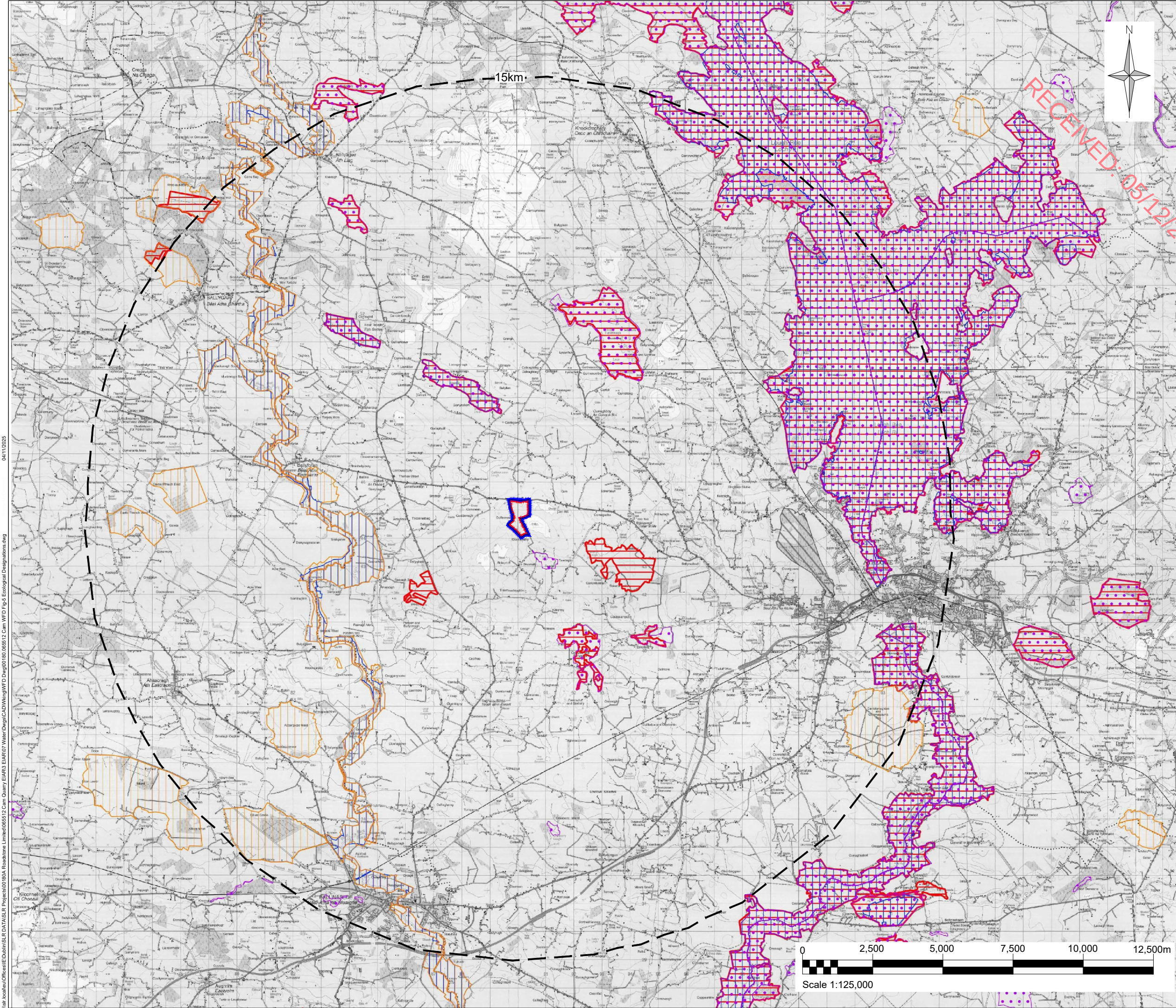




Notes:

1. Based on 50,000 scale Discovery Series Tailte Eireann maps 40 & 47

Legend:

Landholding (c. 66.3 hectares)

Planning Application Area (c. 66.3 hectares)

15km Off-Set from Site Boundary

Natural Heritage Area (NHA)

Proposed Natural Heritage Area (pNHA)

Special Protected Area (SPA)

Special Area of Conservation (SAC)

Rev	Amendments	Date	By	Chk	Auth
SLR www.slrconsulting.com					
Client Roadstone Limited					
Project Continued Use of Existing Cam Quarry at Curry & Cloonacaltry townlands, Co. Roscommon					
Figure Title Ecological Designations					
Water Framework Directive (WFD) Assessment					
Scale 1:125,000 @ A3		SLR Project No. 501.065512.00001			
Designed mcob	Drawn mcob	Checked pg	Authorised pg		
Date 03/25	Date 03/25	Date 10/25	Date 10/25		
Figure Number Figure WFD-5					Rev. 0

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Appendix A WFD Catchments, Watercourses and Groundwater Bodies in Study Area

**Water Framework Directive Assessment Cam, Co.
Roscommon**

Roadstone Ltd

SLR Project No.: 501.065512.00001

Study Area Catchments and Surface Water Bodies (within 15 km of the site)

WFD Catchment Hierarchy	WFD Catchment Name	Distance from Site
Catchments	Upper Shannon, Catchment ID. No. 26D	Site is within catchment
	Upper Shannon, Catchment ID. No. 26G	c. 300m east of the proposed development site
	Upper Shannon, Catchment ID. No. 26E	c. 9.4km north of proposed development site
Sub Catchments	Suck_SC_090	Site is within sub catchment
	Shannon[Upper]SC_100	c. 300m east of the proposed development site
	Shannon[Upper]_SC_090	c. 7.6km east of the proposed development site
	Suck_SC_070	c. 6.8km west of the proposed development site
	Suck_SC_060	c. 6km northwest of site
	Suck_SC_050	c. 9.4km northwest of site
	Knockcroghery_SC_010	c. 9.2km north of site
	Shannon[Lower]_SC_010	c. 13.7km southeast of site
	Shannon[Lower]_SC_020	c. 10.3km south of site
	Suck_SC_080	c. 12.2km southeast of site
River Sub Basins	BALLYGLASS_010	Site is within river sub basin
	CROSS (ROSCOMMON)_020	c. 300m east of the proposed development site
	CROSS (ROSCOMMON)_010	c.2km northeast of site
	KILLEGAN TRIB NORTH_010	c. 3.5km southwest of site
	KILLEGLAN_010	c. 600m south of site
	SUCK_130	c. 4.8km southwest of site
	BALLYDANGAN_010	c. 9.9km south of site
	SHANNON (Upper)_130	c. 13.7km south of site



WFD Catchment Hierarchy	WFD Catchment Name	Distance from Site
	Culliaghbeg_010	c. 14.1km south of site
	SUCK_140	c. 11.6km southwest of site
	AHASCRAUGH_040	c. 12km southwest of site
	AHASCRAUGH_030	c. 13.2km southwest of site
	SHIVEN (SOUTH)_040	c. 12.4km west of site
	SHIVEN (SOUTH)_050	c. 11.1km northwest of site
	SHIVEN (SOUTH)_060	c. 10km northwest of site
	SUCK_120	c. 5.9km northwest of site
	SUCK_110	c. 9.3km northwest of site
	SUCK_090	c. 7.9km north of site
	Knockcroghery_010	c. 8.7km north of site
	CARROWPHADEEN_010	c. 8.7km northeast of site
	LECARROW (LOUGH REE)_010	c. 10.7km northeast of site
	SHANNON (Upper)_110	c. 13.3km northeast of site
	BALLYBAY_010	c. 7km east of site
	CROSS (ROSCOMMON)_030	c. 9.2km southeast of site
	CROSS (ROSCOMMON)_040	c. 11.7km southeast of site
	MIHANBOY_010	c. 8.3km southeast of site
	SHANNON (Upper)_120	c. 9km southwest of site
	BALLYDANGAN_020	c. 10.5km southwest of site
	HIND_030	c. 13.9km north of site



