BALLYAGRAN PUBLIC SUPPLY

GROUNDWATER SOURCE PROTECTION ZONES

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1. SUMMARY OF WELL DETAILS

GSI no.	: 1411NWW035
Grid ref.	: 14701 12808
Owner	: Limerick Co. Co.
Well type	: Borehole
Elevation (top of casing)	: 103.47 m OD (Poolbeg). Ground level is 104.38 m OD.
Depth	: 35.36 m
Depth of casing	: 17.37 m
Diameter	: 200 mm (8")
Depth-to-rock	: estimated to be between 13 and 16 m
Static water level	: 7.35 m below top of casing (96.12 m OD)
Pumping water level	: 18.13 m below top of casing (after 10 hrs continuous pumping)
Drawdown	: 10.78 m
Abstraction rate	: 1080 m^3/d (9,835 gal/hr)
Normal consumption	: ~450 m^3/d (97,700 gal/d on average, over ~10 hrs)
Specific capacity	: 90 m^3/d/m (pumping test data extrapolated to 1 week)

Pumping test summary:

(i) abstraction rate: 1073 m^3/d
(ii) specific capacity : 100 m^3/d/m (10 hours)
(iii) transmissivity: 105 m^2/d [94 – 196 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 a precise location and any relevant borehole, chemistry and pumping test data available.

The second stage comprised site visits and fieldwork in the surrounding area, including a pumping test which was carried out on the public supply well to examine the aquifer characteristics. The area encompassing a 1 km radius around the source was also mapped with regard to subsoil and bedrock geology, hydrogeology and vulnerability to contamination. Finally, two raw water samples were taken in September 1993 and April 1994 for full suites of chemical and bacterial analyses.

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

3. WELL LOCATION AND SITE DESCRIPTION

This source is the main public supply well for Ballyagran and the surrounding area and it is also referred to as the Castletown/Ballyagran or Drewscourt Supply. It is located to the east of the village, in a County Council owned enclosure which is surrounded by a wall and is very well maintained. The wellhead is located outside to

the rear of the pumphouse and it lies below ground level. The chamber above the wellhead is protected by way of removable concrete slabs which are slotted in and lie flush with ground level, but which are not locked.

4. TOPOGRAPHY, SURFACE HYDROLOGY AND LAND USE

Ballyagran lies to the south of the Corronoher ridge, at a height of approximately 100 m OD. The land surface dips gently to the south-southeast, eventually draining into the River Maigue. The ground is relatively flat and low-lying to the south of the village, while becoming more hummocky to the north.

The River Maigue flows in an easterly direction along the county border, collecting drainage from the many surface water courses in the general area. In particular there are two relatively major tributaries in the area of interest, one of which lies to the east, and the other to the west of the village.

Surface drainage is absent in the area to the immediate west of the source and is fairly sparse towards the north; the density of drainage ditches increases however, moving towards the south. There are also a number of isolated ponds dispersed amongst the hummocky terrain to the north. Small springs and seeps are numerous to the north and east of the village, and small streams from these trend in all directions to eventually drain into the River Maigue.

Excluding the village, the land is primarily used for grazing.

5. GEOLOGY

5.1 Bedrock geology

The geology of the area around Ballyagran is dominated by the presence of the west-east trending Rockhill anticline which lies to the east of the village (Fig. 1). The anticline is cored with Kiltorcan Sandstones and these are flanked by the shallow dipping (20°) Mellon House Beds (sandstones, siltstones, shales and limestones), Ringmoylan Shales and Ballysteen muddy limestones, respectively. The public supply borehole was drilled into the Kiltorcan Sandstones which are described from outcrop information further to the east, as coarse grey and yellowish grits, with thin flaggy grey and rusty grits, and shales.

