

SECTION 7 SITE GEOLOGY

7.1 SOILS, SUBSURFACE CONDITIONS AND GROUNDWATER

Soils and Subsurface Conditions

A geotechnical appraisal of the site was carried out by Ove Arup & Partners Ireland in June 1991. This is available for inspection at the offices of Michell Ireland.

The geotechnical appraisal found that in general the site is composed of 0.3 meters of topsoil on approximately 2.0 meters of medium dense brown silty clayey sand with gravel and cobbles. This was over at least 2.0 meters (limit of trial pits) of firm to stiff, brown, sandy, silty clay with some gravel, cobbles and the occasional boulder. This is typical of the well drained granular glacial drift deposits expected from the geological maps of the region. On this basis an overburden general allowable bearing pressure of 100kN/m² was estimated. Due to the susceptibility of the exposed overburden to deterioration in wet or heavily trafficked conditions, summer construction is recommended.

The alluvial flats which the wastewater outfall pipes will pass through are composed of 0.2 meters of topsoil underlain by at least 4.0 meters of soft blackish brown peaty silt. It was concluded that the outfall pipes should also be installed during summer in one day to prevent excessive groundwater infiltration and trench destabilisation.

Groundwater

A trial well drilling and testing programme was carried out on the Killowen site in the autumn of 1990 and the report describing the results are contained in Appendix 19. The drilling programme indicated that the site is underlain by some 30m of unconsolidated overburden overlying a weathered limestone bedrock. The limestone bedrock constitutes a major aquifer and the project's total freshwater demand can be supplied by ground water abstracted from this strata.

The chemical analysis of the groundwater abstracted in the autumn drilling programme (Appendix 19) indicates that the groundwater is safe for human consumption. It is recommended that the water be passed through UV light before consumption as a precautionary measure.

7.2 IMPACT AND MITIGATION

Impact on Soil and Substrata

The development will have no impact on the local soils and substrata as long as the following practices are adhered to during the construction phase:

The recommended allowable bearing pressure is not exceeded.

Major siteworks are undertaken during the summer months to minimise the likelihood of silt laden runoff.

The topsoil removed from the hardstanding and building excavations is respread consistently over the new landscape berms and stabilised by planting as soon as possible.

Truck wheels pass through a wash before leaving the site.

Dust nuisance is minimised by surface spraying the excavated areas.

Impact on Groundwater

The pumping test carried out on one of the trial wells completed on the site returned a drawdown of about 1m for a pumping rate of 900m³/day. This abstraction caused a drawdown of some 0.7m in the observation well located some 130m from the pumping well. This result indicates that the cone of depression associated with the proposed groundwater abstraction will have a very limited impact on the level of the local water table.

The limestone bedrock aquifer may be connected to the water supply available for local surface wells. The developer is advised to monitor the water levels in the neighbouring wells in advance of any groundwater abstraction on the Kilowen site to determine the baseline conditions of these locations. Further regular measurements will indicate what impact, if any, the abstraction is having on the existing levels and the need for any remedial action.

There are no planned discharges to groundwater in the development with all wastewaters being collected, treated and discharged to surface waters. All the wastewater tankage is above ground, to minimise the possibility of an undetected leakage. The proposed development will therefore have no significant impact on local groundwater quality.

**Report on the Drilling and Testing
Of
Trial Water Wells
At
Killowen, Portlaw.**

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December 1990.

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Report on the Drilling and Testing

Of

Trial Water Wells

At

Killowen, Portlaw.

December 1990.

1. Introduction

Michell Leather intend to apply to Waterford County Council for planning permission to develop a wet blue tannery on a site at Killowen, Portlaw in County Waterford. This office was retained by Michell to investigate the possibility of supplying the tannery's fresh water demand estimated at $450\text{m}^3/\text{d}$ with groundwater from production wells located on the development site. This report describes the results of the groundwater investigation programme and makes recommendations on the construction of production wells to supply the proposed factory.

