

BALLIVOR WATER SUPPLY

GROUNDWATER SOURCE PROTECTION ZONES

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BALLIVOR WATER SUPPLY

1. WELL LOCATION AND SITE DESCRIPTION

The Ballivor wells, drilled in 1994, are located at Earl's Bridge on the Stonyford River, 2 km north of Ballivor. The wells are approximately 22 metres from the river bank and are completed below ground level in a manhole (1.6 metres deep) which is surrounded by a concrete base. The supply wells are fenced off (see sketch, page 10). The pumphouse is located on the opposite side of the minor road and on the opposite side of the river. The pumphouse originally pumped water from the river before this was replaced by groundwater in December 1994. The standby well is located in the same manhole and 1.25 metres away. The groundwater is chlorinated (fluoridation to be installed) and filtered in the pumphouse before being pumped to the storage tower in Ballivor village, which has a capacity of 30,000 gallons. The pump operates according to the water level in the storage tower.

There are numerous private wells in the vicinity of the Council wells, particularly to the north. These wells are generally shallow dug wells. The area is also served by the private Kilmurvey Group Scheme (bored well) located at Stonyford Bridge, approximately 5 km downstream.

2. SUMMARY OF WELL DETAILS

Production Well

GSI no.:	2625SW W013
Grid ref.:	26941 25607
Owner:	Meath County Council
Well type:	Production Borehole
Elevation (ground level):	65.30 m OD (Poolbeg).
Depth (finished):	33.40 m
Diameter (finished):	200 mm (8")
Screen:	4.25-10.25m, 27.4-30.3m. (9 m of 200 mm screen, slot size 0.5 mm)
Depth-to-rock:	6.7 m
Static water level:	2.50 m below ground level (November 1994), 3.43 m below top of manhole cover (6/7/95) [manhole cover is 0.3 m above ground level]

Standby Well

GSI no.:	2625SW W014
Grid ref.:	26943 25606
Owner:	Meath County Council
Well type:	Borehole
Elevation (top of manhole):	65.60 m OD (Poolbeg).
Depth (finished):	31 m
Diameter:	200 mm (8")
Depth-to-rock:	6.7 m
Static water level:	2.70 m below ground level (September 1994), 2.80 m top of manhole cover (6/7/95).

12 hours continuous pumping on 6/7/95 (Standby well)

Pumping water level (Maximum):	22.40 m below top of manhole (3 hours)
Drawdown	: 19.70 m
Abstraction rate	: 265 m ³ /d average (2,420 gal/hr)

Normal consumption : 200 m³/d (44,000 gal/d on average)

Pumping test summary:

- (i) abstraction rate : 265 m³/d (11 m³/hour)
- (ii) specific capacity: 14 m³/d/m (12 hours) 8.0 m³/d/m (extrapolated to 1 week)
- (iii) transmissivity: 10 - 200 m²/d

3. METHODOLOGY

There were three stages involved in assessing the area: (a) a detailed desk study, (b) site visits and fieldwork, and (c) analysis of the data. The desk study compiled geology from all available sources. Basic well details, including precise locations and any relevant borehole, chemistry and available pumping test data, were obtained from County Council personnel.

The second stage comprised site visits and fieldwork in the surrounding area. A GSI observation borehole 63 m deep (Ballivor D/H 105) was drilled. A twelve hour pumping test was carried out with a recovery test to examine the aquifer characteristics. Subsequently, the area within 1 km radius was mapped with regard to geology, hydrogeology, and vulnerability to contamination. Raw water samples were taken in March, June and September 1995 for a full suite of chemical and bacterial analyses. A sample of the river was taken in January 1996 as the pumping well was not in operation. Conductivity measurements were taken at regular intervals from early 1995 to mid-1996.

The assessment stage used analytical equations and hydrogeological mapping to delineate protection zones.

4. TOPOGRAPHY, DRAINAGE AND LAND USE

The land surrounding the well is gently undulating ranging from 64 m to 74 m OD. Rathcormick to the north rises to 85 m OD. The Ballivor supply is located beside the Stonyford River, a tributary of the River Boyne. The Stonyford River flows in a southeasterly direction with numerous small streams which drain the area very well.

Agriculture is the principal land use activity in the area, with most of the land around the public supply being used as pasture.

5. GEOLOGY

5.1 Bedrock geology

The wells are located in the Calp Limestone, with Waulsortian Limestone to the north as shown in Figure 1. The limestones in this area dip gently to the northeast. Approximately 700 metres west of the well the Calp is underlain by Waulsortian Limestone. This contact is faulted. Another NE-SW fault is inferred approximately 300 metres to the southeast of the source.

Drilling commenced at Ballivor in June 1994. The first trial well 2625SW015 was drilled by Dunnes Water Services, Dundalk, adjacent to the pumphouse and encountered black limestone at a depth of 5.2 m to 61 m. The standby well no 2625SW014 was drilled in August 1994 and again encountered black limestone from 6.7 m to 91 m. This well is now infilled with gravel pack to a depth of 31 m. The production well 2625SW013, was drilled in October 1994, 1.25 m from the standby well and indicated the same geology. A fracture met at 31.1 m is connected through to the standby well.

A GSI observation borehole 63 m deep (Ballivor D/H 105) was drilled approximately 25 m from the production wells and encountered limestone at 7 m. The limestones are dark grey to black in colour with alternating thin beds of black calcareous shales (1-5 cm thick). The limestones were not regarded

as highly fractured although the recovered core was very broken due to the brittle nature of the rock. Several of the fractures have been infilled with calcite ranging in thickness from 1-2 cm generally. A vein 30 cm thick was encountered from 14.4 m to 14.7 m, which contained small cavities or vugs. There was no evidence of alteration such as dolomitisation.

5.2 Quaternary (subsoils) geology

Several types of Quaternary deposits are present in the vicinity of the Ballivor source (Figure 2).

Along the river is a narrow strip of alluvium varying in width up to 100 m across. The alluvium is generally composed of gravel with sand and is over 5 m thick, thinning away from the river and also thinning down-gradient along the river where the texture becomes increasingly sandy. Some gravel lenses occur within the alluvium as noted in the GSI observation borehole.

Directly west (1.5 km) of the wells is a small area of clayey peat.

To the northwest of the wells is a small area of fluvioglacial gravels at least 2 metres thick which overlies limestone till. The gravels are well sorted and bedded. The gravels are pebble to cobble grade, with a sandy matrix. Sand lenses and interbeds are common. Most of the gravel clasts are of Carboniferous limestone. Two small gravel eskers occur within this gravel area, and a small area of lacustrine sediments.

The areas north and south of the wells and flanking the alluvial deposits are extensive areas of limestone dominated till which is sandy in texture, and with fairly high proportions of clay present.

5.3 Soils

The soils information is taken from the published soil map of County Meath (Finch *et al*, 1983)

The predominant soils in the area around the public supply are derived predominantly from the alluvium. The soils are very immature with poor profile development. The Great Soil Group is the Boyne Alluvium Complex. The alluvium is mainly derived from limestone and shale.

Away from the river the soils are derived from the limestone and shale dominated tills. The dominant soils in the north are the Gley Group, which have developed under conditions of permanent or intermittent water logging due to a high water table resulting from the impervious nature of the subsoils and their parent materials. Because of the heavy texture of the soil and poor drainage, this soil is best suited to pasture only.

In the south, soils of the Grey Brown Podzolic Group are found. These soils are well to moderately drained and are best suited to grassland.

5.4 Depth to rock

The area immediately surrounding the supply wells is overlain by 5 to 10 metres of subsoils. Rock outcrops in a old disused quarry 1 km north of the production wells. Other rock outcrops occur in another small disused quarry at Rathcormick and close to Rathcormick House. Outcrops also occur in stream sections (Rathkenna Bridge).

The depth to bedrock at the well location is 5-7 m. However data from other wells in the vicinity indicate a variable depth to bedrock in the area. To the northeast and southwest, the depth to bedrock is greater than 10 m. Depth to bedrock contours are shown in Figure 3.

6. HYDROGEOLOGY

6.1 Data availability

Hydrogeological data for the Ballivor area are reasonably good although lacking in the area around the public supply. A survey of wells and pollution sources was conducted around the source (Figure 4) and several wells were discovered in the area. A 12 hour pumping test with a recovery test was carried out on the public supply well in July 1995.

The standby well was tested in September 1994 for 72 hours (well was originally 91.4 m deep, now 31 m). This test was conducted in 5 steps.