5.2 Subsoils (Quaternary) geology

The subsoils present in the immediate vicinity of the source are limestone-dominated gravels, tills and till-with-gravel (Fig. 2). Pits are common in the gravel deposits and there are numerous sections as a result. They show primarily coarse sand grading into fine gravels, with larger rounded to sub-rounded clasts and a dominantly silty matrix. A sample taken in a deposit of till-with-gravel to the north of the site (Sample No. 931009; NGR 14662, 12878; Fig. 3) shows a poorly sorted sub-angular to sub-rounded cobble gravel, in a coarse sandy to gravelly, poorly sorted matrix. Two boreholes were drilled by the GSI (as part of the study) in till-with-gravel to the south of the source, on Door's farm (NGR 14668, 12742) and at the Co. Co. sewage works, and the deposits found in each were thin sandy units, interbedded with thicker stiff clayey bands. Limestone till is common further to the north, where it is overlain in places with peaty deposits and till-with-gravel.

The Ballyagran area lies within the extensive ice marginal deposits in Limerick which stretch from the foot of the Galty Mountains, through south Limerick, and up towards Foynes. The deposits are typically quite thick, reaching 40 m in places, and they comprise a mixture of sands and gravels, silty sands, various tills and stiff clays. With the extensive thicknesses and the chaotic depositional processes which are known to occur at the ice margin, it is inevitable that the deposits will vary with depth. In particular it is expected that there may be sandy gravelly lenses within the till, and clay-rich sediments within the till-with-gravel and the sand and gravel deposits.

5.3 Soils

Soils of the area are primarily derived from a parent material of glacial drift origin, mainly limestone with some sandstone, shale and volcanics, and they include members of two of the more common series in Limerick, the Howardstown gleys and the Elton grey brown podzolics. The gleys are found predominantly in the lower lying areas to the south of the source while the Elton podzolics are found on the more gravelly areas to the north and

east. There are also some areas further to the north where the brown earths of the Baggotstown series are present and these are derived from limestone-dominated glacial sands and gravels. The soils are shown on the published soils map of Co. Limerick (Finch and Ryan, 1966) and so are not reproduced.

5.4 Depth-to-rock

Rock crops out to the east of the source on the Rockhill anticline, indicating that rock is generally close to surface in that region although it is often overlain by a thin covering of limestone till. Depth-to-rock in the public supply borehole is estimated at between 13 and 16 m, based on the depth of casing, and thicknesses appear to increase moving southwards towards the river. A bore on Welsh's farm for example, approximately 670 m to the east of the creamery, was drilled through more than 33 m of till-with-gravel. The two GSI boreholes went to depths of approximately 11 m and 18 m without reaching bedrock. Deposits to the north are also quite thick; a depth-to-rock of more than 20 m is recorded at the borehole at Kilgobnet House. The depth-to-rock has been contoured for use in compiling the vulnerability map but it is based on relatively few data points and may need refining as further borehole records become available (Fig. 2).

6. HYDROGEOLOGY

6.1 Data availability

Hydrogeological data for the Ballyagran area are lacking; the following data sources were used in considering the conceptual model:

- Results of a 10 hour drawdown test with four hour recovery which was carried out on the public supply borehole in August 1993 as part of the study.
- Data from the County Council files dating back to 1976 when the borehole was drilled. These include a pumping test of more than 72 hours duration, during which the output and the depth of water over the pump (using a pressure gauge) were measured.
- A Geoex (a hydrogeological consulting firm) report dated 1975 which was commissioned by the County Council to find a suitable supply of water for the new housing scheme.
- GSI well records, although there are few of any significance in the immediate area.
- Drillers logs from the two GSI boreholes which were drilled as part of the study.

6.2 Groundwater levels

Groundwater levels are difficult to assess as there are few relevant data points. The static water level taken in the public supply well on 13/8/93, following overnight recovery, was 7.35 m below the top of casing (96.12 m OD). A borehole to the north of the site, at Kilgobnet House, has a recorded water level of 12.2 m b.g.l. (~97.5 m OD) but the date of measurement is not known. It is reasonable to assume that both of the relatively major streams are in hydraulic continuity with groundwater; water levels in the streams can therefore be taken as groundwater levels. This implies that the water level in the public supply well is more than 5 m higher than the stream to the east of the source. Most of the small springs, rises and isolated ponds in the area are likely to be perched.

6.3 Groundwater flow directions

Groundwater flow, from a regional perspective, is generally in a south-southeasterly direction towards the River Maigue. At a more local scale however, flow directions are likely to vary depending on topography, local streams and the hydraulic connection between the subsoils and bedrock. Local groundwater will generally flow towards the streams in all directions. This is of particular relevance to the north of the source, in the townland of Ballysalla, where local groundwater will flow northwards towards the area where the easterly stream rises. Similarly, groundwater in the area around Kilgobnet House will flow westwards towards the other major stream, and eastwards into Lough Portaghnagourt.