WFD Catchment Hierarchy	WFD Catchment Name	Distance from Site
	HIND_020	c. 12.7km north of site
	ROCKSAVAGE_010	c. 13.4km northwest of site
Surface Water Bodies	BALLYGLASS_010	c. 1.1km northwest of site
	CROSS (ROSCOMMON)_010	c. 2.5km northeast of the site
	SUCK_120	c. 6.9km northwest of the site
	SUCK_130	c. 7.5km west of site
	Killaderry stream_010	c. 7.9km southwest of the site
	LUGHANAGH_010	c. 8.6km southwest of the site
	KILLEGAN TRIB NORTH_010	c. 4.1km south of site
	KILLEGLAN_010	c. 6.1km southwest of site
	CUILLEEN STREAM_010	c. 11.5km southwest of site
	SUCK_140	c. 11.6km southwest of site
	AHASCRAUGH_040	c.13.6km southwest of site
	AHASCRAUGH_030	c. 13.7km southwest of site
	DERRYMULLAN STREAM_020	c. 14.7km southwest of site
	Culliaghbeg_010	c. 14.5km south of site
	BALLYDANGAN_010	c. 10.4km southeast of the site
	BALLYDANGAN_020	c. 10.3km southeast of the site
	SHANNON (Upper)_120	c. 8.7km southeast of the site
	MIHANBOY_010	c. 7.9km southeast of the site
	CROSS (ROSCOMMON)_020	c. 4.5km east of site



WFD Catchment Hierarchy	WFD Catchment Name	Distance from Site
	CROSS (ROSCOMMON)_030	c. 9.3km southeast of the site
	CROSS (ROSCOMMON)_040	c. 12.1km southeast of the site
	SHANNON (Upper)_130	c. 14.5km south of the site
	SHANNON (Upper)_110	c. 12.7km east of the site
	BALLYBAY_010	c. 8.1km east of the site
	Lake Ree	c. 11.9km east of the site
	SHIVEN (SOUTH)_040	c. 12.6km west of the site
	SHIVEN (SOUTH)_050	c. 11.9km northwest of the site
	SHIVEN (SOUTH)_060	c. 9.3km northwest of the site
	SUCK_090	c. 11.1 northwest of the site
	ROCKSAVAGE_010	c. 14.9km northwest of the site
	Knockcroghery_010	c. 10.8km northeast of the site
	LECARROW (LOUGH REE)_010	c. 11.2km northwest of the site
	CARROWPHADEEN_010	c. 10.54km northwest of the site
Groundwater Bodies	Suck South	Site is within
	Funshinagh	c. 840m east of the site
	Aughrim	c.9.7km south of the site
	Athlone West	c. 9.8km south of the site
	Industrial Facility (P0110-01)	c. 10.6km southeast of the site
	Athlone Gravels	c. 12.7km west of the site
	Inny	c. 14km west of the site



WFD Catchment Hierarchy	WFD Catchment Name	Distance from Site
	Ballygar	c. 14km northwest of the site

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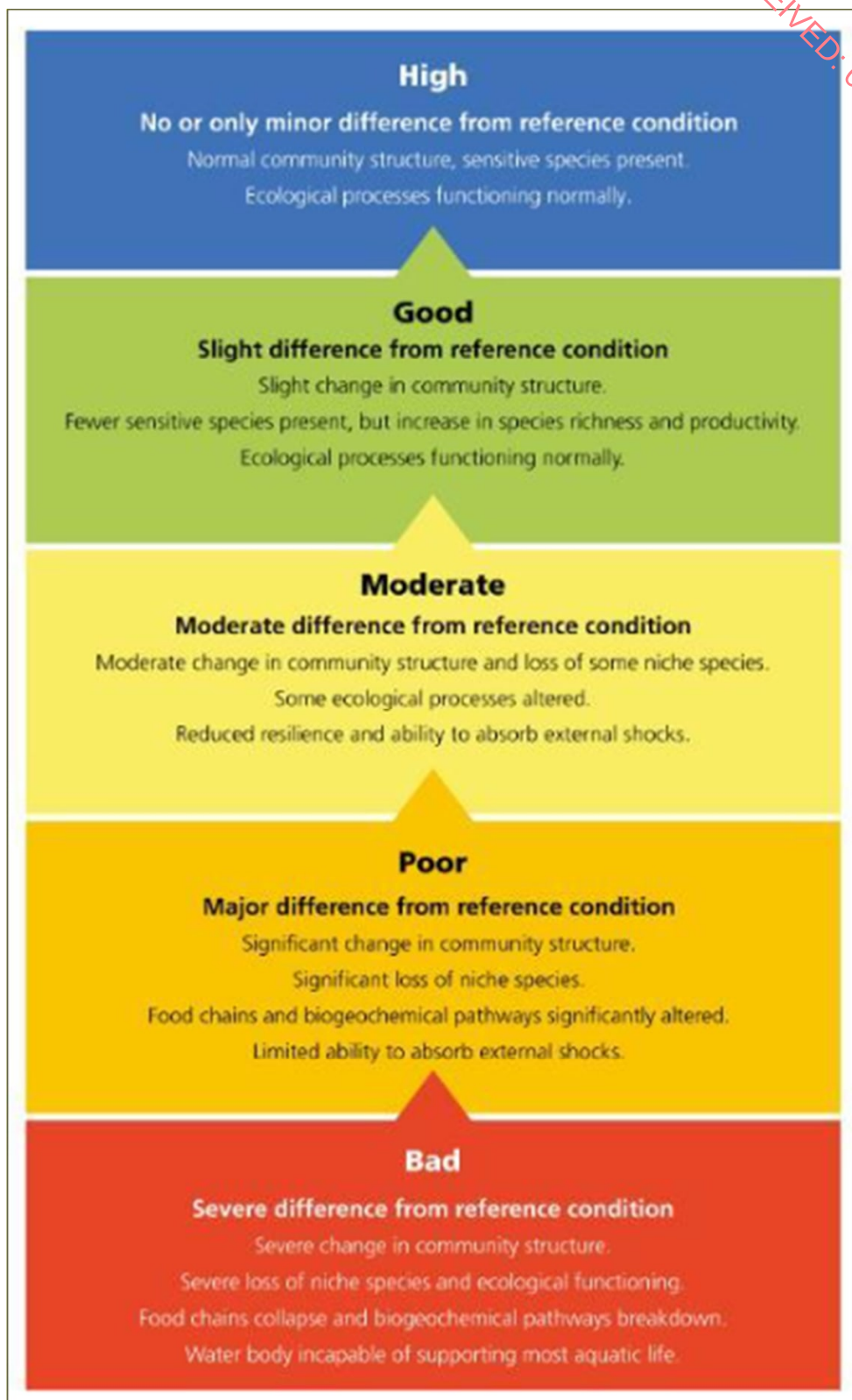
Appendix B Surface Waters Classification

**Water Framework Directive Assessment Cam, Co.
Roscommon**

Roadstone Ltd

SLR Project No.: 501.065512.00001

WFD surface waters classification (Ecological Status).



