CAPPOQUIN PUBLIC SUPPLY

GROUNDWATER SOURCE PROTECTION ZONES

(DRAFT)

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CAPPOQUIN PUBLIC SUPPLY

1. SUMMARY OF WELL DETAILS

GSI no.	:	2009SWW046
Grid ref.	:	21149 09928
Owner	:	Waterford Co. Co.
Well type	:	Bored
Elevation (top of casing)	:	40.24 m OD (Poolbeg).
Depth	:	62.2 m
Depth of casing	:	unknown
Diameter	:	203 mm (8")
Depth-to-rock	:	Unknown, probably less than 10 m.
Static water level	:	32.74 m O.D. (7.5 m b.g.l.) on 1/9/92
Pumping water level	:	30.0 m O.D. (10.24 m b.g.l.) on 1/9/92
Drawdown	:	2.74 m on 1/9/92
Abstraction rate	:	710 m^3/d (6500 gal/hr)
Normal consumption	:	410 m^3/d (90,000 gal/d on average, over approx.14 hrs)

Pumping test summary:

(i) abstraction rate	: 687 m^3/d
(ii) specific capacity	: 160 m^3/d/m (drawdown extrapolated to 1 week)
(iii) transmissivity	: 160 - 170 m^2/d

2. METHODOLOGY

There were three stages involved in assessing the area, a detailed desk study, site visits and fieldwork, and analysis of the data. The desk study was conducted in the Geological Survey where the subsoil and bedrock geologies were compiled from the original 6" field sheets. Basic public supply well details were recorded by County Council personnel in the form of a questionnaire which included precise locations and any relevant borehole, chemistry and pumping test data available.

The second stage comprised site visits and fieldwork in the surrounding area. A three and a half hour recovery test was followed by a two hour pumping test in September 1992 in order to examine the aquifer characteristics. Subsequently, field work was carried out in the area encompassing a circle of 1 km radius in order to examine subsoil and bedrock geology, hydrogeology, vulnerability to pollution and current pollution loading. Finally, two raw water samples were taken in September 1992 and June 1993 for full suites of chemical and bacterial analyses.

Stage three, the assessment stage, utilised analytical equations, hydrogeological mapping and groundwater modelling to delineate protection zones.

3. WELL LOCATION AND SITE DESCRIPTION

The source is the main public supply well for Cappoquin and it is located 1 km east of Cappoquin, near the Cappoquin Monument intersection (Figure 1). The well is in front of a small pumphouse and a small area around the pumphouse is paved and fenced off.

4. TOPOGRAPHY, SURFACE HYDROLOGY AND LAND USE

The well lies near the base of a northwest-southeast trending ridge which rises up to 125 m O.D. immediately to the north-west of the well. Further to the north and north-west (2-3 km), the land rises above 180 m O.D.

The well is located 200 m to the north and 400 m to the west of the Glenshelane River which flows southwards then westwards into the River Blackwater (immediately to the south of Cappoquin). Several springs and small streams can be observed 500m - 1km to the north of the supply. These are assumed to be seasonal.

The land use in the area is primarily grazing, however several arable fields are located to the north and south of the well.

5. GEOLOGY

5.1 Bedrock geology

The public supply is located in the Kiltorcan Formation. The formation consists predominantly of yellow sandstones, with minor mudstone units. Outcrops occur in the Glenshelane River valley to the east of the well and also behind the disused house 200 m to the north east of the well.The thickness of bedding ranges from 10 to 20 cm and the beds dip steeply to the south (between 60 and 80º). The outcrops to the north-east of the well have a significant network of open joints and bedding planes. The Knockmealdown Formation occurs to the north of the Kiltorcan Formation and is composed predominantly of coarse purple sandstones, with siltstones and mudstones. Immediately to the south of the well the Kiltorcan is overlain by Lower Carboniferous shales and limestones which are inturn overlain by the Waulsortion mudbank limestone. Several faults (approx. north-south trending) are present in the general area (Figure 1) . The faults nearest to the well are located to the west, through Cappoquin, and to the east of the well along the River Glenshelane.

5.2 Quaternary (subsoils) geology

The subsoils in the area surrounding the well are poorly exposed. Quaternary mapping in the general area suggests that upland areas are covered with a sandstone till. The till has been described elsewhere in Waterford as red - brown in colour with a sandy matrix and poorly sorted subangular to subrounded mudstone clasts (the Ballyvoyle Member). Alluvium is present along the river valleys, particularly in low lying areas. Sand and gravel is present within the alluvium. This is indicated by a borehole record from the disused bacon factory adjacent to the River Blackwater in Cappoquin which penetrated 39 m of sand and gravel. The subsoils are shown in Figure 2.

