BALTINGLASS WATER SUPPLY

GROUNDWATER SOURCE PROTECTION REPORT

Revised March 2003

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BALTINGLASS PUBLIC WATER SUPPLY

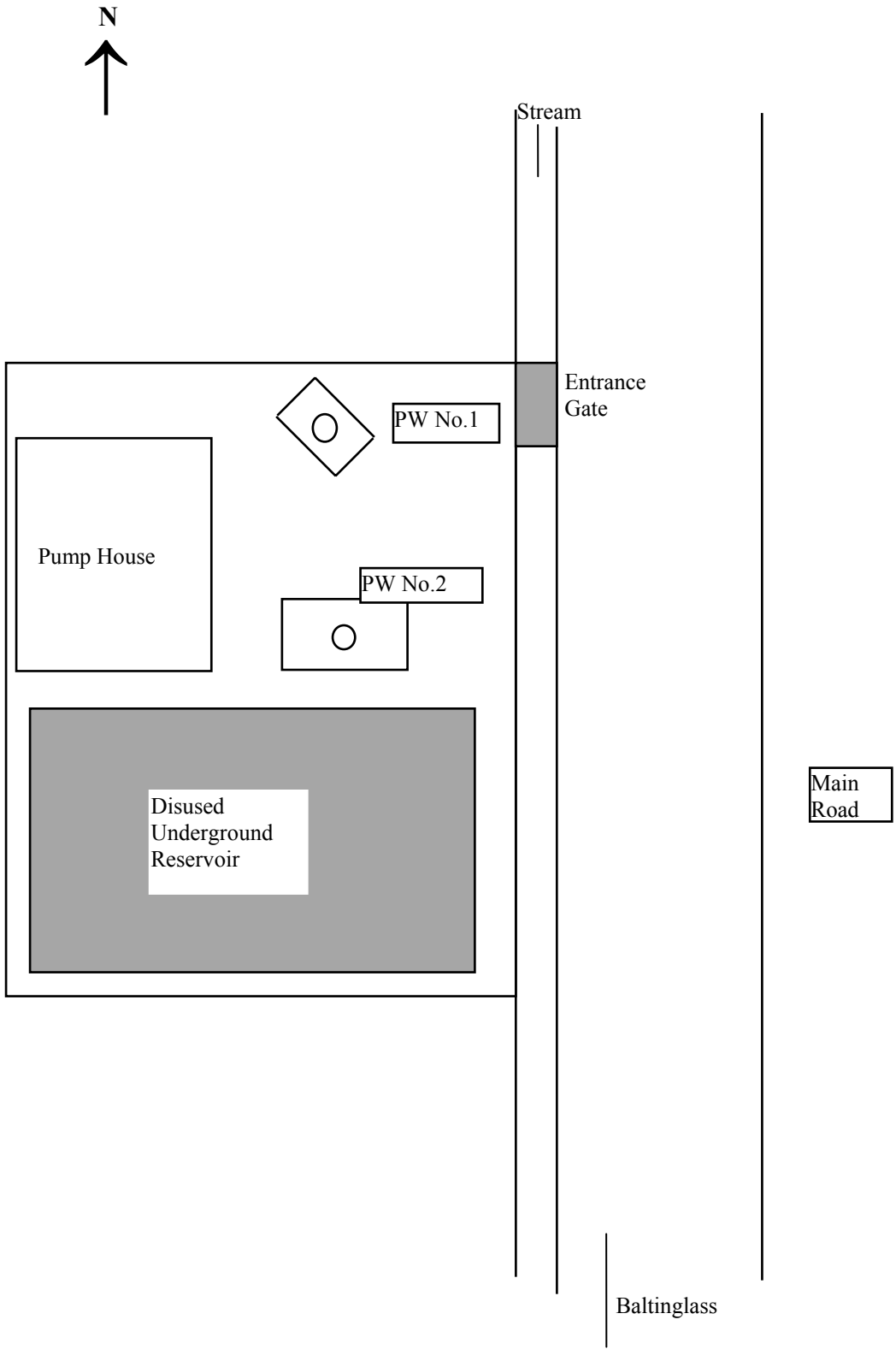
1. Well Locations and Site Descriptions

The Baltinglass Water Supply Scheme is supplied from three sites: two boreholes at Tinoran, another two boreholes at Lathaleere, and two springs at Bawnoge.

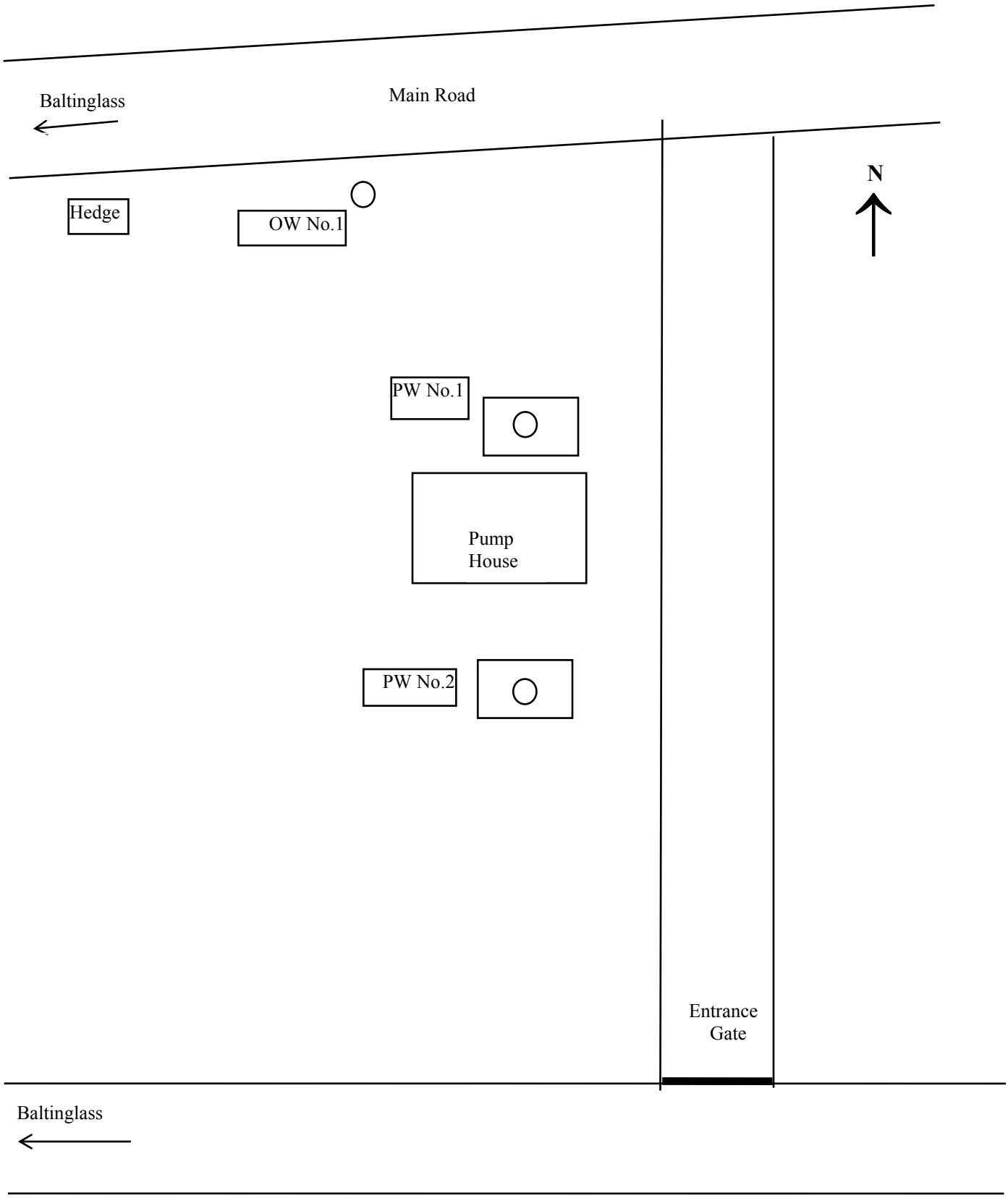
The Tinoran site is located about 1.5 km northwest of Baltinglass village. The wells at Lathaleere are located about 1 km southeast from the main street in Baltinglass village, on the eastern bank of the River Slaney. The springs at Bawnoge, on the west side of the Slaney, are used by the Council to supplement the supply, due to the high demand for water from the expanding village. All the production wells are completed below ground level, each with a metal manhole at ground level covering the well. At both Tinoran and Lathaleere there is a standby well close to the main pumping well which is used intermittently with the main pumping well. The production wells are located beside the pump houses, and are fenced off from the adjacent fields. The Baltinglass groundwater is not treated except for the Bawnoge springs which are chlorinated in the pumphouse before being pumped into supply. There are no storage reservoirs for the borehole supplies, thus the water is generally pumped directly into supply. The springs at Bawnoge are piped to the pumphouse at Parkmore, where there is a small storage reservoir, hence they are referred to as 'Parkmore Springs' in some documents. There are very few private wells being used in the vicinity of these supplies.

2. Well Details

	TINORAN		**LATHALEERE**	
	PW No.1	**PW No. 2**	**PW No. 1**	**PW No. 2**
GSI no.	2617NE 033	2617NE 032	2617NE 046	2617NE 042
Grid ref. (from 1:25,000)	28535 18884	28536 18883	28778 18781	28777 18780
Owner	Wicklow County Council	Wicklow County Council	Wicklow County Council	Wicklow County Council
Well type	Borehole	Borehole	Borehole	Borehole
Elevation (top of manhole cover)	164.60m OD (Malin Head)	164.59m OD (Malin Head)	124.24m OD (Malin Head)	124.59m OD (Malin Head)
Elevation (ground level)	164.60 m OD.	164.59m OD	124.24 m OD	124.59 m OD.
Depth	61 m	61 m	61 m	61 m
Depth of casing	unknown	unknown	unknown	approx. 29 m
Diameter	200 mm (8")	200mm (8")	200 mm (8")	300 mm (12"-10")
Depth-to-rock	unknown	unknown	unknown	unknown
Static water level	5.23 m b.g.l. (10/4/97)	5.23 m b.g.l. (10/4/97)	8.02 m b.g.l. (24/4/97)	8.25 m b.g.l. (24/4/97)
Pumping water level	9.40 m b.g.l. (10/4/97)	5.99 m b.g.l. (10/4/97)	37.9 m b.g.l. (24/4/97)	29.2 m b.g.l. (24/4/97)
Pumping rate	340m^3/d (3,100 gph)		325 m^3/d (3,000 gph)	
Aquifer	Pollaphuca Formation/Butter Mountain Formation Fault Zone		Granite	
Pumping test summary:				
(i) pumping rate	340 m^3/d		260 m^3/d	
(ii) drawdown	4.17 m (10/4/97)	0.76 m (10/4/97)	29.88 m (24/4/97)	20.95 m (24/4/97)
(iii) specific capacity	72 m^3/d/m (extrapolated to 1 wk)		8.7 m^3/d/m	
(iv) transmissivity	150 - 160 m^2/d		15 m^2/d	



Sketch of Tinoran Site, Baltinglass Water Supply
(not to scale)



Sketch of Lathaleere Site, Baltinglass Water Supply
(not to scale)

3. Methodology

Desk study

All available existing data were compiled. Basic well details, including borehole locations and any relevant chemistry data and pumping test data, were obtained from County Council personnel and consultants.