As part of the well survey, water levels from private wells were collected and a water table map constructed to determine the groundwater flow direction. Some of these water level readings were used with caution as the well heads were not accurately levelled in and the survey includes dug wells which may only be tapping a perched water table within the till. The majority of wells in the vicinity of the production well are shallow dug wells. Many of these wells were covered by heavy concrete covers and water levels could not be obtained.

The production well was drilled and tested for 72 hours in late 1994. Design details of the production well are available, giving details of screening.

The GSI drilled a monitoring borehole (June 1995) with an open hole diameter of 75.7 mm (47.6 mm core) and 60 mm plastic pipes were installed in the borehole. The bottom pipes were slotted to allow water entry. The core is stored in the GSI core store. This well is labelled GSI OW No.1.

6.2 Groundwater levels

The static water level in the production well was 62.80 m O.D. (2.50 m below ground level) in November 1994, and 62.10 m O.D. (3.20 m below the top of the manhole) before the pumping test on 6/07/95. The static water level in the standby well was 62.60 m O.D. (2.70m below ground level) in November 1994 and 62.50 m O.D. (2.80 m below the top of the manhole) before the pumping test on 6/07/95. The water level in the GSI observation well was measured at 62.84 m O.D. (3.00 m below the top of the casing) on 6/07/95. The well at the pumphouse has a recorded static water level of 63.70 m O.D. (2.20 m below casing, 0.45 metres above ground level) on 6/07/95.

6.3 Groundwater flow directions and gradients

Regional groundwater flow is generally towards the southeast, but at a more local scale, it is influenced by topography and moves in all directions to the Stonyford River. It is proposed that the river is in hydraulic continuity with the water table. The exact flow direction is difficult to assess.

Gradients in the general area vary with topography. The average gradient (based on the limited data available) between the private wells and the public supply wells are between 0.003-0.004.

6.4 Rainfall, Evaporation and Recharge

Rainfall data for the area is taken from the nearest rainfall station (which is at a similar altitude) in Ballivor, 2 km to the south. Mean annual rainfall as recorded by Met Eireann for 1951 - 1980 was 846 mm. Potential evapotranspiration (P.E.) is estimated from a Met Eireann contoured map as 500 mm/yr. Actual evapotranspiration (A.E.) is calculated by taking 95% of the P.E., to allow for seasonal moisture deficits, as 475 mm/yr. Using these figures the effective rainfall (E.R.) is taken to be approximately 370 mm/yr.

The presence of both free draining soils and permeable till with gravels and some poor draining soils over the area suggests that a high proportion of effective rainfall is infiltrating to the water table. There are several perennial streams present within 2 km of the well, and several smaller streams flow during the wetter months of the year, suggesting that some runoff does occur. 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, the annual recharge in the area is therefore 280 mm.

These calculations are summarised below:

Average annual rainfall	846 mm
Estimated P.E.	500 mm
Estimated A.E. (95% P.E.)	475mm
Effective rainfall	370 mm
Recharge (75% E.R.)	280 mm

6.5 Hydrochemistry and water quality

Most of the analyses carried out on the water supply by Meath County Council at Ballivor are derived from treated water sampled from consumers' taps. Several water samples were taken from the well by the GSI in March, June and September 1995. The first two samples were treated water rather than raw water. A raw water tap was installed in June. River water was sampled in January 1996 as the well was not in operation.

The chemical analyses of groundwater at the Ballivor source indicate a very hard water (370-400 mg/l CaCO_3), with a high alkalinity (300-380 mg/l CaCO_3). Conductivities are also relatively high ranging from 525-795 $\mu\text{S/cm}$ (Table 1). This groundwater can be classed as a calcium bicarbonate water. The groundwater analyses are in the Appendices.

Table 1. Conductivity readings from the Ballivor Source

	Production Well		River	
Date	Conductivity	Temperature	Conductivity	Temperature
	$\mu\text{S/cm}$	$^{\circ}\text{C}$	$\mu\text{S/cm}$	$^{\circ}\text{C}$
+23-3-95	525	7.0		
+14-6-95	585	12.6		
27-6-95	596	14.2		
6-7-95	570 -590	13.1 - 13.8	594 - 612	16 -17.4
3-8-95	586	15.4		
14-9-95	569	14.4		
+28-9-95	570	14.0		
2-11-95	561	12.1		
1-12-95	569	10.9		
+9-1-96	-	-	585	8.0
26-3-96	717	6.4		
16-5-96	746	10.3		

+ Full Analyses

The water quality at Ballivor is good with no evidence of contamination; all major cations, anions and trace elements are within the Irish Drinking Water Standards and within EU limits except for iron and manganese which are naturally high. Calcium and sulphate levels are above guide values.

6.6 Aquifer coefficients

The pumping test analyses provided apparent transmissivities of 10-200 m^2/d from the 12 hour pumping test and from the recovery tests. A value of 50 m^2/d is taken as the most reasonable figure of apparent transmissivity based on pumping test results from other wells in the region.

At Ballivor only one of the pumping wells was tested, PW No.2 (standby well), because it was not possible to run both pumps together. PW No.1 (the main production well) was not in operation at the time. The testing (July 5th to 6th) began with a recovery test, with the pump turned off from 21:00 on July 5 to 6:00 on July 6. The drawdown test began at 6:00 on July 6, when PW No.2 was turned on, and continued until 18:00 (12 hours duration), followed by a one-hour recovery test.

During the test, water levels were monitored in both pumping wells, and the GSI observation well. Conductivity and temperature readings were monitored continuously throughout the pumping test.

The datalogger could not be installed on the meter to record the changes in the discharge during pumping, so readings were taken manually throughout the test.

The discharge from the well was allowed to go directly to the consumers, or into the reservoir. After 4 hours the demand for water reduced, and the pumping rate decreased, which allowed the water level to start recovering. The water was not able to back-feed into the reservoir at the same rate that was being pumped. Attempts to increase the discharge of the well, by changing the control valves to allow the discharge water to pump directly to the reservoir, were unsuccessful. These problems interfered with the test and reduced the value of the data collected.

The specific capacity calculated was $14 \text{ m}^3/\text{d}/\text{m}$ after 3 hours pumping. After an initial drawdown in the well of 19.65 metres during the first 12 minutes, the drawdown remained steady until 3 hours when the well started to recover as the demand for water decreased and the discharge of the well dropped. This suggests that the yield of the well could be increased slightly, but more comprehensive testing would be needed to confirm the sustainable maximum yield of the well.

The specific yield of 0.01-0.02 was calculated from data from the observation wells and indicates that the aquifer is unconfined.

The pumping test data are in the Appendices.

6.7 Conceptual Model

The aquifer feeding the Ballivor source is the Calp Limestone. This is overlain by 5 to 10 metres of alluvium and highly permeable limestone till-with-gravel, therefore the aquifer is considered to be unconfined. The thin unsaturated zone (0-5 m) in this unconfined aquifer (in the vicinity of the well) suggests that the aquifer is relatively impermeable, which is reflected by the well yield. Permeabilities within the bedrock will be increased by joints and fractures. A major fracture was observed during the drilling of the production well (approximately 34.30m O.D., 31.1 m below the top of the casing), but this has now been cased off with a blank tail piece. The production well is screened from 4.25-10.25 m and from 27.4-30.3 m, a total of 9 metres of 200mm screen, slot size 0.5mm which is gravel packed to ground surface. The top 6 metres of screen bridges the overlying alluvium deposits and the limestone.

Groundwater flow is influenced by the surface topography. Groundwater flow to the public supply is assumed to be towards the river from a north-northwest direction. It is assumed that a groundwater divide occurs at Rathcormick Hill.

The close proximity of the production well to the river, the increase in the temperature of the groundwater during the summer months and the similarity of the surface water to the groundwater, indicates that the wells are drawing water from the river.

6.8 Aquifer category

The Calp Limestone is classed as a **locally important aquifer** which is **generally moderately productive (Lm)**. The aquifer category for the adjacent Waulsortian Limestone is locally important, moderately productive only in local zones (LI).

7. GROUNDWATER VULNERABILITY

The catchment area for the source at Ballivor is predominantly mapped as highly vulnerable to pollution, due to the highly permeable alluvial subsoils. Using the GSI vulnerability mapping guidelines, areas where rock is less than 3 m below surface are mapped as having ‘extreme vulnerability’ and occur in two localities north of the source. A large area around the source is covered by 5-10 metres of subsoil, but the permeability of this subsoil results in this area being classified as ‘highly vulnerable’. An area to the north-northeast of the source is mapped as ‘moderately vulnerable’. The vulnerability zones are shown on Figure 5.