2. Regional Setting And Resistivity Survey

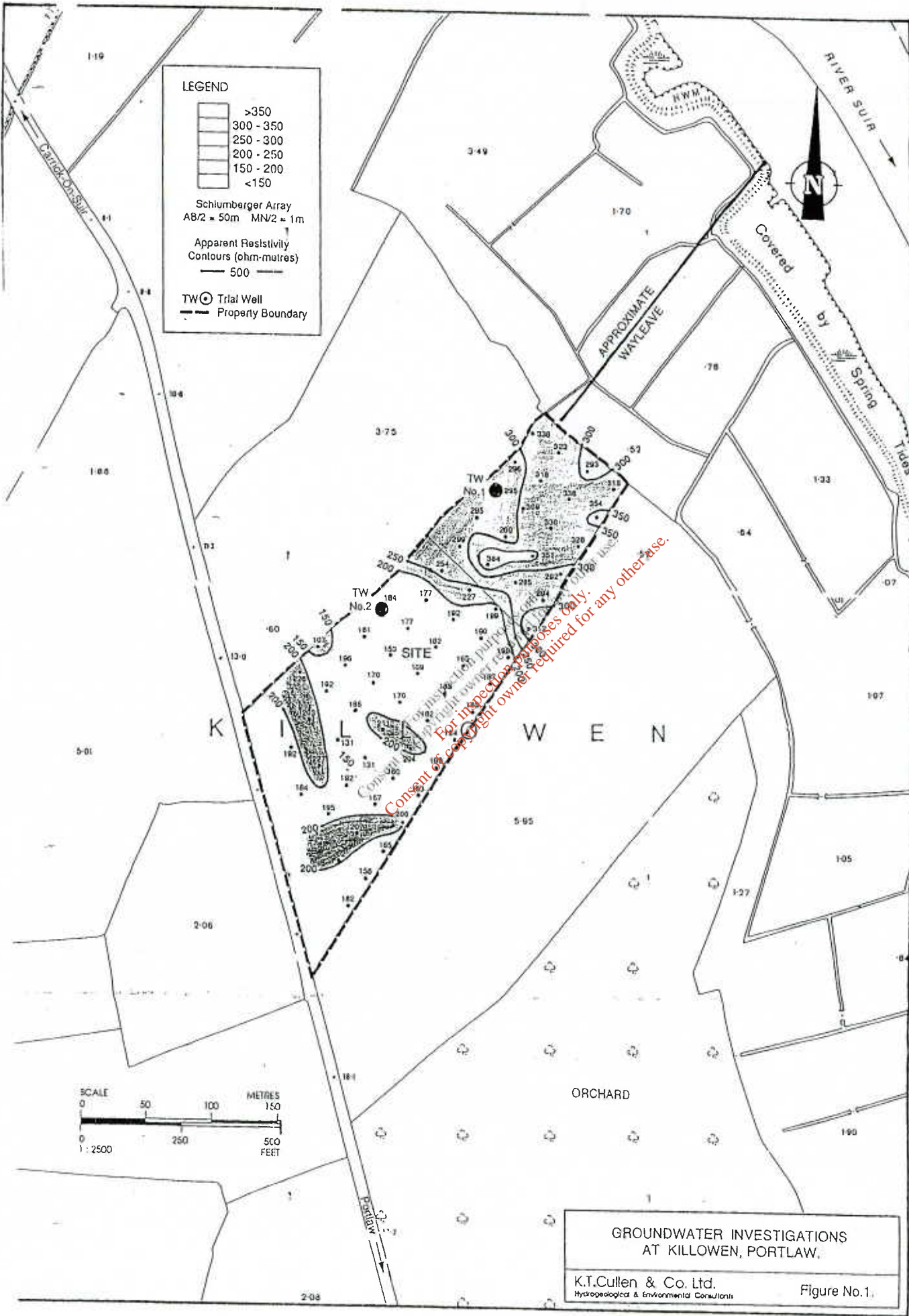
The Portlaw Site occupies relatively low lying ground on the southern bank of the River Suir. This narrow tract of low ground separates the high ground of the Slievenamon Mountains to the north of the River Suir and the Comeragh Mountains to the south. The elevated ground is underlain by inliers of Lower Palaeozoic and Devonian rocks composed mainly of shales and sandstones. The intervening low ground is underlain by Lower Carboniferous strata of the Carrick-On-Suir Syncline. The Carboniferous rocks consist mainly of limestones although the lower part of the successions contains a number of sandstone units. The marked elevation difference between the Carboniferous strata and the older Lower Palaeozoic rocks is a common feature throughout the island and reflects the easily weathering nature of limestones in comparison to the more weather resistant shales and sandstones.

The entire area was glaciated in the recent geological past by at least one major glacial event. The high ground tends to have only a thin covering of glacial tills. The lower lying ground can have widely varying depths of glacial overburden depending on the undulations within the buried bedrock surface.