Site visits and fieldwork

An observation well was drilled by GSI in April 1997 beside the Lathaleere Production Wells. Pumping tests and recovery tests were carried out at Tinoran and Lathaleere to examine the aquifer characteristics. The areas around the sources were surveyed with regard to geology, hydrogeology, vulnerability to pollution and current pollution loading. Raw water samples were taken from both sources in February, May and August 1997 for full suites of chemical and bacterial analyses. Conductivity measurements were taken between February and July 1997 by Council personnel. Well-head elevations were measured by GSI staff.

Assessment

Analytical equations and hydrogeological mapping were used to delineate protection zones.

4. Topography, Drainage and Land Use

The Baltinglass supply sources are located in southwest County Wicklow. The topography is very undulating, ranging from 115 m OD (380 ft) to over 365 m OD (1200 ft).

The River Slaney flows through the area in a south-southwesterly direction, with some smaller streams joining it. The Lathaleere site is about 300 metres northeast of the river at its nearest point. The Tinoran site is about 1200 metres due west of the Slaney, in a small valley drained by an unnamed tributary stream. The Bawnoge springs lie some 130-220 m to the southwest of the Slaney, at the foot of the slope rising from the alluvial flat.

The drainage is moderate with numerous small drainage ditches.

Excluding the village and its immediate surrounds, the land use in the area is primarily tillage and pasture. The fields around the wells are permanently in grassland.

5. Geology

5.1 Bedrock geology

The geology in the vicinity of the Baltinglass sources is quite complex. Lathaleere and the Bawnoge springs are underlain by Granite. Tinoran is underlain by greywackes and shales of the Pollaphuca Formation (Kilcullen Group), and the dark grey slates and grey quartzites of the Butter Mountain Formation (Ribband Group) which become schistose towards the granite. The contact between these rocks at Tinoran is a fault and the wells are probably located in the fault zone. The exact location of the fault is not known, due to the cover of overlying glacial deposits, thus a fault zone up to 400 metres wide is drawn on the geology map (Figure 1), between the known control points and using the general trend for faults in this area.

The granites have been intruded into the Lower Palaeozoic rocks and form part of the Leinster Granite batholith, which is comprised of five plutons. The Tullow Pluton underlies Baltinglass and is a pale, fine to coarse-grained granite.

The Pollaphuca Formation consists of coarse graded greywackes, grey to dark grey shales and occasional quartzites and is Lower Ordovican to Silurian in age.

The Butter Mountain Formation is lithologically similar to the Maulin Formation and is dominated by dark blue-grey slates, occasionally interbedded with grey quartzites. Volcanic rocks are more abundant in this formation, with andesites and andesitic tuffs (McConnell & Philcox, 1994).

The borehole log of the 56 m deep Lathaleere observation well (Baltinglass D/H 97/6), close to PW 1, indicates up to 12 m of gravelly till and 13 m of sand and gravel which may be interpreted as highly weathered granite bedrock. The underlying granite was highly broken, and initial recovery of core was very poor down to 30 m and greatly improved from 46 m down. There was only 25% core recovery from 23-26 m and no recovery from 26-29 m. The bedrock geology is shown in Figure 1.

5.2 Quaternary (subsoils) geology

The Quaternary geology in the vicinity of the Baltinglass sources is very complex, with several types of deposit represented.

The area to the east of the River Slaney, around Lathaleere, is underlain by a gravelly Lower Palaeozoic or chert-derived till. Both rounded and angular clasts occur within the tills in about equal quantities, generally with a silty sandy matrix. The sand fraction dominates the particle size distribution. Palaeo-meltwater channels occur in the Baltinglass region and produced extensive gravel deposits on the west side of the Slaney. Around Lathaleere the tills may be reworked glaciofluvial sand and gravel deposits. Locally, gravels occur above and within the tills, in particular close to the Lathaleere Well. The till has a gravelly texture but clay dominates the matrix in all cases investigated.

The tills are interpreted as a slightly overconsolidated lodgement or melt-out till which was deposited during the last glacial period.

Along the River Slaney are extensive gravels, flanked by alluvial deposits. To the west and northwest of Tinoran is an area of limestone dominated till, generally clayey in texture, also interpreted as a lodgement till. Much of the higher ground has outcropping bedrock, particularly to the northwest and northeast.

5.3 Depth-to-rock

Rock outcrops on the higher ground around Glennacanon and around Tuckmill Hill. Depth-to-rock around the public supply boreholes is 8-12 m (Table 1 below) and is generally greater than 10 metres to the southwest and southeast of Baltinglass but to the north the subsoils are much thinner.

The depth to rock contouring (for groundwater vulnerability assessment) was based on very limited data points and may need refining as further depth to bedrock records become available.

Table 1: GSI Depth-to-bedrock auger holes, 1997 (Bakker, M., 1997)

GSI Well No.	GSI drill No.	East	North	Depth hm	Depth to bedrock m	Subsoil Log
2617NE 058	97/87	28537	18888	10	8	0-6m: sandy silty Lr Palaeozoic diamicton 6-8m: gravelly silty Lr Palaeozoic diamicton 8-10m: silty clayey Lr Palaeozoic diamicton
2617NE 059	97/85	28518	18860	10	>10	0-6m: diamicton: clayey silt matrix 6-8m: diamicton: sandy silt matrix 8-10m: sandy silt
2617NE 060	97/86	28465	18953	8	6	0-4m: silty Lr Palaeozoic diamicton 4-8m: clayey silt to clay Lr Palaeozoic diamicton
2617NE 057	97/84	28578	18807	10	>10	0-10m: clayey silty Lr Palaeozoic diamicton
2619SE 057	97/88	32335	18480	9	>9	0-4m: clayey sandy silty Lr Palaeozoic diamicton 4-9m: gravelly clayey silty Lr Palaeozoic diamicton

GSI Well No.	GSI drill No.	East	North	Dept hm	Depth to bedrock m	Subsoil Log
2617NE	97/89	28638	18838	10	>10	0-10m: silty clayey Lr Palaeozoic diamicton
2617NE	97/90	28658	18934	6	>6	1-6m: gravelly silty Lr Palaeozoic diamicton
2617NE	97/91	28678	18995	7	>7	0-6m: gravelly silty Lr Palaeozoic & limestone diamicton 6-7m: sandy silty Lr Palaeozoic diamicton
2619SE	97/92	28744	19055	5	>5	0-2m: gravelly clayey silt Lr Palaeozoic diamicton 2-5m: sandy silty Lr Palaeozoic diamicton
2617NE	97/93	28777	18825	14		0-10m: gravelly sandy Lr Palaeozoic & limestone diamicton 10-14m: silty sandy granite diamicton
2617NE	97/94	28857	18753	12		0-12m: gravelly silty sandy Lr Palaeozoic & limestone diamicton
2617NE	97/95	28865	18770	9.5		0-6m: sandy silty Lr Palaeozoic diamicton 6-9.5m: sandy silty granite diamicton
2617NE	97/96	28732	18784	6		*(no samples)*
2617NE	97/97	28672	18748	15		0-1.5m: made ground 1.5-15m: sandy granite diamicton

Note: the technical term 'diamicton' usually denotes a glacial till or 'boulder clay'.

6. Hydrogeology

6.1 Data availability

Hydrogeological data for the Baltinglass pumping wells and the surrounding area were lacking. In particular, data from the drilling and initial testing of the production wells were not available. The GSI monitoring borehole at Lathaleere (OW No.1) has a diameter of 75.7 mm (47.6 mm core) and 50mm plastic pipes were installed in the borehole, the bottom pipes slotted to allow water entry.

Pumping tests and recovery tests were carried out in April 1997 at Tinoran and Lathaleere and surveys of potential pollution sources and wells were conducted within a kilometre of each source (Figure 4). The surveys indicated very few private wells in the Lathaleere area; where possible, water levels from private wells were measured and a water table map drawn to ascertain the approximate groundwater flow directions. The well-heads were not accurately levelled in but as the survey included dug wells or springs which may be tapping a perched water table within the till, these water level readings were used with caution.

6.2 Groundwater levels

Groundwater is generally close to the surface, especially along the river. Static water levels in the wells, after overnight recovery, and pumping water levels after 12 hours pumping, are shown below:

Date	Well Number	Static Water Level		Pumping Water Level	
		metres (b.g.l)	metres O.D.	metres (b.g.l)	metres O.D.
Tinoran					
7-5-97	PW No.1	5.23	159.37	9.4	155.2
7-5-97	PW No.2	5.23	159.36	6.0	158.6
Lathaleere					
7-5-97	PW No.1	8.02	116.22	37.9	86.34
7-5-97	PW No.2	8.25	116.34	29.2	95.39
7-5-97	OW No.1	8.11	116.44	12.9	111.65

6.3 Groundwater flow directions and gradients

Regional groundwater flow is generally towards the River Slaney and southward, but locally it is dependent on topography. At Tinoran the groundwater flow direction is from the northeast and northwest and then southwards along the valley. The water table at the pumping wells is over 5 metres below ground level, which suggests that the small stream is not in hydraulic continuity with the water table and seems to be perched.

At Lathaleere the groundwater flow direction is from the north-northeast. The exact flow direction was difficult to assess here due to the lack of water level data in the vicinity of the wells. Groundwater gradients in the general area may range from approximately 0.02 to 0.04, depending on the local topography.

At Bawnoge groundwater flow is assumed to be eastwards, towards the Slaney. The springs drain thick gravels, and the groundwater gradient is likely to be around 0.02.

6.4 Rainfall, Evaporation and Recharge

The nearest rainfall station is at Donard, 10 km northeast. The mean annual rainfall as recorded by Met Eireann for 1951-1980 was 1100 mm. Potential evapotranspiration (P.E.) is estimated from a Met Eireann contoured map as 530 mm/yr. Actual evapotranspiration (A.E.) has been estimated at 500 mm by calculating a percentage (95%) of the P.E., to allow for seasonal soil moisture deficits. Using the above figures the effective rainfall (E.R.) is taken to be approximately 600 mm/yr.

At Tinoran there is one main drainage ditch in the immediate area of the supply and the subsoils are relatively poorly draining and generally thin, especially to the north, and the steep gradients allow a high proportion of the effective rainfall to run off. Estimating runoff to be of the order of 70%, the actual annual recharge to the aquifer is estimated to be 180mm/yr.

At Lathaleere there are few drainage ditches and streams in the immediate area of the supply and the subsoils are free draining, so a high proportion of the effective rainfall infiltrates to the water table. Estimating runoff to be of the order of 30%, the recharge to the aquifer is estimated to be 420mm/yr.

At Bawnoge the area is underlain by permeable gravels which will have a high infiltration rate. Recharge to the aquifer is expected to be about 90% of effective rainfall, i.e. about 540 mm/yr.