8. DELINEATION OF SOURCE PROTECTION AREAS

Source protection areas are delineated for the output (265 m³/d) that is currently abstracted, and a buffer zone is incorporated to allow for expansion of the zone of contribution during dry weather and any slight increase in the demand.

8.1 Inner Protection Area (SI)

The Inner Protection Area 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.

Using the following aquifer coefficients: permeability (k) = 20 m/d, porosity = 0.02, and hydraulic gradient (i) = 0.004, the 100 day time of travel distance to the well is estimated to be approximately 400 metres (Figure 6).

8.2 Outer Protection Area (SO)

The Outer Protection Area includes the remainder of the catchment area to the source, i.e. the zone of contribution (ZOC), and is defined by the area required to support abstraction from long-term recharge. The ZOC at Ballivor is derived from hydrogeological mapping techniques and is controlled primarily by the surface water divides to the east and west of the source and by the groundwater flow direction. The ZOC is shown in Figure 6. Its size is based largely on the Recharge Equation. Taking the average annual recharge to be 280 mm as previously indicated, the area required to supply the pumping rate of 265 m³/d is calculated to be 0.35 km². The null point or down-gradient boundary of the ZOC (the distance down-gradient after which water is not contributing to the well) extends to the river only. The pumping test had no effect on the observation well located at the pumphouse on the opposite side of the river. A buffer (safety margin) is included in the final zone of contribution by incorporating a $\pm 20^\circ$ error margin in the estimated groundwater flow direction.

9. GROUNDWATER PROTECTION SCHEME

Combining the Inner and Outer Source Protection Areas with the vulnerability ratings produces the groundwater protection zones for Ballivor. These are listed here in order of decreasing degree of protection required and are shown in Figure 7:

- Inner Protection Area / High (SI/H)
- Inner Protection Area / Moderate (SI/M)
- Outer Protection Area / Extreme (SO/E)
- Outer Protection Area / High (SO/H)
- Outer Protection Area / Moderate (SO/M)

10. POTENTIAL POLLUTION SOURCES

A small number of houses and farmyards are present in the general area of the wells. Two farmyards in particular are located approximately 1 km and 1.5 km immediately up-gradient of the well. These farms store silage and have cattle feeding yards which may pose a significant risk to the wells.

Thus close checks need to be kept on the silage effluent, particularly during summer and winter months and on other farmyard practices.

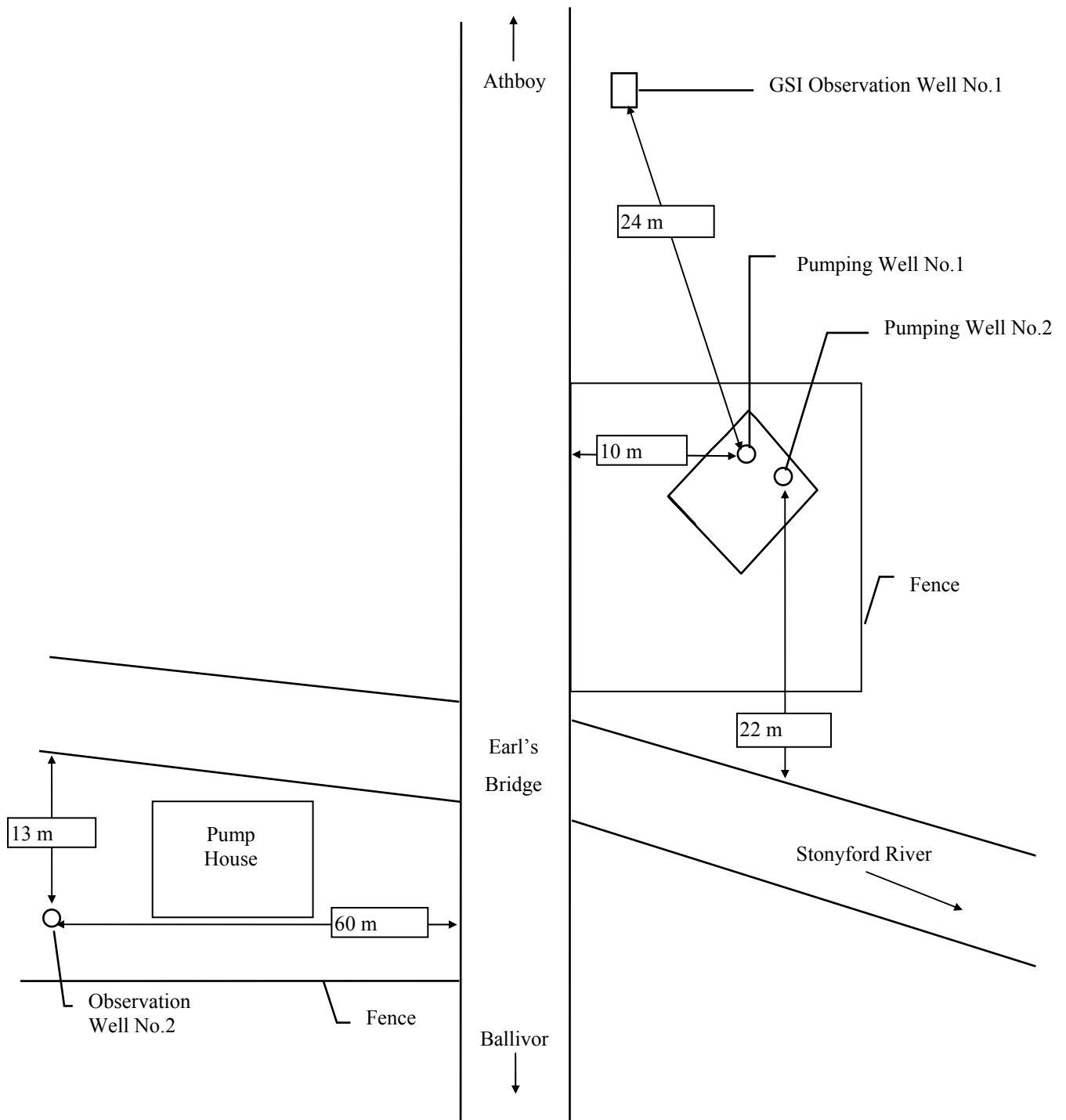
Other potential sources of contamination are the dispersed septic tanks and dumping in the disused quarries.

As the pumping wells are drawing water from the Stonyford River the quality of the river is very important and thus the river catchment requires adequate protection from potential pollution sources.

11. CONCLUSIONS AND RECOMMENDATIONS

Overall the source at Ballivor has a reasonably high yielding well which can probably support a small increase in the yield. The water analyses indicate that there were no water quality problems at this source, except for the natural occurring iron and manganese problem, but the supply is highly vulnerable to pollution due to the shallow thickness and permeability of the subsoils in the immediate vicinity of the supply.

It is recommended that the Council monitor the raw water from Ballivor public supply and the Stonyford River to examine the effects of the potentially polluting activities near to the well. In addition it is recommended that the Council control and monitor potentially polluting activities in the delineated groundwater source protection zones, in particular, the farmyards uphill from the wells. Activities along the Stonyford River should also be controlled.



Sketch of Ballivor Water Supply
(Not to Scale)

Appendix 1

Pump Test Data

PUMPING TEST DATA SHEET

Location : BALLIVOR

Borehole name : PW No.2

Date : 12/09/1994

Test : Drawdown Data from PW No.2

Weather : Dry

Duration : 72hrs.

Well depth : 91.4m, infilled with gravel pack from PW No.1

Height of datum point above ground level : 0.2m

Datum Point : ?

