Tourig Group GWB: Summary of Initial Characterisation.

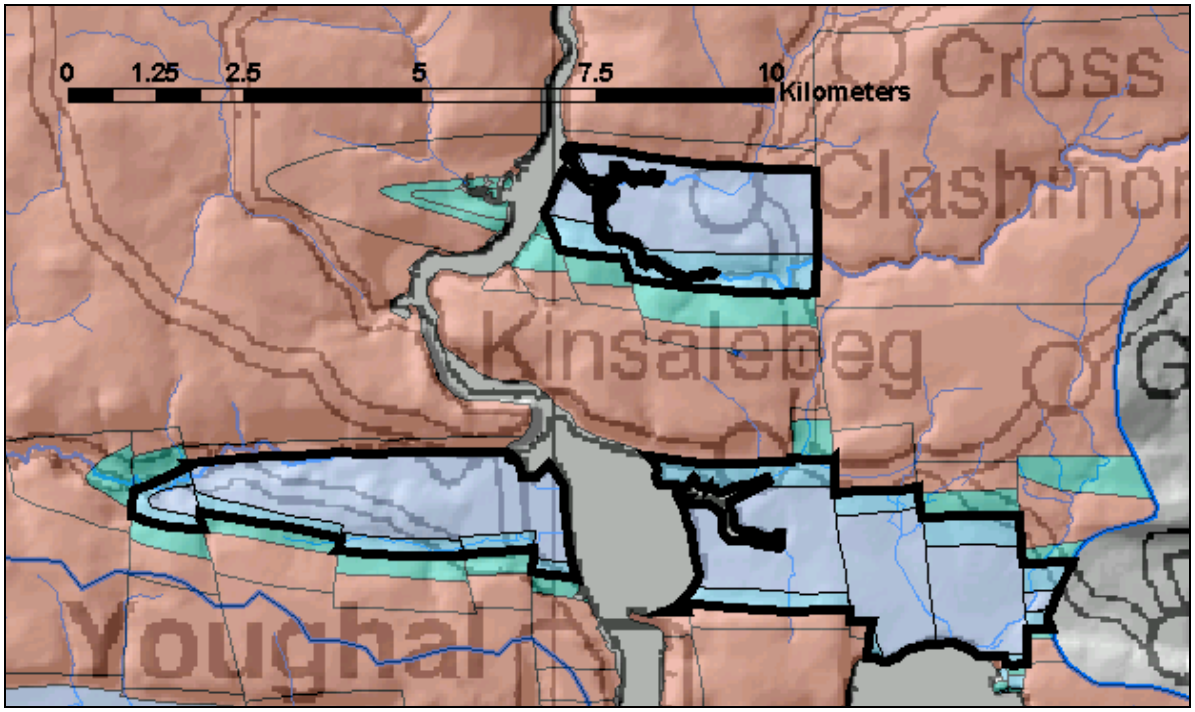
Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
18 Cork Co. Co. Waterford Co. Co.	**Rivers:**.Tourig, Licky, small unnamed streams **Lakes:** None	Blackwater River and Estuary (000072)	Total 46 km^2 (12 km^2, 14 km^2, 20 km^2)