These calculations are summarised below:

Average annual rainfall	1100 mm
Estimated P.E.	530 mm
Estimated A.E. (95% P.E.)	500 mm
Effective rainfall	600 mm
Tinoran Recharge	180 mm
Lathaleere Recharge	420 mm
Bawnoge Recharge	540 mm

6.5 Hydrochemistry and Water Quality

Tinoran: The chemical analyses indicate a calcium bicarbonate water type which is moderately soft (82-94 mg/l $CaCO_3$) with a low alkalinity (45-65 mg/l $CaCO_3$) and conductivity varies from 210-260 μS/cm.

The groundwater at Tinoran is very good with the exception of the nitrate which is consistently higher than 25 mg/l, the EU Guide Level, and values of up to 39 mg/l are recorded.

The water quality in the adjacent Tinoran stream is very variable with high ammonium, iron, nitrite and potassium together with high numbers of bacteria which all indicate farmyard contamination.

The boreholes may not have been grouted to prevent the entry of contaminated surface water (well construction details unavailable). The steep local gradients allow abundant and rapid runoff to occur.

Lathaleere: The chemical analyses indicate a calcium bicarbonate water type which is moderately hard (204-216 mg/l $CaCO_3$), with a moderate alkalinity (178-190 mg/l $CaCO_3$) and conductivity varies from 380-470 µS/cm. The higher values can be attributed to the overlying carbonate rich subsoils.

The quality of the groundwater from Lathaleere is generally good although there are some natural background Coliforms. Nitrate levels are just below the guide level – mean 19 mg/l, max. 23 mg/l.

The Lathaleere source was closed in November 2002 due to the concentrations of Uranium found in the water. A new well drilled at Carsrock will be commissioned in the summer of 2003 to augment the supplies from the Tinoran and Parkmore sources.

Bawnoge Springs: The hydrochemical analyses again indicate a calcium bicarbonate water type which is hard (286-324 mg/l $CaCO_3$) with a moderate alkalinity (238 - 280 mg/l $CaCO_3$).

The springs tend to have intermittent contamination from *E.coli* occurring at times. Chloride ranges from 16 to 19 mg/l. Conductivity is high (524-605) which is due to the dissolution of calcium carbonate from the limestone dominated subsoils. Nitrate levels are generally above the EU Guide Level, ranging from 23-39 mg/l with a mean of 27 mg/l.

The gravel aquifer is unconfined and mapped as 'highly' vulnerable to contamination. Recent housing development has encroached on the Zone of Contribution. The risk of contamination of these sources is relatively high.

The groundwater analyses are in the Appendices.

Table 1. Conductivity readings from the Baltinglass Sources

	Lathaleere		Parkmore Springs	
Date	**Conductivity**	**Temperature**	**Conductivity**	**Temperature**
	(µS/cm)	**(^{O}C)**	**(µS/cm)**	**(^{O}C)**
*4/2/97	433	10.6	562	9.5
11/2/97	467	11.2	604	10.2
5/3/97	443	11.6	573	9.8
21/4/97	459	11.8	590	10.7
*14/5/97	433	11.8	557	10.7
3/7/97	459	12.4	588	11.6
*11/8/97	426	14.5	562	13

	Tinoran		Tinoran Stream	
Date	**Conductivity**	**Temperature**	**Conductivity**	**Temperature**
	(µS/cm)	**(^{O}C)**	**(µS/cm)**	**(^{O}C)**
*4/2/97	229	9.8	256	7.5
11/2/97	245	10.8		
5/3/97	234	10.4	262	8.3
21/4/97	243	10.8	242	9.7
*14/5/97	225	10.5	255	9.8
3/7/97	233	11.2		
*11/8/97	232	15.5	258	15.1

* Full analyses

6.6 Aquifer coefficients

The pumping test data are in the Appendices.

Tinoran:

The discharge-drawdown graph indicated that the final pumping water level was close to a steady state condition. The yields of the Tinoran wells are the maximum possible from the pumps.

Analysis of the 12 hour pumping test provided an apparent transmissivity of 150-160 m^2/d. The calculated specific capacity (extrapolated to 1 week) was around 72 $m^3/d/m$. A specific yield of 0.03 was calculated from the late data from the observation well and indicated that the aquifer is unconfined.

Lathaleere:

An approximate steady state pumping water level was attained during the 8 hour test at Lathaleere. The water level was close to the pump level after 6 hours of pumping and a reduction in the discharge allowed the water level to steady. Further tests are required to obtain an optimum pumping rate for these pumping wells. During very dry summers the pumping water level at Lathaleere is close to or at the pump intake.

The two observation wells (PW2 & OW1) displayed rather different responses to pumping in PW1. PW2 responded in a very similar fashion to the pumping well, but with a slightly reduced drawdown, in both the discharge and recovery phases. This may imply that the two wells (only 7.5 m apart) both draw water from a connected fissure system. In contrast, OW1 had a much more muted response and a much lower drawdown. The observation well encountered very weathered and broken granite down to about 30 m. It appears that this material is more permeable than the rock found in the two production wells, and showed signs of delayed yield (i.e. after about 2-3 hours, the drawdown was reduced by slow drainage of the sandy weathered granite).

Analysis of the 8 hour pumping test provided an apparent transmissivity of about 15 m^2/d (from OW1 data) to about 4 m^2/d (PW2 data). The calculated specific capacity was around 8.7 $m^3/d/m$. A specific yield of 0.0004 was calculated from the late data from the observation well and indicated that the aquifer may be confined.

6.7 Conceptual Models

Tinoran: The aquifer feeding the source at Tinoran is possibly a fault zone between the Pollaphuca Formation and the Butter Mountain Formation. The wells are located in the bottom of a small 'U' shaped valley. The valley sides are quite steep. On the northern side of the valley rock is at or close to the surface. On the valley floor close to the wells, there are up to 8 m of till (generally silty stony clays). On the southern side of the valley are relatively thick deposits of Limestone dominated till. Down-gradient of the wells are areas of alluvial deposits and gravels.

The aquifer is considered to be unconfined, at least near the wells. The unsaturated zone is up to 6 m thick. The aquifer is very permeable, at least in the upper part, and this is supported by the high yield from the wells. Permeabilities within the bedrock are increased by joints and fractures which are directly related to the faulting close to the wells.

There is no information available about the drilling of these wells, the initial testing or well design. It is assumed the subsoils are cased off and the groundwater is obtained from the underlying bedrock. A north/south fault separates the adjacent rock formations and due to the limited rock exposure the exact location of this fault is within a 400 m wide zone (see Figure 1). It is assumed that the high transmissivities are associated with this fault and thus groundwater is transmitted rapidly along the fault to the well.

Groundwater flow is influenced by topography and mirrors the ground levels, flowing from the higher ground, down and along the small valley. A natural groundwater catchment can be deduced along the top of topographical ridges. The groundwater flow to the public supply is therefore presumed to be from the west and the east and then southwards.

Lathaleere: At Lathaleere, the wells are located 300 m from the River Slaney and the site is overlain by over 12 m of till cover, which has a moderate permeability as a result of its gravelly nature. Directly to the north of the production wells, rock is at or close to the surface. The aquifer feeding the source at Lathaleere is Granite and is considered to be confined at least near the wells. The unsaturated zone is up to 8 m thick. The GSI monitoring borehole indicates that the uppermost part of the aquifer is highly fractured and broken, particularly down to 30 m.

Groundwater flow is influenced by topography and mirrors the ground levels, flowing from the higher ground, down to the Slaney Valley and discharges into the river. The groundwater flow to the public supply is therefore presumed to be from the northeast.

The main inflow into the wells is possibly through the broken granite below 30 m. Direct inflows to the wells from the subsoils and weathered granite are prevented by the presence of the steel casing. The pumping well was reported initially to be capable of producing over 600 m^3/d, but the sustainable rate has now decreased to less than 300 m^3/d. The reduction in the yield may have resulted from overpumping lowering the pumping water level below the main inflows to the well, or from poor well construction and development. The pumping test results indicate a relatively low permeability, probably decreasing with increasing depth below ground level.

The groundwater may be hydraulically connected to the river although the wells are a sufficient distance from the river to be unaffected by recharge from the river.

Bawnoge: The Bawnoge springs issue from the foot of a gravel slope, where the gravel deposit meets the alluvial flat of the Slaney. The catchment area is conceptualised as a simple body of gravel, more than 10 m thick.

6.8 Aquifer category (Figure 2)

Tinoran: The aquifer supplying the Tinoran source is the Pollaphuca Formation and the Butter Mountain Formation and the fault zone between them. Considering the aquifers in terms of well yields and specific capacities over the county they are classed as a **locally important aquifer** which is **moderately productive only in local zones (Ll).** The fault zone at Tinoran is thus one of the productive 'local zones'.

Lathaleere: The aquifer supplying the Lathaleere source is the Granite. Considering the aquifer in terms of well yields and specific capacities over the county it is classed as a **Poor aquifer - generally unproductive except for local zones (Pl).**

Bawnoge: The aquifer supplying the Bawnoge Springs is the gravel (overlying granite), which is classified as a **Locally Important Gravel Aquifer (Lg)**.

7. Groundwater Vulnerability

The catchment areas for the Baltinglass sources are regarded as being extremely to moderately vulnerable to pollution. The subsoils in the vicinity of the pumping wells are relatively thick, (around 8 m at Tinoran) and moderately permeable. Directly north of the source the subsoils are very thin with some rock outcrops and are extremely vulnerable to pollution and to the west of Tinoran the subsoils are much thicker and are moderately permeable and thus moderately vulnerable, although detailed investigation would be required to confirm this.

At Lathaleere the subsoils are much thicker, around 12 m and are moderately permeable. To the north the subsoils are not as thick and are extremely to highly vulnerable.

Under the GSI vulnerability mapping guidelines, areas where rock is less than 3 m below surface are mapped as having an 'extreme' vulnerability. Such areas occur especially on the higher ground to the north. The 3 m depth-to-bedrock contours are interpreted using the available data points and the aerial photographs. The surrounding area is classified as 'highly vulnerable' due to the moderate permeability of the subsoil and the shallow cover. The remainder of the surrounding area is classified as 'moderately vulnerable'. The vulnerability zones are shown on Figure 3.

The apparent catchment area to the Bawnoge Springs is entirely underlain by fairly thick gravels with a water table over 3 m deep (except immediately around the springs themselves), hence the groundwater vulnerability is 'high'.

8. Source Protection Areas

8.1 Inner Protection Area (SI)

The Inner Protection Area is defined by a 100 day time of travel to the source and 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.

As a result of the inferred higher permeability close to the surface (upper 30 metres) in the vicinity of the sources, and the fracture/fault zone at Tinoran, high aquifer coefficients are used to determine the 100 day time of travel distance.

Tinoran

Using the following aquifer coefficients: permeability (k) = 10 m/d, porosity = 0.03, and the hydraulic gradient (i) = 0.02, the 100 day time of travel distance to the wells is estimated to be approximately 750 metres (Fig. 4).

Lathaleere

Using the following aquifer coefficients: permeability (k) = 5 m/d, porosity = 0.02, and the hydraulic gradient (i) = 0.02, the 100 day time of travel distance to the wells is estimated to be approximately 500 metres (Fig. 4).

Bawnoge

Using the following aquifer coefficients: permeability (k) =30 m/d, porosity =0.2, and the hydraulic gradient (i) = 0.02, the 100 day time of travel distance to the springs is estimated to be approximately 300 metres (Fig. 4).