Groundwater has been widely developed in the limestones of southern Ireland. While the limestone bedrock itself lacks an intergranular permeability, fracturing and karstification have combined to make these strata regionally important aquifers. Unfortunately, as is common to most fissure flow aquifers, the groundwater potential of a particular site is difficult to predict and requires a trial well drilling programme to define the actual ground conditions present. Surface resistivity has proven to be a useful tool in groundwater development projects in Ireland as it provides a general appreciation of the variation in the underlying geology and usually provides suitable well drilling targets. It is not used as a tool to quantify the groundwater potential of a site but rather to indicate changes in the underlying geology and to provide drilling targets.

The Killowen site was surveyed with surface resistivity and the results of this work are given in the accompanying Fig. No. 1. The survey was carried out using an Abem SAS 300 resistivity meter with readings taken every 25m along profile lines 25m apart. The contoured apparent resistivity values shown in Fig. No. 1 define two zones with slightly differently resistivity characteristics. The ground closer to the River Suir is marked by apparent resistivity values above 250ohm-metres while the slightly higher two thirds of the site returned values of less than 200ohm-m. While this difference is not large in real terms the division is quite definite and obviously reflects a geological discontinuity of some description.

The range of values defined by the geophysical survey at Killowen would suggest either thick overburden or conductive bedrock. Two trial well drilling sites were chosen as shown in Fig. No. 1 to investigate the groundwater potential in these two areas within the development site. As Site No. 2 was more suitable in terms of the tannery development this site was investigated first while Site No. 1 was subsequently drilled to provide additional hydrogeological information.



LEGEND

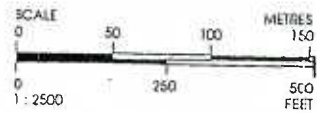
[Shaded box]	>350
[Shaded box]	300 - 350
[Shaded box]	250 - 300
[Shaded box]	200 - 250
[Shaded box]	150 - 200
[Shaded box]	<150

Schlumberger Array
 AB/2 = 50m MN/2 = 1m

Apparent Resistivity
 Contours (ohm-metres)

— 500 —

TW ⊙ Trial Well
 - - - Property Boundary



**GROUNDWATER INVESTIGATIONS
 AT KILLOWEN, PORTLAW.**

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Figure No.1.

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3. Drilling Results

A trial water well (Trial Well No. 2) was drilled at Site No. 2 and the log of this borehole is given in Fig. No. 2 accompanying this report. The well was drilled using a down-the-hole-hammer drilling system using compressed air as the flushing medium. The trial well construction involved the setting of 150mm diameter casing down to 35m below ground level and deepening the well to a total depth of 55m. The well encountered silty sand to 5m, underlain by pebbly clay to 19m. A layer of sandy gravel was intersected from 19m to the rock surface at 34m. The underlying limestone was heavily weathered and numerous large fractures and cavities were encountered from 34m to the bottom of the well at 55m. It had been planned to complete the trial well down to 90m but the collapsing conditions encountered within the weathered limestone prevented drilling below 55m.

Groundwater inflows were recorded in both the sandy gravel and the underlying limestone. The upper inflows were sealed off by the steel casing and it was not possible to fully test the output of the bedrock inflows due to the fractured nature of the bedrock. However, it was estimated at the time of drilling that the trial well had a yield of some 275 - 360m³/day which was close to the projected tannery demand.

A second trial well (Trial Well No. 1) was drilled at the lower site to investigate the ground conditions in this portion of the property and to provide additional pumping capacity if required. The log and construction details of this well are given in Fig. No. 3. This well was drilled to a depth of 25m and it encountered some 12.5m of clay and sand overlying what appears to be a heavily weathered limestone bedrock. As with the first trial well the bedrock contained numerous fractures and cavities and required support with steel casing to the total depth of the well at 25m. Groundwater was encountered in both the overburden and the underlying bedrock but it was difficult to quantify the output of either of these units due to the unstable nature of the formations. The occurrence of bedrock at a shallower depth in the second trial well is consistent with the resistivity results and suggests that the upper part of the site is underlain by an over-deepened channel now infilled with glacial and post glacial sediments.

Drilling with down-the-hole-hammer with compressed air provides a fast efficient method of well drilling and is widely used throughout Ireland for domestic, agricultural and industrial water wells. Under most circumstances it is possible to provide reliable geological logs and to complete the wells to the target depth. The ground conditions found at Killowen can be described as the most unsuitable for this drilling method as the well walls remained unstable throughout. In these conditions the resultant geological logs can only be taken as a guide to the stratification beneath the site as the returned samples are a mixture of the well walls above a particular depth. A different method of drilling would be required to provide more accurate geological logs and to provide geotechnical samples of both the overburden and bedrock beneath the Killowen site.