Date	Time	Time since pumping began (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	
12-09-94	10:30	0	2.9	0			Step 1
		1	2.98	0.08			
		2	2.99	0.09			
		3	2.99	0.09			
		4	3	0.1			
		5	3	0.1			
		6	3	0.1			
		7	3	0.1			
		8	3	0.1			
		9	3	0.1			
		10	3	0.1			
		12	3.01	0.11			
		14	3.02	0.12	90		
		16	3.01	0.11			
		18	3.02	0.12			
		20	3.02	0.12			
		22	3.01	0.11			
		24	3.02	0.12			
		26	3.02	0.12	90		
		28	3.02	0.12			
		30	3.02	0.12			
		35	3.02	0.12			
		40	3.03	0.13			
		45	3.03	0.13			
		50	3.03	0.13			
		55	3.03	0.13			
	11:30	60 (1hr)	3.03	0.13			Step 2
		60.5	3.5	0.6			
		61	3.58	0.68			
		61.5	3.63	0.73			
		62	3.62	0.72			
		62.5	3.62	0.72			
		63	3.63	0.73			
		64	3.63	0.73			
		65	3.65	0.75			
		66	3.66	0.76			
		67	3.66	0.76			
		68	3.66	0.76			
		69	3.65	0.75			
		70	3.65	0.75	255		
		72	3.65	0.75			
		74	3.66	0.76			
		76	3.67	0.77			
		78	3.67	0.77			
		80	3.67	0.77			
		82	3.67	0.77			
		84	3.67	0.77			
		86	3.67	0.77			
		88	3.68	0.78			
		90	3.68	0.78	255		
		95	3.69	0.79			
		100	3.7	0.8			
		105	3.71	0.81			
		110	3.71	0.81			
		115	3.72	0.82			
	12:30	120 (2hrs)	3.73	0.83			
		135	3.75	0.85	255		
		150	3.76	0.86			Step 3
		150.5	4.06	1.16	390		
		151	4.1	1.2			

PUMPING TEST DATA SHEET

Location : BALLIVOR

Borehole name : PW No.2

Date : 12/09/1994

Test : Drawdown Data from PW No.2

Weather : Dry

Duration : 72hrs.

Well depth : 91.4m, infilled with gravel pack from PW No.1

Height of datum point above ground level : 0.2m

Datum Point : ?

Date	Time	Time since pumping began (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	
		151.5	4.19	1.29			
		152	4.17	1.27			
		152.5	4.18	1.28			
		153	4.17	1.27			
		154	4.18	1.28			
		155	4.18	1.28			
		156	4.18	1.28			
		157	4.19	1.29			
		158	4.2	1.3			
		159	4.2	1.3			
		160	4.21	1.31	390		
		162	4.22	1.32			
		164	4.23	1.33			
		166	4.24	1.34			
		168	4.24	1.34			
		170	4.25	1.35			
		172	4.25	1.35			
		174	4.27	1.37			
		176	4.27	1.37			
		178	4.28	1.38			
	13:30	180 (3hrs)	4.28	1.38			
		185	4.29	1.39			
		190	4.3	1.4			
		195	4.31	1.41			
		200	4.31	1.41			
		205	4.32	1.42			
		210	4.33	1.43			
		225	4.35	1.45	390		
	14:30	240 (4hrs)	4.37	1.47	390		
		270	4.4	1.5	490		Step 4
		270.5	5.15	2.25			
		271	5.17	2.27			
		271.5	5.19	2.29			
		272	5.21	2.31			
		272.5	5.23	2.33			
		273	5.26	2.36			
		273.5	5.27	2.37			
		274	5.29	2.39			
		274.5	5.3	2.4			
		275	5.3	2.4			
		276	5.32	2.42			
		277	5.33	2.43			
		278	5.35	2.45			
		279	5.35	2.45			
		280	5.35	2.45			
		282	5.38	2.48			
		284	5.39	2.49			
		286	5.4	2.5			
		288	5.42	2.52			
		290	5.42	2.52			
		292	5.43	2.53			
		294	5.44	2.54			
		296	5.44	2.54			
		298	5.45	2.55			
	15:30	300 (5hrs)	5.46	2.56	490		
		305	5.47	2.57			
		310	5.49	2.59			
		315	5.5	2.6			
		320	5.5	2.6			
		325	5.52	2.62	490		

PUMPING TEST DATA SHEET

Location : BALLIVOR

Borehole name : PW No.2

Date : 12/09/1994

Test : Drawdown Data from PW No.2

Weather : Dry

Duration : 72hrs.

Well depth : 91.4m, infilled with gravel pack from PW No.1

Height of datum point above ground level : 0.2m

Datum Point : ?

Date	Time	Time since pumping began (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	
		330	5.54	2.64	650		Step 5
		330.5	6.78	3.88			
		331	7.02	4.12			
		331.5	7.32	4.42			
		332	7.46	4.56			
		332.5	7.55	4.65			
		333	7.68	4.78			
		333.5	7.75	4.85			
		334	7.82	4.92			
		334.5	7.87	4.97			
		335	7.93	5.03			
		336	7.99	5.09			
		337	8.02	5.12			
		338	8.05	5.15			
		339	8.28	5.38			
		340	8.33	5.43			
		342	8.4	5.5			
		344	8.45	5.55			
		350	9	6.1			
		352	9.08	6.18			
		354	9.12	6.22			
		356	9.16	6.26			
		358	9.25	6.35			
	16:30	360 (6hrs)	9.32	6.42	650		
		365	9.54	6.64			
		370	9.68	6.78			
		375	9.81	6.91			
		380	9.95	7.05			
		390	10.04	7.14			
		405	10.2	7.3			
	17:30	420 (7hrs)	10.3	7.4			
	18:30	480 (8hrs)	10.83	7.93	575		
	19:30	540 (9hrs)	11.08	8.18			
	20:30	600 (10hrs)	11.3	8.4			
	22:30	720 (12hrs)	11.9	9			
13/09/94	00:30	840 (14hrs)	13.9	11			
	02:30	960 (16hrs)	17.8	14.9			
	04:30	1080 (18hrs)	54.2	51.3	490		

Closed down Pump Gate Valve.

	06:30	1200 (20hrs)	48.59	45.69			
	08:30	1320 (22hrs)	47.69	44.79	390		
	10:30	1440 (24hrs)	8.52	5.62	450		
	12:30	1560 (26hrs)	9.78	6.88			
	14:30	1680 (28hrs)	10.02	7.12			
	16:30	1800 (30hrs)	9.98	7.08			
	18:30	1920 (32hrs)	10.02	7.12	500		
	20:30	2040 (34hrs)	9.97	7.07			
	22:30	2160 (36hrs)	10	7.1			
14/09/94	04:30	2520 (42hrs)	10.48	7.58			
	10:30	2880 (48hrs)	8.88	5.98	500		
	12:30	3000 (50hrs)	9.59	6.69	550		Step 6
	13:30	3060 (51hrs)	9.64	6.74	550		
	14:30	3120 (52hrs)	9.68	6.78	550		
	15:30	3180 (53hrs)	8.55	5.65	550		
	16:30	3240 (54hrs)	8.66	5.76	550		
	22:30	3600 (60hrs)	9.31	6.41			
15/09/94	04:30	3960 (66hrs)	9.6	6.7			
	10:30	4320 (72hrs)	8	5.1	550		

PUMPING TEST DATA SHEET

Location : Ballivor

Borehole name : PW No.1

Date : 09/11/94

Test : Drawdown Data from PW No.1

Weather : Dry

Duration : 72hrs.

Well depth : 33.4m

Height of datum point above ground level : 0.75m

Datum Point : ?

Date	Time	Time since pumping began (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m ³ /d	Temperature C	Conductivity uS/cm @20 C
09-11-94	11:00	0	3.25	0			
		0.5	4.99	1.74			
		1	5.47	2.22			
		1.5	5.65	2.4			
		2	5.75	2.5			
		2.5	5.82	2.57			
		3	5.85	2.6			
		3.5	5.87	2.62			
		4	5.88	2.63			
		5	5.9	2.65			
		6	5.92	2.67			
		7	5.95	2.7			
		8	5.99	2.74			
		9	5.99	2.74			
		10	6.1	2.85	576		
		12	6.23	2.98			
		14	6.33	3.08			
		16	6.4	3.15			
		18	6.45	3.2			
		20	6.48	3.23	576		
		22	6.5	3.25			
		26	6.58	3.33			
		28	6.67	3.42			
		30	6.74	3.49			
		35	6.87	3.62	530		
		40	6.89	3.64			
		45	6.91	3.66			
		50	6.95	3.7			
		55	6.98	3.73	576		
	12:00	60 (1hr)	6.98	3.73	640		
		75	10.37	7.12	640		
		90	10.4	7.15	640		
		105	10.75	7.5			
	13:00	120 (2hrs)	10.81	7.56			
		150	11.01	7.76	640		
	14:00	180 (3hrs)	11.14	7.89	640		
		210	11.34	8.09			
	15:00	240 (4hrs)	11.48	8.23	640		
	16:00	300 (5hrs)	11.89	8.64	640		
	17:00	360 (6hrs)	11.95	8.7	615		
	18:00	420 (7hrs)	12.35	9.1	615		
	19:00	480 (8hrs)	12.8	9.55			
	20:00	540 (9hrs)	13.17	9.92	640		
	21:00	600 (10hrs)	13.5	10.25			
	23:00	720 (12hrs)	14.06	10.81	630		
10-11-94	01:00	840 (14hrs)	14.59	11.34			
	03:00	960 (16hrs)	15.07	11.82	620		
	05:00	1080 (18hrs)	15.42	12.17	620		
	07:00	1200 (20hrs)	15.85	12.6	630		
	09:00	1320 (22hrs)	16.34	13.09	600		
	11:00	1440 (24hrs)	16.81	13.56	630		
	13:00	1560 (26hrs)	17.18	13.93	630		
	17:00	1860 (30hrs)	18.1	14.85	630		
	21:00	2040 (34hrs)	18.68	15.43	620		
	23:00	2160 (36hrs)	18.9	15.65			
11-11-94	05:00	2520 (42hrs)	21	17.75	600		
	11:00	2880 (48hrs)	21.52	18.27	600		
	17:00	3240 (54hrs)	20.5	17.25	620		
	23:00	3600 (60hrs)	21.85	18.6	620		
12-11-94	05:00	3960 (66hrs)	22.47	19.22			
	11:00	4320 (72hrs)	22.63	19.38	600		

