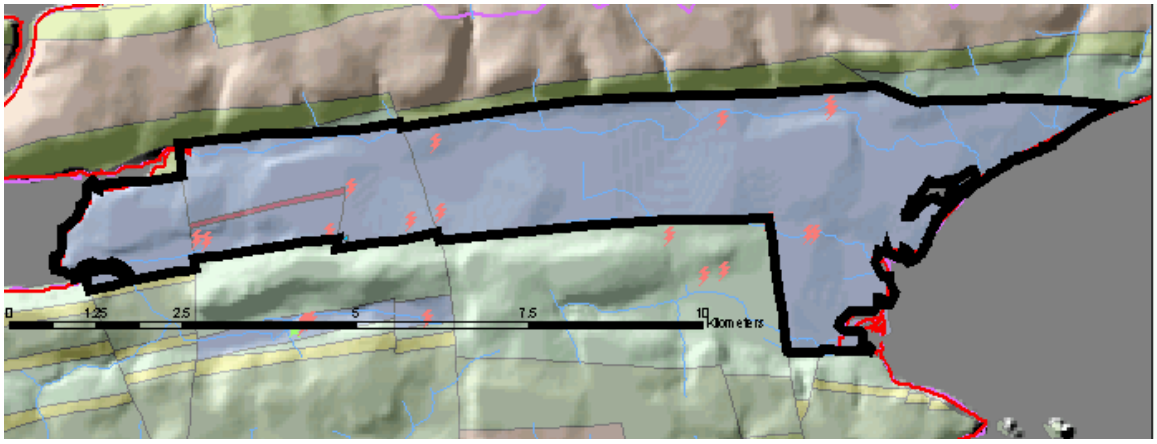


Figure 2: Groundwater hydrographs
(GSI Well Hydrograph)



Cloyne GWB (For Reference)



List of Rock units in Cloyne GWB

Rock unit name and code	Description	Rock unit group
Waulsortian limestones (WA)	Massive unbedded fine-grained limestone	Dinantian Pure Unbedded limestones
Cork Red Marble Formation (CK)	Red brecciated calcilutite limestone	Dinantian Pure Bedded Limestones
Gyleen Formation (GY)	*Sandstone with mudstone and siltstone*	*Devonian Old Red Sandstones*

SITE SYNOPSIS

SITE NAME: ROSTELLAN LOUGH, AGHADA SHORE AND POULNABIBE INLET

SITE CODE: 001076

This site occupies the north-east corner of Cork Harbour, west of Saleen and Rostellan. Geologically, Cork Harbour consists of several limestone basins reported from the sea and from each other by ridges of Old Red Sandstone.

According to a description provided for this site in the 1986 County Report, Rostellan Lough differs from the rest of Cork Harbour in that it is impounded and so is no longer tidal. As a result its bird community is distinct, with diving ducks and grebes most noticeable, little Grebe (50), Pochard (100), and Tufted Duck (60) are frequent species, some of which breed here along with Mallard. Snipe are the most obvious waders present.

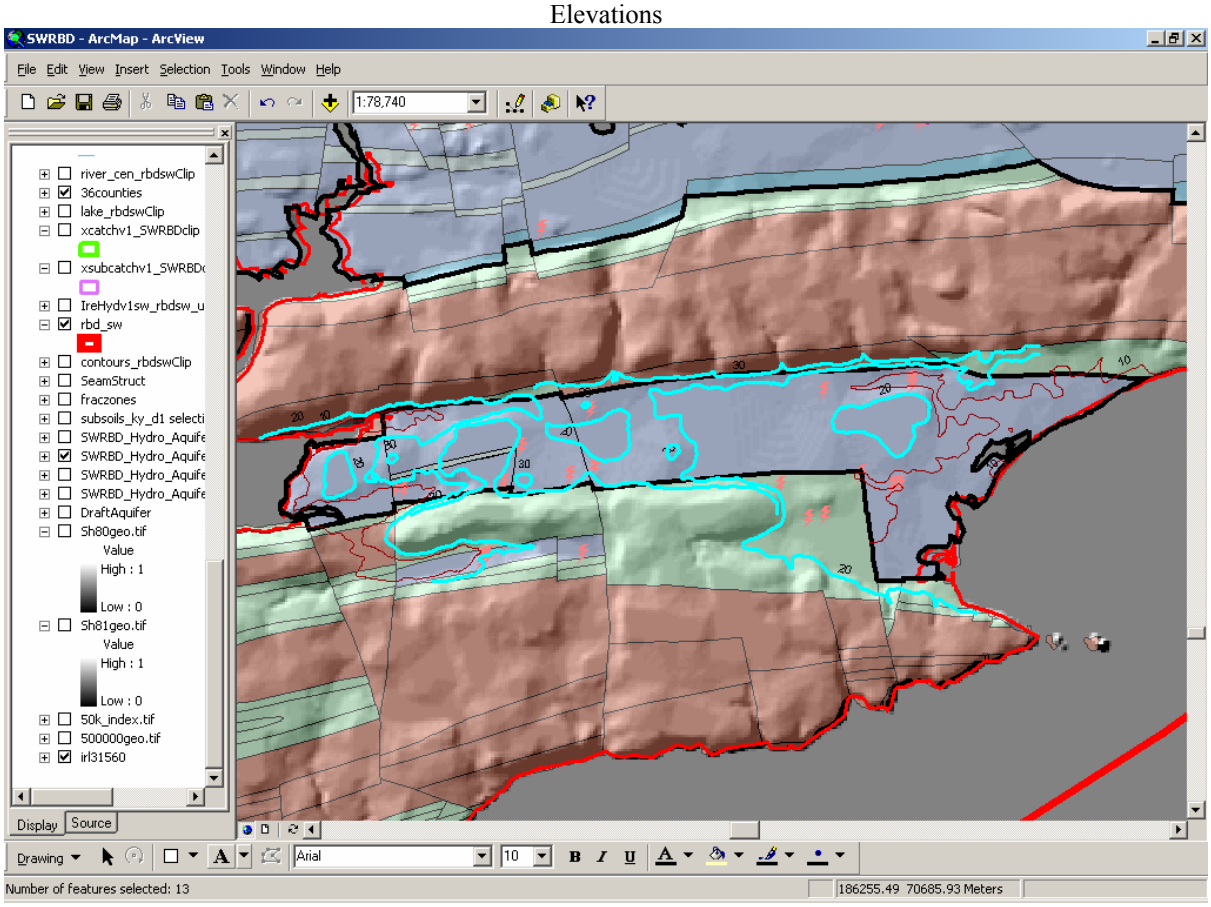
Vegetation on the lake margins is mostly Club-rushes (Scirpus lacurtris and S. maritinus especially), with a little Bulrush (Typha latifolia). A little wet woodland of Alder (Alnus glutinosa) occurs on some of the shore and wet grassland is frequent, with plants such as Bearded Couch (Elymus caninus), Creeping Bent (Agrostis stolonifera) and Water Mint (Mentha aquatica). Algae are very common in the lough itself, but the brackish nature of the water apparently inhibits the growth of many higher plants.