8.2 Outer Protection Area (SO)

The Outer Protection Area includes the remainder of the complete catchment area to the source, i.e. the zone of contribution (ZOC), which is delineated as the area required to support an abstraction from long-term recharge. The ZOCs at Baltinglass are derived from hydrogeological mapping and are controlled primarily by the groundwater divides and the groundwater flow directions. ZOCs are shown in Figure 4 for Tinoran, Lathaleere and Bawnoge; their sizes are based largely on the Recharge Equation.

Tinoran: The source protection area is delineated for a higher output (510 m^3/d) than is currently abstracted, to facilitate an increase in demand of 50% and to allow for expansion of the zone of contribution during dry weather.

Assuming an average annual recharge for Tinoran of 180 mm, the area required to supply the pumping rate of 510 m^3/d is estimated at 1.05 km^2. The null point or down-gradient boundary of the ZOC (the distance down-gradient beyond which water is not contributing to the well) is approximately 100 metres. As it is thought that a high percentage of the groundwater to the Tinoran wells travels along a north-south fault zone located to the west of the wells, an additional area has been included in the final zone of contribution, by incorporating the 400 m wide fault zone as a safety margin for the groundwater flow along the fault. In addition, the wells may also be recharged by water from the adjacent small stream so the catchment of this stream is within the final zone of contribution shown on Figure 4. The actual area of the ZOC in Figure 4 is about 1.4 km^2, because of the need to include all the hydrological catchment to the source.

Lathaleere: The source protection area is delineated for the maximum output of 325 m^3/d which is currently abstracted, and also allows for expansion of the zone of contribution during dry weather.

Assuming an average annual recharge for Lathaleere of 420 mm, the area required to supply the pumping rate of 325 m^3/d is estimated at 0.3 km^2. The null point or down-gradient boundary of the ZOC (the distance down-gradient beyond which water is not contributing to the well) is approximately 100 metres. A buffer (safety margin) is included in the final zone of contribution by

incorporating a 10-20^{o} error margin for the estimated groundwater flow direction, thus the ZOC is conservative. The actual area of the ZOC in Figure 4 is approximately 0.5 km^2.

Bawnoge: No flow records are available for the Bawnoge Springs, hence a Zone of Contribution cannot be estimated using a water balance. Considering the topography alone, the ZOC can be expected to extend southwestwards for about 600 m to a water divide. A total ZOC of approximately 0.45 km^2 appears likely (Figure 4). Assuming an annual recharge of 540 mm, this would imply an annual flow of approximately 243,000 m^3/year, or roughly 665 m^3/day. This, in turn, suggests that the low flow in the springs may be of the order of 200 m^3/day, or 2.3 litres/second.

9. Groundwater Source Protection Zones

Combining the Source Protection Areas with the vulnerability ratings produces the Source Protection Zones, listed below in order of decreasing degree of protection required and shown in Figure 4:

Tinoran

- Inner Protection Area /Extreme (SI/E)
- 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)

Lathaleere

- 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)

Bawnoge

- Inner Protection Area / High (SI/H)
- Outer Protection Area / High (SO/H)

10. Potential Pollution Sources

Tinoran: The primary threat to the source is the quality of the water in the river adjacent to the source. Surface water quality may be affected especially by surface run off in fields, by septic tanks and farm effluent. All these potentially polluting activities within the catchment to the stream upstream of Baltinglass could affect the quality of this groundwater source.

A few houses are present in the ZOC. There are several farmyards located up-gradient of the wells which store silage or have cattle feeding yards and may pose a risk to the wells if farmyard activities are not controlled. There is no mains sewerage scheme in this area, thus all the houses are served by septic tanks which if not adequately controlled may also pose a risk to the groundwater.

Lathaleere: The primary threat to the public supply is from the factories up-gradient. Accidental spillages could pose a significant threat to the supply wells

A few houses are present in the ZOC. There are several farmyards located up-gradient of the wells which store silage or have cattle feeding yards and may pose a risk to the wells if farmyard activities are not controlled. There is no mains sewerage scheme in this area, thus all the houses are served by septic tanks which if not adequately controlled may also pose a risk to the groundwater.

The main potential sources of contamination would appear to be the developments at the eastern edge of Baltinglass village and the surrounding houses and farmyards. There is a sewerage scheme in operation although not all the houses are connected and there are some septic tanks close to the

source. The zone of contribution extends under some residential estates and industrial developments. It is possible that over time a combination of leaky sewer pipes and septic tanks could cause groundwater contamination. The major sewer pipe runs close to the wells along the main road. There is also a risk from surface runoff from farmyards and landspreading of organic wastes.

Bawnoge: No detailed field survey was carried out for this specific area, but there has been significant new housing development in recent years. The main potential sources of contamination appear to be a number of houses and a couple of farmyards, including some within the Inner Protection Area, and road run-off.

11. Conclusions and Recommendations

The Lathaleere source was closed in November 2002 due to the concentrations of Uranium found in the water. A new well drilled at Carsrock will be commissioned in the summer of 2003 to augment the supplies from the Tinoran and Parkmore sources.

An increased yield is possible at Tinoran with the installation of a larger pump providing there are no pipeline restrictions. The water analyses indicate that there were no water quality problems at this source, except for the high nitrates. However the source catchment is **extremely** to **highly** vulnerable to pollution. The groundwater quality may also depend on the stream water quality as the stream could be recharging the aquifer.

The Tinoran source protection zones extend into County Kildare. Co-operation from Kildare County Council will be essential in controlling potentially polluting activities in the protection zones.

It is recommended that the Council continue to sample the raw water from the Baltinglass public supplies to monitor the bacteria, ammonium, nitrate, potassium, chloride and conductivity levels, and 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 within the delineated groundwater source protection zones. In particular, the Council should monitor farmyard activities up-gradient from the sources and all industrial and commercial developments.

12. References

Bakker, M. 1997. County Wicklow Groundwater Protection Scheme: Quaternary Geology. Appendix I: Drilling Report; Appendix III: Grain Size Analyses.

DELG/EPA/GSI, 1999. *Groundwater Protection Schemes.* Department of Environment & Local Government, Environmental Protection Agency and Geological Survey of Ireland, joint publication.

McConnell, B. & Philcox, M.E. 1994. Geology of Kildare – Wicklow: A Geological description to accompany the Bedrock Geology 1:100,000 map series, Sheet 16. Geological Survey of Ireland.

Addendum

Uranium^{238} concentrations in Lathaleere Borehole and Bawnoge Springs

As this report was going through its final revisions in late 2002, it became known that the Lathaleere Boreholes and, to a lesser extent, the Bawnoge Springs, contained anomalously high concentrations of Uranium^{238}, a naturally occurring weakly radioactive element.

When the County Wicklow Groundwater Protection Project was being undertaken in 1996-7, no analyses of Uranium concentrations were available for any of the County's water sources. However, it has been known for many years that the Wicklow Granite contains some Uranium and that the concentrations of U^{238} in the rock are patchy. It appears that the U^{238} anomalies are due to natural causes and that the catchment of the Lathaleere borehole includes a zone where the U^{238} is particularly concentrated in the granite aquifer.

The Lathaleere source was closed in November 2002 due to the concentrations of Uranium found in the water. A new well drilled at Carsrock will be commissioned in the summer of 2003 to augment the supplies from the Tinoran and Parkmore sources.

Appendix 1
Pumping Test Data

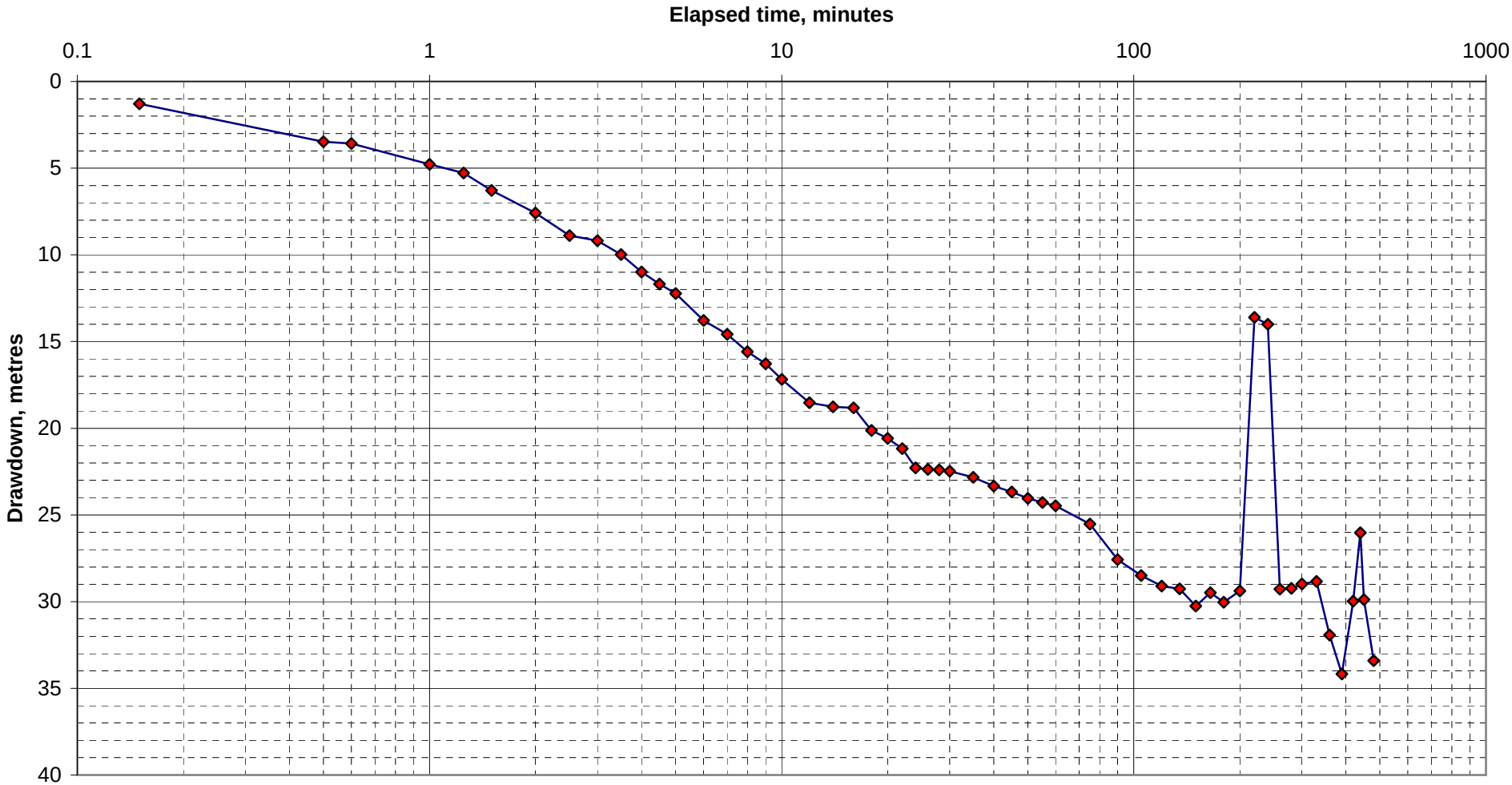
PUMPING TEST DATA SHEET

Location : **Lathaleere** **County :** **Wicklow** **Date :** **24/4/1997**
Borehole Name : PW No.1 **Number :** 2617NE 046
Duration Time : 8 hours **Test Type :** Drawdown
Pump Depth : ? **Weather :** Overcast and showery

