HOSPITAL PUBLIC SUPPLY

GROUNDWATER SOURCE PROTECTION ZONES

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1. SUMMARY OF WELL DETAILS

GSI no.	:	1713SWW043	1713SWW042
Reference name	:	Hospital Castlefarm	Hospital Inner
Grid ref.	:	17051, 13636	17060, 13630
Owner	:	Limerick Co. Co.	Limerick Co. Co.
Well type	:	Borehole	Borehole
Elevation (Poolbeg)	:	88.13 m OD (top of casing)	88.39 m OD (top of casing)
Depth	:	46.3 m	51.8 m
Diameter	:	150 mm	150 mm
Depth-to-rock	:	7.6 m	estimated at <5 m
Static water level	:	1.34–7.05 m below top of casing	1.74–6.84 m below casing
Pumping water level (summer)	:	9.1 m below top of casing	12.5 m below casing
Abstraction rate	:	366 m^3/d (3,350 gal/hr)	251 m^3/d (2,300 gal/hr)
Total normal consumption	:	664 m^3/d (over 21–24 hrs; both wells)	
Specific capacity	:	165 m^3/d/m (1 week)	44 m^3/d/m (1 week)

Pumping test summary (Castlefarm):

(i) abstraction rate: 366 m^3/d
(ii) specific capacity : 226 m^3/d/m (10 hours)
(iii) transmissivity: 75 m^2/d [67 – 136 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, 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, 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 analytical equations computer modelling (WHPA Code, United States EPA) and hydrogeological mapping to understand the hydrogeology and to delineate the protection zones.

3. WELL LOCATION AND SITE DESCRIPTION

There are two wells currently supplying water to the Hospital area and both are situated to the north of the village, in the field behind the convent. Access to the sources is via a small grassed track to the south of the convent walls. The oldest well, which is the one nearest to the road, is referred to as the Inner well or Well B, while the other is known as Castlefarm or Well A. Both wellheads are fully housed and the Castlefarm pumphouses is fenced off in a well maintained enclosure which is owned by the County Council. The Hospital wells are linked to the Knocklong and Scarteen supplies and they are all used to supplement each other depending upon demand.

4. TOPOGRAPHY, SURFACE HYDROLOGY AND LAND USE

There are two small hills in the Hospital area, one to the north (Hospital Hill, 115 m OD) and a smaller one to the south (101 mOD) in the village. The wells lie at approximately 88 m OD between the hills, to the north of the River Mahore.

The River Mahore is a tributary of the River Maigue catchment and it drains the small valley through the village, in a westerly direction. A smaller stream rises to the northeast of the sources and flows away from Hospital Hill in a northerly direction. Drainage is poor in the lower lying areas close to the river and to the northeast of Hospital Hill, while the higher areas are relatively free draining.

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

5. GEOLOGY

5.1 Bedrock geology

The bedrock geology of the area comprises light grey, fossiliferous crystalline limestones which are interbedded with thin bands of fossiliferous shale. Borehole records near the village suggest the presence of a white limestone up to 30 m thick, which is encountered in drillcore at approximately 70 m OD. The beds are generally shallow dipping at 6–8° and have a joint set perpendicular to the direction of dip. Karstification and solution has occurred in an upper weathered zone of bedrock over approximately 8 m. Drilling reports from the Castlefarm borehole and two other County Council trial wells drilled in the townland of Millfarm, also suggest that dolomitisation has occurred; they record the presence of caverns filled with broken stone and sand at depth (at approx. 42 m OD at Castlefarm, at the bottom of the borehole). The rocks are Lower Carboniferous in age and comprise the lower part of the Ballysteen Limestones.