Mudflats occur westwards to Aghada and these were utilised by many feeding waders, while the sea offshore is used by species such as Scamp, Goldeneye and Great Crested Grebe.

Although the site itself is seen to support only moderate numbers of waterfowl, the area forms an integral part of Cork Harbour, which is a wetland of international importance for its wintering populations of Black-tailed Godwit, Curlew and Redshark and its spring migration numbers of Whimbrel. Twelve species occur at nationally important levels and Cork Harbour is one of only a few Irish wetlands to regularly hold over 20,000 waterfowl. The birdlife in this part of the Harbour offers an interacting contrast with the rest of the area and this feature could be used for educational purposes.

The whole Cork Harbour area is under pressure from industrial and urban development, pollution and from recreational usage. Drainage or reclamation would be particular threats to this sector of the Harbour, and the level of shooting could usefully be controlled to protect bird populations. Cord-grass (Spartina sp.) occurs at Poulnabibe, possibly posing a threat to the quality of the mudflats there for feeding birds. The Rostellan Lough, Aghada Shore and Poulnabibe Inlet NHA is of local significance for its waterfowl. This status is enhanced, though, as the whole of Cork Harbour is of international importance and as such is a proposed Special Protection Area. Sections such as this NHA should not be considered in isolation as the bird populations are very mobile throughout the area.

Elevations



NOTES

Draft Conceptual Model of Groundwater Flow in the Waulsortian Limestones in the Southern Region

Groundwater flow within the Waulsortian Limestones in the south of the country is controlled to a large extent by the regional geological structure. Rocks in the region were compressed from the south into a series of folds on an east west axis. Subsequent erosion stripped the softer more soluble limestones from the fold crests or ridges (anticlines) exposing the harder more resistant sandstones underneath. The Carboniferous limestones, including the Waulsortian, were preserved in the fold troughs which today form elongate east west trending valleys separated by the intervening sandstone ridges. The folding was accompanied by extensive fracturing and faulting which, in the Carboniferous limestones, created numerous potential pathways for groundwater movement. In pure limestones like the Waulsortian, which are susceptible to karstification, these faults and joints were opened up by solution as groundwater moved through the limestones enlarging the fissures and producing karst features.

The sandstone ridges act as regional groundwater recharge zones which supply recharge to the limestone aquifers in the valleys. There is a high density of surface drainage on the sandstone ridges indicating that the permeability of the sandstones is relatively low. (Recharge to the ridges is expected predominantly move as through flow to streams with limited percolation to bedrock.) Streams run off the sandstone ridges into the limestone valleys.

The topography of the valleys is relatively flat although there can be some topographic highs along the centre of the valleys. The ready weathering of the thin shaly limestones which separate the main limestones from the underlying sandstones is thought to be responsible for the topographic lows along the edges of the valleys. Another cause is the presence of subsidiary folding in the core of the limestones.

The valley floors are characterised by a general lack of surface drainage. The Waulsortian Limestone in the valleys is highly karstified with sinking streams, springs, numerous cave systems, sinkholes and other collapse features common. Karstification is known to extend well below present sea levels the base of karstification estimated to extend to depths of 50 to 60 m below O.D. Malin Head. Groundwater flow rates are rapid within the limestones and there is evidence for conduit flow.

