# **BRUFF PUBLIC SUPPLY**

## **GROUNDWATER SOURCE PROTECTION ZONES**

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#### 1. SUMMARY OF WELL DETAILS

GSI no.	:	1413SEW090	1413SEW089
Reference name	:	Moloney's field	Sycamore Drive
Grid ref.	:	16262, 13682	16288, 13623
Owner	:	Limerick Co. Co.	Limerick Co. Co.
Well type	:	Borehole	Borehole
Elevation (Poolbeg)	:	76.71 m OD (top of casing)	73.37 m OD (top of casing)
Depth	:	122 m	unknown
Diameter	:	150 mm	203 mm
Depth-to-rock	:	3 m	3 m
Static water level	:	63.81 m OD (Nov. 1995)	unknown
Pumping water level (summer)	:	51.46 m OD (Oct. 1995)	unknown
Abstraction rate	:	378 m <sup>3</sup> /d (3,460 gal/hr)	220 m <sup>3</sup> /d (~2,000 gal/hr)
Total normal consumption	:	427 m <sup>3</sup> /d (over ~17 hours; both wells)	
Specific capacity	:	$\sim 30 \text{ m}^{3}/\text{d/m}$	

#### 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. The area encompassing a 1 km radius around the source was mapped with respect to subsoil and bedrock geology, hydrogeology and vulnerability to contamination. Raw water samples were taken in September 1993, April 1994 and March 1995 for full suites of chemical and bacterial analyses.

Stage three, the assessment stage, utilised a number of different methods including computer modelling (FLOWPATH), analytical equations and hydrogeological mapping to delineate the protection zones.

#### 3. WELL LOCATION AND SITE DESCRIPTION

There are two wells currently supplying water to the Bruff area. The first is situated in a field to the north of the village and it is referred to as the Moloney's field well. The second is located on Sycamore Drive in a housing estate in the village. The wellhead at the Moloney's field source is housed separately from the pumphouse and it is 1.2 m below ground level. The Sycamore Drive wellhead is not housed and it is covered by metal sheeting. Both sources are located in well maintained, fenced of enclosures, which are owned by the County Council.

## 4. TOPOGRAPHY, SURFACE HYDROLOGY AND LAND USE

The land around Bruff slopes gently in a westerly direction from a small hill to the east of the sources known as Bruff Hill (95 m OD; 312 ft), towards the lower lying areas of the River Maigue catchment. The Sycamore Drive source lies at a ground elevation of 74.4 m OD (244 ft) but there is a slight rise in topography in the vicinity of the Moloney's field source and it has a ground elevation of 77.91 m OD (256 ft).

The Morning Star River, a tributary of the River Maigue, trends through the village in a westnorthwesterly direction. A smaller stream rises to the east-northeast of the Moloney's field source and flows in a westerly direction around the small topographic mound to join the Morning Star River. Drainage is relatively good in the vicinity of both sources although it is difficult to objectively ascertain with the presence of the built up area.

The land is used primarily for grazing with the exception of the residential areas around the village.

## 5. GEOLOGY

#### 5.1 Bedrock geology

The bedrock geology of the area comprises grey and blue-grey limestones which are thickly bedded in places and are occassionally cherty. To the west of the Moloney's field source, an outcrop is described on the old 6 inch geology maps as being a dark grey-black slaty limestone. Rock crops out on Bruff Hill in a 'limestone pavement' fashion, indicating that severe solution has occurred at least in the upper few metres of rock. The rock samples taken were dark grey nodular fossiliferous (Brachiopods) limestones and they showed a lineation in an east-west direction; the solution has taken place along the same line. The beds are generally shallow dipping  $(10^\circ)$  to the north. The rocks are Lower Carboniferous in age and are part of the Ballysteen Limestones.

#### 5.2 Subsoils (Quaternary) geology

The subsoils in the area are predominantly clayey limestone tills. Alluvium is present along the course of the river and in the lower lying area to the northeast of the Moloney's field source around the stream. These deposits are likely to be composed primarily of fine silts judging by the overlying soil type (refer to next section), and the poor drainage associated with them (Fig. 1).