Completed Well Design

Trial Well No.1

Client : Michell
 Project : Portlaw
 Location : Killowen
 County : Waterford
 Date : October 1990
 Driller : D.O'Donohoe
 Aquifer : Weathered Limestone
 Output : Est. >1000 m³/day
 Specific Capacity : — m³/day/m
 National Grid : 247,000 East
 Co - ordinates : 118,500 North

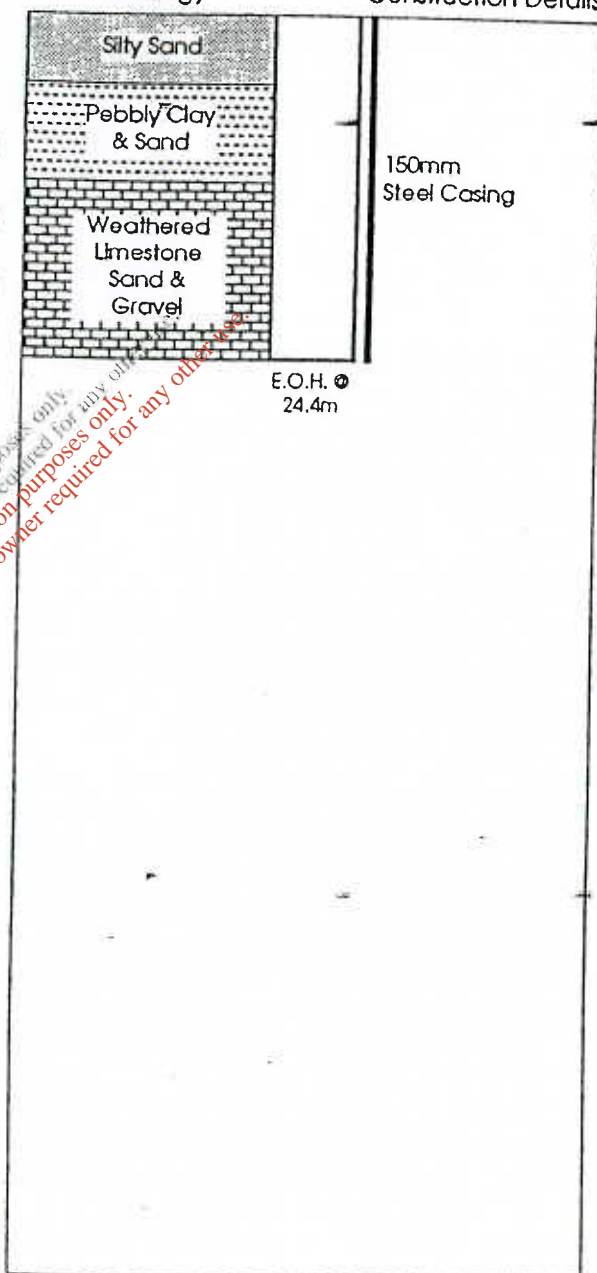
Remarks

Static Water Level →

		Diameter (mm)											
		Grout	Water Levels	Water Entry	Water Loss	Casing	Casing 150	Casing	Casing	Screen	Screen	Open Hole	Open Hole
Remarks	Static Water Level →												

Geology

Construction Details



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Figure No.3.