- Groundwater gradients are steep in the lower permeability sandstones of the ridges and flow direction is towards the limestones in the valley. Groundwater gradients are flatter in the more permeable limestones and regional flow direction is to the sea or to major rivers to the east or west along the valley.
- The groundwater in the Waulsortian limestones is unconfined. There are large fluctuations in water levels between winter and summer which can be up to 4-5 m, with seasonal variations in drawdown also observed.
- Rivers within the limestone valleys have relatively high dry weather flows
- Permeability in the Limestones is highest in the uppermost few metres of intense weathering.
- Sand and gravel deposits occurring in the valleys in hydraulic continuity with the underlying limestones can supply additional storage.

Una Leader November 2002

Notes (cont.)

Source	Sample date	pH (lab.)	Total Hardness (mg/l CaCO3)	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Potassium (mg/l)	Total Alkalinity (mg/l CaCO3)	Sulphate (mg/l)	Chloride (mg/l)	EC (µS/cm)	Iron (mg/l)	Manganese (mg/l)
Cloyne, Co Cork (Commons East BH)	Sep 1999	7.4	317.7	114	8.2	19.3	1.7	248	18.8	33.4	596	0.16	<0.05
Cloyne, co Cork (Lissanly BH)	Sep 1999	7.3	347.3	123	9.85	19.5	2	268	19	37.4	644	<0.1	<0.05

Table 1 Aquifer Properties

Source Name and GSI Well Number	*Transmissivity* (m^2/d)	Permeability (m/d)
Northern Region		
Longwood and Summerhill areas, Co Meath	30-40	
Tulla PS, Co Clare	13	
Southern Region		
Downing Bridge, North Co. Cork	3400	10-200
Cloyne, Southeast Co. Cork	200-2000	3-30
Croom, Co. Limerick (1413NWW201)	120	4.2
Fedamore, Co. Limerick (1413NEW140)	34	0.5
Lefanta, Co Waterford (2009SWW047)	3600	
Ardmore, Co Waterford (2007SE W014)	170	26.5
Dungarvan, Co Waterford (2009SEW069-072)	900-13000	25-190 (100)

The permeability of these limestones has developed in response to structural movements and karstification to deeper drainage levels that existed in the past. They are examples of a drowned karst terrain. The limestones are unconfined. Over a significant part of the valleys the limestones are overlain by sands and gravels with which they are in continuity and which provides them with additional storage. There are numersou karst features in these limestones, i.e. caves, swallow holes, collapse features and large springs.

The potential for saline intrusion is a constraint on development near the coast.

1.3.4 Hydrochemistry

The Waulsortian Limestone is a carbonate rock type. The hydrochemistry of the carbonate rocks is dominated by calcium and bicarbonate ions. Hardness is in the range from 200 mg/l to >400 mg/l (as $CaCO_3$), i.e. moderately hard to very hard. Spring waters tend to be softer as throughput is quicker and there is less time for the dissolution of minerals into the groundwater. This is particularly true where the limestones have been karstified.

Groundwater alkalinity is high, up to 400 mg/l ($CaCO_3$). Alkalinity is less than hardness indicating that ion exchange (where calcium or magnesium are replaced by sodium) is not significant. Typical limestone water conductivities are of the order of 500-700 µS/cm. Lower values suggest that the residence times of some of the sources are very short, for example at the Dower Spring where conductivities average 396 µS/cm. This value reflects a karstic system (in the Waulsortian) with rapid flow velocities. Table 2 shows major ions and other water quality parameters from a number of locations in the Waulsortian Limestones.

Table 2: Major ions and other water quality parameters in groundwaters from Waulsortian limestone aquifers.

Source	Sample date	pH (lab.)	Total Hardness (mg/l CaCO3)	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Potassium (mg/l)	Total Alkalinity (mg/l CaCO3)	Sulphate (mg/l)	Chloride (mg/l)	EC (µS/cm)	Iron (mg/l)	Manganese (mg/l)
Dower Spring, Co Cork	Range	7.18-8.25								34.2-46.69	219-740		
Cloyne, Co Cork (Commons East BH)	Sep 1999	7.4	317.7	114	8.2	19.3	1.7	248	18.8	33.4	596	0.16	<0.05
Cloyne, co Cork (Lissanly BH)	Sep 1999	7.3	347.3	123	9.85	19.5	2	268	19	37.4	644	<0.1	<0.05
Croom, Co Limerick	Sep 1993		373	110	24.1	13.9	2.2	332	21.4	32.5	779	<0.01	<0.005
Fedamore, Co Limerick	Sep 1993		427	111	23.7	13.9	3.1	381	18.3	31.2	802	<0.01	<0.005
Mountbolus, Co Offaly			369							16-28	634		
Ballivor, Co Meath (PW1)	Sep 1995	7.1	378	132	11.9	9.899	2.078	302	56.5	15.7	711	0.069	0.071

Note: MDLs are Method Detection Limits.