5.2 Subsoils geology (Quaternary Geology)

The subsoils in the area are predominantly clayey tills and alluvium. The tills are limestone dominated although have some sandstone clasts in places. Alluvium is present along the course of the river and in the lowlying area to the northeast of Hospital Hill. 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 Hospital Hill, 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 cropping out in the higher areas and in the river bed near Hospital Bridge. The depth-to-rock at the Castlefarm borehole is recorded as 7.6 m b.g.l. but it is expected that subsoils will be less than 5 m in thickness at Hospital Inner. Moving further south, borehole records on the Bruff road show depth-to-bedrock to be in the region of 13 m. The depth-to-rock contouring is 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 Hospital area are relatively good; the following data sources were used in considering the conceptual model:

- Results of a 10 hour drawdown test with more than four hours recovery which was carried out on the public supply borehole in August 1993, as part of the study. The Castlefarm well was pumped during the test and Hospital Inner was used as an observation well.
- Basic data from the County Council files dating back to 1976 when the borehole was drilled.
- A Geoex (a hydrogeological consulting firm) report dated 1975 which has reviewed the groundwater resources of the region. Some of the observations are used with caution however, as wellheads are not all accurately levelled in and shallow wells which may be tapping perched water tables have also been used.
- GSI well records.
- A river bed section for the relevant sector of the River Mahore obtained from the Office of Public Works.
- A water level in the river on the date of the pumping test from an automatic recorder maintained by the EPA.

6.2 Groundwater levels

The static water levels taken in the wells on 18/8/93, following overnight recovery, were 81.08 m OD (7.05 m below top of casing) and 81.55 m OD (6.84 m below top of casing) for Castlefarm and Hospital Inner respectively. (It must be noted however, that the overnight resting period does not appear to have been long enough for the water levels to recover completely; refer to section 6.6). Water levels were measured again on 29/11/95, following overnight recovery, and were found to be 86.79 m OD (1.34 m below top of casing) at Castlefarm and 86.65 m OD (1.74 m below top of casing) in the Hospital Inner well. A water level of 83.21 m OD (5.18 m below top of casing) was also recorded in Hospital Inner in 1975 as part of the Geoex study. A test borehole located to the northeast of the sources at the fork in the road, which was part of that study, records the groundwater level at 88.08 m OD (7.9 m below top casing); the date of measurement however, is not known.

Generally speaking, groundwater levels are quite shallow in the area and there are a number of small springs to the east and north of the site. The level of water in the river is higher than the water levels in the boreholes; a level of approximately 87 m OD (0.06 m above the base of the river bed) was recorded by an automatic recorder on the day of the pumping test.

6.3 Groundwater flow directions and gradients

It is assumed that there are groundwater divides through Hospital Hill and the hill in the village, and that the watertable is a subdued reflection of topography. To the east of Hospital Hill, groundwater will flow off in a northeasterly direction, via the stream. Taking the various water levels from the test borehole, the public supply boreholes and the Geoex study, the groundwater gradient in the area is estimated to be in the region of 0.017–0.024; for the purposes of the analytical equations an average of 0.02 is used.

6.4 Meteorology and recharge

Rainfall data for the area are taken from the local weather station in Hospital. Long-term mean annual rainfall for the years 1941–1980, as recorded by the Meteorological Service, was 921 mm. Potential evapotranspiration (P.E.) is estimated from a Meteorological Service regional contoured map, and a ranking scheme with all the other sources, as 470 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 484 mm per annum.

The subsoil deposits are generally quite thin in the immmediate vicinity of the source, in particular in the region of the two hills where rock comes close to surface. There are no surface drainage ditches or 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. Allowing for an average surface runoff for the area of 25%, recharge to the aquifer is estimated to be approximately 365 mm per annum.

These calculations are summarised below:

Average annual rainfall	921 mm
Estimated P.E.	470 mm
Estimated A.E. (93% P.E.)	437 mm
Effective rainfall	484 mm
Recharge (75% E.R.)	~365 mm

6.5 Hydrochemistry and water quality

The hydrochemical properties of the groundwater at Hospital are typical of a limestone aquifer in which carbonate dissolution is the dominant chemical process. The analyses indicate a hard (338–427 mg/l; $CaCO_3$) calcium bicarbonate type water with high alkalinity (290–360 mg/l; $CaCO_3$). Conductivities are often higher than 700 μS/cm and reach more than 1000 μS/cm on occasion. The magnesium-calcium ratios are low and do not suggest that dolomitisation is influencing the hydrogeological regime within the public supply boreholes.