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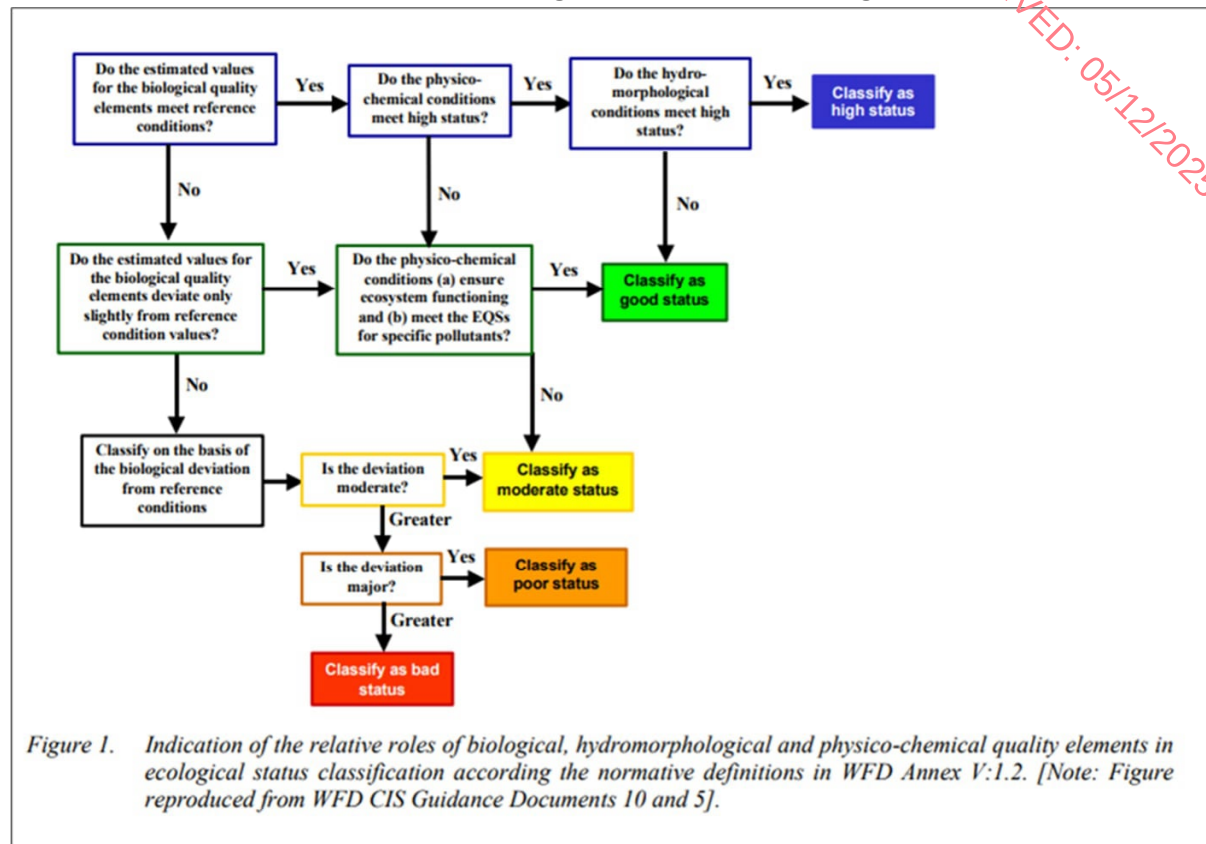
Appendix C Ecological Status Classification

**Water Framework Directive Assessment Cam, Co.
Roscommon**

Roadstone Ltd

SLR Project No.: 501.065512.00001

Approach to the classification of ecological status and ecological potential



Source: Common Implementation Strategy for the Water Framework Directive (2000/60/EC). Guidance document No. 13 Overall approach to the classification of ecological status and ecological potential



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Appendix D WFD Stage 1 Screening for surface water bodies and WFD details

**Water Framework Directive Assessment Cam, Co.
Roscommon**

Roadstone Ltd

SLR Project No.: 501.065512.00001

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WFD Stage 1 Screening for surface water bodies and WFD details.

Surface water body	Distance from Site	Ecological Status (2009 - 2015)	Ecological Status (2013 - 2018)	Ecological Status (2016 - 2021)	WFD Second Cycle Pressures (2016 - 2021)	WFD Third Cycle Risk (2022 - 2027)	Catchment (ID)
Ballyglass River (BALLYGLASS_010)	Surface water is located c. 1.1km northwest of site	Unassigned	Good	Good	N/A	Under review	Upper Shannon (26D)
CROSS (ROSCOMMON)_010	c. 2.5km northeast of the site	Poor	Poor	Moderate	Morphological, Organic, Other Significant Impacts from Hydromorphology and Industry	At risk	Upper Shannon (26G)
SUCK_120	c. 6.9km northwest of the site	Moderate	Moderate	Moderate	Hydrological, Morphological from Hydromorphology	At risk	Upper Shannon (26D)
SUCK_130	c. 7.5km west of site	Good	Good	Good	N/A	Not at risk	Upper Shannon (26D)
Killaderry stream_010	c. 7.9km southwest of the site	Unassigned	Moderate	Moderate	N/A	Under review	Upper Shannon (26D)
LUGHANAGH_010	c. 8.6km southwest of the site	Unassigned	Good	Good	N/A	Under review	Upper Shannon (26D)
KILLEGAN TRIB NORTH_010	c. 4.1km south of site	Unassigned	Moderate	Good	N/A	Under review	Upper Shannon (26D)



Surface water body	Distance from Site	Ecological Status (2009 - 2015)	Ecological Status (2013 - 2018)	Ecological Status (2016 - 2021)	WFD Second Cycle Pressures (2016 - 2021)	WFD Third Cycle Risk (2022 - 2027)	Catchment (ID)
KILLEGLAN_010	c. 6.1km southwest of site	Poor	Moderate	Good	N/A	Not at risk	Upper Shannon (26D)
CUILLEEN STREAM_010	c. 11.5km southwest of site	Poor	Moderate	Good	Sediments and Nutrients from Agriculture	At risk	Upper Shannon (26D)
SUCK_140	c. 11.6km southwest of site	Moderate	Moderate	Moderate	Hydrological, Morphological from Hydromorphology	At risk	Upper Shannon (26D)
AHASCRAGH_040	c.13.6km southwest of site	Good	Good	Good	N/A	Not at risk	Upper Shannon (26D)
AHASCRAGH_030	c. 13.7km southwest of site	Moderate	Poor	Poor	Sediment, Morphological, Nutrients, Organic from Hydromorphology, Agriculture and Urban Waste Water	At risk	Upper Shannon (26D)
DERRYMULLA N STREAM_020	c. 14.7km southwest of site	Moderate	Moderate	Moderate	Unknown Impact Type	At risk	Upper Shannon (26D)
Culliaghbeg_010	c. 14.5km south of site	Unassigned	Moderate	Moderate	N/A	Under review	Upper Shannon (26D)



Surface water body	Distance from Site	Ecological Status (2009 - 2015)	Ecological Status (2013 - 2018)	Ecological Status (2016 - 2021)	WFD Second Cycle Pressures (2016 - 2021)	WFD Third Cycle Risk (2022 - 2027)	Catchment (ID)
BALLYDANGAN_010	c. 10.4km southeast of the site	Good	Good	Moderate	N/A	Under review	Upper Shannon (26G)
BALLYDANGAN_020	c. 10.3km southeast of the site	Poor	Poor	Poor	Morphological, Organic, Other Significant Impacts from Hydromorphology and Industry	At risk	Upper Shannon (26G)
SHANNON (Upper)_120	c. 8.7km southeast of the site	Poor	Poor	Poor	Hydrological, Morphological, Nutrients from Hydromorphology and Peat	At risk	Upper Shannon (26G)
MIHANBOY_010	c. 7.9km southeast of the site	Moderate	Moderate	Moderate	Morphological from Hydromorphology and Peat	At risk	Upper Shannon (26G)
CROSS (ROSCOMMON)_020	c. 4.5km east of site	Good	Good	Moderate	Sediment, Morphological, Nutrients, Organic from Hydromorphology	At risk	Upper Shannon (26G)
CROSS (ROSCOMMON)_030	c. 9.3km southeast of the site	Good	Moderate	Moderate	Sediment, Morphological, Nutrients, Organic from Hydromorphology,	At risk	Upper Shannon (26G)



Surface water body	Distance from Site	Ecological Status (2009 - 2015)	Ecological Status (2013 - 2018)	Ecological Status (2016 - 2021)	WFD Second Cycle Pressures (2016 - 2021)	WFD Third Cycle Risk (2022 - 2027)	Catchment (ID)
					Agriculture and Urban Waste Water		
CROSS (ROSCOMMON)_040	c. 12.1km southeast of the site	Moderate	Moderate	Moderate	Hydrological, Morphological, Nutrients from Hydromorphology and Peat	At risk	Upper Shannon (26G)
SHANNON (Upper)_130	c. 14.5km south of the site	Unassigned	Poor	Moderate	N/A	Under review	Upper Shannon (26G)
SHANNON (Upper)_110	c. 12.7km east of the site	Unassigned	Poor	Poor	Morphological, Nutrients from Agriculture, Hydromorphology and Atmospheric	At risk	Upper Shannon (26E)
BALLYBAY_010	c. 8.1km east of the site	Unassigned	Poor	Moderate	N/A	Under review	Upper Shannon (26E)
Lake Ree	c. 11.9km east of the site	Moderate	Good	Good	N/A	Not at risk	Upper Shannon (26G)
SHIVEN (SOUTH)_040	c. 12.6km west of the site	Good	Good	Good	N/A	Not at risk	Upper Shannon (26D)