5.3 Depth-to-rock

Rock outcrops are only visible in the Glenshelane River valley to the north-east of the well and in small stream valleys to the north-west of Cappoquin. Quaternary mapping in the general area suggests that the thickness of the sandstone till covering the upland areas is less than 10 m thick. The alluvium and sand and gravel deposits are likely to be over 10 m thick in places, particularly along the River Blackwater. Outcrops and proposed depth to bedrock contours are shown on Figure 2. The depth-to-rock has been contoured for ease of incorporation into the vulnerability map but it is based on few data points and may need refining as further borehole records become available.

6. HYDROGEOLOGY

6.1 Data availability

Hydrogeological data for the area around Cappoquin are poor. A brief well survey was conducted during the site visit on the 27/2/96, however only one water level could be found in the area around the public supply. A 3.5 hour recovery test was followed by a 2 hour pumping test in September 1992. A longer test would have been preferable.

6.2 Groundwater levels

Groundwater levels in the area are variable, depending on the time of year. The static water level in the public supply on the 1/9/92 was 32.74 m O.D. (7.5 m b.g.l.). It was not possible to measure the water level in the public supply during the second visit due to problems in getting the dipper past an obstruction in the well. The static water level in a well (of unknown depth) 200 m to the north-east of the public supply was approximately 58.0 m O.D.(5.5 m b.g.l.) on 26/2/96. Modelling suggests that this water level may represent a perched water table. The level of the river Glenshelane immediately south of the well is approx. 13.5 m below the static water level in the well (19.24 m O.D.).

6.3 Groundwater flow directions and gradients

Groundwater flow to the well is likely to be dominated by flow from the hill immediately to the north east which acts as a recharge mound. Due to the lack of groundwater level data it is not possible to obtain an accurate groundwater gradient. The groundwater gradient is likely to be flatter within the more permeable Kiltorcan formation and relatively steep in the less permeable Kilmacthomas and Carboniferous formations. Numerical modelling suggests that gradients for the Kiltorcan range from 0.03 to 0.08. Gradients for the lower permeability units range from 0.08 to 0.15. The variable groundwater gradients are a reflection of significant differences in permeability.

6.4 Meteorology and recharge

Rainfall data for the area are taken from a contoured rainfall map of Waterford (Duffy, 1994) based on data from the Meteorological Service. For the years 1951 - 1980 the mean annual rainfall for the area was 1200 mm. Evaporation data for the area are taken from a national contoured map as recorded by the Meteorological Service. Potential evapotranspiration (P.E.) is estimated as 510 mm/yr. Actual evapotranspiration (A.E.) is then calculated by taking 95% of the potential figure, to allow for soil moisture deficits for part of the year, so A.E. is estimated as 485 mm/yr. Using these figures the effective rainfall (E.R.) is taken to be approximately 715 mm/yr.

The permeability of the bedrock is variable over the area to the north of the well with the Kiltorcan sandstones having a higher permeability than the Knockmealdown sandstones, however only a few outcrops are visible to the north-east of the well. The sandstone till is considered to be moderately permeable and less than 10 metres thick. Topography is steep in the vicinity of the well and general drainage of the land appears to be moderate/good. Although the proportion of effective rainfall infiltrating to the water table is not known with certainty, it is assumed that 75% is a realistic estimate, consequently the actual annual recharge in the area is therefore approximately 535 mm.

These calculations are summarised below:

Average annual rainfall	1200 mm
Estimated P.E.	510 mm

Estimated A.E. (95% P.E.)	485 mm
Effective rainfall	715 mm
Recharge (75% E.R.)	535 mm

6.5 Hydrochemistry and water quality

Two raw water samples were taken for chemical and bacterial analysis. The hydrochemical analyses indicate a **'moderately soft'** water (71 - 75 mg/l $CaCO_3$) with a relatively low alkalinity (39 -43 mg/l $CaCO_3$). Conductivities were also relatively low (155 - 195 µS/cm). All the major cations, anions and trace elements are within EC limits, however levels of nitrate (29 - 42 mg/l) were higher than the expected background (approx. 5 mg/l). No comprehensive well head analyses were performed, however the temperature and conductivity of the groundwater measured on 27/2/96 were 10.5°C and 210 µS/cm.