Distance from Pumping Well : **Well Depth :** 61 m **Well Diameter :** 250 mm
Datum Point : Metal edge of manhole cover **Height of datum point above ground :** zero

Date	Time	Time since pumping began (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	Conductivity uS/cm @20 C
24/4/1997	07:00	0	8.02	0			
		0.15	9.3	1.28			
		0.5	11.5	3.48			
		0.6	11.6	3.58			
		1	12.8	4.78			
		1.25	13.3	5.28			
		1.5	14.3	6.28			
		2	15.6	7.58			
		2.5	16.9	8.88			
		3	17.2	9.18			
		3.5	18	9.98			
		4	19	10.98			
		4.5	19.7	11.68			
		5	20.25	12.23			
		6	21.8	13.78			
		7	22.6	14.58			
		8	23.6	15.58			
		9	24.3	16.28			
		10	25.2	17.18			
		12	26.55	18.53			
		14	26.79	18.77		10.8	426
		16	26.85	18.83			
		18	28.15	20.13			
		20	28.6	20.58			
		22	29.2	21.18			
		24	30.3	22.28			
		26	30.4	22.38			
		28	30.43	22.41			
		30	30.5	22.48	260	11.2	423
		35	30.85	22.83			
		40	31.35	23.33			
		45	31.7	23.68			
		50	32.06	24.04			
		55	32.3	24.28			
	08:00	60	32.5	24.48	260	11.2	426
		75	33.55	25.53			
		90	35.6	27.58		11.2	433
		105	36.52	28.5	273		
	09:00	120	37.12	29.1		11.4	434
		135	37.28	29.26			
		150	38.28	30.26			
		165	37.5	29.48			
	10:00	180	38.05	30.03	260	12	432
		200	37.4	29.38			
		220	37.2	13.6			
	11:00	240	37.6	14	260	11.9	432
		260	37.3	29.28	267	12.2	431
		280	37.25	29.23			
	12:00	300	37	28.98	252	11.9	431
		330	36.86	28.84	288		
	13:00	360	39.95	31.93	325	11.9	431
		390	42.2	34.18			
	14:00	420	38	29.98	202	11.7	432
		440	34.05	26.03	230		
		450	37.9	29.88			
	15:00	480	41.42	33.4		11.7	432

Lathaleere PW1 Pumping Test, 24 April 1997, Drawdown data



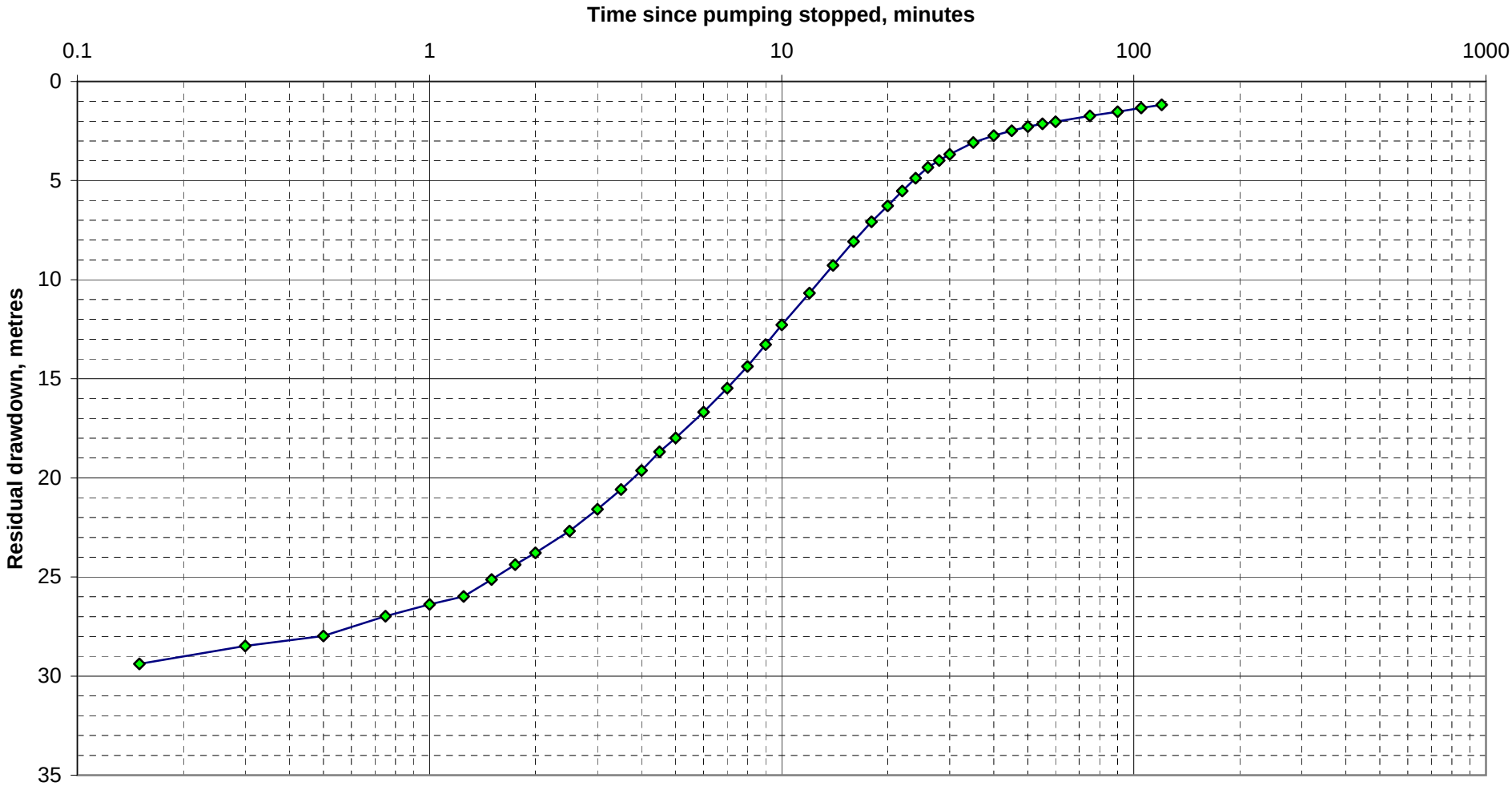
PUMPING TEST DATA SHEET

Location : **Lathaleere** **County :** **Wicklow** **Date :** **24/4/1997**
Borehole Name : PW No.1 **Number :** 2617NE 046
Duration Time : 2 hours **Test Type :** Recovery
Pump Depth : ? **Weather :** Overcast and showery

Distance from Pumping Well : **Well Depth :** 61 m **Well Diameter :** 250 mm
Datum Point : Metal edge of manhole cover **Height of datum point above ground level** zero

Date	Time	Time since pumping ended (min.)	Water level below datum (metres)	Recovery (metres)	Discharge m3/d	Temperature C	Conductivity US/cm @20 C
24/4/1997	15:30	0	37.8	0			
		0.15	37.4	29.38			
		0.3	36.5	28.48			
		0.5	36	27.98			
		0.75	35	26.98			
		1	34.4	26.38			
		1.25	34	25.98			
		1.5	33.15	25.13			
		1.75	32.4	24.38			
		2	31.8	23.78			
		2.5	30.7	22.68			
		3	29.6	21.58			
		3.5	28.6	20.58			
		4	27.65	19.63			
		4.5	26.7	18.68			
		5	26	17.98			
		6	24.7	16.68			
		7	23.5	15.48			
		8	22.4	14.38			
		9	21.3	13.28			
		10	20.3	12.28			
		12	18.7	10.68			
		14	17.3	9.28			
		16	16.1	8.08			
		18	15.1	7.08			
		20	14.3	6.28			
		22	13.55	5.53			
		24	12.9	4.88			
		26	12.35	4.33			
		28	12	3.98			
		30	11.7	3.68			
		35	11.1	3.08			
		40	10.75	2.73			
		45	10.5	2.48			
		50	10.3	2.28			
		55	10.15	2.13			
	16:30	60	10.05	2.03			
		75	9.75	1.73			
		90	9.55	1.53			
		105	9.35	1.33			
	17:30	120	9.2	1.18			

Lathaleere PW1 Pumping Test, 24 April 1997, Recovery data



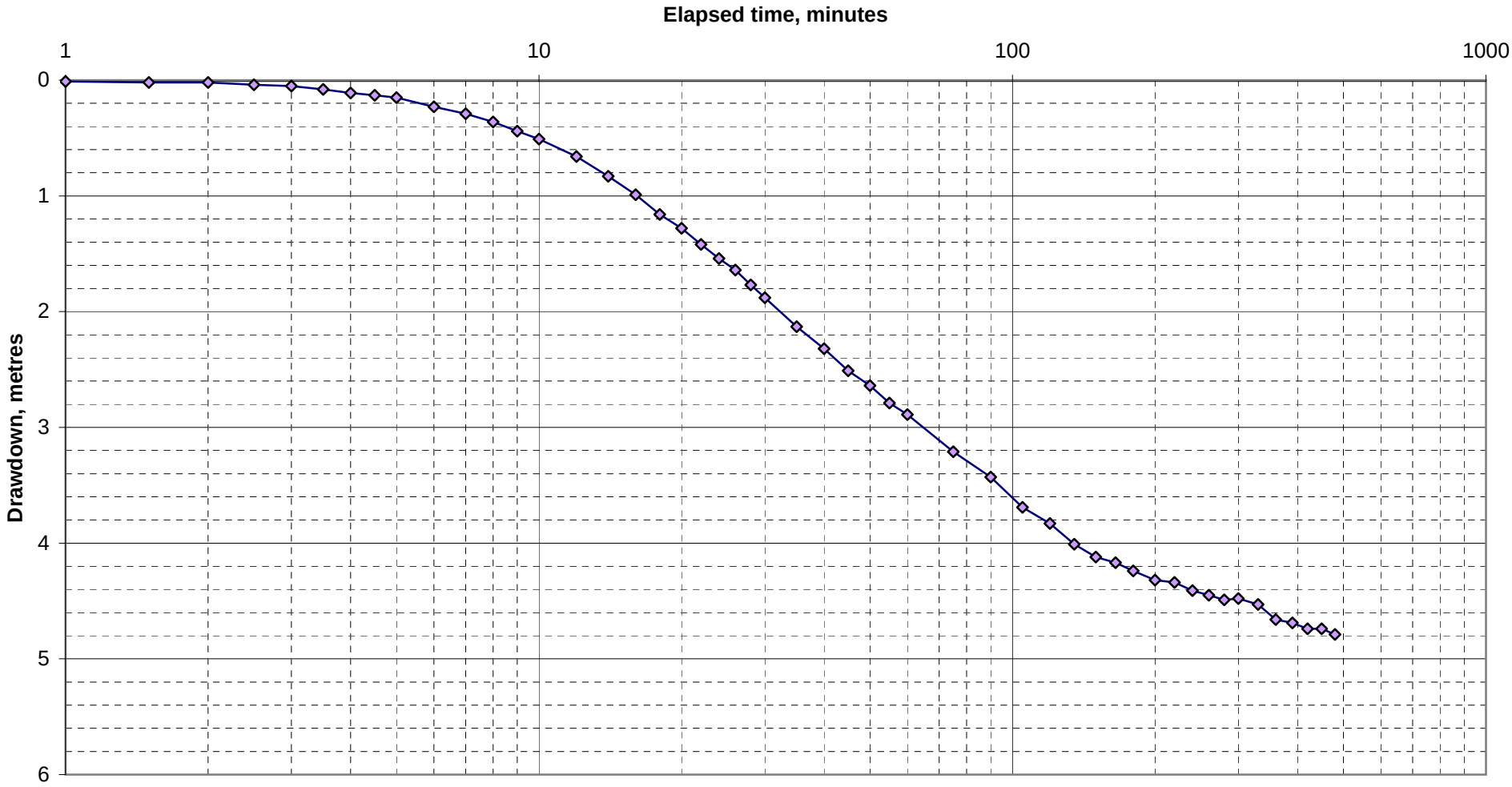
PUMPING TEST DATA SHEET

Location : **Lathaleere** **County :** **Wicklow** **Date :** **24/4/1997**
Borehole Name : OW No.1 **Number :** 2617NE 061
Duration Time : 8 hours **Test Type :** Drawdown
Pump Depth : ? **Weather :** Overcast and showery