Completed Well Design

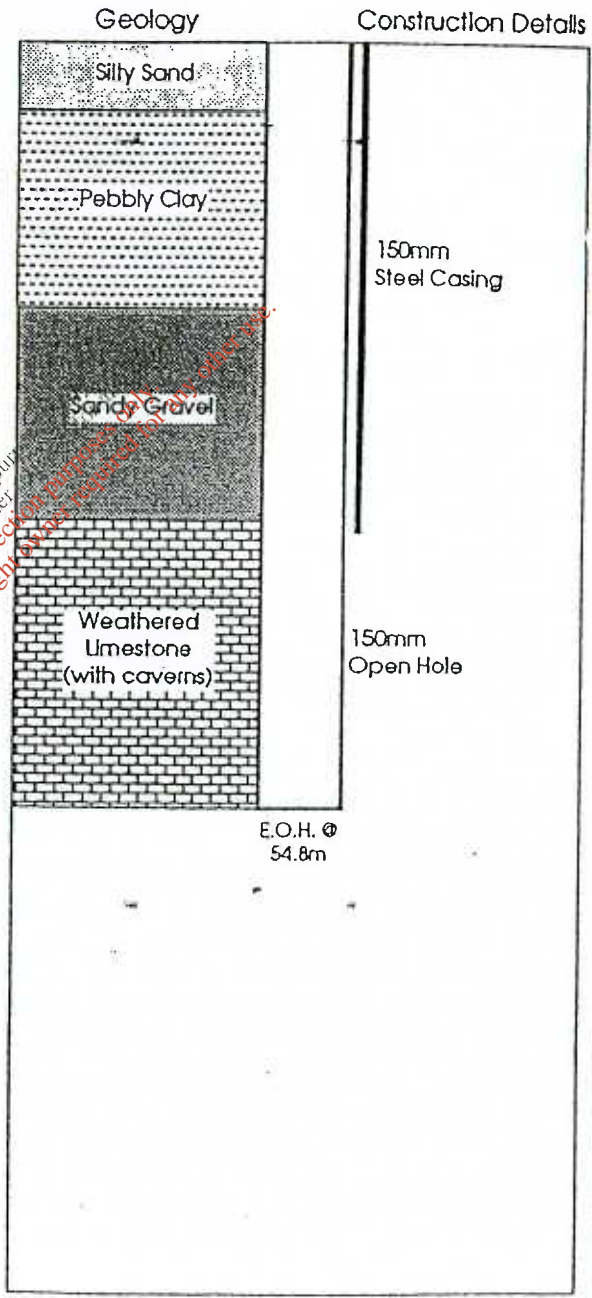
Trial Well No.2

Client : Michell
 Project : Portlaw
 Location : Killowen
 County : Waterford
 Date : October 1990
 Driller : D.O'Donohoe
 Aquifer : Weathered Limestone
 Output : Est. >1000 m³/day
 Specific Capacity : — m³/day/m
 National Grid : 247,000 East
 Co - ordinates : 118,500 North

Remarks

Static Water Level

	Diameter (mm)									
Grout										
Water Levels										
Water Entry										
Water Loss										
Casing										
Casing 150										
Casing										
Casing										
Screen										
Screen										
Open Hole 150										
Open Hole										



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Figure No.2.

4. Pump Testing

On completion of the drilling exercise Trial Well No. 2 was test pumped to provide yield information and the resulting time-drawdown data is tabulated in Appendix I and shown graphically in Fig. No. 4. The test was carried out using a Mono-pump powered by a diesel engine with the pumped water piped to the River Suir. The pumping rates were determined with an on-line flow meter and confirmed by filling a container of known volume. Water level measurements were collected at regular intervals throughout the test which were continuously supervised by the contractor. Water level measurements were taken by an electrical contact dipper installed in a dipper pipe to prevent cascading effects.