#### 5.3 Soils

The majority of the soils of the area are derived from a parent material of glacial drift origin, mainly limestone with some shale, sandstone and volcanics and they comprise one of the more common soil series in Limerick, the Elton grey-brown podzolics. These soils have formed over most of the free draining areas while to the northeast of the Moloney's field source, gleys of the Howardstown series are present. This latter soil type normally occurs in areas with low permeabilities or on wet ground and its presence is coincident with the alluvial deposits. The soils are shown on the published soils map of Co. Limerick (Finch and Ryan, 1966) and so are not reproduced here.

#### 5.4 Depth-to-rock

Bedrock is generally close to surface and crops out in the areas to the east and west of the sources. The depth-to-rock in both boreholes is recorded as approximately 3 m. A well located 455 m to the west of the Moloney's field source, along the road, has a recorded depth to solid rock as approximately 34 m. It is expected however, from the original record, that rock was first hit at 1 m, and that the rock was broken and fractured to 34 m. The depth-to-rock contours are based on few data points and may need refining as further borehole records become available (Fig. 1).

## 6. HYDROGEOLOGY

## 6.1 Data availability

Hydrogeological data for the Bruff area are relatively poor; the following data sources were used in considering the conceptual model:

- Results of a 1 hour recovery test which was carried out on the Moloney's field supply borehole in October 1995, as part of the study.
- Basic data from the County Council files dating back to 1979 when the first borehole was drilled; these include water quality analyses and results of a three-day yield test.
- Water levels taken in the stream and the river in October 1995, estimated from the nearest benchmark.
- GSI well records.

## 6.2 Groundwater levels

The static water levels taken in the Moloney's field source on 29/11/95, following overnight recovery, was 63.81 m OD (12.9 m below top of casing). A water level of 62.2 m OD was recorded in the well 455 m to the west, although the date of measurement is not known. It is reasonable to assume that both the stream and the river are in hydraulic continuity with groundwater; water levels in these are therefore taken to be representative of groundwater levels. A level of 63.7 m OD is estimated for the level of water in the river in October 1995, at the easterly bridge to the south of the village. The level in the stream at the bridge to the north of the sources was slightly higher at approximately 66.5 m OD. There are two further levels of 61 m OD estimated in the surface water courses where they cross the 200 ft contour to the west of the sources.

Wells located in the region of Bruff Hill are known to have water levels which are far below the surface suggesting that the unsaturated zone may be significantly large.

#### 6.3 Groundwater flow directions and gradients

The watertable is likely to be a subdued reflection of topography in the area; consequently, a groundwater mound is present in the area between the rivers and, in particular, in the vicinity of Bruff Hill. As the River Maigue will have a greater impact on water table than the streams to the north and east of Bruff Hill, the mound is likely to be further to the north than topography would suggest. Taking the various water levels from the Moloney's field source, the well 455 m to the west and the levels in the surface water courses at the contours, the groundwater gradient in the area is estimated to be in the region of 0.005–0.007.

## 6.4 Meteorology and recharge

Rainfall data for the area are taken from the local weather station in Bruff. Long-term mean annual rainfall for the years 1951–1980, as recorded by the Meteorological Service, was 881 mm. Potential evapotranspiration (P.E.) is estimated from a Meteorological Service regional contoured map, and a ranking scheme with all the other sources, as 480 mm per annum. Actual evapotranspiration (A.E.) is then calculated by taking 93% of the potential figure, to allow for soil moisture deficits during part of the year. Using these figures, the average annual effective rainfall (E.R.) is taken to be approximately 435 mm.

The subsoil deposits are relatively thin in the immediate vicinity of the sources, and there is an abundance of outcropping rock, in particular in the region of Bruff Hill. There are few surface drainage ditches and streams and it is therefore expected that, in the areas not covered by alluvium, a high proportion of effective rainfall will infiltrate. In contrast, there will be little recharge through the alluvium and there will be additional runoff as a consequence of the built up area and roads within the catchment area. Allowing for an average surface runoff for the area of 25%, recharge to the aquifer is estimated to be approximately 325 mm per annum.