6.4 Meteorology and recharge

Rainfall data for the area are taken from the nearest, most representative weather station which is located in Kilmeedy, some 5.5 miles to the west. Mean annual rainfall, as recorded by the Meteorological Service, for the years 1941–1980 was 976 mm. Potential evapotranspiration (P.E.) is estimated from a regional Meteorological Service contoured map, and a ranking scheme with all the other sources, as 490 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 520 mm per annum.

The subsoil deposits to the north of the area, up-gradient of the source, do not appear from the surface drainage patterns to be particularly permeable. Even in the sand and gravel, and in the till-with-gravel areas there is surface water ponding occurring and the vegetation is often suggestive of permanently wet conditions. Despite this there is a relatively low density of surface water streams and infiltration must be occurring over the area. To the south of the source, the drainage ditch density increases and although recharge in these areas will be limited, they are not expected to be part of the zone of contribution. Recharge will occur most readily in the area to the east of the source where rock is close to the surface. An average value for runoff within the expected zone of contribution is estimated at approximately 30% of the effective rainfall implying that recharge to the aquifer is of the order of 365 mm per annum.

These calculations are summarised below:

Average annual rainfall	976 mm
Estimated P.E.	490 mm
Estimated A.E. (93% P.E.)	456 mm
Effective rainfall	520 mm
Recharge (70% E.R.)	~365 mm

6.5 Hydrochemistry and water quality

The hydrochemical analyses of groundwater at the source in Ballyagran are suggestive of a **hard** bicarbonate type water. The mean conductivity throughout the County Council analyses is 650 μS/cm, and the hardness from the State Laboratory analyses is in the region of 335 mg/l ($CaCO_3$) while the alkalinity is approximately 310 mg/l ($CaCO_3$). It must be noted that one of the analyses from the State Laboratory showed the groundwater to be much softer than the above and was more indicative of a sandstone-dominated water. Although there may have been a problem with that sample, further raw water analyses should be carried out to confirm the limestone signature.

The water quality in the Ballyagran Source appears to be reasonably good. Nitrate is generally low ranging from 9 to 11 mg/l (NO_3) and chloride is generally less than 30 mg/l. The September analysis from the State Laboratory showed a slightly elevated potassium level of 3.3 mg/l but as potassium may be naturally present in sandstones this is not thought to be cause for concern. Fluoride is often high at more than 0.9 mg/l.

6.6 Aquifer coefficients

The pumping test analyses provided transmissivities ranging from 94 to 196 m^2/d with 105 m^2/d appearing to be the best estimate. The test graphs did not indicate any major recharge or barrier boundaries and with the steady drawdown and the high specific capacity of 100 $m^3/d/m$ (10 hours), the borehole is capable of sustaining the required yield and more. (Note that a 1¼ inch diameter plastic pipe was inserted into the borehole for the pumping test to house the dipper to prevent it from becoming entangled in the wiring.)

6.7 Conceptual model

The permeabilities of the bedrock in the area are variable and are dependent largely on the rock lithologies. The sandstones will have a relatively high fissure permeability as they tend to fracture more readily than the more elastic shaley formations; the latter are, as a result, much less permeable. The Mellon House Beds have proven to have reasonable permeabilities in other areas in Limerick (e.g. Clouncagh) but the Ringmoylan Shales have a relatively low permeability. Due to the nature of the folding in the area, the Kiltorcan Sandstones and the Mellon House Beds are confined by the Ringmoylan Shales in all directions, except eastwards along the axis of the anticline.

The variability in the subsoils of the area also gives rise to a large range in permeabilities. The permeable sands and gravels will be highly transmissive, while the clayey tills will support little groundwater movement. Till-with-gravel deposits will have lateral discontinuities throughout and so although there are often clayey sediments present, it is probable that there will be hydraulic connection through the sand/gravel units.