Distance from Pumping Well : 13.7 m **Well Depth :** 56 m **Well Diameter :** 80 mm
Datum Point : Metal edge of well head cover **Height of datum point above ground :** zero

Date	Time	Time since pumping began (min.)	Water level below datum (metres)	Drawdown (metres)	Discharge m3/d	Temperature C	Conductivity uS/cm @20 C
24/4/1997	07:00	0	8.11	0			
		0.5	8.11	0			
		1	8.12	0.01			
		1.5	8.13	0.02			
		2	8.13	0.02			
		2.5	8.15	0.04			
		3	8.16	0.05			
		3.5	8.19	0.08			
		4	8.22	0.11			
		4.5	8.24	0.13			
		5	8.26	0.15			
		6	8.34	0.23			
		7	8.4	0.29			
		8	8.47	0.36			
		9	8.55	0.44			
		10	8.62	0.51			
		12	8.77	0.66			
		14	8.94	0.83			
		16	9.1	0.99			
		18	9.27	1.16			
		20	9.39	1.28			
		22	9.53	1.42			
		24	9.65	1.54			
		26	9.75	1.64			
		28	9.88	1.77			
		30	9.99	1.88			
		35	10.24	2.13			
		40	10.43	2.32			
		45	10.62	2.51			
		50	10.75	2.64			
		55	10.9	2.79			
	08:00	60	11	2.89			
		75	11.32	3.21			
		90	11.54	3.43			
		105	11.8	3.69			
	09:00	120	11.94	3.83			
		135	12.12	4.01			
		150	12.23	4.12			
		165	12.28	4.17			
	10:00	180	12.35	4.24			
		200	12.43	4.32			
		220	12.45	4.34			
	11:00	240	12.52	4.41			
		260	12.56	4.45			
		280	12.6	4.49			
	12:00	300	12.59	4.48			
		330	12.64	4.53			
	13:00	360	12.77	4.66			
		390	12.8	4.69			
	14:00	420	12.85	4.74			
		450	12.85	4.74			
	15:00	480	12.9	4.79			

Lathaleere Pumping Test, 24 April 1997, OW1 Drawdown data



Appendix 2
Water Quality Data

Baltinglass WSS
Water Quality Analyses

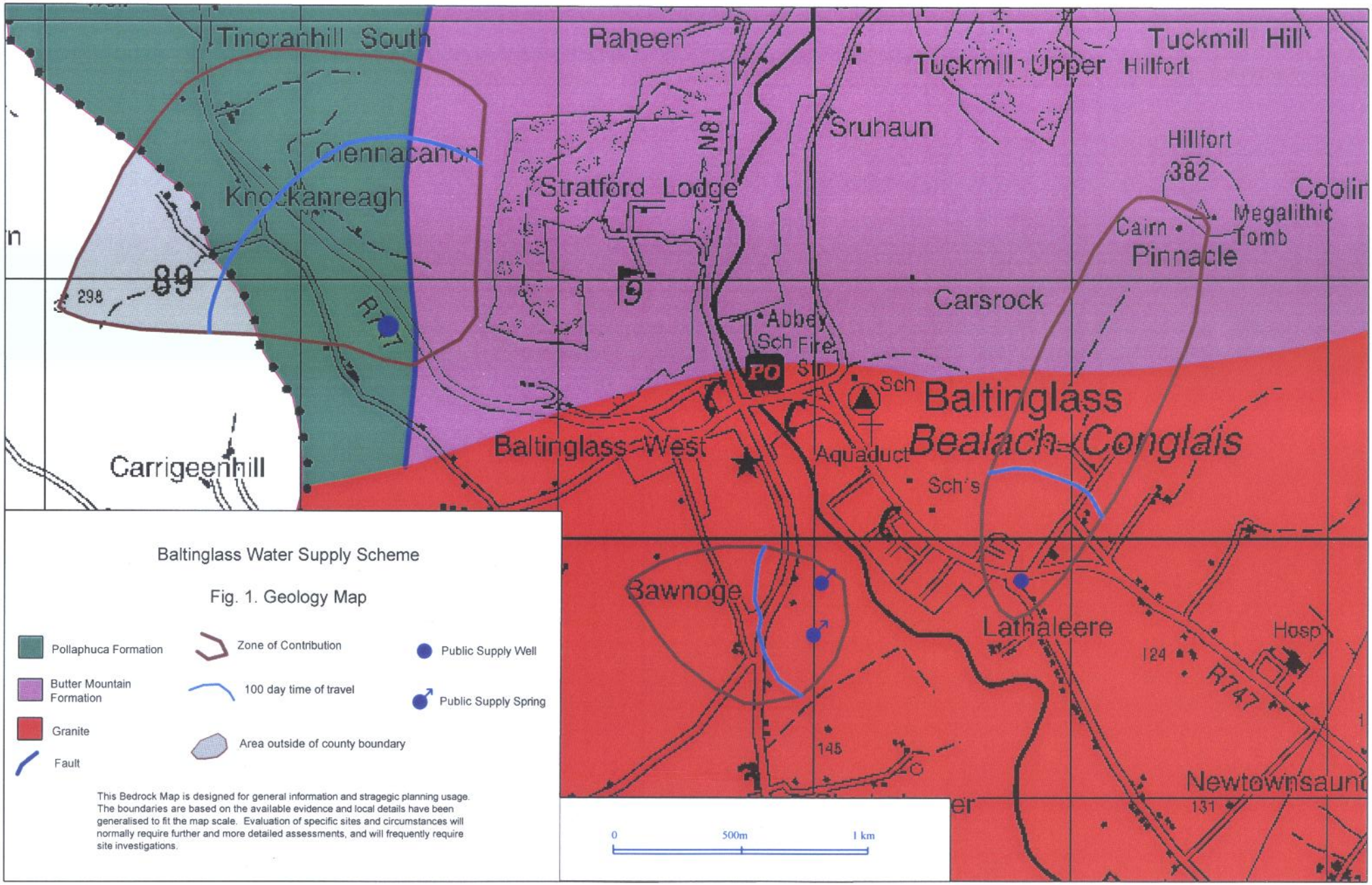
Location			Baltinglass	Baltinglass	Baltinglass	Baltinglass	Tinoran	Tinoran	Tinoran	Tinoran St	Tinoran St	Tinoran St
Site/Sample No.			Tinoran	Tinoran	Tinoran	Tinoran	97WI 1013	97WI 2019	97WI 3004	97WI 1014	97WI 2020	97WI 3005
Site ID No.			2619NE032/033		2619NE032/033		2619NE032/033			Tinoran Stream		
Sample date			7/11/1995	27/6/1996	27/11/1996	10/12/1996	4/2/1997	14/5/1997	11/8/1997	4/2/1997	14/5/1997	11/8/1997
Time			11:50	11:45	12.45	11:40	10:40	10:15	10:05	10:40	10:20	10:10
Parameters	**Units**	**MAC**										
Colour		20	25	7	1	1	clear	clear	clear	Discoloured	Discoloured	Discoloured
Turbidity		4		2.8	0.01	0.01						
Temperature			15.9	21	16.7	14.5	9.8	10.5	15.5	7.5	9.8	15.1
Field pH							6.2	6.2	6.6	7.4	8	7.8
Field E.C. @ 20	µS/cm						229	225	232	256	255	258
Field E.C. @ 25	µS/cm						255	251	259	286	285	288
Alkalinity	mg/l	-	65	60	60	60	46	48	52	70	74	72
Aluminium	mg/l	0.2					<0.02	<0.02	<0.02	0.08	0.023	0.047
Ammonium as N	mg/l	0.23	0.001	0.01	0.01	0.01	<0.015	<0.015	<0.015	0.027	<0.015	0.984
Antimony	mg/l						0.001	-0.001	0.003	-0.002	-0.001	0.002
Arsenic	mg/l	0.05					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Barium	mg/l	0.5					0.054	0.052	0.064	0.072	0.068	0.055
Boron	mg/l	2					0.007	0.009	0.007	0.013	0.017	0.016
Cadmium	mg/l	0.005					<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Calcium	mg/l	200					27	26	26.4	33	32	29.5
Chloride	mg/l	250	19	18	19	17	17	16	17	20	19	19.2
Chromium	mg/l	0.05					<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper	mg/l	0.5					0.008	0.007	0.019	0.006	<0.005	<0.005
Cyanide	mg/l	0.05					<0.01	<0.01	-	<0.01	<0.01	-
E.C.	µS/cm	1,500	253	210	216	244	248	242	246	279	278	273
Fluoride	mg/l	1					<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Hardness (Total)	mg/l	-	94	88	88	82	85	82	85	99	97	91
Iron (total)	mg/l	0.2					0.01	<0.005	0.024	0.113	0.08	0.325
Lead	mg/l	0.05					<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Magnesium	mg/l	50					4.2	4.1	4.7	4	4.3	4.3
Manganese	mg/l	0.05					<0.005	<0.005	0.005	<0.005	<0.005	0.036
Nickel	mg/l	0.05					<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/l	11.3	6	7	8	7.8						
Nitrate as NO3	mg/l	50	26.6	31.0	35.4	34.5	39	36	37	27	24	23.5
Nitrite as N	mg/l	0.03					<0.1	<0.1	<0.1	<0.1	<0.1	0.74
pH		6-9	6.8	6.4	6.7	6.6						
Ortho-phosphate	mg/l	3.3			0.085	0.091			-			-
Phosphate	mg/l	2.2					<0.5	<0.5	<0.5	<0.5	<0.5	0.79
Phosphorus	mg/l	5	0.272	0.2			<0.25	<0.25	<0.25	<0.25	0.274	0.43
Potassium	mg/l	12					1.5	1.5	1.6	6.3	8.5	9.4
Selenium	mg/l	0.01					<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Silver	mg/l	0.01					<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Sodium	mg/l	150					13	13	13	12	11.7	11.9
Strontium	mg/l	-					0.086	0.084	0.09	0.093	0.09	0.08
Sulphate	mg/l	250					10.5	9.8	9.7	9.7	8.3	8.8
Susp. solids	mg/l	none	11	0.001	1	2			-			-
Zinc	mg/l	1					0.034	0.05	0.11	0.004	0.009	0.02
Total Cations	meq/l	-					2.2891	2.2278	2.3117	2.6497	1.8934	2.582
Total Anions	meq/l	-					2.2499	2.2016	2.321	2.5874	2.5701	2.5437
Ion-balance error	%	-					0.9	0.6	-0.2	1.2	1.9	0.75
Total Coliforms	n/100ml	0	0	0	11	0	0	0	0	6,200	570	920
E. coli	n/100ml	0	0	0	0	0	0	0	0	>100	110	>200
Chlorinated			No	No	No	No	No	No	No	No	No	No

