Ringaskiddy 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:** Owenboy	Lough Beg (001979), Owenboy River (001990)	16.7

Topography	This small GWB occupies an east west trending valley on the west side of Cork Harbour. The valley is bounded by the Ballinhassig GWB. The valley floor is generally flat to gently undulating. Ground elevations range from 0 to 55 m OD. The higher ground occurs along the centre of the valley (20-55 m OD) but ground is generally lower along the valley margins, and in the southeast of the body near the coast (<20 m OD). The ready weathering & erosion of the thin shaly limestones which occur at the margins of the body is thought to be responsible for the topographic lows along the edges of the valley. Much of the GWB comprises urban and/or industrial areas.	
Geology and Aquifers	**Aquifer categories**	**Lk**: Locally important karstified aquifer (67%). Due to the small areal extent occupied by the aquifer it is classified as locally important rather than regionally important. **Ll:** Locally important aquifer, moderately productive only in local zones (33%)
	Main aquifer lithologies	Dinantian Pure Unbedded Limestones (67% - 11 km^2), Dinantian Mudstones and Sandstones (Cork Group) (27% - 5 km^2) The GWB also contains very small areas of Devonian Old Red Sandstones, Namurian Sandstones and Dinantian Lower Impure Limestones.
	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 line elongate east-west trending valleys separated by the intervening sandstone ridges. 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. swallow holes, 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) where the main passages or 'galleries' have developed along north-south joints in the order of 1 to 6 metres apart (Wright 1979). One natural karst feature is known in this GWB - Shanbally Cave (1705NWK002); and karstification was also recorded in at least one of the boreholes at the Pfizer site (1705NWK001). Other features may be obscured by subsoils. Most data for this GWB come from water well drilling at the Pfizer site in the 1970s, where several high-yielding wells were drilled. Transmissivity in the pure unbedded limestones can range up to a few thousand m^2/d. Pumping tests in the same rock type in the Cloyne GWB to the east of this body gave a range of transmissivity of 200 to over 2000 m^2/day, and 900 - 13,000 m^2/d for a water supply borehole near Dungarvan, Co Waterford (Dungarvan GWB, SERBD). Groundwater gradients within the pure unbedded limestones are low, around 0.001-0.002. (Wright & Gately 2002). Springs in the pure unbedded limestone range in size from small to large, but have reliable discharges. The pure bedded limestones are also highly productive although less evidence of extensive karstification is currently recorded. In the impure limestones, transmissivities are lower; they will generally be in the range 5-20 m^2/d but may be higher where karstification has occurred. Storativity is low in all aquifers.
	Thickness	The Dinantian Pure Unbedded Limestones (Waulsortian Limestone) are at least 600m 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 which intersect major zones of fissuring at depth have been observed in Waulsortian Limestone at Cloyne, Co Cork (Cloyne GWB), where a major zone of fissuring occurs at approximately 41m below ground level, i.e. approximately 20m below O.D and at Ringaskiddy (this GWB), where major water inflows occur down to 40m below O.D (Wright, 1979). In the past sea level is estimated to have been approximately 50-60m below present day O.D., 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. In the Impure Limestones that occur at the margins of this GWB, most groundwater flow occurs in an upper weathered layer of a few metres and a zone of interconnected fissures often not extending more than 15 m from the top of the rock, although occasional deep inflows associated with major faults can be encountered. Impure limestones are also much less susceptible to karstification.