The aquifer supplying the Ballyagran source is the Kiltorcan Sandstone. Recharge to the water table will occur through both the sandstones and the Mellon House Beds. The hydrochemical analyses would suggest that limestone dissolution processes are contributing to the groundwater characteristics and this is likely to be a consequence of recharge infiltrating through the limestone-dominated subsoils.

There is a slight possibility that some recharge to the Kiltorcan Sandstone aquifer is occurring in the Corronoher area, 3.5 km to the northwest of the source. The sandstones outcrop in this area at a height of 222 m OD, approximately 120 m higher than at Ballyagran. Recharge may flow, under confined conditions, beneath the Ringmoylan Shales to re-emerge at Ballyagran.

6.8 Aquifer categories

Considering the Kiltorcan Sandstones in terms of well yields, specific capacities, lithology and structure over the county, they are classed as a **regionally important aquifer** which is dominated by **fissure flow**. The Mellon House Beds and the Ballysteen Limestones are classed as **locally important aquifers** which are **generally moderately productive only in local zones**, while the Ringmoylan Shales are a **poor aquifer** which is **generally unproductive**. The gravels in the area are too small in areal extent to merit aquifer status.

7. VULNERABILITY

Using the GSI vulnerability mapping guidelines, the area around Ballyagran is regarded as being highly vulnerable to contamination, due the large expanses of high permeability sand and gravel and till-with-gravel in the immediate area of the supply (Fig. 4).

The area to the east of the source, where rock comes close to surface, is mapped as having a **probably extreme** vulnerability. Areas outside of this, where rock is 3–5 m below surface, have a **probably high** vulnerability, as do all areas where there are till-with-gravel and sand and gravel deposits. Limestone tills of 5–10 m in thickness are classed as having a **probably moderate** vulnerability, while greater than 10 m is **probably low**.

8. DELINEATION OF SOURCE PROTECTION AREAS

Source Protection Areas are delineated for a 50% higher output than the current abstraction (i.e. 675 m^3/d) 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 Ballyagran public supply is primarily controlled by the bedrock geology. It is delineated as the area within which recharge may occur and it is bounded by the contact between the Mellon House Beds and the Ringmoylan Shales (Fig. 5). An arbitrary 50 m safety margin is added to the northerly boundary of the area for the following reasons:

- there is poor geological control to the north of the source and the geological contacts may not be accurately located;
- it will allow for groundwater flow into the recharge area from the subsoils to the north;
- the surface water catchment boundary is located in this area; beyond this the shallow groundwater is expected to flow off in other directions.

The eastern boundary of the ZOC is more difficult to ascertain. The natural groundwater gradient would appear to have an easterly component towards the stream (refer to Section 6.3), so the eastern boundary of the ZOC will be controlled by the extent of the zone of influence of the public supply well, i.e. the area within which the water table is drawn down due to pumping. The lack of observation boreholes and more comprehensive hydrogeological investigations, however, means that mathematically delimiting the extent of this area is difficult. Groundwater flow is likely to mirror the surface water flow patterns and so it is assumed that the groundwater divide will be in the vicinity of the surface water divide. This is a conservative assumption and will delineate a larger area than the zone of influence requires with the current groundwater abstraction.

The Recharge Equation estimates that the area required to collect enough recharge to sustain the increased discharge at the source, on an annual basis, is in the region of 675000 m^2 (0.7 km^2), equivalent to a circular area of radius ~465 m. The area given by the geological boundaries and the surface water divide is slightly larger than this and will therefore incorporate an additional safety margin. (Any additional groundwater contributing from the Corronoher area will be protected via the resource protection scheme, and will have had sufficient residence time to have naturally diluted and/or attenuated any likely contaminants.)

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.

In view of the lack of definitive information on the hydraulic gradients, the Volumetric Flow Equation was considered to be more useful than the Time of Travel Equation. Taking the aquifer thickness as approximately 28 m, i.e. the saturated thickness in the borehole, and assigning a porosity value of 0.025, the 100 day time of travel radius, for the increased pumping rate, is calculated as approximately 175 m (Fig. 5). This radius will only be valid within the ZOC and so the shape of the area is amended accordingly.

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), and is designed to maintain good wellhead sanitary protection. The fenced off enclosure around the source at Ballyagran, which is owned by the County Council, is designated the Source Site Area.