Baltinglass WSS
Water Quality Analyses

Location		Baltinglass	Baltinglass	Baltinglass	Baltinglass	Baltinglass	Parkmore Sp	Parkmore Sp	Parkmore Sp	Bawnoge Sp
Site/Sample No.		Parkmore Sp	Parkmore Sp	Parkmore Sp	Parkmore Sp	Parkmore Sp	97WI 1016	97WI 2023	97WI 3007	97WI 1015
Site ID No.		2619NE048	2619NE048	2619NE048	2619NE048	2619NE048	2619NE048	2619NE048	2619NE048	2619NE047
Sample date		7/11/1995	27/5/1996	27/6/1996	27/11/1996	10/12/1996	4/2/1997	14/5/1997	11/8/1997	4/2/1997
Time		12:00	10:30	11:30	12:37	12:00	11:30	10:30	11:00	11:10
Parameters	**Units**									
Colour		26		2	1	1	clear	clear	clear	clear
Turbidity				2	0.01	0.01				
Temperature		15.7		19.4	15.2	14.8	9.5	10.7	13	9.5
Field pH							7.2	7.2	7.3	6.8
Field E.C. @ 20	µS/cm						562	557	562	544
Field E.C. @ 25	µS/cm						628	621	628	610
Alkalinity	mg/l	275		270	280	275	256	256	258	238
Aluminium	mg/l						<0.02	<0.02	<0.02	<0.02
Ammonium as N	mg/l	0.001		0.01	0.01	0.01	<0.015	<0.015	<0.015	<0.015
Antimony	mg/l						-0.002	0.000	0.000	-0.001
Arsenic	mg/l						<0.05	<0.05	<0.05	<0.05
Barium	mg/l						0.088	0.09	0.085	0.041
Boron	mg/l						0.023	0.017	0.024	0.035
Cadmium	mg/l						<0.005	<0.005	<0.005	<0.005
Calcium	mg/l						109	112	108	103
Chloride	mg/l	19		19	18	19	17	16	17	19
Chromium	mg/l						<0.005	<0.005	<0.005	<0.005
Copper	mg/l						0.007	<0.005	0.008	<0.005
Cyanide	mg/l						<0.01	<0.01	-	<0.01
E.C.	µS/cm	597		524	555	608	602	605	591	588
Fluoride	mg/l						<0.25	<0.25	<0.25	<0.25
Hardness (Total)	mg/l	306		304	324	306	303	310	301	286
Iron (total)	mg/l						0.012	<0.005	0.031	<0.005
Lead	mg/l						<0.02	<0.02	<0.02	<0.02
Magnesium	mg/l						7.5	7.6	7.7	7.3
Manganese	mg/l						<0.005	<0.005	0.005	<0.005
Nickel	mg/l						<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/l	5.1		5.4	6.8	7.6				
Nitrate as NO3	mg/l	22.6		23.9	30.1	33.7	34	32	32	38.5
Nitrite as N	mg/l						<0.1	<0.1	<0.1	<0.1
pH		7		7.1	7	7				
Ortho-phosphate	mg/l				0.1	0.12			-	
Phosphate	mg/l						<0.5	<0.5	<0.5	<0.5
Phosphorus	mg/l	0.28		0.18			<0.25	<0.25	<0.25	<0.25
Potassium	mg/l						1.78	1.78	1.9	1.78
Selenium	mg/l						<0.05	<0.05	<0.05	<0.05
Silver	mg/l						<0.005	<0.005	<0.005	<0.005
Sodium	mg/l						8.8	8.8	9	9.9
Strontium	mg/l						0.188	0.197	0.19	0.182
Sulphate	mg/l						15.7	14.3	14.5	12.8
Susp. solids	mg/l	20		5	2	4			-	
Zinc	mg/l						0.126	0.117	0.31	<0.001
Total Cations	meq/l						6.4887	6.6409	6.4595	6.1901
Total Anions	meq/l						6.4747	6.3815	6.449	6.1833
Ion-balance error	%						0.11	1.99	0.08	0.05
Total Coliforms	n/100ml	12	0	2	24	0	1	0	4	0
E. coli	n/100ml	12	0	0	1	0	2	0	1	0
Chlorinated		No	No	No	No	No	No	No	No	No

Baltinglass WSS
Water Quality Analyses

Location		Baltinglass	Baltinglass	Baltinglass	Baltinglass	Lathaleere	Lathaleere	Lathaleere
Site/Sample No.		Lathaleere	Lathaleere	Lathaleere	Lathaleere	97WI 1017	97WI 2021	97WI 3000
Site ID No.		2619NE042/046		2619NE042/046		26/19NE042/046		
Sample date		7/11/1995	27/6/1996	27/11/1996	10/12/1996	4/2/1997	14/5/1997	11/8/1997
Time		12:06	11:30	12:28	11:25	11:45	10:30	10:30
Parameters	**Units**							
Colour		8	19	1	1	clear	clear	clear
Turbidity			2.1	0.01	0.01			
Temperature		15.7	20.8	15.8	14.7	10.6	11.8	14.5
Field pH						7.2	7.3	7.5
Field E.C. @ 20	µS/cm					433	433	426
Field E.C. @ 25	µS/cm					483	483	475
Alkalinity	mg/l	185	185	190	180	180	184	178
Aluminium	mg/l					<0.02	<0.02	0.029
Ammonium as N	mg/l	0.001	0.02	0.02	0.01	<0.015	<0.015	<0.015
Antimony	mg/l					-0.001	0.002	0.006
Arsenic	mg/l					<0.05	<0.05	<0.05
Barium	mg/l					0.023	0.024	0.025
Boron	mg/l					0.011	0.011	0.015
Cadmium	mg/l					<0.005	<0.005	<0.005
Calcium	mg/l					58	61	58.5
Chloride	mg/l	25	24	25	25	24	23	23
Chromium	mg/l					<0.005	<0.005	<0.005
Copper	mg/l					0.01	0.014	0.02
Cyanide	mg/l					<0.01	<0.01	-
E.C.	µS/cm	451	381	406	464	467	470	451
Fluoride	mg/l					<0.25	<0.25	<0.25
Hardness (Total)	mg/l	216	204	215	206	209	212	208
Iron (total)	mg/l					<0.005	<0.005	0.065
Lead	mg/l					<0.02	<0.02	<0.02
Magnesium	mg/l					15.4	15	15
Manganese	mg/l					<0.005	<0.005	<0.005
Nickel	mg/l					<0.01	<0.01	<0.01
Nitrate as N	mg/l	3.5	3.5	4.4	4.2			
Nitrate as NO3	mg/l	15.5	15.5	19.5	18.6	23	23	22.1
Nitrite as N	mg/l					<0.1	<0.1	<0.1
pH		7.3	7.3	6.9	7			
Ortho-phosphate	mg/l			0.44	0.45			-
Phosphate	mg/l					<0.5	<0.5	<0.5
Phosphorus	mg/l	0.6	0.5			<0.25	<0.25	<0.25
Potassium	mg/l					2.1	2	2.1
Selenium	mg/l					<0.05	<0.05	<0.05
Silver	mg/l					<0.005	<0.005	<0.005
Sodium	mg/l					14.4	14.2	13.8
Strontium	mg/l					0.194	0.2	0.2
Sulphate	mg/l					10.6	10.4	10.2
Susp. solids	mg/l	0.001	0.001	2	2			-
Zinc	mg/l					0.02	0.04	0.11
Total Cations	meq/l					4.856	4.9	4.8053
Total Anions	meq/l					4.8568	4.9	4.7803
Ion-balance error	%					-0.008	0	0.3
Total Coliforms	n/100ml	1	0	17	1	0	0	1
E. coli	n/100ml	0	0	0	0	0	0	0
Chlorinated		No	No	No	No	No	No	No