6.6 Aquifer coefficients

The pumping test analyses provided transmissivities of 170 m²/d from the 2 hour pumping test and 157 m²/d from the 3.5 hour recovery test. A value of 160 m²/d is taken as the most reasonable figure.

The specific capacity calculated from the pumping test was 258 m³/d/m after 2 hours pumping (steady drawdown in the well had not been reached at this stage). When drawdown data was extrapolated to 1 week a value of specific capacity of 160 m³/d/m was obtained. More comprehensive pumping tests would be needed to confirm the sustainable maximum yield of the supply.

6.7 Conceptual model

The aquifer feeding the Cappoquin source is primarily the Kiltorcan Formation, but also includes the Kilmacthomas Formation to the north. These units are overlain by 0 to 10 metres of sandy till that is moderately permeable, therefore the aquifers can be considered to be unconfined. Although the sandstones within the Kiltorcan Formation are sometimes slightly friable and may have a minor component of intergranular porosity, outcrops to the north of the well are compact. Permeability is therefore considered to be entirely secondary (through joints and fissures).

Groundwater flow is influenced by topography and a groundwater recharge mound is present to the north/north-west of the supply. The general groundwater flow direction in the vicinity of the well is therefore south and south-eastwards towards the River Glenshelane. This is supported by the available groundwater level data and by numerical modelling. Modelling also suggests that there is a northwest to southeast component of groundwater flow, within the more permeable Kiltorcan Formation in the area around Cappoquin, towards the River Blackwater.

A groundwater divide is assumed to coincide with the topographic divide which is present to the north and northwest of the well (Figure 4). Ideally groundwater level data would be needed to confirm this.

It is assumed that the faults to the east and west do not affect groundwater flow in the vicinity of the well, however it is possible that the low drawdown in the well and the high transmissivity derived from the pumping test may be the result of a high permeability zone along a fault which is not apparent from surface exposures.

6.8 Aquifer category

The Kiltorcan Formation is classed as a **Regionally Important** aquifer where fissure flow is dominant. The Kilmacthomas Formation is a **Locally Important** aquifer which is moderately productive only in local zones.

7. VULNERABILITY

The source at Cappoquin is regarded as being high to extremely vulnerable to pollution. The sandy tills are moderately permeable and less than 10 m thick throughout most of the area. The alluvium deposits along the Glenshelane and Blackwater rivers are considered extremely vulnerable to pollution as these deposits include river gravels. The thickness and distribution of the gravels is generally unknown, however there is evidence to suggest that gravel forms a significant deposit along the River Blackwater (Figure 2).

Vulnerability is shown in Figure 3.

8. DELINEATION OF SOURCE PROTECTION AREAS

8.1 Outer protection area

The Outer Protection Area (SO) includes the complete catchment area to the source, i.e. the zone of contribution (ZOC), and it is delineated as the area required to support an abstraction from long-term recharge. The ZOC is delineated by the following:

i) By calculating an area required to provide the abstraction, using the average recharge and the pumping rate.

ii) Numerical modelling and hydrogeological mapping techniques.

iii) Encorporating a safety margin, if considered advisable, to allow for errors in the estimation of groundwater flow direction

Taking the average annual recharge to be 535 mm as previously indicated, the area required to supply an increased pumping rate of 615 m^3/d, is calculated to be 0.42 km^2 (the pumping rate is increased to take account of enlargement of the ZOC in dry weather and any potential increases in discharge). This is equivalent to a circular area with a radius of 365 m.

The most accurate ZOC at Cappoquin is derived from numerical modelling of the groundwater system together with hydrogeological mapping techniques. The ZOC is controlled primarily by the groundwater flow direction and by the recharge mound to the north and north east. The proposed ZOC extends over the groundwater divide as the groundwater divide may be drawn back as a result of pumping.

The parameters used in modelling the source are listed below:

Discharge	615 m^3/d
Aquifer thickness	55 m

Hydraulic conductivity		
	Kiltorcan	2 m/d
	Other formations	0.07 m/d
Effective porosity		
	Kiltorcan	0.025
	Other formations	0.01
Recharge		535 mm/yr

A buffer (safety margin) is included in the final zone of contribution (where appropriate), by incorporating a ±20% error margin in the estimated groundwater flow direction. The zone of contribution is shown in Figure 4.

8.2 Inner protection area

The Inner Protection Area (SI) is the area defined by a 100 day time of travel from a point below the water table to the source and it is delineated to protect against the effects of potentially contaminating activities which may have an immediate influence on water quality at the source, in particular from microbial contamination.