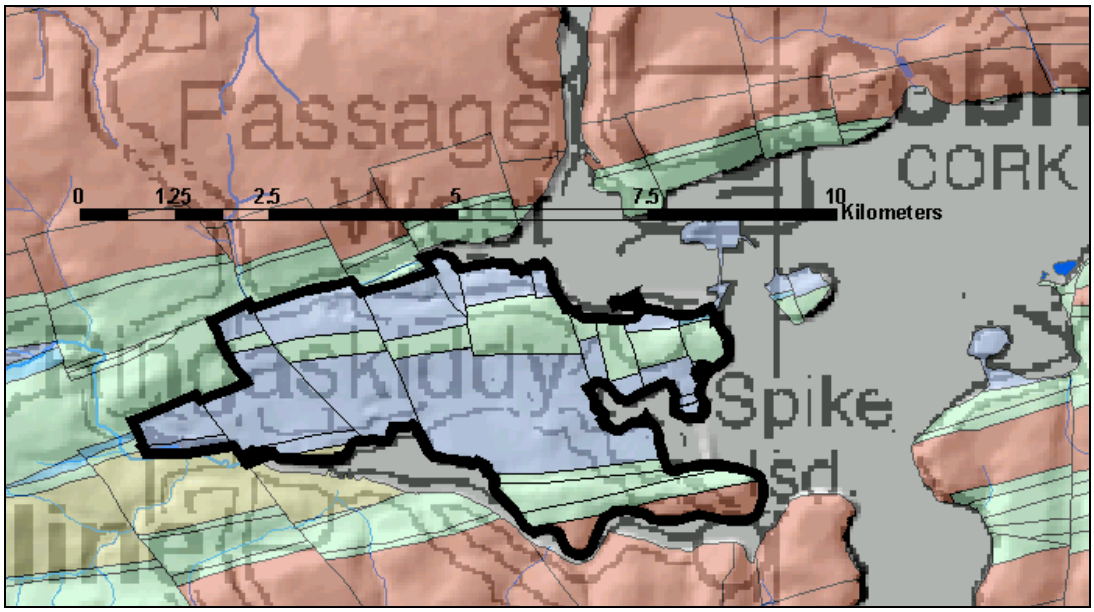
Overlying Strata	**Lithologies**	*Subsoil Types identified in Ringaskiddy GWB by Teagasc Parent Material Mapping (Draft): Alluvium (A); Marine sands and gravels (MGs); Made Ground (Made); Estuarine sediments (silts/clays) (Mesc); Rock outcrop and rock close to surface (Rck); Till – Devonian Carboniferous Sandstone and Shale Till (TDCSsS); Devonian Sandstone Till (TDSs), Limestone Till (TLs).* This GWB is primarily covered by glacial till of variable depth. There are also significant areas of 'made ground', i.e. urban and/or industrial areas.
	Thickness	There are many areas within this GWB with subsoils of <3m where rock outcrop is common. Elsewhere subsoil depths appear to be generally <5m, but isolated points of deeper subsoil occur – in some cases this may be due to buried karst features. Subsoil depths can therefore be highly variable within short distances.
	% area aquifer near surface	*High*
	Vulnerability	This GWB has predominantly Extreme Vulnerability, the remaining area is of High Vulnerability.
Recharge	**Main recharge mechanisms**	The sandstone ridges to the north and south of this GWB (Ballinhassig GWB), provide abundant runoff which augments recharge to the limestone aquifer in the valley. A small volume of groundwater may cross as through-flow from the sandstones into this GWB. In the GWB itself both point and diffuse recharge will occur. Swallow holes and collapse features may provide access for point recharge to the karstified aquifer. Diffuse recharge will occur over the entire GWB via rainfall percolating through the subsoil. The general lack of surface drainage indicates that potential recharge readily percolates into the groundwater system. In this highly productive aquifer there are some low-lying areas with a high water table, where a proportion of the effective rainfall is rejected due to lack of storage space in the aquifer. The generally 'moderate' permeability tills will generally not restrict percolation of recharge. However, the extent of paved ground and sewered areas, coupled with an extended coastline/estuary, will combine to increase rapid surface runoff.
	Est. recharge rates	*To be assessed.*
Discharge	**Large springs and high yielding wells (m^3/d)**	*Note: The following data needs to be checked and updated by RBD Project Consultants.* Data from GSI Well Database: Excellent BHs Shanbally – 3 BHs in Pfizer chemical plant (632 m^3/d),(802 m/3), (>400 m^3/d) Good BHs Ringaskiddy East (>100 m^3/d) Curraghbinny (273 m^3/d) Additional data from EPA Groundwater Sources List:
	Main discharge mechanisms	Groundwater discharges to the rivers and streams crossing the GWB, and to the sea in Cork Harbour.
	Hydrochemical Signature	The groundwater in this body is dominated by calcium and bicarbonate ions. Hardness can range from moderately hard to very hard (200 mg/l 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 $CaCO_3$). Alkalinity is generally less than hardness, indicating that ion exchange (where calcium or magnesium are replaced by sodium) is not significant. These hydrochemical signatures are characteristic of clean limestone. Like hardness and alkalinity, electrical conductivities (EC) can vary greatly. Typical limestone water conductivities are of the order of 500 - 700 µS/cm. 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 normal filtering and protective action of the subsoil is often bypassed in karstic aquifers due to the number of swallow holes, dolines and large areas of shallow rock. The hydrochemical signature of groundwater should be similar to that in the nearby Cloyne GWB.

Groundwater Flow Paths	These rocks have no intergranular permeability. Groundwater flow occurs in the 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). Groundwater in this GWB is generally unconfined. Groundwater flow paths will be limited by the small extent of the GWB, and may be significantly shorter in areas where the water table is very close to the surface. Regional groundwater flow is towards the rivers draining the valley, and to the sea in the east.
Groundwater & Surface water interactions	The nature of the karstic system can lead 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, and to the sea.