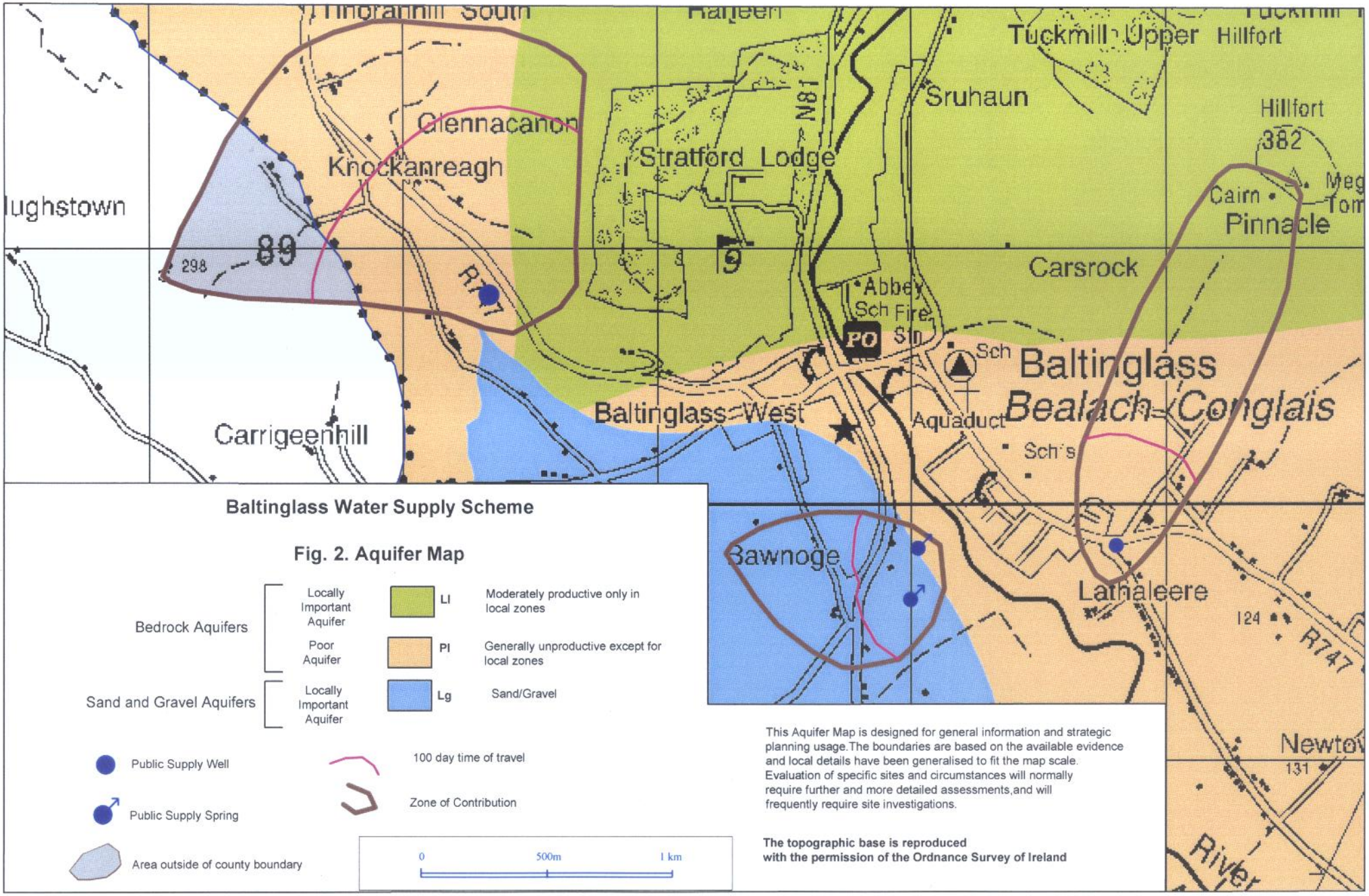


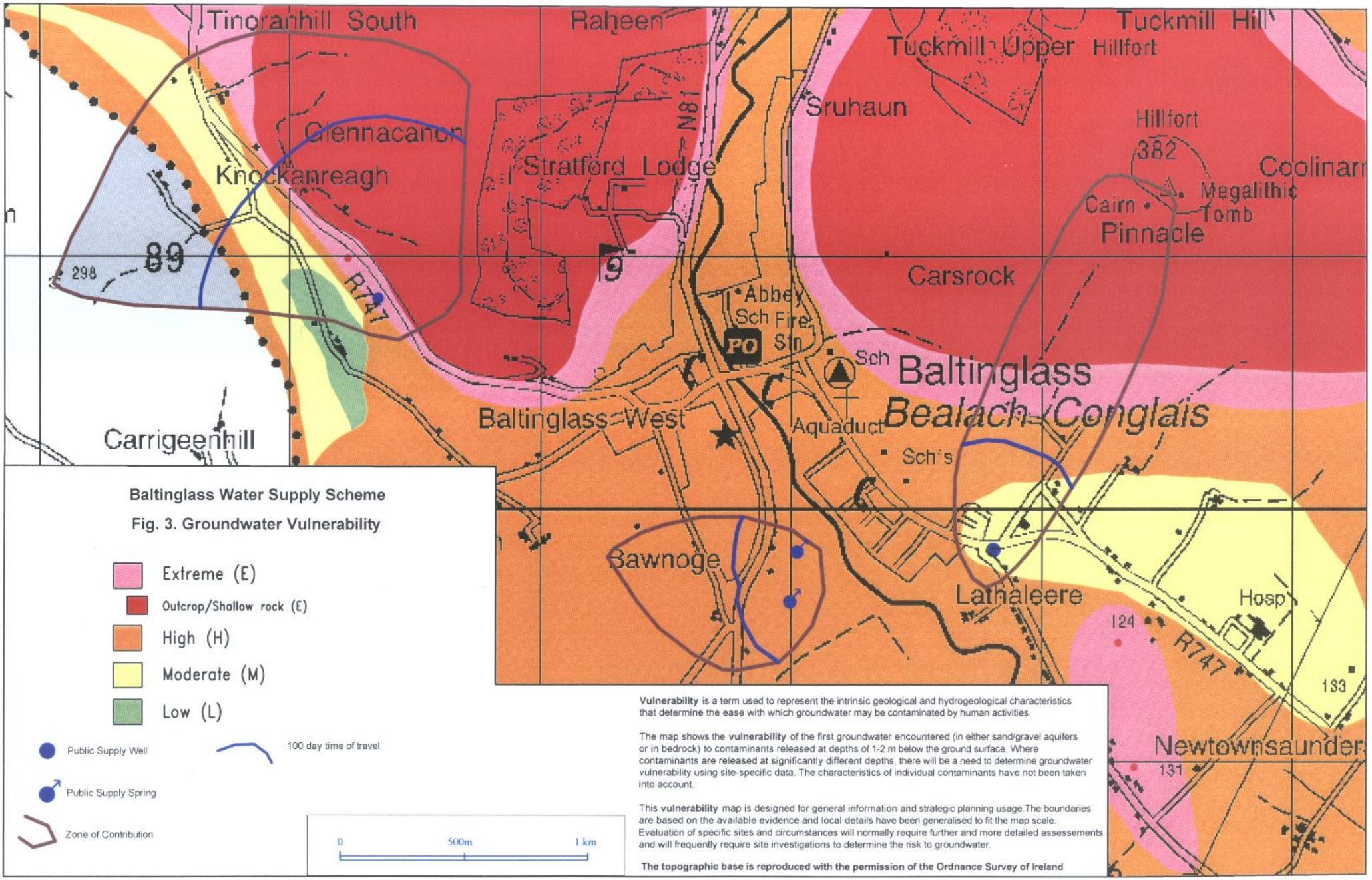
Baltinglass Water Supply Scheme

Fig. 1. Geology Map

- Pollaphuca Formation
- Butter Mountain Formation
- Granite
- Fault
- Zone of Contribution
- 100 day time of travel
- Area outside of county boundary
- Public Supply Well
- Public Supply Spring

This Bedrock Map is designed for general information and stragegic 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.

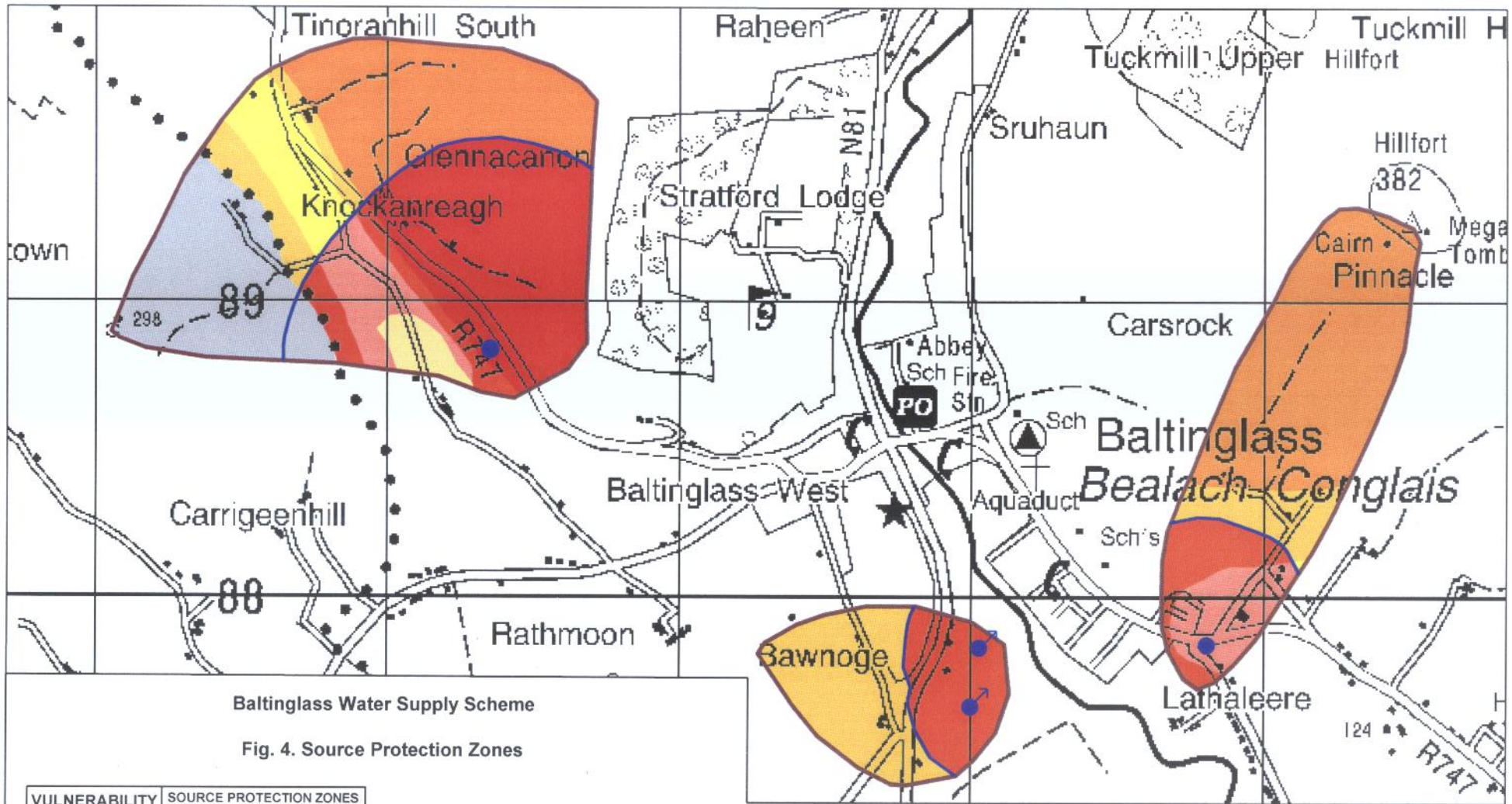

Tinbrannill South
Harleen
Tuckmill Upper
Hillfort
Sruhaun
N81
Glennacanon
Knockanreagh
Stratford Lodge
Hillfort
382
Cairn
Pinnacle
lughstown
89
298
19
R747
Carsrock
Abbey
Sch
Fire Stn
PO
Sch
Baltinglass
Bealach Conglais
Baltinglass West
Aquaduct
Sch's
Carrigeenhill
Bawnoge
Lathaleere
124
R747
Newtow
131
River
Baltinglass Water Supply Scheme
Fig. 2. Aquifer Map
Bedrock Aquifers
Locally Important Aquifer
LI
Moderately productive only in local zones
Poor Aquifer
PI
Generally unproductive except for local zones
Sand and Gravel Aquifers
Locally Important Aquifer
Lg
Sand/Gravel
Public Supply Well
Public Supply Spring
Area outside of county boundary
100 day time of travel
Zone of Contribution
0
500m
1 km
This Aquifer 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.
The topographic base is reproduced with the permission of the Ordnance Survey of Ireland



Vulnerability is a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities.

The map shows the **vulnerability** of the first groundwater encountered (in either sand/gravel aquifers or in bedrock) to contaminants released at depths of 1-2 m below the ground surface. Where contaminants are released at significantly different depths, there will be a need to determine groundwater vulnerability using site-specific data. The characteristics of individual contaminants have not been taken into account.

This **vulnerability** 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 assessements and will frequently require site investigations to determine the risk to groundwater.



Baltinglass Water Supply Scheme

Fig. 4. 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 (not present)

Area outside county boundary

Public Supply Well

Public Supply Spring

100 day time of travel

Zone of Contribution

0 500m 1 km

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 assessements 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