PUMPING TEST DATA SHEET

Location : BALLIVOR

Borehole name : PW No.1

Date : 12/11/94

Test : Recovery Data from PW No.1

Weather : Wet

Duration : 30mins.

Well depth : 33.4m

Height of datum point above ground level : 0.75m

Datum Point : ?

Date	Time	Time since pumping ended (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m ³ /d	Temperature C	Conductivity uS/cm @20 C
12-11-94	11:00	0	22.63	19.38			
		0.5	16.5	13.25			
		1	12.33	9.08			
		1.5	8.48	5.23			
		2	5.25	2			
		2.5	4.75	1.5			
		3	4.7	1.45			
		3.5	4.68	1.43			
		4	4.69	1.44			
		4.5	4.67	1.42			
		5	4.68	1.43			
		6	4.5	1.25			
		7	4.54	1.29			
		8	4.53	1.28			
		9	4.51	1.26			
		10	4.49	1.24			
		12	4.45	1.2			
		14	4.43	1.18			
		16	4.4	1.15			
		18	4.38	1.13			
		20	4.38	1.13			
		22	4.33	1.08			
		24	4.32	1.07			
		26	4.3	1.05			
		28	4.26	1.01			
	11:30	30	4.28	1.03			

PUMPING TEST DATA SHEET

Location : BALLIVOR

Borehole name : PW No.2

Date : 05/07/95

Test : Recovery Data from PW No.2.

Duration : 9hrs

Weather : Fair

Distance from Pumping Well :

Well depth : 91.4m, infilled with gravel pack from PW No.1

Height of datum point above ground level : 0.3m

Datum Point : Inside manhole cover at top of wood.

Date	Time	Time since pumping ended (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m ³ /d	Temperature C	Conductivity uS/cm @20 C
05-07-95	21:00	0	20.43	17.48			
		0.5	17.4	14.45			
		1	14.93	11.98			
		1.5	12	9.05			
		2	10	7.05			
		2.5	8.2	5.25			
		3	7.1	4.15			
		3.5	6.24	3.29			
		4	5.3	2.35			
		4.5	4.75	1.8			
		5	4.15	1.2			
		6	3.5	0.55			
		7	3.25	0.3			
		8	3.22	0.27			
		9	3.22	0.27			
		10	3.22	0.27			
		12	3.21	0.26			
		14	3.21	0.26			
		16	3.2	0.25			
		18	3.2	0.25			
		20	3.2	0.25			
		22	3.2	0.25			
		24	3.18	0.23			
		26	3.17	0.22			
		28	3.17	0.22			
		30	3.16	0.21			
		35	3.16	0.21			
		40	3.15	0.2			
		45	3.14	0.19			
		50	3.14	0.19			
		55	3.13	0.18			
	22:00	60 (1hr)	3.12	0.17			
		90	3.1	0.15			
	23:00	120 (2hrs)	3.08	0.13			
		150	3.05	0.1			
	24:00	180(3hrs)	3.04	0.09			
	01:00	240 (4hrs)	3.02	0.07			
	02:00	300 (5hrs)	3	0.05			
	03:00	360 (6hrs)	2.98	0.03			
	05:00	480 (8hrs)	2.96	0.01			
	06:00	540 (9hrs)	2.95	0			

PUMPING TEST DATA SHEET

Location : BALLIVOR

Borehole name : PW No.2

Date : 06/07/95

Test : Drawdown Data from PW No.2.

Weather : Fair

Duration : 12hrs

Well depth : 91.4m, infilled with gravel pack from PW No.1

Height of datum point above ground level : 0.3m

Datum Point : Inside manhole cover at top of wood.

Date	Time	Time since pumping began (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	Conductivity uS/cm @20 C
06-07-95	06:00	0	2.95	0			
		0.5	8.5	5.55	384		
		1	11	8.05			
		1.5	12.7	9.75			
		2	12.65	9.7			
		2.5	13.1	10.15			
		3	14	11.05			
		3.5	15.3	12.35			
		4	16.15	13.2			
		4.5	16.9	13.95			
		5	17.55	14.6			
		6	18.6	15.65			
		7	19.4	16.45			
		8	20.15	17.2	336		
		9	20.17	17.22			
		10	20.4	17.45			
		12	22.6	19.65	312		
		14	22.6	19.65			
		16	22.55	19.6	216		
		18	22.56	19.61	288		
		20	22.54	19.59		13.1	570
		22	22.54	19.59			
		24	22.54	19.59			
		26	22.55	19.6			
		28	22.55	19.6	288		
		30	22.55	19.6		13.2	560
		35	22.55	19.6			
		40	22.55	19.6			
		50	22.55	19.6			
	07:00	60 (1hr)	22.55	19.6			
		75	22.55	19.6	265	13.2	572
		90	22.56	19.61			
		105	22.56	19.61			
	08:00	120 (2hrs)	22.56	19.61		13.2	556
		135	22.56	19.61			
		150	22.56	19.61			
		165	22.56	19.61	276	13.4	572
	09:00	180 (3hrs)	22.56	19.61	271	13.6	578
		200	22.05	19.1	270		
		220	21.3	18.35			
	10:00	240 (4hrs)	22.35	19.4	266	13.6	582
		260	21	18.05			
		280	21.2	18.25			
	11:00	300 (5hrs)	20.48	17.53	274	13.6	586
		330	20.63	17.68	260		
	12:00	360 (6hrs)	20.75	17.8	262	13.8	584
		390	20	17.05			
	13:00	420 (7hrs)	19.82	16.87	266		
		450	19.75	16.8			
	14:00	480 (8hrs)	19.8	16.85	265		
		510	19.69	16.74			
	15:00	540 (9hrs)	19.68	16.73	265		
		570	19.75	16.8			
	16:00	600 (10hrs)	19.7	16.75	265	13.4	580
		630	19.6	16.65			
	17:00	660 (11hrs)	19.6	16.65			
		690	19.56	16.61	264	13.2	587
	18:00	720 (12hrs)	19.56	16.61			

PUMPING TEST DATA SHEET

Location : BALLIVOR

Borehole name : PW No.1

Date : 05/07/95

Test : Recovery Data from PW No.1.

Duration : 9hrs.

Weather : Fair

Distance from Pumping Well : 1.25m

Well depth : 33.4m

Height of datum point above ground level : 0.3m

Datum Point : Wooden plank across manhole.