Topography	This GWB groups together the limestone aquifers in three small east-west trending valleys in east Cork (Tourig Valley) and west Waterford (Clashmore/Licky Valley and Ardmore Syncline). The valleys are bounded to the north and south by parallel east-west trending sandstone ridges of the Glenville GWB. The valley floors are generally flat to gently undulating, with ground elevations range from 2–30 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.	
Geology and Aquifers	**Aquifer categories**	The main aquifer category in this GWB group is: **Rkd**: Regionally important karstified aquifer dominated by diffuse flow (73%). A narrow area around the margins of the three GWB sections has an aquifer category of: **Ll:** Locally important aquifer which is moderately productive only in local zones (27%)
	Main aquifer lithologies	The main aquifer lithology in this GWB is Dinantian Pure Unbedded Limestones (Waulsortian Limestone Formation) (73%). A narrow area (6 km^2 in total) around the margins of the three GWB sections is composed of Dinantian Lower Impure Limestones (27%).
	Key structures	During the Variscan Orogeny (mountain building episode), rocks in the South Munster region 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 the South Munster region are highly productive. Faults and joints were enlarged by karstification as groundwater moved through the limestones. 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). Transmissivity in the pure unbedded limestones can range up to a few thousand m^2/d. Groundwater gradients within the pure unbedded limestones are low, around 0.001-0.002. (Wright & Gately 2002). In the impure limestones, transmissivities are lower, generally 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 (Carrigaline 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 Tourig Group GWB Teagasc Parent Material Mapping (Draft): Alluvium (A); Karstified limestone bedrock at surface (KaRck); Lake sediments undifferentiated (L); Made Ground (Made); Beach/raised beach sand (Mbs); Estuarine sediments (silts/clays) (Mesc); Rock outcrop and rock close to surface (Rck); Till – Devonian Sandstone Till (TDSs), Limestone Till (TLs).* This GWB is primarily covered by glacial till, probably of generally 'moderate' permeability. Some areas of rock outcrop and shallow rock occur in this GWB.
	Thickness	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 significant areas of Extreme Vulnerability, especially along the streams. Elsewhere, vulnerability is mostly 'High', with an area of 'Moderate' in the centre of the Ardmore Syncline.
Recharge	**Main recharge mechanisms**	The sandstone ridges to the north and south of this GWB (Glenville GWB), provide abundant runoff which supplements recharge to the limestone aquifer in the valleys. A little groundwater may cross as through-flow from the sandstones into this GWB. In the GWB itself both point and diffuse recharge will occur. Diffuse recharge will occur over the entire GWB via rainfall percolating through the subsoil. The lack of surface drainage in several parts of this GWB indicates that potential recharge readily percolates into the groundwater system. In some 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 will probably show a rapid response to recharge. The subsoils will probably not restrict recharge.
	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: Rath BH (218 m^3/d) – 2007SWW107 Additional data from EPA Groundwater Sources List:
	Main discharge mechanisms	Groundwater discharges to springs within the GWB and to the rivers and streams crossing the GWB. Rivers overlying the limestones in the South Munster Synclines have relatively high dry weather flows representing contributions from the underlying aquifer.
	Hydrochemical Signature	Data are sparse. 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 $CaCO_3$). The hydrochemical signatures are characteristic of clean limestone. Like hardness and alkalinity, electrical conductivity (EC) can vary greatly. Typical limestone water conductivity is 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.
Groundwater Flow Paths		These rocks have no 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). Hydrographs in east Cork show annual fluctuation of water levels in the limestone of about 3-5 metres. Groundwater in this GWB is generally unconfined. The highly permeable aquifer supports a regional-scale flow system, though limited by the extent of the bodies. Groundwater flow paths can be up to a kilometre or so long, but 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, to the sea in the east and to surface water channels to the west and south west of the body. The limestones in this body may be overlain by 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. Near the coast, tidal effects may be experienced in boreholes or springs, and brackish water may be encountered.

Conceptual model	• This GWB occupies the floor of three east west trending valleys in east Cork and west Waterford. The body is generally flat to gently undulating (2-30 mAOD). • The GWB is bounded to the north and south by the contact with the low permeability sandstones and mudstones of the Glenville GWB. It is also bounded by the Blackwater Estuary. • 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 not recorded in this GWB but may occur beneath the subsoil. 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 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 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 bedded limestones of the South Munster region, 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 may be up to a kilometre or so 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 Blackwater Estuary. • 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 much of this GWB indicates that potential recharge readily percolates into the groundwater system. A relatively small volume of groundwater may cross as through-flow into this GWB from the adjacent low transmissivity GWB. • There are significant areas of Extreme Vulnerability within this GWB, particularly along the streams. Elsewhere the remainder of the body is generally of High or Moderate Vulnerability. In a 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. • The limestones in this body may be overlain by 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 may be 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 groundwater body.
Attachments	None
Instrumentation	**Stream gauges:** 18046* * Adjusted Dry Water Flow available. **EPA Water Level Monitoring boreholes:** None **EPA Representative Monitoring points:** None
Information Sources	Hudson M, Daly D, Johnston P, Duffy S (1998) *County Waterford Groundwater Protection Scheme*. Main Report. Final report to Waterford County Council. Geological Survey of Ireland 87pp Kelly D, Leader U, Wright G (2002) *South Cork Groundwater Protection Scheme*. Main Report. Final Report to South Cork County Council. Geological Survey of Ireland. Sleeman AG, McConnell B (1995). Geology of East Cork - Waterford. A geological description of East Cork, Waterford and adjoining parts of Tipperary and Limerick, to accompany the Bedrock Geology 1:100,000 scale map series, Sheet 22, East Cork - Waterford. Geological Survey of Ireland. 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.
Disclaimer	Note that all calculation and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae

Tourig Group GWB (For Reference)



List of Rock units in Tourig Group GWB

Rock unit name and code	Description	Rock unit group	Aquifer Classification
Waulsortian Limestones (WA)	Massive unbedded fine-grained limestone	Dinantian Pure Unbedded Limestones	Rk^{d}
Ballysteen Formation (BA)	Fossiliferous dark-grey muddy limestone	Dinantian Lower Impure Limestones	Ll