Conceptual model	• This GWB occupies the floor of a small east-west trending valley in south Cork. The body is generally flat to gently undulating (2-55 m OD) with ground elevation at centre of the valley generally higher than at the valley margins. • The GWB is bounded to the north, west and south by the contact with the low permeability sandstones and mudstones of the Ballinhassig GWB. It is bounded to the east by Cork Harbour • The GWB is composed mainly of diffusely karstified, highly permeable pure limestones with a narrow underlying layer of less permeable impure limestone around the margins of the body. To the north and south of the body are ridges of low permeability sandstones. • The regional structural deformation that created the characteristic South Munster sandstone ridge (anticline)-limestone valley (syncline) topography was accompanied by intense fracturing and high frequency jointing (N-S jointing dominates) within the limestone synclines. Subsequent karstification of these openings has significantly enhanced the permeability of the pure limestones. Karst features are known in this GWB. Karstification is known to extend well below present sea levels, and is estimated to extend to depths of 50 to 60 m below O.D. Malin Head. • Groundwater flows through the 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 where there are two components to groundwater flow. Groundwater flows through interconnected, solutionally enlarged conduits and cave systems that are controlled by structural deformation (influence of N-S jointing). In addition there is a more dispersed slow groundwater flow component in smaller fractures and joints outside the larger conduits. Generally this connected fractured zone extends to about 30 mbgl in pure limestones, however in the pure limestones of South Munster, deep inflows from major zones of fissuring have been encountered to 40-50 mbgl. • Groundwater in this body is unconfined. The water table is generally less than 10 metres below the surface with an average annual fluctuation up to 6 metres. Groundwater gradients are very flat in the permeable limestones (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 rivers draining the valley and ultimately to the sea in the east and the surface water channels to the west and south west of the body. • Recharge to this GWB is both point and diffuse. The ridges to the north and south of this GWB provide runoff which supplies recharge to the limestone aquifer in the valley. Diffuse recharge will occur over the entire GWB via rainfall percolating through the subsoil. The lack of surface drainage in this GWB indicates that potential recharge readily percolates into the groundwater system. A very small volume of groundwater may cross as through-flow into this GWB from the adjacent low transmissivity GWB. • There are many areas of Extreme Vulnerability within this GWB. Outside areas of Extreme Vulnerability the remainder of the body is generally of High vulnerability, there are areas of Moderate Vulnerability due to the presence of > 5 m 'low' permeability subsoils. 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. • There is a high degree of interaction between surface water and groundwater in this GWB. Swallow holes and caves receive surface water, and groundwater is discharged to surface as springs or as baseflow to rivers crossing the GWB, and to the sea.
Attachments	
Instrumentation	**Stream gauges:** none **EPA Water Level Monitoring boreholes:** none **EPA Representative Monitoring points:** none

Information Sources	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 Farrington A (1959) The Lee Basin Part one: glaciation. Proc. R. Ir. Acad. 60B (3), 135-166. Wright GR (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.
Disclaimer	Note that all calculation and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae

Ringaskiddy GWB (For Reference)



List of Rock units in Ringaskiddy GWB

Rock unit name and code	Description	Rock unit group	Aquifer Classification
White Strand Formation (WS)	Sandstone & interbedded pyritic mudstone	Namurian Sandstones	Ll
Pigs Cove Member (KNpc)	Sand-lensed mudstone	Dinantian Mudstones and Sandstones (Cork Group)	Ll
Cuskinny Member (KNcu)	Flaser-bedded sandstone & mudstone	Dinantian Mudstones and Sandstones (Cork Group)	Ll
Old Head Sandstone Formation (OH)	Flaser-bedded sandstone & minor mudstone	Dinantian Mudstones and Sandstones (Cork Group)	Ll
Little Island Formation (LI)	Massive and crinoidal fine limestone	Dinantian Pure Unbedded Limestones	Lk
Loughbeg Formation (LB)	Cherty calcareous mudstone & limestone	Dinantian Pure Unbedded Limestones	Lk
Waulsortian Limestones (WA)	Massive unbedded fine-grained limestone	Dinantian Pure Unbedded Limestones	Lk
Ballysteen Formation (BA)	Fossiliferous dark-grey muddy limestone	Dinantian Lower Impure Limestones	Ll
Ballyknock Member (Gybn)	Green sandstone, siltstone & mudstone	Devonian Old Red Sandstones	Ll