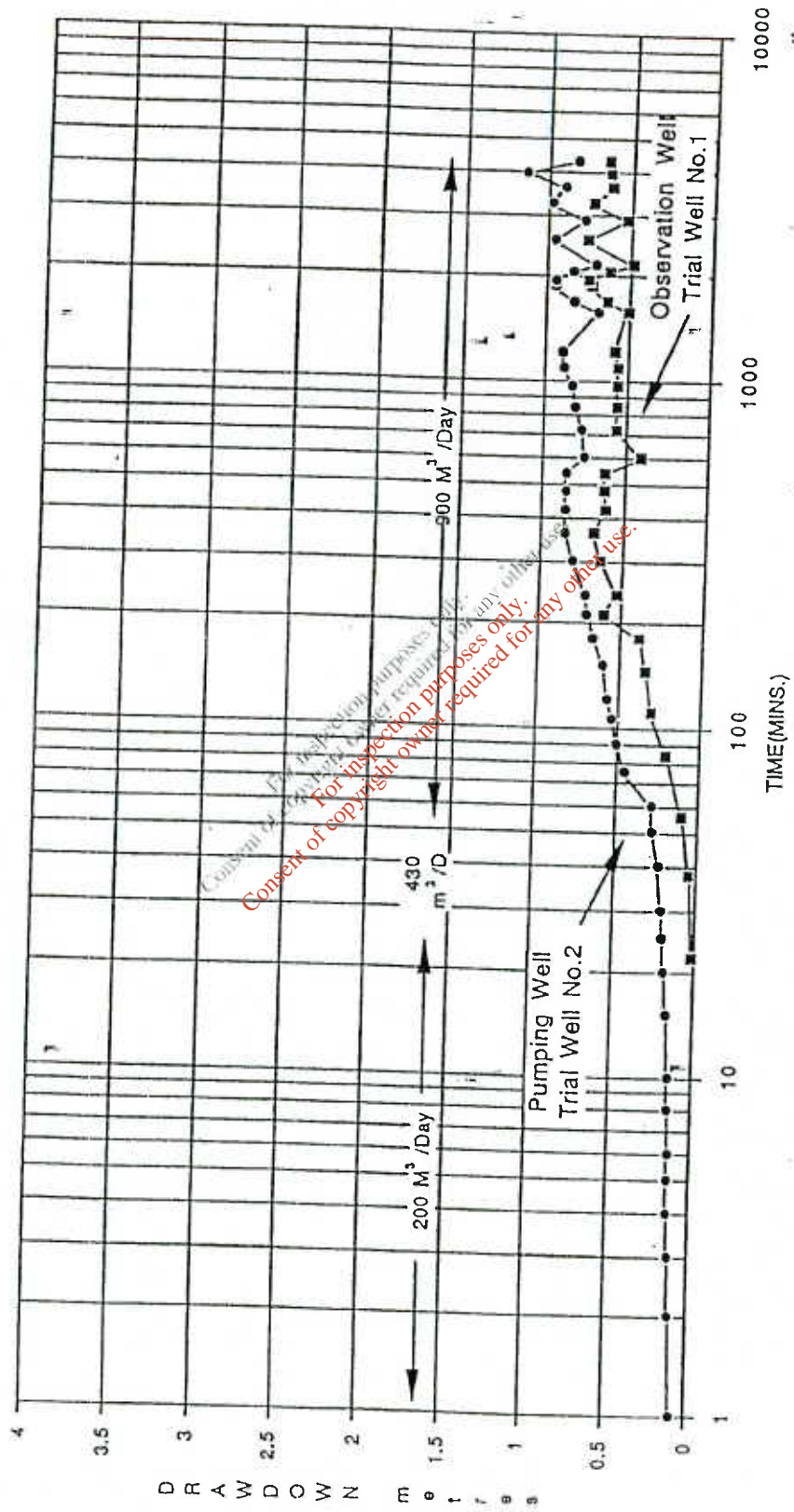
The well was pumped for 30 minutes at a rate of $200\text{m}^3/\text{day}$ at which time the rate was increased to $430\text{m}^3/\text{day}$. The output was again increased to $900\text{m}^3/\text{day}$ after 60 minutes into the test and maintained at this rate for the remainder of the test. The drawdown at the end of the 72 hour test was less than 1m. This result indicates that the limestones beneath the Killowen site constitute a major aquifer which is capable of supplying large quantities of groundwater. In particular, the result indicates that the projected demand of the tannery ($450\text{m}^3/\text{day}$) can be supplied by a single production well.

Water levels were monitored in Trial Well No 1 during the pumping test and these are also shown in Fig. No 4. While the drawdown in this observation well is less than in the pumped well as expected the fluctuation in the water levels in both wells during the latter part of the test reflect tidal influences. This result indicates a hydraulic continuity between the aquifer tapped by the trial wells and the nearby River Suir which is tidal for some distance upstream of the Killowen site.

5. Hydrochemistry

Samples of the pumped water were collected and sent for chemical and bacteriological analyses and the results are tabulated in Table No. 1. The groundwater at Killowen is of excellent quality with a hardness of 214mg/l Ca CO_3 and a conductivity of 395 US/cm . The chloride level of 18mg/l is low and shows that the groundwater is free from salt water contamination. In addition the relatively low conductivity value indicates a lower mineral content than would be found in most Irish limestone aquifers. This characteristic may reflect the sandstone horizons found here, especially the Devonian strata that are known to lie between the Carboniferous limestones and the Lower Palaeozoic shales and sandstones.

The bacteriological quality is generally good with no E. Coli or coliforms recorded. The plate count at 22°C is high but this figure may reduce with continuous pumping.



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Figure No. 4 Time Drawdown Graph of pumping and observation wells at Killowen, Portlao.