The water quality in each of the Hospital sources is relatively poor. In both sources, all of the usual contaminant indicators have significantly higher concentrations than background levels, which suggests that contamination is occurring. Nitrate is usually higher than 25 mg/l, the EC Guide Level, and values of more than 30 mg/l are recorded. Chloride is also generally high, reaching 44 mg/l in the County Council analyses in May 1993. The analyses from the State Laboratory showed elevated potassium levels in both wells with values approaching the Guide Level of 10 mg/l. Electrical conductivities in this type of environment are not likely to reach as high as 1000 μS/cm unless contamination is occurring. Further evidence of contamination is provided by *E. coli*, which were present in a raw water sample from Hospital Inner

6.6 Aquifer coefficients

The pumping test analyses provided transmissivities ranging from 67 to 136 m^2/d although the best estimate value is approximately 75 m^2/d. (The water levels in both wells were still recovering from the effects of long-term pumping during the test; the observation well data are not considered to provide a representative transmissivity value as the test was too short and the wells had not recovered fully.) The specific capacities are relatively high for this rock type at 44 $m^3/d/m$ and 165 $m^3/d/m$ (1 week) for the Inner well and Castlefarm, respectively. (Note that a 1¼ inch diameter plastic pipe was emplaced in the Inner well for the pumping test, to house the dipper and prevent it from becoming entangled in the wiring.)

6.7 Conceptual model

The aquifer supplying the Hospital sources is the Ballysteen limestones. The permeabilities of these rocks have been increased by solution and weathering, and this has occured, in particular, in the top few metres of bedrock. It is these upper permeable zones that are likely to provide most of the supply to the sources. The area of the aquifer providing water to the wells however, is constrained by the two groundwater divides (beyond which groundwater will flow in other directions), and it is considered to be relatively small. The reduction in well yields and groundwater levels, which are known to occur during periods of dry weather, are considered to be a consequence of the limited aquifer storage which causes the dewatering of the aquifer.

The level of water in the river is higher than that in either of the boreholes and it is likely, due to the presence of the fine grained alluvial deposits, that there is a poor hydraulic connection between the river and the aquifer. However, rock crops out in the river bed close to the bridge, and it is probable that there will be some leakage to the aquifer, in particular under dry weather conditions when the head difference is at its greatest.

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**.

7. VULNERABILITY

Using the GSI vulnerability mapping guidelines, the area around Hospital 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).

The hilly areas to the north and south of the source, where rock comes close to surface, is mapped as having a **probably extreme** vulnerability. The majority of the area outside of this, where rock is 3–5 m below surface, has a **probably high** vulnerability. However, the area to the southwest where limestone till is considered to be generally 5–10 m thick is classed as having a **probably moderate** vulnerability.

8. DELINEATION OF SOURCE PROTECTION AREAS

Source Protection Areas are not delineated for a higher output than the current abstraction as it is considerd that the sources would not sustain an increased pumping rate during the summer months.

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 Hospital public supplies is primarily controlled by the groundwater divides (Fig. 3). The divide on Hospital hill is likely to be displaced in a northerly direction away from the source, under a pumping regime, and this displacement is incorporated into the ZOC. The area extends under the river as the hydraulic connection between the river and the water table is poor, and it is considered that groundwater can therefore be drawn in from both sides. The eastern and western boundaries however, are constrained by the size of the ZOC as given by the Recharge Equation.

Using the Recharge Equation, the estimated area required to collect enough recharge to sustain the current discharge at the source, on an annual basis, is in the region of 0.664 km^2, equivalent to a circular area of radius 460 m. This area does not take account of leakage from the river, which would allow it to be reduced somewhat. The delineated zone of contribution is slightly larger than 0.664 km^2 and therefore incorporates an additional safety margin to allow for expansion of the ZOC in dry weather.

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 most useful. Taking the aquifer thickness as approximately 40 m, i.e. the smaller saturated thickness of the boreholes, and assigning a porosity value of 0.015, the 100-day time of travel radius is calculated as approximately 190 m (Fig. 4). The equation is calculated based on the total abstraction from both sources and the radius is therefore applied to the centre point between the two sources. (Note that radii calculated separately using the individual well abstractions, both fall inside the delineated area.)

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 enclosures around the sources at Hospital, which are owned by the County Council, are designated the Source Site Areas.