These calculations are summarised below:

Average annual rainfall	881 mm
Estimated P.E.	480 mm
Estimated A.E. (93% P.E.)	446 mm
Effective rainfall	435 mm
Recharge (75% E.R.)	~325 mm

## 6.5 Hydrochemistry and water quality

The hydrochemical properties of the groundwater at Bruff are typical of a limestone aquifer in which carbonate dissolution is the dominant chemical process. The analyses indicate a **hard** to **very hard** (316–401 mg/l; CaCO<sub>3</sub>) calcium bicarbonate type water with relatively high alkalinity (292–339 mg/l; CaCO<sub>3</sub>). Conductivities are usually of the order of 700  $\mu$ S/cm but vary from 630–900  $\mu$ S/cm on occasion. Generally speaking the water in the Sycamore Drive source is slightly less hard than that in the Moloney's field source. The water in Sycamore Drive also has a high magnesium-calcium ratio, suggesting that dolomitisation may be influencing the hydrogeological regime. It may also however, be a consequence of contamination (see below).

The water quality in the Bruff sources requires some further investigation but from the limited available analyses of the raw water, it would appear that there is contamination occurring at times. A sample analysed by the Department of Pathology in the Regional Hospital, Limerick in December 1979, indicated the presence of *E. coli*. (20/100 ml). Chloride is significantly higher than background levels in the Moloney's source; a level of 65 mg/l was indicated by the Institute for Industrial Research and Standards in June 1975, and more recent County Council analyses show concentrations to be consistently higher than background, reaching 43 mg/l in August 1993. Nitrate is relatively low, and Manganese approached the EC MAC in January 1992 (44  $\mu$ g/l). Potassium is also considered to be slightly elevated at 3.5 mg/l in the Moloney's field source.

#### 6.6 Aquifer coefficients

The 1 hour recovery test at the Moloney's field source provided an estimate of transmissivity of approximately  $40 \text{ m}^2/\text{d}$ . The specific capacity was estimated at  $30 \text{ m}^3/\text{d/m}$ . (These values must be treated cautiously as the test was very short).

## 6.7 Conceptual model

The aquifer supplying the Bruff sources is the Ballysteen limestones. The permeabilities of these rocks have been increased by solution and weathering, and this is likely to have occured, in particular, in the top few metres of bedrock. Groundwater may also flow preferentially in an east-west direction along the widened fractures. The modelling excercise confirmed the recharge mound around the Bruff Hill area, from which groundwater radiates in all directions.

#### 6.8 Aquifer categories

Considering the Ballysteen Limestones in terms of well yields, specific capacities, lithology and structure over the county, they are classed as **locally important aquifers** which are **generally moderately productive only in local zones** (Ll). However, the information on well yields, the hydraulic gradients and the modelling (see section 8.1) suggest that permeabilities are relatively high and therefore a more appropriate classification for the Bruff area would be a **regionally important aquifer** (**Rf**) or, at worst, **locally important aquifer** which is generally **moderately productive** (**Lm**). As the boundaries of the high permeability area cannot be delineated, the Ll aquifer category is maintained on the regional aquifer map.

#### 7. VULNERABILITY

Using the GSI vulnerability mapping guidelines, the area around Bruff is generally regarded as being extreme to highly vulnerable to contamination, due the extent of outcropping rock and the generally thin subsoil cover (Fig. 2).

Most of the area, where rock comes close to surface, is mapped as having a **probably extreme** vulnerability. To the northwest of the Moloney's field source, the subsoils are slightly thicker and the vulnerability rating is lowered to **probably high**.

## 8. DELINEATION OF SOURCE PROTECTION AREAS

Source Protection Areas are delineated for a 50% higher output than the current abstraction (i.e.  $404 \text{ m}^3/\text{d}$  at the Moloney's field source and 237 m<sup>3</sup>/d at Sycamore Drive) to facilitate an increase in demand and to allow for expansion of the zone of contribution in dry weather.