PARAMETERS	UNIT	WELL No. 2	POTABLE Water M.A.C.
Calcium	Ca mg/l	62	200
Magnesium	Mg mg/l	14	50
Sodium	Na mg/l	10	150
Potassium	K mg/l	1.1	12
Bicarbonate	HCO ₃ mg/l	219	---
Sulphate	SO ₄ mg/l	13	250
Chloride	Cl mg/l	18	250
Ammonium	NH ₄ mg/l	<0.05	0.3
Nitrate	NO ₃ mg/l	12.3	50
Nitrite	NO ₂ mg/l	0.06	0.1
Copper	Cu mg/l	<0.01	0.5
Iron	Fe mg/l	0.13	0.2
Manganese	Mn mg/l	<0.01	0.05
P.V. @ 4 hours	O ₂ mg/l		5
T.O.C.	C mg/l	16	---
pH	units	7.7	6 - 9
Hardness	CaCO ₃ mg/l	214	>60
Colour	mg/l Pt/Co	7.5	20
Turbidity	F.T.U.	21	4
Conductivity	μ S/cm	395	1,500
Alkalinity	CaCO ₃ mg/l	184	>30
Coliforms	MPN/100ML	0	0
E - coli	MPN/100ML	0	0
Plate Count @ 37 C	COL/ML	40	No significant increase above background level
Plate Count @ 22 C	COL/ML	11300	

NOTE: N.E. = Not Examined N.D. = None Determined < = Less Than

M.A.C. = Maximum Admissible Concentration under E.C. directive (No.80/778/E.C.)

e1 Chemical Analysis of groundwater at Killowen, Portlaw.

6. Conclusions And Recommendations

The results of the trial well drilling and testing programme have indicated that;

1. The Killowen site is underlain by heavily weathered limestone bedrock.
2. The bedrock is overlain by a variable depth (12.5 - 35m) of unconsolidated clays, silts, and gravel.
3. The limestone bedrock constitutes a major aquifer capable of supplying large volumes of groundwater.
4. The groundwater at Killowen is of potable quality with a relatively low hardness of 214mg/l Ca CO₃ and a conductivity value of 395 US/cm.
5. A single production well at the Killowen site would be capable of providing the total fresh water demand of the tannery which is estimated at 454m³/day.

The drilling results at the two trial well sites have shown that the Killowen site is underlain by unconsolidated overburden overlying a heavily weathered limestone bedrock. The construction of production water wells to a depth of 50 - 60m in these conditions will be a difficult operation. It is recommended that duty and stand-by production wells be developed at the Killowen site at the site of Trial Well No. 2. These wells should be fully lined and screened over their total depth to prevent against pump loss due to well wall collapse. The installation of well screens in these unstable conditions will probably require the use of mud drilling, although cable tool drilling might be able to case the weathered limestone. In any event the construction of the production wells at Killowen should be controlled by a definite contract as the cost of providing a finished diameter well of 200mm is likely to be significantly higher than would normally be the case in Ireland. The use of down-the-hole-hammer drilling should not be used for the construction of the production wells.

Appendix I

Time Drawdown Data

From

Pumping Test at Killowen, Portlaw,

Co. Waterford.

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TIME (mins.)	WATER LEVEL below G.L. (m.)	DRAWDOWN (metres)
0	3.88	0
22	3.91	0.03
38	3.94	0.06
56	3.99	0.11
83	4.09	0.21
111	4.19	0.31
145	4.23	0.35
180	4.27	0.39
210	4.48	0.6
240	4.41	0.53
300	4.51	0.63
360	4.56	0.68
420	4.49	0.61
480	4.5	0.62
540	4.5	0.62
600	4.29	0.41
720	4.44	0.56
840	4.44	0.56
960	4.44	0.56
1080	4.44	0.56
1200	4.46	0.58
1560	4.39	0.51
1680	4.51	0.63
1860	4.61	0.73
1920	4.63	0.75
2040	4.5	0.62
2160	4.37	0.49
2520	4.64	0.76
2880	4.41	0.53
3240	4.61	0.73
3600	4.5	0.62
3960	4.51	0.63
4320	4.52	0.64

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Time Drawdown Data from Trial Well NO.1 Killowen, Portlao.