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 Ballyagran source. These are listed here and are shown in Figure 6 (with the exception of the Source Site):

- Source Site / High SS – H
- Inner Protection Area / High SI – H
- Outer Protection Area / Extreme SO – E
- Outer Protection Area / High SO – H
- Outer Protection Area / Moderate SO – M
- Outer Protection Area / Low SO – L

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 and the EPA, with assistance from the GSI.

10. POTENTIAL POLLUTION SOURCES

Of particular note is the pond behind the Council houses which lies at the boundary of the ZOC; when the site was visited during the summer of 1993, it was being used as a local tip site with refuse lying both above and below the water table. It has been reported that slurry spreading is practised in the field adjacent to the source. The village is also located within the zone of contribution.

11. CONCLUSIONS AND RECOMMENDATIONS

Overall the source at Ballyagran is a high yielding well which has good potential for further development if required. The groundwater quality appears to be relatively good, despite the current sources of contamination within the zone of contribution, suggesting that any contaminants introduced below ground level are being attenuated by the clay-rich subsoils before reaching the source. It is recommended that the Council control and monitor potentially contaminating activities in the area of gravels within the ZOC to the northwest of the

source. In particular they should investigate the pond behind the Council houses. More thorough analyses of the raw water should be carried out to assist in the understanding of the flow regime.

Kiltorcan Sandstone

Ballysteen Limestones

Kiltorcan Sandstone

Mellon House Beds

Ringmoylan Shales

Mellon House Beds

Ringmoylan Shales

Ballysteen Limestones

Ballysteen Limestones

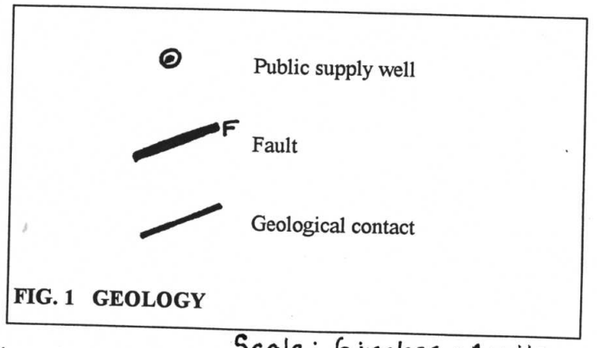
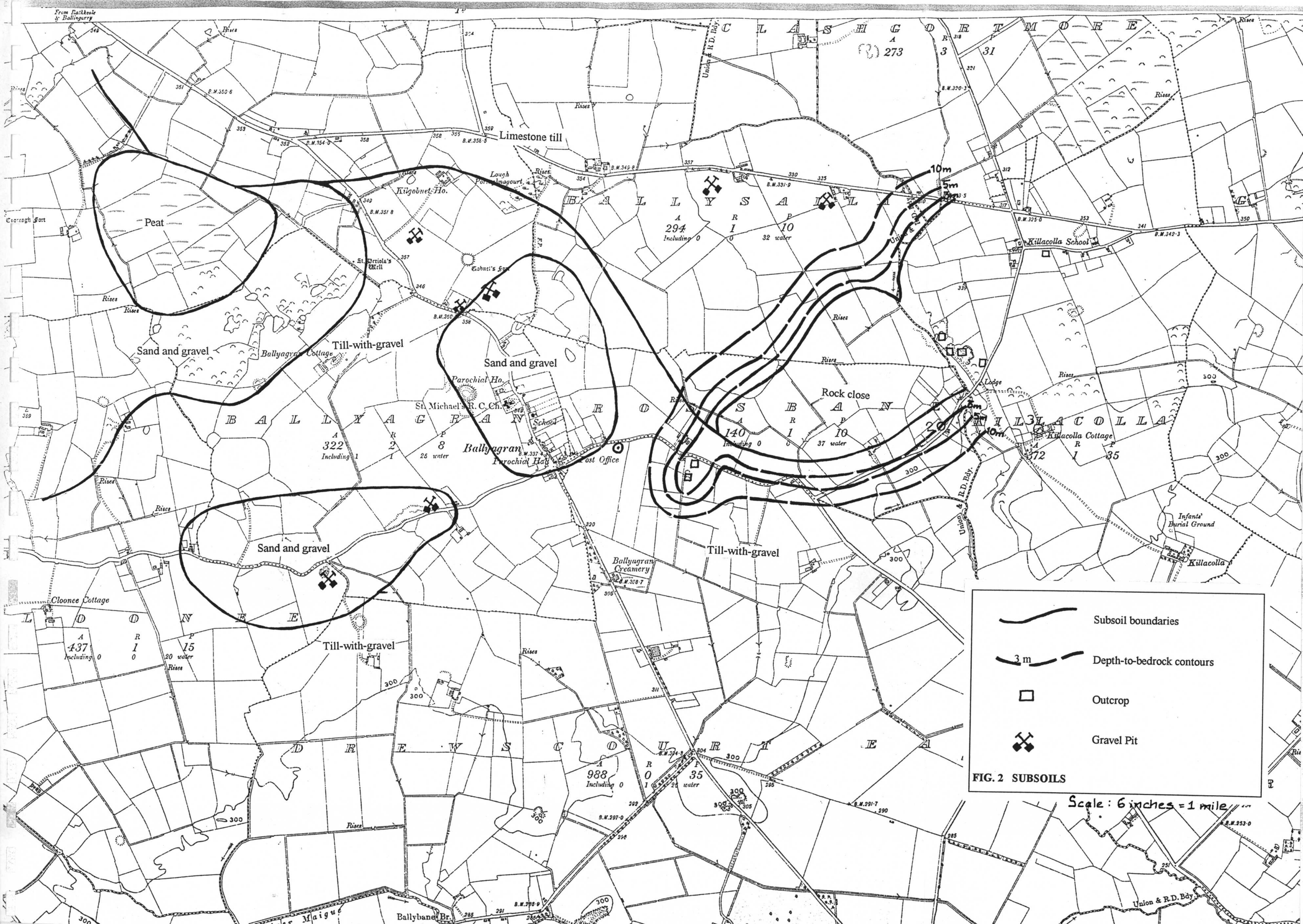