Surface water body	Distance from Site	Ecological Status (2009 - 2015)	Ecological Status (2013 - 2018)	Ecological Status (2016 - 2021)	WFD Second Cycle Pressures (2016 - 2021)	WFD Third Cycle Risk (2022 - 2027)	Catchment (ID)
SHIVEN (SOUTH)_050	c. 11.9km northwest of the site	Good	Good	Good	Hydrological, Morphological from Hydromorphology	At risk	Upper Shannon (26D)
SHIVEN (SOUTH)_060	c. 9.3km northwest of the site	Unassigned	Good	Good	N/A	Not at risk	Upper Shannon (26D)
SUCK_090	c. 11.1 northwest of the site	Good	Moderate	Poor	Sediment, Morphological, Nutrients, Organic from Hydromorphology and Agriculture	At risk	Upper Shannon (26D)
ROCKSAVAGE_010	c. 14.9km northwest of the site	Moderate	Moderate	Moderate	Morphological, Nutrients, Organic from Hydromorphology and Agriculture	At risk	Upper Shannon (26E)
Knockcroghery_010	c. 10.8km northeast of the site	Unassigned	Good	Moderate	N/A	Not at risk	Upper Shannon (26E)
LECARROW (LOUGH REE)_010	c. 11.2km northwest of the site	Unassigned	Moderate	Moderate	N/A	Under review	Upper Shannon (26E)



Surface water body	Distance from Site	Ecological Status (2009 - 2015)	Ecological Status (2013 - 2018)	Ecological Status (2016 - 2021)	WFD Second Cycle Pressures (2016 - 2021)	WFD Third Cycle Risk (2022 - 2027)	Catchment (ID)
CARROWPHAD EEN_010	c. 10.54km northwest of the site	Unassigned	Moderate	Moderate	N/A	Under review	Upper Shannon (26E)



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Appendix E WFD Stage 1 Screening for groundwater bodies and WFD details

**Water Framework Directive Assessment Cam, Co.
Roscommon**

Roadstone Ltd

SLR Project No.: 501.065512.00001

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WFD Stage 1 Screening for groundwater bodies WFD Details.

Groundwater Body	Distance from Site	Overall Status (2010 - 2015)	Overall Status (2013 - 2018)	Overall Status (2016 - 2021)	WFD Second Cycle Pressures (2016 - 2021)	WFD Third Cycle Risk (2022 - 2027)
Suck South	Site is within GWB	Good	Good	Good	N/A	Not at risk
Funshinagh	c. 840m east of the site	Good	Good	Good	N/A	Not at risk
Aughrim	c.9.7km south of the site	Good	Good	Good	N/A	Not at risk
Athlone West	c. 9.8km south of the site	Good	Good	Good	N/A	Not at risk
Industrial Facility (P0110-01)	c. 10.6km southeast of the site	Good	Good	Good	N/A	Under review
Athlone Gravels	c. 12.7km west of the site	Good	Good	Good	N/A	Not at risk
Inny	c. 14km west of the site	Good	Good	Good	N/A	Not at risk
Ballygar	c. 14km northwest of the site	Good	Good	Good	N/A	Not at risk



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Appendix F Designated Areas

**Water Framework Directive Assessment Cam, Co.
Roscommon**

Roadstone Ltd

SLR Project No.: 501.065512.00001

Designated Areas – including European Sites within the Zone of Influence of the Project.

Designated Site	Site Code	Location at Closest Point to the Project Site ⁵	Zone of Influence
Feacle Lough pNHA	001634	c.1.9km southeast of site	Proposed Development is within the 15 km Zone of Influence and has hydrogeological link to the Site..
Ballynamona Bog and Corkip Lough SAC	002339	c. 3.2km southeast of site	Proposed Development is within the 15 km Zone of Influence and has hydrogeological link to the Site...
Lough Croan Turlough SAC, SPA and pNHA	SAC/pNHA: 000610 SPA: 004139	c.2.6km north of the proposed application site	Proposed Development is within the 15 km Zone of Influence and has hydrogeological link to the Site..
Lough Funshinagh SAC and pNHA	000611	c. 5.79km northeast of site	Proposed Development is within the 15 km Zone of Influence.
Four Roads Turlough SPA, SAC and pNHA	SAC/pNHA: 001637 SPA: 004140	c. 7.7km northwest of site	Proposed Development is within the 15 km Zone of Influence.
Lough Ree SPA, SAC and pNHA	SAC/pNHA: 000440 SPA: 004064	c. 9.79km northeast of site	Proposed Development is within the 15 km Zone of Influence.
Castlesampson Esker SAC and pNHA	001625	c. 4.5km southeast of site	Proposed Development is within the 15 km Zone of Influence.
Killeglan Grassland SAC	002214	c. 4km southwest of site	Proposed Development is within the 15 km Zone of Influence.
River Suck Callows SPA and NHA	SPA: 004097 NHA: 000222	c. 6.2km southwest of site	Proposed Development is within the 15 km Zone of Influence and has hydrological link (downstream) to the Site.
Castle Ffrench East and West Bog NHA	East: 001244 West: 000280	c.11.41km west of site	Proposed Development is within the 15 km Zone of Influence.

⁵ When measured in a straight line over the shortest distance between the Site and European site



Designated Site	Site Code	Location at Closest Point to the Project Site5	Zone of Influence
Ballygar (Aghrane) Bog SAC and NHA	SAC : 002199 NHA: 000229	c. 14.12km northwest of site	Proposed Development is within the 15 km Zone of Influence.
Lisduff Turlough SAC and pNHA	000609	c. 11.17km northwest of site	Proposed Development is within the 15 km Zone of Influence.
Carrickynaghtan Bog NHA	001623	c. 13.96km southeast of site	Proposed Development is within the 15 km Zone of Influence.
River Shannon Callows SAC and pNHA / Middle Shannon Callows SPA	SAC/pNHA: 000216 SPA: 004096	c. 13.7km southeast of the site	Proposed Development is within the 15 km Zone of Influence and has hydrological link (downstream) to the Site.
Annaghbeg Bog NHA	002344	c. 10.68km southwest of site	Proposed Development is within the 15 km Zone of Influence.
Killure Bog NHA	001283	c. 13.92km southwest of site	Proposed Development is within the 15 km Zone of Influence.



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Appendix G Drinking Water Protected Areas

**Water Framework Directive Assessment Cam, Co.
Roscommon**

Roadstone Ltd

SLR Project No.: 501.065512.00001

Drinking Water Protected Area	Location at Closest Point to Project Site	Hydrological Connectivity to Site (i.e. same SW catchment, Aquifer or in PWS Zone of Contribution)
Killeglan PWS	Located directly south of southern boundary of Site	Within 15km potential zone of influence and is hydraulically linked to Site
Mount Talbot PWS	Located c. 7.75km northwest of Site	Within 15km potential zone of influence and is not hydraulically linked to Site
Roscommon Ballinagard RWSS	Located c. 13km north of Site	Within 15km potential zone of influence and is not hydraulically linked to Site
Knockcroghery Lecarrow PWS	Located c. 14.7km north of Site	Within 15km potential zone of influence and is not hydraulically linked to Site
Lowville No. 1 GWS	Located c. 14.5km southwest of Site	Within 15km potential zone of influence and is not hydraulically linked to Site



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Appendix H Hydrogeological Report by OGE

**Water Framework Directive Assessment Cam, Co.
Roscommon**

Roadstone Ltd

SLR Project No.: 501.065512.00001

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DATA SHEETS



Table No. 2: Summary of Likely Quarry Discharges

Bench No.	Precipitation daily average		Storage		Ground Water Inflow	
	Best Case	Worst Case	Best Case	Worst Case	Best Case	Worst Case
Bench 1 80m-110m O.D.	297 m ³ /day	1,297 m ³ /day	-	-	-	-
Bench 2 60m-80m O.D.	297 m ³ /day	1,297 m ³ /day	-	Localised small quantities	-	Limited and intermittent
Bench 3 40m-60m O.D.	297 m ³ /day	1,297 m ³ /day	5.5 m ³ /day	16.5 m ³ /day	<620 m ³ /day	1240 m ³ /day

Based upon the above table the worst case scenario for quarry water management when the quarry has been developed to an elevation of 40m O.D. is approximately 2,600m³/day, i.e., precipitation, water from storage and ground water inflow.

$$=-150.65\text{m}^2$$

The average drawdown is therefore

$$150.65\text{m}^2/507\text{m} = 0.297\text{m}$$

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The average calculated drawdown above is based upon a theoretical cone of drawdown with a circular plan. In reality the cone of drawdown would be elliptical and these calculations again represent a worst case scenario. The aerial extent of this theoretical cone of drawdown will be approximately 807,545m². The total rock volume within this cone of drawdown will therefore be 239,840m³.