TIME (mins.)	WATER LEVEL below G.L. (m.)	DRAWDOWN (metres)	YIELD (m ³ /day)
0	7.9	0	
1	8	0.1	
2	8.02	0.12	200
3	8.03	0.13	
4	8.04	0.14	
5	8.04	0.14	
6	8.04	0.14	
8	8.05	0.15	
10	8.05	0.15	
15	8.07	0.17	
20	8.09	0.19	
25	8.1	0.2	
30	8.11	0.21	430
40	8.14	0.24	
50	8.18	0.28	
60	8.19	0.29	
75	8.36	0.46	900
90	8.41	0.51	
105	8.44	0.54	
120	8.47	0.57	
150	8.5	0.6	
180	8.56	0.66	
210	8.61	0.71	
240	8.62	0.72	
300	8.7	0.8	
360	8.75	0.85	
420	8.75	0.85	
480	8.75	0.85	
540	8.75	0.85	
600	8.65	0.75	
720	8.67	0.77	
840	8.71	0.81	
960	8.73	0.83	
1080	8.78	0.88	
1200	8.8	0.9	
1560	8.59	0.69	
1680	8.73	0.83	
1860	8.85	0.95	
1920	8.85	0.95	
2040	8.74	0.84	
2160	8.61	0.71	
2520	8.86	0.96	
2880	8.68	0.78	
3240	8.88	0.98	
3600	8.81	0.91	
3960	9.05	1.15	
4320	8.73	0.83	

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Time Drawdown Data from Trial Well NO.2 Killowen, Portlao.

Appendix 3.6

- Groundwater Test Results from IPC Licence 238.

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Water, Soil & Air Testing

Customer Name	Dermot Moore	Lab Report Ref. No.	1540/004/01S
Company	Micheil Ireland	Date of Receipt	26/02/04
Address	Killowen Portlao	Date Testing Commenced	26/02/04
	Waterford	Received or Collected	Collected by Courier
CustomerPO	24538	Condition on Receipt	Acceptable
		Date of Report	30/03/04

CERTIFICATE OF ANALYSIS - Supplementary

ClientRef: Bore 1

Lab Ref: 1540/004/01

Test Parameter	Method of Analysis	Analytical Technique	Result	Units
BOD	SOP 113	Electrometry	3	mg/L
Chromium	SOP 177	ICPMS	<10	ug/L
Conductivity	SOP 112	Electrometry	434	uscm -1 @ 25C
Pesticides (Organochlorine)	SOP 156	GC-MS	<0.1	ug/L
Pesticides (Organophosphorous)	SOP 159	GC-MS	<0.1	ug/L
pH	SOP 110	Electrometry	7.8	pH Units

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Signed: Donna Heslin

Date: 30/03/04

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* Indicates test which has been subcontracted



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Environmental Science & Management
Water, Soil & Air Testing

Customer Name	Dermot Moore	Lab Report Ref. No.	1640/004/02S
Company	Michell Ireland	Date of Receipt	26/02/04
Address	Killowen	Date Testing Commenced	26/02/04
	Portlaw	Received or Collected	Collected by Courier
	Waterford	Condition on Receipt	Acceptable
CustomerPO	24538	Date of Report	30/03/04

CERTIFICATE OF ANALYSIS - Supplementary

ClientRef: Bore 2
Lab Ref: 1540/004/02

Test Parameter	Method of Analysis	Analytical Technique	Result	Units
BOD	SOP 113	Electrometry	<2	mg/L
Chromium	SOP 177	ICPMS	<10	ug/L
Conductivity	SOP 112	Electrometry	499	uscM -1 @ 25C
Pesticides (Organochlorine)	SOP 156	GC-MS	<0.1	ug/L
Pesticides (Organophosphorous)	SOP 159	GC-MS	<0.1	ug/L
pH	SOP 110	Electrometry	7.7	pH Units

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Date: 30/03/04

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Water, Soil & Air Testing

Customer Name	Demot Moore	Lab Report Ref. No.	1540/005/01
Company	Michell Ireland	Date of Receipt	01/03/2004
Address	Killowen Portlaw	Date Testing Commenced	01/03/2004
	Waterford	Received or Collected	Delivered by Customer
CustomerPO		Condition on Receipt	Acceptable
		Date of Report	24/03/2004

CERTIFICATE OF ANALYSIS

Client Ref: Bore 3
Lab Ref: 1540/005/01

Test Parameter	Method of Analysis	Analytical Technique	Result	Units
BOD	SOP 113	Electrometry	<2	mg/L
Chromium	SOP 177	ICPMS	<10	ug/L
Conductivity	SOP 112	Electrometry	502	uscm -1 @ 25C
Pesticides (Organochlorine)	SOP 156	GC-MS	<0.1	ug/L
Pesticides (Organophosphorous)	SOP 159	GC-MS	<0.1	ug/L
pH	SOP 110	Electrometry	7.8	pH Units

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Donna Heslin - Senior Laboratory Technician

Date: 24/03/04

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indicates test which has been subcontracted