Numerical modelling was used to derive the 100 day time of travel zone which extends approximately 300 m upgradient of the well.

8.3 Source site

In addition to the Inner and Outer Areas there is a third protection area, the Source Site (SS), which is delineated as the area in the immediate vicinity of the source (minimum 10 m radius) in order to maintain good wellhead sanitary protection. The enclosure around the source at Cappoquin is designated the Source Site Area.

9. GROUNDWATER PROTECTION SCHEME

Combining the Source Protection Areas, as described above, with the vulnerability ratings produces three groundwater protection zones for the source at Cappoquin. These are listed here in order of decreasing degree of protection required and are shown in Figure 5 (with the exception of the Source Site):

- Source Site / High
- Inner Protection Area / High
- Outer Protection Area / High

It is not within the scope of this report to delineate the protection zones in the surrounding area and this is dealt with at the regional resource protection scale.

The accompanying code of practice imposing restrictions on developments will follow when discussions as to the degree of restriction necessary in each protection zone have been carried out between the Council, the EPA and the GSI.

10. POTENTIAL POLLUTION SOURCES

The current primary threat to the public supply at Cappoquin is the level of nitrate within the groundwater system, which is approaching the EC maximum allowable concentration (50 mg/l). The land to the north and north-west of the source is a combination of grassland and arable crops. It is likely that the nitrate is derived from the application of organic and/or inorganic fertilizer to the area around the well. The only possible point source of pollution within the ZOC is the house 200 m to the north-east of the well which may have a septic tank (the house was vacant on the 27/2/96). Other indicators of septic tank contamination were absent. The field immediately south-east of the well was covered in organic fertilizer at the time of the site visit on 27/2/96.

11. CONCLUSIONS AND RECOMMENDATIONS

Overall the source at Cappoquin is an excellent yielding well which is located in a regionally important aquifer. The test pumping indicates that the normal consumption of the well could be increased, although more comprehensive pumping tests would be needed to confirm the sustainable maximum yield of the supply. The area around the supply is high to extremely vulnerable to pollution. The water analyses showed elevated levels of nitrate, which is likely to be derived from the application of fertilizers to the surrounding land.

It is recommended that the Council monitor the raw water quality of the public supply regularly in order to check on the levels of nitrate in the groundwater. Further increases in the level of nitrate in the groundwater may require restrictions on the levels of fertilizer application within the ZOC.

12. ACKNOWLEDGEMENTS

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SCALE 6 Inches = 1 Mile

Public supply well

Geological Boundary

Fault Boundary

Dip of Bedding

FIG. 1 GEOLOGY

Knockmealdown Formation

Kiltorcan Formation

Lower Limestone Shale

Ballymartin Formation

Ballysteen Formation

SCALE 6 Inches = 1 Mile

Subsoil boundaries

Outcrop

3m Depth to Bedrock Contours

FIG. 2 SUBSOILS AND DEPTH TO BEDROCK

SCALE 6 Inches = 1 Mile

Vulnerability Boundary (Probable)

Outcrops (points of extreme vulnerability)

FIG. 3 VULNERABILITY

Probably High

Probably Extreme

Probably High

Probably High

Probably High

Probably Extreme

Probably High

Probably Extreme

Probably High

Probably Extreme

PARKNOE

TINNAGROUN

MONABREEKA

ALLNOE EAST

Boherboy Wood

BOHERBOY

KNOCKAUN EAST

TINTAU

KADDUAGA

LTEREBRIDGE

COOLNASMUTTAN

BOLQUIN DEMESNE

CAPPOQUIN

KILBEE EAST

LITTLEBRIDGE INCHES

DERRIHEEN

Bonla Bridge

Glenshelane

Knockaun Wood

Cappoquin Ho.

Aronmore Bridge

Kilbree House

Shillerbridge House

Glenribbeen Br.

St. Joseph's Convent

SHANBALLY

BELLE

Belleville Park

Derriheen House

Little Dr.

Bishop's Fishery

RAILWAYS

Level Crossing

Lackwater River

Zone of contribution (including buffer)

100 day time of travel zone

FIG.4 RECOMMENDED ZONE OF CONTRIBUTION AND 100 DAY TIME OF TRAVEL ZONE

SCALE 6 Inches = 1 Mile

SI/H	Inner Zone - High
SO/H	Outer Zone - High

FIG. 5 GROUNDWATER PROTECTION ZONES