#### 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 groundwater recharge.

The zone of contribution for the two Bruff public supplies were delineated using FLOWPATH, and they are primarily controlled by the groundwater divides and the recharge mound at Bruff Hill. (Fig. 3). The boundary conditions used in the model were as follows: (i) fixed heads along the river and the stream to the north, calculated using average river bed gradients; (ii) constant heads along the 200 m OD groundwater contour to the west of the sources; and (iii) a no-flow boundary along the groundwater divide to the east of the sources. The model was calibrated using the water level in the Moloney's field public supply well.

The data input was as follows:

Discharge	404 m <sup>3</sup> /d (Moloney's) and 237 m <sup>3</sup> /d (Sycamore Drive)
Bottom elevation	-40 m OD (aquifer thickness of 104 m)
Permeability	0.6 m/d
Porosity	0.015
Infiltration	0.0008904 m/d

A second simulation of the model was run to account for the possible east-west variation in permeabilities. The permeability in the x-direction was taken to be 0.9, while that in the Y-direction was 0.3 (the average permeability is therefore the same as taken in the first simulation). The delineated zone takes account of both.

Using the Recharge Equation, the estimated area required to collect enough recharge to sustain the increased discharge at the sources, on an annual basis, is in the region of  $0.45 \text{ km}^2$  at Moloney's field and  $0.26 \text{ km}^2$  at Sycamore Drive, equivalent to circular areas of radii 380 m and 290 m respectively. The delineated zones of contribution are slightly larger and therefore incorporate an additional safety margin.

#### 8.2 Inner Protection Area

The Inner Protection Area (SI) is the area defined by a 100-day time of travel from any 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 pollution. The particle tracking facility of the model was used to produce a 100-day travel time for each of the sources. The aquifer thickness was reduced to 60 m, as the full saturated thickness was not considered appropriate for the 100-day travel time calculations, and this gave an approximate upstream radius of 210 m at the Moloney's field source and 125 m at Sycamore Drive (Fig. 3).

## 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 sources (minimum 10 m radius), and is designed to maintain good wellhead sanitary protection. The fenced off enclosures around the Moloney's field source is adequate for the Source Site Areas, but the Sycamore Drive enclosure is a little too small.

## 9. GROUNDWATER PROTECTION SCHEME

Combining the Source Protection Areas, as described above, with the vulnerability ratings, delineates a total of six groundwater source protection zones for the Bruff sources. These are listed here in order of decreasing degree of protection required and are shown in Figure 4 (with the exception of the Source Sites):

•	Source Site / Extreme	(SS/E)
•	Source Site / High	(SS/H)
•	Inner Protection Area / Extreme	(SI/E)
•	Inner Protection Area / High	(SI/H)
•	Outer Protection Area / Extreme	(SO/E)

• Outer Protection Area / High (SO/H)

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 main threats to the water quality at the Bruff sources are the village, and in the case of the Moloney's field source, the farm in the adjacent field which is located less than 70 m to the south-southeast of the well. A large proportion of the zone of contribution extends under the residential area of the village and leaky sewers and/or septic tanks may be contributing to the slight contamination. In addition, the area on Bruff Hill where rock crops out is a point of rapid access to the aquifer for potential pollutants. During site visits this field was used for grazing and cattle tended to gather around the outcrops.

#### 11. CONCLUSIONS AND RECOMMENDATIONS

Overall the sources at Bruff are high yielding wells which may have some potential for further development if required. The vulnerability of the area however, is generally extreme to high, and this is reflected in the water quality which shows evidence that contamination is occurring at times.

It is recommended that the Council carry out more comprehensive water quality analyses on the raw water at each of the sources to help ascertain the cause of the contamination, in particular at the Moloney's field source. It is recommended that the Council control and monitor potentially contaminating activities in the area of the zone of contribution, in particular with respect to the farm management practices at Moloney's farm.