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 Hospital source. These are listed here in order of decreasing degree of protection required and are shown in Figure 4 (with the exception of the Source Site):

- 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)
- Outer Protection Area / Moderate (SO/M)

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 threat to the water quality at the Hospital sources is the village. A large proportion of the zone of contribution extends under the residential area and leaky sewers and/or septic tanks are likely to be causing the current water quality problems. Contamination events occurring in the river may also influence the sources as it is likely that there is some leakage to the groundwater.

11. CONCLUSIONS AND RECOMMENDATIONS

Overall the sources at Hospital are moderate yielding wells which do not have potential for further development as the aquifer storage is limited and during the summer months the groundwater resources decline. The vulnerability of the area is generally high to extreme, and with the relatively high contaminant loading factor, this is indicated by the often poor water quality.

It is recommended that the Council consider finding a new source for the Hospital as there is significant contamination in the current sources, there are often problems with the yields in summer months and there is no scope for further development of the water scheme if it is required.

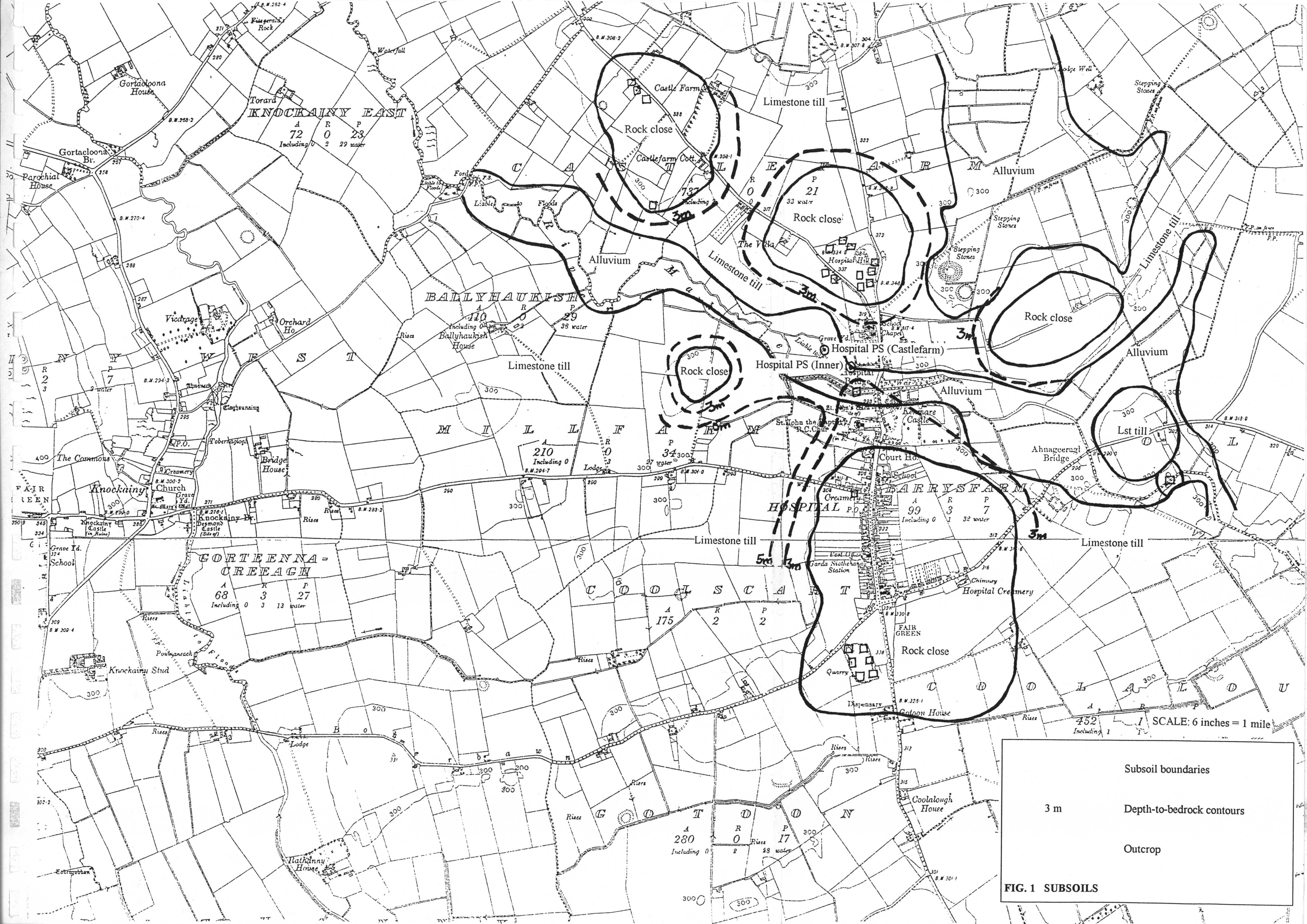

FIG. 1 SUBSOILS

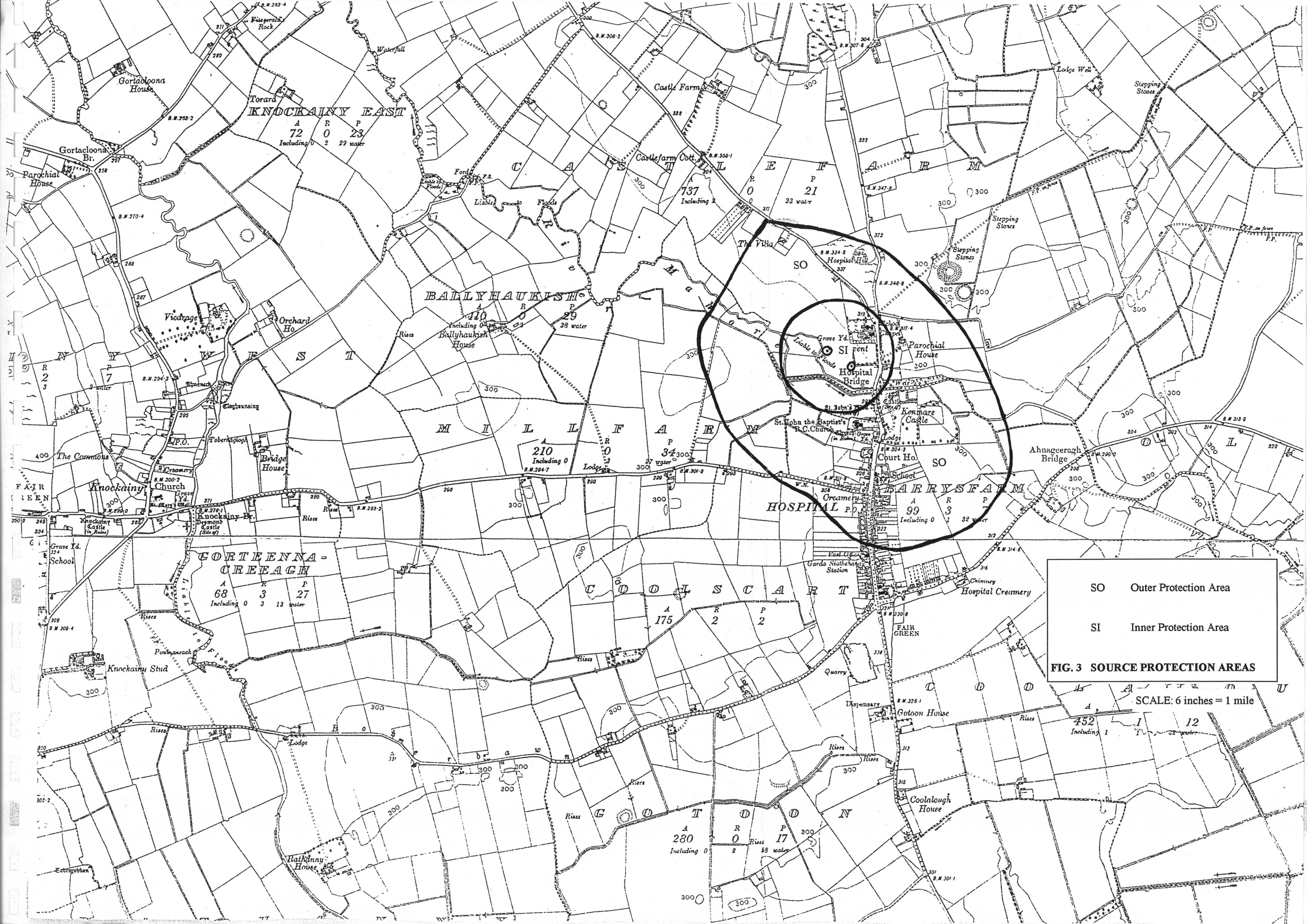

FIG. 3 SOURCE PROTECTION AREAS

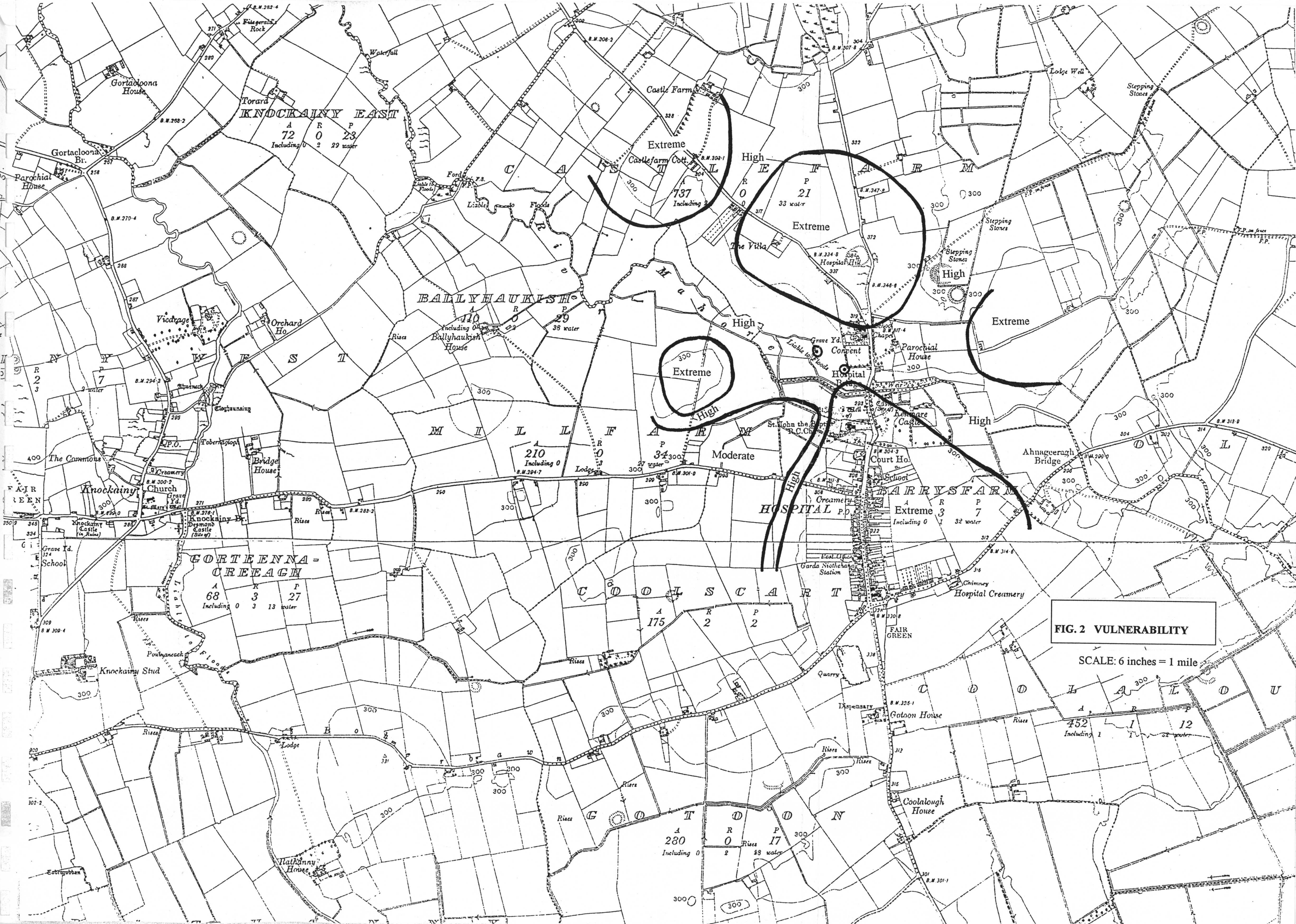

FIG. 2 VULNERABILITY

SCALE: 6 inches = 1 mile

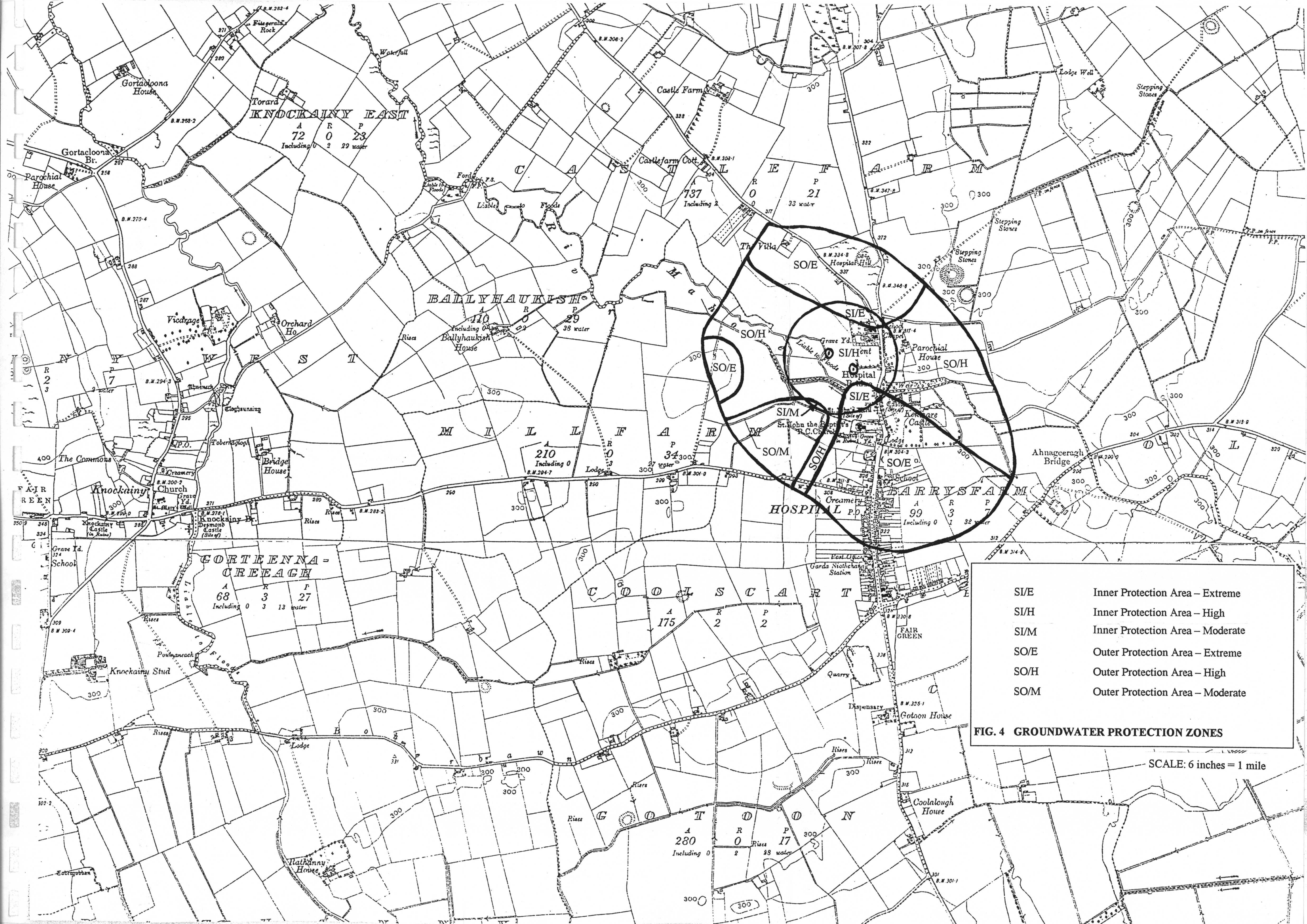

FIG. 4 GROUNDWATER PROTECTION ZONES