FIG. 1 GEOLOGY

Scale: 6 inches = 1 mile


Limestone till
Peat
Sand and gravel
Till-with-gravel
Sand and gravel
Rock close
Till-with-gravel
Sand and gravel
Till-with-gravel
10m
5m
5m
10m
Subsoil boundaries
3 m
Depth-to-bedrock contours
Outcrop
Gravel Pit
FIG. 2 SUBSOILS
Scale : 6 inches = 1 mile
BALLYAGRAN
BALLYSALLA
CLASHGORTMORE
KILLACOLLA
LOON
DREWSCOURT
Ballyagran
Killacolla School
Killacolla Cottage
Infants' Burial Ground
Killacolla
Ballyagran Creamery
Parochial Ho.
St. Michael's R.C. Ch.
Parochial Hall
Post Office
Kilgobnet Ho.
Coorragh Fort
Cloonee Cottage
Ballybane Br.
Union & R.D. Bdy.

Low

Low

High

High

Low

Moderate

High

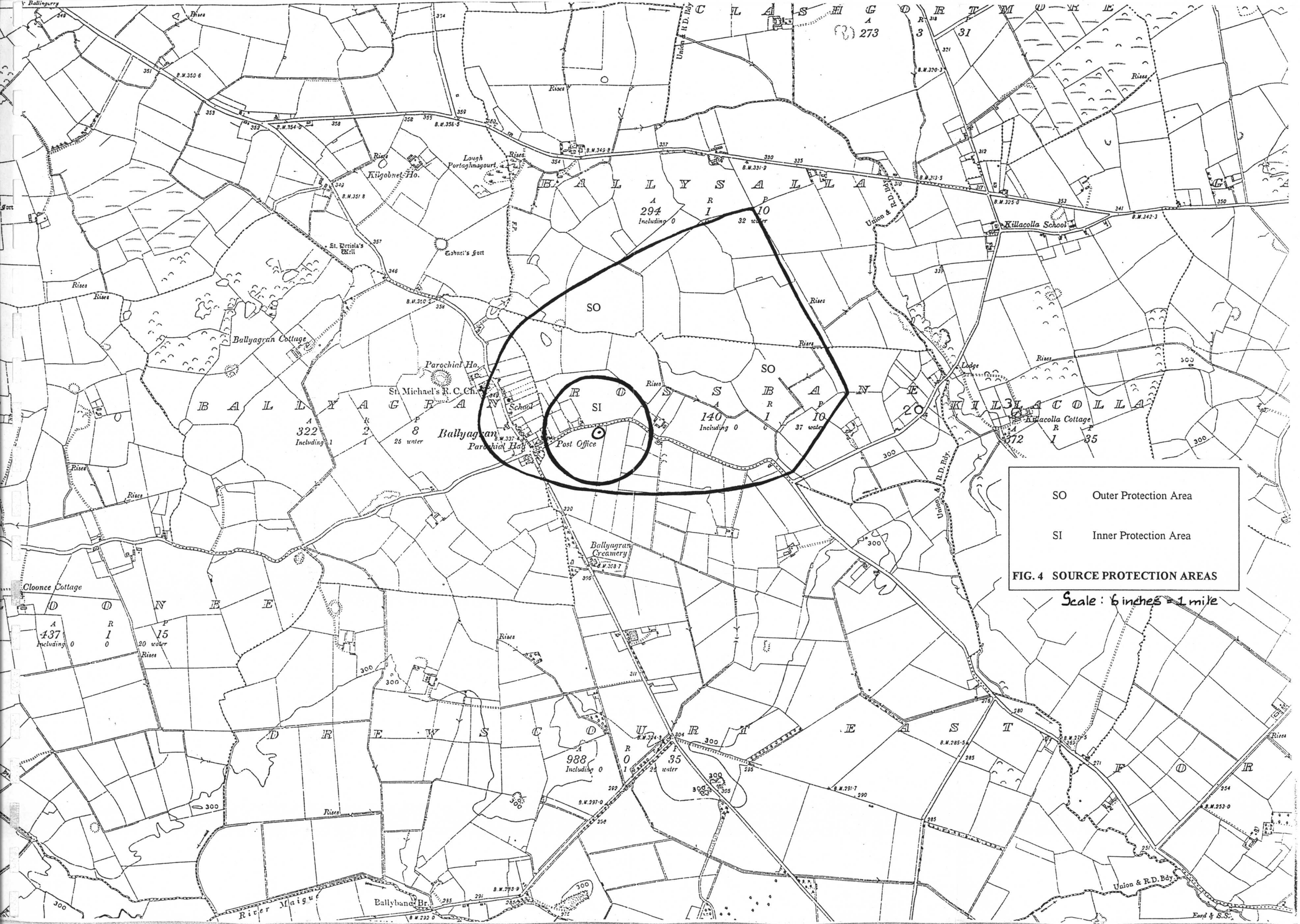
Extreme

High

High

FIG. 3 VULNERABILITY

Scale: 6 inches = 1 mile


SO
SI
Parochial Ho.
St. Michael's R. C. Ch.
School
Parochial Hall
Post Office
Ballyagran
Ballyagran Cottage
Kilgobnet Ho.
Lough Portaghnagourt
Gobnet's Fort
St. Ursula's Well
Killacolla School
Killacolla Cottage
Ballyagran Creamery
Cloonce Cottage
Ballybane Br.
River Maigue
BALLYAGRAN 322 2 8 Including 1 25 water
BALLYSALLA 294 1 10 Including 0 32 water
ROSSBAN 140 1 10 Including 0 37 water
KILLACOLLA 20 372 1 35
DOONEE 437 1 15 Including 0 0 20 water
DREWSCOURT EAST 988 Including 0 0 1 35 water
CLASHGORTMORE 273 3 31
Union & R.D. Bdy.
Rises
SO Outer Protection Area
SI Inner Protection Area
FIG. 4 SOURCE PROTECTION AREAS
Scale : 6 inches = 1 mile

SO/L

SO/M

SO/H

SO/H

SI/H

SO/E

SO/H

SI/H	Inner Protection Area – High
SO/E	Outer Protection Area – Extreme
SO/H	Outer Protection Area – High
SO/M	Outer Protection Area – Moderate
SO/L	Outer Protection Area – Low

FIG. 5 GROUNDWATER PROTECTION ZONES

Scale : 6 inches = 1 mile