Date	Time	Time since pumping ended (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m ³ /d	Temperature C	Conductivity uS/cm @20 C
05-07-95	21:00	0	12.3	8.84			
		0.5	12.3	8.84			
		1	12.13	8.67			
		1.5	11.2	7.74			
		2	10.7	7.24			
		2.5	8.2	4.74			
		3	7.6	4.14			
		3.5	7	3.54			
		4	6.5	3.04			
		4.5	5.1	1.64			
		5	4.8	1.34			
		6	4.38	0.92			
		7	4.1	0.64			
		8	4	0.54			
		9	3.98	0.52			
		10	3.98	0.52			
		12	3.97	0.51			
		14	3.92	0.46			
		16	3.92	0.46			
		18	3.92	0.46			
		20	3.92	0.46			
		22	3.92	0.46			
		24	3.9	0.44			
		26	3.9	0.44			
		28	3.89	0.43			
		30	3.88	0.42			
		35	3.87	0.41			
		40	3.85	0.39			
		45	3.85	0.39			
		50	3.84	0.38			
		55	3.83	0.37			
	22:00	60(1hr)	3.83	0.37			
		90	3.78	0.32			
	23:00	120(2hrs)	3.75	0.29			
		150	3.72	0.26			
	24:00	180(3hrs)	3.69	0.23			
	01:00	240(4hrs)	3.64	0.18			
	02:00	300(5hrs)	3.6	0.14			
	03:00	360(6hrs)	3.55	0.09			
	05:00	480(8hrs)	3.48	0.02			
	06:00	540(9hrs)	3.46	0			

PUMPING TEST DATA SHEET

Location : BALLIVOR

Borehole name : PW No.1

Date : 06/07/95

Test : Drawdown Data from PW No.1 while PW No.2 is pumping.

Duration : 12hrs.

Weather : Fair

Distance from Pumping Well : 1.25m

Well depth : 33.4m

Height of datum point above ground level : 0.3m

Datum Point : Wooden plank across manhole.

Date	Time	Time since pumping began (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m ³ /d	Temperature C	Conductivity uS/cm @20 C
06-07-95	06:00	0	3.46	0			
		0.5	3.85	0.39			
		1	4.67	1.21			
		1.5	5.15	1.69			
		2	5.6	2.14			
		2.5	5.9	2.44			
		3	6.08	2.62			
		3.5	6.5	3.04			
		4	6.65	3.19			
		4.5	6.9	3.44			
		5	7.23	3.77			
		6	8.05	4.59			
		7	9	5.54			
		8	9.88	6.42			
		9	10.65	7.19			
		10	11.43	7.97			
		12	12.54	9.08			
		14	14.3	10.84			
		16	14.15	10.69			
		18	14.32	10.86			
		20	14.34	10.88			
		22	14.34	10.88			
		24	14.35	10.89			
		26	14.35	10.89			
		28	14.36	10.9			
		30	14.36	10.9			
		40	14.37	10.91			
		50	14.38	10.92			
	07:00	60 (1hr)	14.39	10.93			
		75	14.4	10.94			
		90	14.4	10.94			
		105	14.41	10.95			
	08:00	120 (2hrs)	14.42	10.96			
		135	14.42	10.96			
		150	14.43	10.97			
		165	14.43	10.97			
	09:00	180 (3hrs)	14.44	10.98			
		200	14.45	10.99			
		220	14.44	10.98			
	10:00	240 (4hrs)	14.27	10.81			
		260	14.12	10.66			
		280	14.01	10.55			
	11:00	300 (5hrs)	12.79	9.33			
		330	13.22	9.76			
	12:00	360 (6hrs)	12.23	8.77			
		390	13.13	9.67			
	13:00	420 (7hrs)	12.96	9.5			
		450	12.78	9.32			
	14:00	480 (8hrs)	12.64	9.18			
		510	12.59	9.13			
	15:00	540 (9hrs)	12.4	8.94			
		570	12.37	8.91			
	16:00	600 (10hrs)	12.36	8.9			
		630	12.3	8.84			
	17:00	660 (11hrs)	12.24	8.78			
		690	12.12	8.66			
	18:00	720 (12hrs)	12.1	8.64			

PUMPING TEST DATA SHEET

Location : Ballivor

Borehole name : OW No.1.

Date : 05/07/95

Test : Recovery Data from OW No.1.

Duration : 9hrs.

Weather : Fair

Distance from Pumping Well : 25m

Well depth : 63m

Height of datum point above ground level : 0m

Datum Point : Top of casing.

Date	Time	Time since pumping ended (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m ³ /d	Temperature C	Conductivity uS/cm @20 C
05-07-95	21:00	0	3.18	0.16			
		0.5	3.18	0.16			
		1	3.18	0.16			
		1.5	3.18	0.16			
		2	3.18	0.16			
		2.5	3.18	0.16			
		3	3.18	0.16			
		3.5	3.18	0.16			
		4	3.18	0.16			
		4.5	3.18	0.16			
		5	3.18	0.16			
		6	3.18	0.16			
		7	3.17	0.15			
		8	3.17	0.15			
		9	3.17	0.15			
		10	3.17	0.15			
		12	3.16	0.14			
		14	3.16	0.14			
		16	3.15	0.13			
		18	3.15	0.13			
		20	3.15	0.13			
		22	3.15	0.13			
		24	3.14	0.12			
		26	3.14	0.12			
		28	3.14	0.12			
		30	3.14	0.12			
		35	3.13	0.11			
		40	3.13	0.11			
		45	3.13	0.11			
		50	3.12	0.1			
		55	3.12	0.1			
	22:00	60 (1hr)	3.12	0.1			
		90	3.11	0.09			
	23:00	120 (2hrs)	3.11	0.09			
		150	3.1	0.08			
	24:00	180 (3hrs)	3.09	0.07			
06/07/95	01:00	240 (4hrs)	3.07	0.05			
	02:00	300 (5hrs)	3.06	0.04			
	03:00	360 (6hrs)	3.05	0.03			
	05:00	480 (8hrs)	3.03	0.01			
	06:00	540 (9hrs)	3.02	0			

PUMPING TEST DATA SHEET

Location : BALLIVOR

Borehole name : OW No.1

Date : 06/07/95

Test : Drawdown Data from OW No.1 while PW No.2 is pumping.

Duration : 12hrs.

Weather : Fair

Distance from Pumping Well : 25m

Well depth : 63m

Height of datum point above ground level : 0m

Datum Point : Top of casing.

Date	Time	Time since pumping began (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	Conductivity uS/cm @20 C
06-07-95	06:00	0	3.02	0			
		1	3.02	0			
		2	3.02	0			
		2.5	3.03	0.01			
		3	3.03	0.01			
		4	3.03	0.01			
		5	3.03	0.01			
		6	3.04	0.02			
		7	3.04	0.02			
		8	3.04	0.02			
		9	3.04	0.02			
		10	3.05	0.03			
		12	3.05	0.03			
		14	3.06	0.04			
		16	3.06	0.04			
		18	3.06	0.04			
		20	3.07	0.05			
		22	3.07	0.05			
		24	3.07	0.05			
		26	3.08	0.06			
		28	3.08	0.06			
		30	3.08	0.06			
		35	3.09	0.07			
		40	3.09	0.07			
		45	3.09	0.07			
		50	3.1	0.08			
	07:00	60 (1hr)	3.1	0.08			
		75	3.12	0.1			
		90	3.12	0.1			
		105	3.13	0.11			
	08:00	120 (2hrs)	3.13	0.11			
		135	3.14	0.12			
		150	3.14	0.12			
		165	3.14	0.12			
	09:00	180 (3hrs)	3.15	0.13			
		200	3.16	0.14			
		220	3.16	0.14			
	10:00	240 (4hrs)	3.16	0.14			
		260	3.16	0.14			
		280	3.16	0.14			
	11:00	300 (5hrs)	3.16	0.14			
		330	3.16	0.14			
	12:00	360 (6hrs)	3.16	0.14			
		390	3.17	0.15			
	13:00	420 (7hrs)	3.17	0.15			
		450	3.17	0.15			
	14:00	480 (8hrs)	3.19	0.17			
		510	3.18	0.16			
	15:00	540 (9hrs)	3.18	0.16			
		570	3.18	0.16			
	16:00	600 (10hrs)	3.18	0.16			
		630	3.18	0.16			
	17:00	660 (11hrs)	3.18	0.16			
		690	3.18	0.16			
	18:00	720 (12hrs)	3.18	0.16			