Since an average discharge volume of 36.9m³/d, for the first 46.5 hours, produced 0.297m of drawdown over an area of an area of 807,545m², this discharge rate should therefore produce a theoretical 1 metre of drawdown over an area of 239,840m². Since the quarry footprint is believed to be 200,000m² the discharge rate to produce 1 metre of drawdown over the planned quarry area will be 30.8m³/d. Since the average summer ground water table in the proposed extractive area is 60m O.D. and therefore 20 metres of drawdown is required to maintain dry conditions in the quarry to an elevation of 40m O.D., then a discharge rate of 620m³/day should achieve this. Since the quarry is to be developed only in relatively unfractured bedrock and there was evidence of recharge of the aquifer during the constant discharge rate pump test this figure should be considered a worst case scenario. It would be prudent however to build into any calculation of potential ground water inflow a safety margin of 100%. OGE would therefore contend that the likely ground water in flow to the quarry at a working level of 40 m O.D will be less than 1240m³/day.

Quarry Development and Discharges

Discharges from the quarry will have three components, effective rainfall, ground water released from storage and ground water inflow to retain dry conditions in the quarry. The level of effective rainfall requiring management is based upon the average daily effective rainfall falling on the application site. The amount of run-off requiring management (and discharge) as presented below is therefore the worst case scenario. Detailed water balance calculations for the site are presented in the EIS Water Section. The likely ground water discharges from the site as the quarry is developed are summarised in the *Table No. 2*.



average interconnected porosity in the bedrock is around 4%. OGE would contend that effective porosity and storage will generally decrease with depth and in areas where the rock is less fractured.

As a first pass OGE have assumed that the average (of the whole rock mass to a final elevation of 40m O.D.) effective porosity and storativity in relatively unfractured limestone is around 1%. Karstified limestone can potentially have interconnected porosity of 15%, but the indications from the drilling work is that many of the fractures are clay filled. As a worst case scenario OGE have assumed that the highly fractured areas of limestone have interconnected porosity of approximately 10%. Moderately fractured limestones are assumed to have interconnected porosity of 2% - 5%. The quarry is to be located within the relatively unfractured bedrock. Based upon the estimates of the effective porosity of the bedrock and the planned area of extraction, OGE calculate a worst case scenario would require approximately 6,000m³ of ground water from storage to be managed per annum or 16.5m³ per day.

Ground Water Inflow and Drawdown under the Proposed Development

Based on the findings of the constant discharge rate pumping test a distance/drawdown relationship for the bedrock during the test can be constructed. A graph of the distance drawdown relationship for the pump test is shown in the Data Sheets. The regression line of the distance/drawdown curve was determined as the following:

$$y = 0.297\ln(x) - 1.85$$

The integral of the above equation is

$$= 0.297(\ln(x).x-x) - 1.85(x)$$

Since the maximum drawdown is at 0m from the pumping well and the zero drawdown point is 507m from the pumping well, the average drawdown can be estimated by integrating the above equation between the known limits. The integral of the above equation between the limits of 0 and 507 is thus

$$= (0.297(\ln(507)507-507) - 1.85(507)) - (0.297(\ln(0)0-0) - 1.85(0))$$

$$= (-1387.71+1675.24)-(0)$$



illustrating the drawdown in, and discharge from, the production well during the test is also shown in graphical form within the Data Sheets.

The water levels within the monitoring wells are detailed in tabular form within the Data Sheets. This information is also shown in graphical form in the Data Sheets. Maximum drawdown values within the monitoring wells are taken from the level of maximum drawdown in the production well approximately 47 hours from the start of the test. These details are summarised in *Table No. 1*.

Table No 1. Summary of Observed Pumping Test Results

Borehole	Static Water Level 28/06/04 prior to 12:32:00 m O.D.	Abstraction rate	Duration (minutes since start of the test)	Change in Water Level over Duration of Pumping Test (m)	Distance from Production Well (m)
Production Well PW2A	54.24	0.265 – 0.410 l/s		-2.55	-
BH1	67.70		2917	+0.730	871
BH3	54.72		2898	-0.035	268
BH5	54.14		2923	-0.085	749
BH6	70.75		2906	-0.24	499
BH8	55.64		2955	-0.055	469
BH9	68.09		2978	-0.30	354
BH10	54.82		2758	-0.89	17
BH11	61.31		2988	0.16	516
MW1	53.79		2948	-0.05	593
MW2	63.02		2736	0.04	455

Values in RED are drawdown, black values represent recovery during test

Rainfall

Periodic showers occurred during the pump test allowing limited recharge.

Hydrochemistry

The unstable hydrochemistry of the discharge was monitored during the test. The results are presented with the main pump test data of the data sheet and also presented in graphical form in the Data Sheets. A water sample was taken at the end of the test and sent for analysis. The results of this analysis are presented in the EIS Water Section.

Ground Water Storage in the Bedrock

Based upon the medium term ground water monitoring results the average annual fluctuation in the ground water level below the site is approximately 10 metres. A probable upper range estimate of

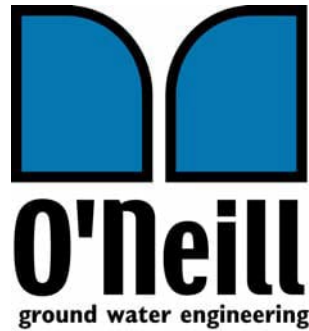


The pumping test was commenced at 12:32:00 on the 28th June 2004 and completed at 12:30:00 on the 1st July 2004, a period of 72 hours (4318 minutes). The recovery was measured from 12:30:00 on the 1st July 2004 to 12:35:00 on the 2nd July 2004, a period of 24 hours (1445 minutes).

Excluding the production well (PW2A) there were ten boreholes monitored during the test. The production well (PW2A) and two monitoring wells (MW1 and MW2) were drilled specifically for the undertaking of the hydrogeological investigation between March and May 2004. The production well was located within a central location of the application site within fractured bedrock probably associated with a fault zone. Details of the boreholes drilled for this investigation are contained within the appendices to the EIS Water Section. Eight other ground water monitoring boreholes previously constructed by Roadstone Provinces Limited either on the application site or in adjacent land were also monitored during the test. A location map of the site boreholes is contained within the EIS Water Section.

An Airlift test was carried out on the Production Well (PW2A) on the 11th May 2004. The maximum short term yield of the well was assessed at 0.56l/s. Details of the Airlift Test are contained within Data Sheets at the end of this report. Although the bedrock encountered within the production well was fractured the majority of these fractures appeared clay-filled. OGE assessed the predominant water making feature within the well was a cavity located at between 47.00 and 50.20 metres O.D. Only small inflows occurred from other levels.

On the basis of the observations of the Airlift Test, a pump was selected that could potentially abstracted close to that of the maximum yield of the well. OGE assessed that if the water level in the production well was drawn down below the main cavity then the maximum safe yield of the well would be exceeded and the water level in the borehole would then rapidly drawdown. The initial flow rate from the production well at the start of the test was 0.265l/s, less than originally intended. The drawdown in the production well after a period of 22 hours (1344 minutes) was 1.40 metres from a rest level of 44.24 m below datum. A second pump was installed and started at 10:54:00 on the 29th June 2004. The discharge from the production well was increased to 0.41 l/s, approximately 75% of the estimated maximum yield of the well. After a period of 24.6 hours (1477 minutes) the second pump failed, however, a drawdown of 2.55 metres was achieved. The water level within the production well was therefore less than 1 metre above the main water bearing feature. The test was continued for a further 25.45 hours (1527 minutes) at the reduced pumping rate of 0.265 l/s. Details of the data obtained during the test are presented in tabular form in the Data Sheets. A graph



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HYDROGEOLOGICAL REPORT FOR PROPOSED QUARRY AT CURRY/CLOONACALTRY CO. ROSCOMMON FOR ROADSTONE PROVINCES LIMITED

Introduction

O'Neill Ground Water Engineering Limited (OGE) were engaged by Roadstone Provinces Limited to undertake a hydrogeological investigation for a proposed quarry site at Curry/Cloonacaltry, Co. Roscommon. The objective of that work was to establish the hydrogeological constraints to the full development of the proposed quarry. Essentially two questions were required to be answered.