Appendix 2

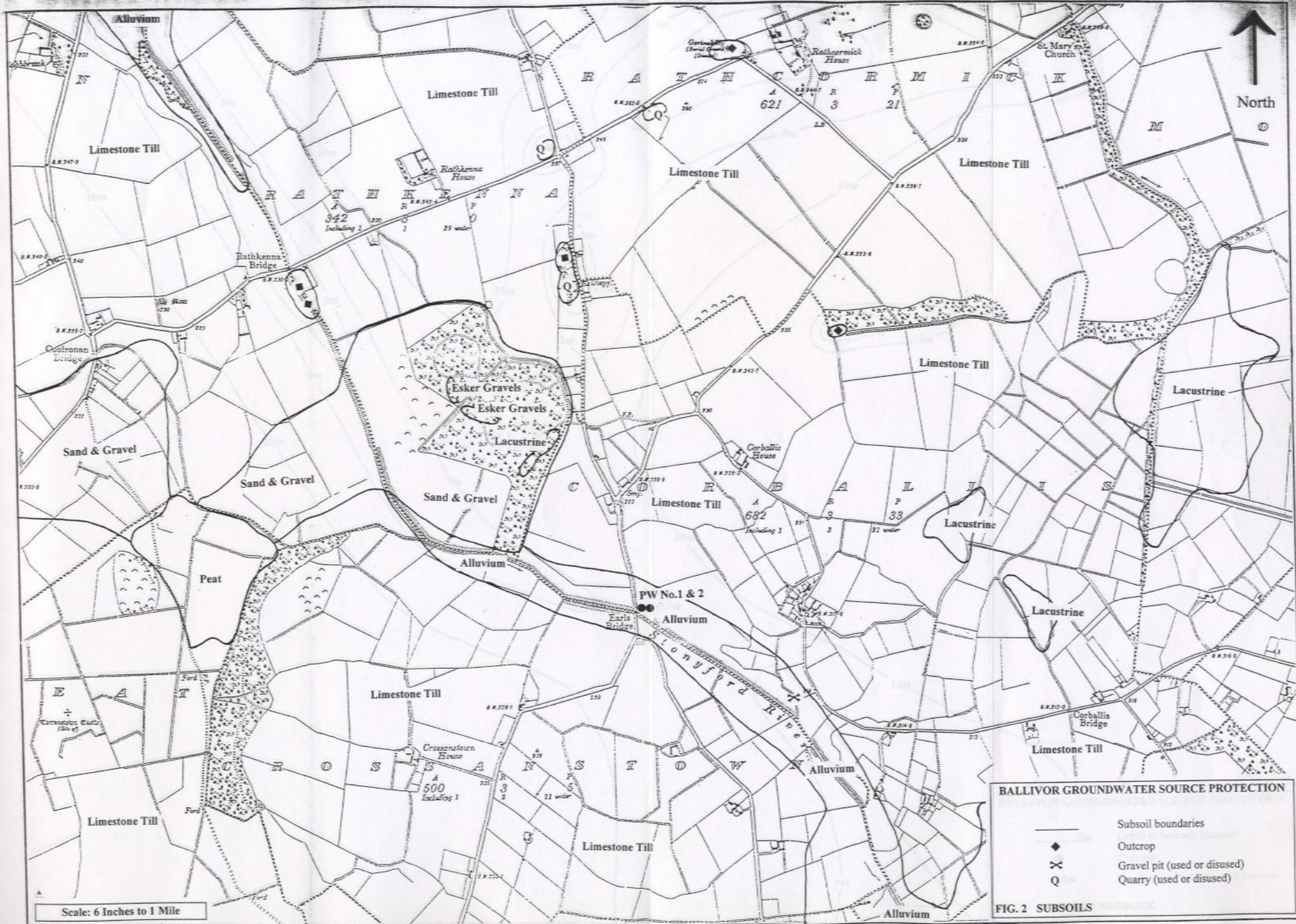
Maps

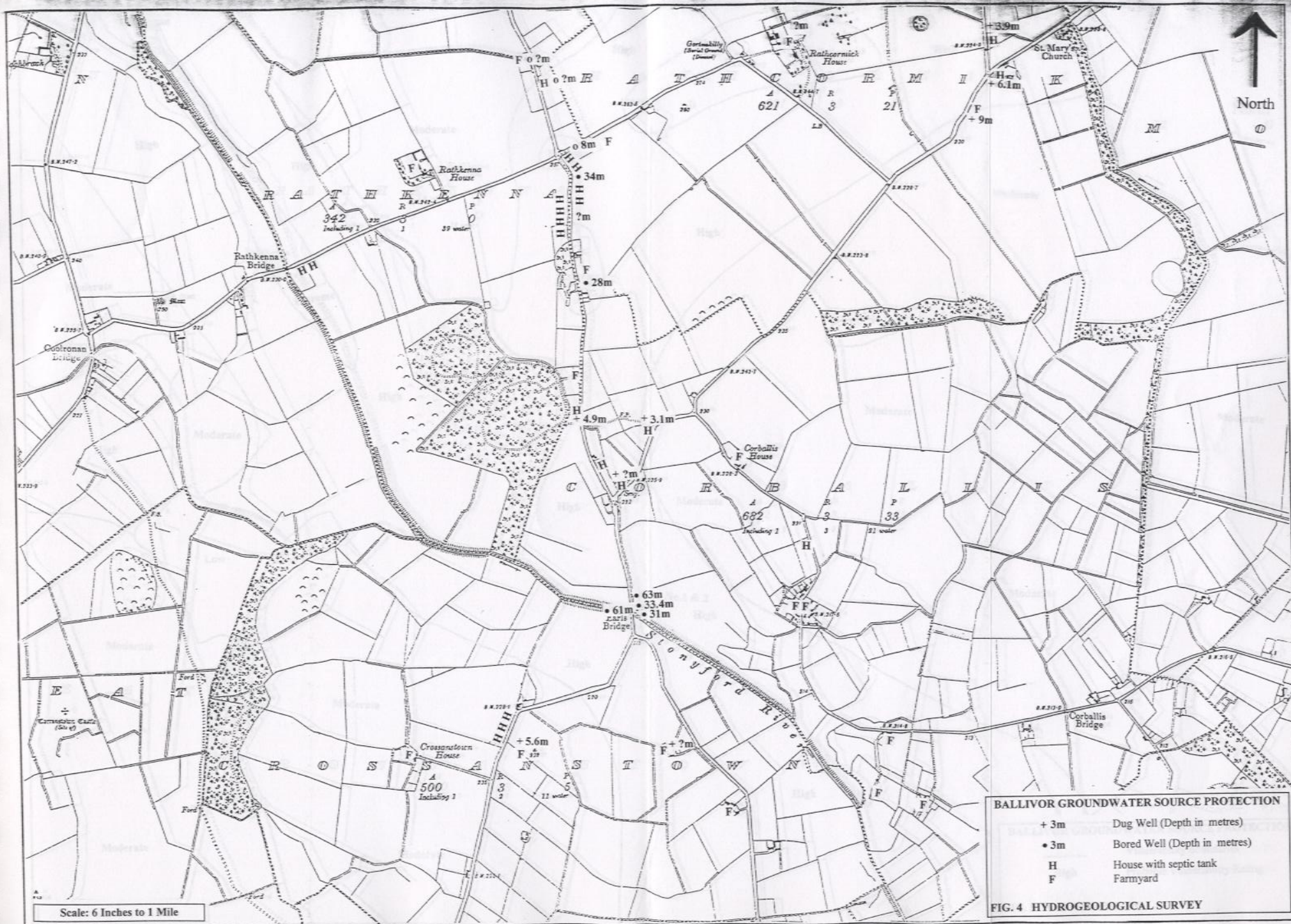


BALLIVOR GROUNDWATER SOURCE PROTECTION

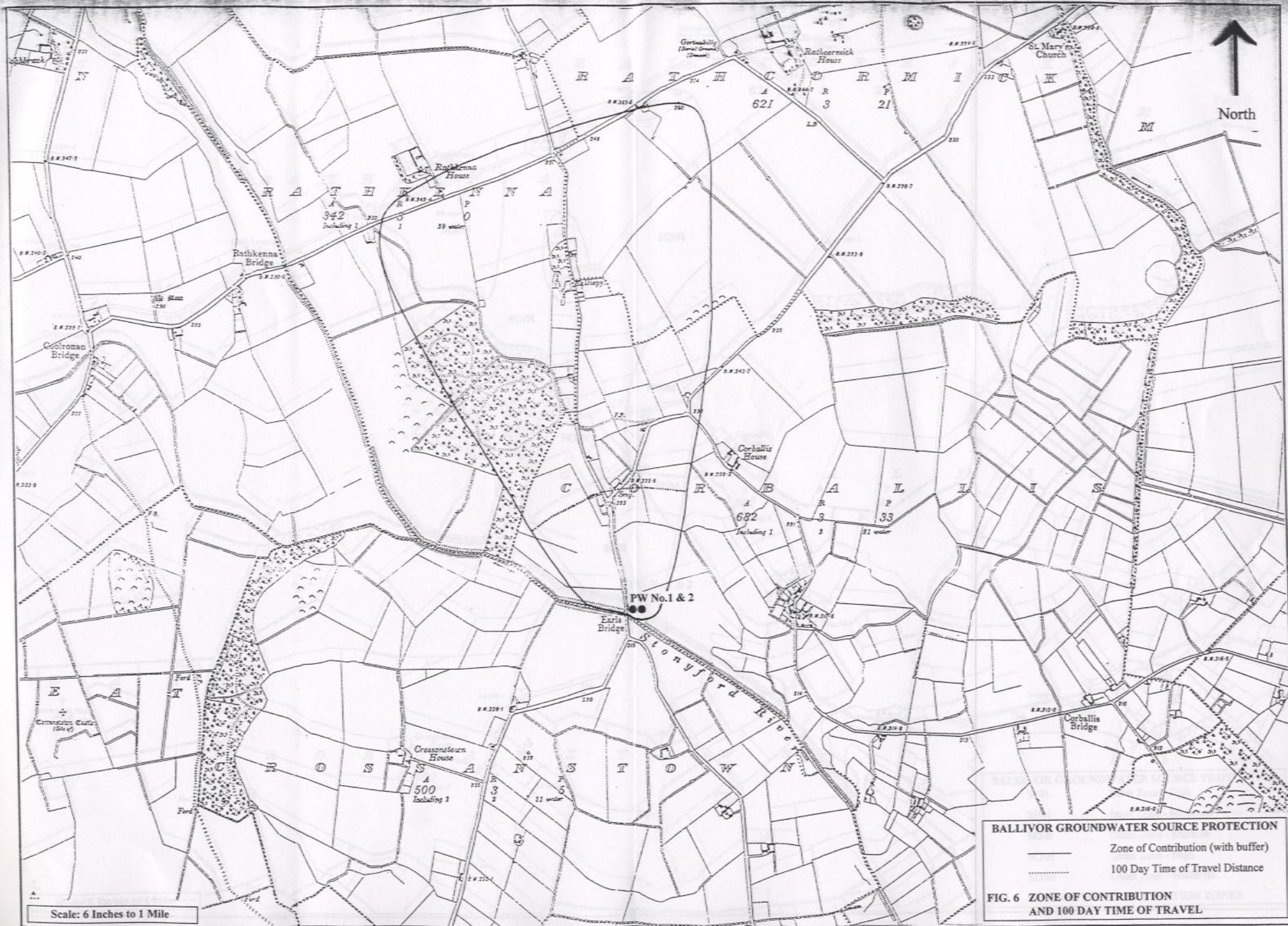
- Public supply well
- Geological Boundary
- - - Fault Boundary
- ↙ Direction and Dip of Bedding

FIG. 1 GEOLOGY









BALLIVOR GROUNDWATER SOURCE PROTECTION

— Zone of Contribution (with buffer)
 - - - 100 Day Time of Travel Distance

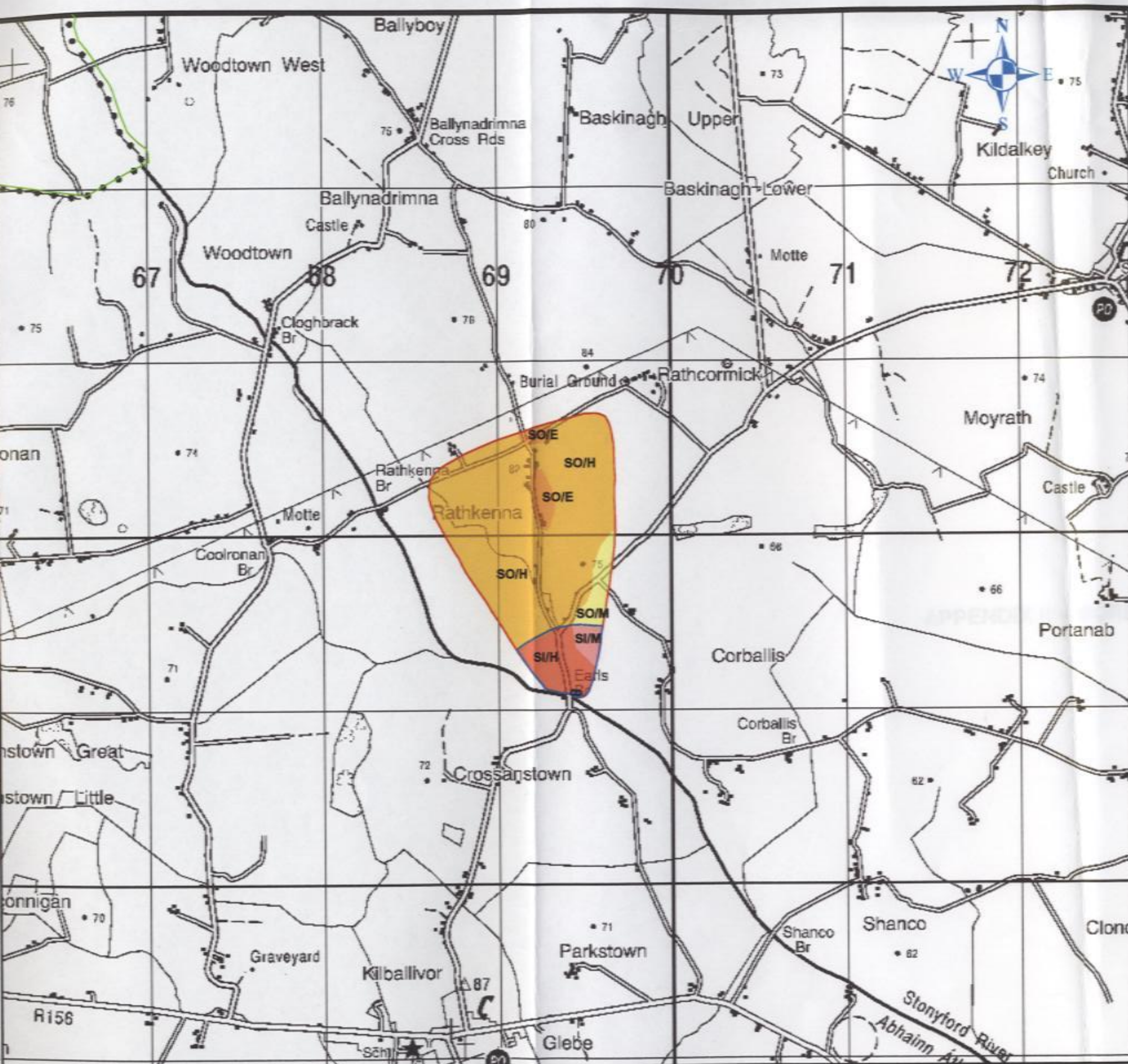
FIG. 6 ZONE OF CONTRIBUTION AND 100 DAY TIME OF TRAVEL



BALLIVOR GROUNDWATER SOURCE PROTECTION

SI/H	Inner Zone - High
SI/M	Inner Zone - Moderate
SO/E	Outer Zone - Extreme
SO/H	Outer Zone - High
SO/M	Outer Zone - Moderate

FIG. 7 GROUNDWATER PROTECTION ZONES



COUNTY MEATH GROUNDWATER PROTECTION SCHEME SOURCE PROTECTION ZONES

Vulnerability Rating	Source Protection Zones	
	Inner (SI)	Outer (SO)
Extreme (E)	SI/E	SO/E
High (H)	SI/H	SO/H
Moderate (M)	SI/M	SO/M
Low (L)	SI/L	SO/L

- Zone of Contribution of Wells (SO)
- Inner protection area (SI)
- County Boundary
- Public Supply Well

Project Hydrogeologist: Coran Kelly
Project Manager: Geoff Wright
Digital Map Production: Silvia Caloca

This Source Protection Zone map is designed for general information and strategic planning usage. The boundaries are based on the available evidence and local details have been generalised to fit the map scale. Evaluation of specific sites and circumstances will normally require further and more detailed assessments and will frequently require site investigations to determine the risk to groundwater.

The map is intended for use in conjunction with groundwater protection responses for potentially polluting activities, which lists the degree of acceptability of these activities in each zone and describes the control measures necessary to prevent pollution.

The topographic base is reproduced with the permission of the Ordnance Survey of Ireland.



Year	Area	Population	Area	Population
1991	100	100	100	100
1996	100	100	100	100
2001	100	100	100	100
2006	100	100	100	100
2011	100	100	100	100



Ballivor
1:25,000