- Can the quarry be developed to the maximum planned depth of approximately 40 to 70 metres bgl (40 metres O.D.);
- How much water would require to be managed and discharged as the quarry is deepened.

This report summarises the findings of a constant discharge rate pumping test carried out on the site between the 28th June 2004 and 1st July 2004, an Airlifting Test carried out on the 11th May 2004, and combines ground water information collected by OGE and Roadstone Provinces Limited over a six month period to provide provisional answers to the above questions. All the data compiled during the constant discharge pumping test and ground water reading taken prior to the test is presented in tabular and graphic form in the Data Sheets at the end of this report. OGE installed pressure transducers in two boreholes (MW1 and MW2) to monitor trends within the ground water at these locations. This information is presented in tabular form within the Data Sheets at the end of this report. Ground water data from the other monitoring points compiled by OGE and Roadstone Provinces Limited is also presented within the Data Sheets at the end of this report. These two data sets are combined in graphical form with the rainfall data (sourced from Met Éireann) from the nearest weather station over this period to illustrate the medium term ground water trends below the site. This graph is also included in the Data Sheets.

Constant Discharge Pumping Test - Methodology

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Making Sustainability Happen

Appendix 7-J 2004 Environmental Impact Assessment (EIS) Water Chapter

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**ENVIRONMENTAL IMPACT STATEMENT - WATER SECTION FOR THE PROPOSED
QUARRY AT CURRY/CLOONACALTRY, NR BRIDESWELL, CO. ROSCOMMON FOR
ROADSTONE PROVINCES LIMITED.**

CONTENTS

INTRODUCTION	5
SOURCES OF DATA	6
METHODOLOGY	7
THE EXISTING ENVIRONMENT	8
Topography	8
Bedrock Geology	8
Karstification	9
Geophysical Survey and Bedrock Structure of the Application Site	10
Quaternary Geology	11
Soils	12
Depth to Bedrock	12
Conclusions on Site Geology from a Hydrogeological Perspective	14
HYDROLOGY	14
Regional Hydrology	14
Local Hydrology	16
Water Balance	16
Designated Hydrological Sites Significant to the Hydrogeology of Site and Adjoining Areas	20
Interim Conclusions of Hydrology	21
Regional Surface Water Quality	22
Theoretical Flows and Bankfull Capacities in the Ballyglass River at the Proposed Quarry Water Discharge Point	23
Dry Weather Flow (DWF)	23
Catchment mean flow	24
Determination of Q Mean (Annual Maximum Flood) from Catchment Characteristics of Ballyglass River at the point of proposed quarry water discharge	26
Determination of Q ₅₀ and Q ₁₀₀ from Q Mean of the Ballyglass River	27
Mixing Proportion of the Ballyglass River discharge and potential quarry water discharge	28

Capacity of channel & Instantaneous Discharge Readings	28
Quarry Water Management.....	30
HYDROGEOLOGY	34
Well Data	34
Ground Water Flow Directions	35
Recalculated Water Balance for Application Site	36
Ground recharge and discharge	37
Aquifer Classification	38
Ground water Vulnerability and Resource Protection	39
Bedrock Aquifer Properties	40
Existing Potential Contamination.....	40
Site Water Chemistry	41
Impact of Quarry Discharge on Killeglan Public Water Supply	42
Impact of Quarry Discharge on Corkip Lough	43
Impact of Quarry Discharge on Feacle Lough	44
Assimilative Capacity of Ballyglass River at the Proposed Discharge Point of the Quarry Water ..	45
IMPACT OF PROPOSED DEVELOPMENT	48
Ground Water	48
Surface Waters	48
MITIGATION MEASURES FOR WATER RESOURCES	49
Ground water	49
Surface Waters	50
References.....	51

Tables

Table No. 3.4.1: Depth to bedrock within the application area

Table No. 3.4.2: Depth to bedrock within study area based on well data supplied by the GSI and other sources

Table No. 3.4.3: Annual Average Rainfall Data adjacent to Site

Table No. 3.4.4: River Water Quality data from selected locations on the River Sick and Killeglan River upstream and downstream of the site (Data supplied from the Environmental Protection Agency website)

Table No. 3.4.5: Hydrochemical data of river water samples from selected locations on the River Suck from 1995 to 2000 (EPA website) and from Killeglan Public Water Supply (Roscommon County Council) 2002 to 2004

Table No. 3.4.6: Summary of Likely Flows in the Ballyglass River at the Proposed Quarry Water Discharge Point

Table No. 3.4.7: Relative Proportions of Proposed Quarry Discharge Water in the Ballyglass River During Different Discharge Conditions

Table 3.4.8: Percentage of Bank Full Capacity of the Ballyglass River under Various Flow Conditions



Table No. 3.4.9: Predicted run-off from areas of hardstanding on site

Table No. 3.4.10: Summary of Quarry Water Management System

Table No 3.4.11: Summary of Site and Third Party Wells

Table No. 3.4.12: Summary of Ground Water and Surface Water Catchments within Different Sub-divisions of the Application Site

Table No. 3.4.13: Revised Water Balance for the Application Site

Table No. 3.4.14: Vulnerability Mapping Guideline (Adapted from DELG, 1999)

Table No.3.4.15: Hydrochemical Results of the Ground Water Sample from the site and Surface Water Sample from the Ballyglass River

Table No. 3.4.16: Predicted Hydrochemistry of Receiving Water Following Mixing with Discharge Water

Figures

Figure No. 3.4.1: Site Location, Study Area and Topographic Trends

Figure No. 3.4.2: Quaternary Geology and Karst Features

Figure No. 3.4.3: Ground Water Contours and Significant Hydrogeological Features on the Application Site

Figure No. 3.4.4: Bedrock Quality and Topography of the Application Site

Figure No. 3.4.5a: Conceptual Hydrogeological Model of Application Site

Figure No. 3.4.5b: Hydrogeological Cross Section

Figure No. 3.4.6: Location of Meteorological Stations and Regional Hydrology(including EPA Water Quality Sampling Points and Location of Proposed Quarry Water Discharge)

Figure No. 3.4.7: Location Map of Wells

Figure No. 3.4.8: Aquifer Vulnerability and Depth to Bedrock Map

Appendices

Appendix 3.4.1: Hydrogeological Report Compiled by OGE for Roadstone Provinces Limited

Appendix 3.4.2: GSI Karst Database

Appendix 3.4.3: Borehole Records

Appendix 3.4.4: Hydrochemical and Abstraction Data from the Killeglan Public Water Supply (Roscommon County Council

Appendix 3.4.5: 50 and 100 Year Return Period Storm Event Calculations for Proposed Development



Appendix 3.4.6: Bank Full Capacity of the Ballyglass River

Appendix 3.4.7: Quarry Water Treatment System Design

Appendix 3.4.8: Site Assessment for Waste Water Treatment System

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INTRODUCTION

3.4.1 This report focuses on the surface water and ground water components of the Environmental Impact Statement (EIS).

Personnel involved in the assessment were:

Dr. Cameron Latimer BSc PhD

EurGeol Shane O'Neill MSc PGeo DipCECLA

3.4.2 The objectives of this chapter of the EIS are to:

- Characterise the current hydrological and hydrogeological systems within the area of study;
- Assess the impact of the present activities and proposed development on the following:
 - Soils and geology in the context of the water environment;
 - Surface water flows;
 - Surface water hydrochemistry and quality;
 - Ground water flows and local wells;
 - Ground water hydrochemistry and quality;
 - Management of water within the quarry;
 - Aquifer vulnerability, with regard to potential increases in vulnerability during operation of the proposed quarry;
 - Resource Protection, and,
 - The impacts of the proposed quarry water discharge on the Ballyglass River.
- Provide mitigation solutions to minimise the impact and maintain a good water quality status for all waters which may be potentially impacted upon by the proposed development.

- 3.4.3 The site is located on lands at Curry/Cloonacaltry; some 3.5 kilometres west of Brideswell, Co. Roscommon. The centre of the site is located at approximate National Grid Reference E 190050 N 244850, see *Figure No. 3.4.1*. The site occupies an area of approximately 68 Ha (c. 168 acres) and is currently utilized as rough pasture. The site is approximately irregular in shape and measures approximately 1350 metres north to south and a maximum 480 metre east to west. Roadstone Provinces Limited is seeking planning permission for the development of a limestone quarry.
- 3.4.4 The primary study area is shown on *Figure No. 3.4.1* and represents a radius of study of approximately 2 kilometres from the centre of the site. The northern limit of the study area is Cuilleenirwan Lough, the eastern limit is Cam village, the southern limit is the townlands of Boleyduff, Skeavally, Feacle and Tawnagh, and the western limit is the Ballyglass River. Since a portion of the southern part of the application site falls within the Zone of Contribution to the Killeglan Public Water Supply aspects of the hydrology and hydrogeology relating to this water supply are also considered.

SOURCES OF DATA

- 3.4.5 Background data on the site was compiled by OGE. Further information and data was collected on site by OGE during the course of the field visits. OGE were contracted by Roadstone Provinces Limited to produce a Hydrogeological Report assessing the ground water conditions of the site. The aim of the hydrogeological investigation was to produce a conceptual ground water model for the site and adjacent areas. In addition to the information sources the hydrogeological investigation utilized the following data sources:

- Nine (9) cored holes (on the site) completed with ground water monitoring standpipes;
- A geophysical survey of the site with accompanying report;
- Long term ground water monitoring data compiled by OGE and Roadstone Provinces Limited;
- Two (2) additional ground water monitoring wells and a production well for the purposes of undertaking a pump test; and
- A 3 day pumping test.

3.4.6 The Factual Hydrogeological Report compiled by OGE is included as *Appendix 3.4.1*. The conclusions of the conceptual ground water model are detailed later in this chapter.

3.4.7 All other relevant data was compiled and collated by OGE, from data sourced at Roscommon County Council (Water Services Department), Geological Survey of Ireland (GSI), Environmental Protection Agency (EPA), Ordnance Survey of Ireland (OSI), Teagasc and Met. Éireann.

METHODOLOGY

3.4.8 There were three stages to this investigation:

- A desk study and analysis where data was collected from the GSI and Roscommon County Council. Data from the EPA, Teagasc, Met Éireann and the OSI was also reviewed at the offices of OGE.
- The undertaking of a hydrogeological investigation with accompanying report (*Appendix 3.4.1*).
- Site visits and fieldwork (for the Environmental Impact Statement) which included:
 - An assessment of the surface drainage patterns within the study area;
 - Ground water monitoring of the existing site boreholes;
 - An assessment of the bedrock and quaternary geology and geomorphology of the study area and the relationship of these to surface and groundwater flow patterns;
 - Collection of surface and ground water samples for chemical analysis;
 - An assessment of the projected water management of the site;
 - Compilation of third party well data from the GSI and fieldwork;
 - An assessment of the potential surface water and ground water hazards within the study area; and,
 - Design of proposed waste water treatment system;

THE EXISTING ENVIRONMENT

Topography

- 3.4.9 The proposed development is located within an area of undulating and hummocky topography varying in elevation from approximately 80 metres O.D along the north, eastern and southeastern margins of the application site and rising in the central and western portion of the site to approximately 110 metres O.D. The northern edge zone of contribution to the Killeglan Public Water Supply has been delimited by Kelly and Lee (2003) to fall in the southern part of the application area along a topographic divide. This topographic divide is shown on *Figure No. 3.4.1*.
- 3.4.10 Within the site are a number of bowl-shaped structures on the order of 10's of metres in diameter which probably represent enclosed depressions related to the karstification of the area.
- 3.4.11 A number of possible lineaments can be determined when the topography of the application site and environs are examined. The possible lineament trending north-west to south-east may link Corkip Lough with a linear valley structure to the north-west and probable enclosed depression in the north part of the application site. This lineament may represent a fault that has undergone preferential weathering and karstification and is marked as *Lineament 1* on *Figure No. 3.4.1*. The hill forming the central upland area of the site has a north-west to south trend although this swings to north-northwest-south-southeast trend southwards. Although less well developed than *Lineament 1*, this feature, marked *Lineament 2* on *Figure No. 3.4.1* may also be indicative of a fault structure along the south-western flank of the hill. The north-western faces of the hill form the uplands of the application site, Cam Hill and a hill to north of the townland of Boleyduff form a general south-west to north-east trend and are identified as *Lineament 3* on *Figure No. 3.4.1*.

Bedrock Geology

- 3.4.12 The site is underlain by Lower Carboniferous age Undifferentiated Visean Limestone. Logged rock core from the site indicate that the limestone is a grey, crystalline and bioclastic with corals, brachiopods and crinoid fragments.
- 3.4.13 These rocks have undergone partial karstification and locally have many clay filled fractures and fissures. These fissures and fractures probably follow the main faulting and jointing pattern of the area which is inferred to be orientated south-west to north-east and north-west to south-east reflecting the more regional faulting pattern around the site. The regional faulting pattern can be seen on Sheet 12 (Geology of Longford - Roscommon) of 1:100,000 scale GSI bedrock geology maps.

Karstification

- 3.4.14 The formation of karst features exploit structural weaknesses or faults in the rock, and these features can be greatly enhanced by chemical weathering. Substantial falls in sea-level during the Triassic, Tertiary and most recently the Holocene glacial periods and the related drop in ground water levels below the present ground water levels facilitated the deep weathering of these limestones by meteoric waters and the creation of a network of fissures/cavities through which water could move. The formation of karst features occurs where the bedrock limestone is unsaturated. In Ireland today ground water tables are generally high so active karst formation is only occurring in limited geographical areas. Permeabilities in the karstified rocks are extremely variable, although they are generally highest in the upper (more weathered) part of the aquifer. The upper highly weathered karstified limestone is referred to as *Epikarst*.
- 3.4.15 Within this part of County Roscommon karst features are common. A list of karst features as recorded by the GSI are presented in *Appendix 3.4.2*. A map of those which fall within the study area is shown on *Figure No. 3.4.2*. In addition to the karst features identified by GSI three possible karst features (enclosed depressions) identified on the application site, but not recorded by the GSI are also shown on *Figure No. 3.4.2*. From information in the GSI karst database only Corkip Lough (turlough) and Feacle Lough (turlough) which are discussed later in this chapter, Tobermore Spring (Killeglan Public Water Supply) which is discussed throughout this chapter, and Cuilleenirwan Lough (turlough) are considered significant to this study. Cuilleenirwan Lough feeds the Ballyglass River. Hydrological calculations on the Ballyglass River are presented later in this chapter, although it is likely that water depth within the Cuilleenirwan Lough does not vary significantly seasonally unlike Corkip Lough and Feacle Lough. The surface water level of Coolagarry Lough which is in connection with Cuilleenirwan Lough is 65 metres O.D.
- 3.4.16 In this report additional karst features identified as significant in the context of the hydrogeology of the application site are summarised below:
- 3 No. circular depressions in the northern part of the application area which represent potential sinks of surface run-off to ground water; the locations of these circular depressions are shown on *Figure No. 3.4.2*;
 - A pond located at approximate NGR E189800 E246080 possibly representing a spring and therefore sourced by ground water. This potential spring lies up hydraulic gradient from Cuilleenirwan Lough and to the north of the application site. The approximately reduced level of this pond is 69 metres O.D.; and,

- Three approximately linear areas of broken bedrock have been identified during the geophysical survey conducted by Apex Geoservices Limited. A discussion of the fracturing within the bedrock derived from the finds of the Apex Geoservices Limited report is presented in the next section.

3.4.17 During the exploratory drilling for the Hydrogeological Investigation programme a number of cavities were encountered below the site on selected boreholes. In general significant cavities were not found during the drilling works with the exception of production well PW2A. Where cavities have been identified these were either clay-filled or had relatively poor yields of ground water. Details of these cavities are found in the borehole records in *Appendix 3.4.3*.

Geophysical Survey and Bedrock Structure of the Application Site

3.4.18 Apex Geoservices Limited undertook various geophysical surveys while a programme of exploratory hole drilling at the application site was undertaken between 2001 and 2003. This information was used to produce an interpretative map of the bedrock quality underlying the site. This interpretative map based on the geophysics and the drilling was reproduced in the project scoping document dated January 2004, and reproduced as *Figure No. 3.4.4* in this report. The bedrock is classified into 4 zones:

- Zone 1 - Area of thicker overburden (3-16m) and probably highly fissured and karstified bedrock;
- Zone 2 - Area of variable overburden (1-10) and highly to moderately fissured/weathered bedrock;
- Zone 3- Area of medium thickness overburden (1-10m) overlying moderate to slightly fissured good rock quality limestone; and,
- Zone 4 - Area of shallower overburden (0-4m) overlying generally strong, clean, slightly fissured, thickly bedded limestone.

3.4.19 For simplicity, OGE have grouped both Zone 1 and Zone 2 (of the Apex Geosciences Limited definitions) into areas of fractured and karstified rock and Zone 3 and Zone 4 into areas of relatively unfractured and unkarstified rock. This interpretation is shown on *Figure No. 3.4.5a* and from this the fractured and karstified areas of the site bedrock form two approximately north-west to south-

east trending lineaments. Although not shown in Apex Geoservices Limited December 2003 report additional geophysical investigative works were carried out to the east of the application site. These works suggested a third zone of broken and karstified rock trending north-northwest to south-south-east. Borehole BH5 is located close to this karstified zone.

- 3.4.20 A 2-D Resistivity Profile (Profile No. 5 of Apex Geoservices Limited December 2003 Report) identified an area of deep weathering and fracturing representing a probable fault. Boreholes BH10 and PW2A were drilled through this fault zone. The fault appears to trend south-west to north-east and dips at around 70° to the south-east. The results of the exploratory boreholes undertaken during the initial phase of investigative works and those undertaken for the hydrogeological investigation are consistent with the findings of the geophysical investigation in terms of depth to bedrock and overall bedrock quality. On the basis of the geophysical investigations the planned area of extraction was located in areas that had been assessed as relatively unfractured. The exploratory boreholes in confirming the veracity of the geophysical investigations indicate that the assumptions upon which the initial quarry design were based are valid.

Quaternary Geology

- 3.4.21 Based upon the evidence of the exploratory boreholes undertaken at the site, overburden deposits comprise a sandy Glacial Till with frequent cobbles and boulders. Locally this may be absent and the overburden comprises highly weathered bedrock. Within areas of karstification broken bedrock with sand and clay infilling may be present to some depth. These above deposit types are difficult to distinguish by rotary drilling techniques. Overburden thickness generally varies from approximately 3 metres to 12 metres, although is locally reported to be up to 16 metres in thickness. In selected locations overburden thickness is however 2 metres or less. According to the records of the GSI the high ground of the site (above approximately 80 metres) is covered by peat lying directly over bedrock. The lower ground has a covering of glacial till dominated by limestone clasts. Evidence from the exploratory holes suggests that thin or patchy glacial till covers a greater area of, and persists to a greater elevation on, the site than indicated by the records of the GSI. To the south of site there are two ridges formed of glacial sand and gravel. These ridges have north-west to south-east orientation. An area of marl is shown in the locality of Feacle Lough. A map of the Quaternary Geology of the study area reproduced from the records of the GSI is presented as *Figure No. 3.4.2*.

Soils

- 3.4.22 The soil type of the site is typical of that developed from Glacial Till parent material namely minimal grey-brown podzolics. The ground surface is generally boulder strewn and soil development is probably very patchy.

Depth to Bedrock

- 3.4.23 Depth to bedrock information has been compiled from the following sources:

- Nine cored boreholes drilled on the site in June 2003 for Roadstone Provinces Limited
- Five boreholes (including 2 which were terminated and backfilled) drilled as part of the Hydrogeological investigation;
- 2D Resistivity survey lines undertaken as part of a large geophysical survey of the site and surrounding areas in January 2003;
- Well data supplied by the GSI;

- 3.4.24 The available information on the depth to bedrock in the areas within and immediately adjacent to the application area is presented below (*Table Nos. 3.4.1 and 3.4.2*). As part of a Geological and Geophysical Report compiled by Apex Geoservices Limited for Roadstone Provinces Limited a geological classification of the application site was produced combining information from the cored boreholes and resistivity survey with other geophysical techniques. The map produced by Apex Geoservices Limited classified the site in terms of overburden thickness and the degree of bedrock fracturing. This interpretation has been used with other information to produce an interpretative hydrogeological map of the site.

Table No. 3.4.1: Depth to bedrock within the application area

Data Source	Location NGR	Depth to Rockhead (metres) and Nature of Drift (if known)
Site Borehole BH-03	E 190099 N 244700	3 metres (overburden type not recorded)
Site Borehole BH-06	E 190211 N 244403	5.5 metres (overburden type not recorded)
Site Borehole BH-07	E 189939 N 244576	8 metres (overburden type recorded as rock and boulders)
Site Borehole BH-08	E 189933 N 244912	3 metres (overburden type recorded as boulders and clay)

Data Source	Location NGR	Depth to Rockhead (metres) and Nature of Drift (if known)
Site Borehole BH-09	E 190273 N 244912	3 metres (overburden type not recorded)
Site Borehole BH-10	E 189894 N 245238	9 metres (overburden type recorded as boulders and clay to 7.40m bgl)
Site Borehole BH-11	E 190056 N 244348	2.5 metres (overburden type not recorded)
Monitoring Borehole MW1	E 190427 N 245328	7.50m (Glacial Till/Highly Weathered Limestone)
Monitoring Borehole MW2	E 190281 N 244897	4.20m (Glacial Till/Highly Weathered Limestone)
Pumping Well PW2A (Roadstone Provinces Ltd)	E 190281 N 244897	7.00m (Glacial Till/Highly Weathered Limestone)
Abandoned Well PW1	E 190174 N 244806	2.00m (Glacial Till/Highly Weathered Limestone)
2D - Resistivity Survey line 5 (Apex Geoservices)	SSE and NNW of Borehole BH10	c.2.0m-c.4.0m (high boulder and low clay content overburden) SSE part of line and c 7.0m-c.16.0m (low boulder and high clay content overburden) NNW part of site
2D - Resistivity Survey line 6 (Apex Geoservices)	From Borehole BH9 to SE	c.4.0m-c.9.0m (medium to high boulder and medium to low clay content overburden)
2D - Resistivity Survey line 7 (Apex Geoservices)	From Borehole BH3 to the NW	c. 1.0m-c.2.0m (high boulder and low clay content overburden)
2D - Resistivity Survey line 8 (Apex Geoservices)	SSE and NNW of Borehole BH 6	c. 1.0m-c.3.0m (high boulder and low clay content overburden)
2D - Resistivity Survey line 9 (Apex Geoservices)	From Borehole BH7 to ENE	c. 2.0m->10.0m (high boulder and low clay content overburden)
2D - Resistivity Survey line 10 (Apex Geoservices)	SW corner of application site	c. 2.0m-c.7.0m (high boulder and low clay content overburden)
Various Resistivity Surveys in NE of site (Apex Geoservices)	NE of application site	c. 2.0m-c.12.0m (high boulder and low clay content overburden)

3.4.25 The GSI Geodata database (of well records) provided depth to bedrock information for the study area, which is summarized in *Table No. 3.4.2* below. Details of the known rock outcrops (or areas of shallow rock) are shown in map format on *Figure No. 3.4.2*.

Table No. 3.4.2: Depth to bedrock within study area based on well data supplied by the GSI and other sources

Data Source	Location (NGR)	Depth to Bedrock
Site Borehole BH-01	E 190455 N 244044	3 metres (overburden type not recorded)
Site Borehole BH-05	E 190606 N 244222	6 metres (overburden type not recorded)
Resistivity Survey	Lands immediately south of application site	c. 1.0m-c.2.0m (medium boulder and medium clay content overburden)
Resistivity Survey	Lands immediately southeast of application site	Variable c. 1.0m-c.5.0 of (low boulder and high clay content overburden and high boulder and low clay content overburden)
GSI Database	E 189000 N 245000	2 metres (overburden not recorded)
GSI Database	E 189100 N 242950	6 metres (overburden not recorded)
GSI Database	E 189700 N 242940	39 metres (overburden not recorded)
GSI Database	E 189750 N 243060	33 metres (overburden not recorded)
GSI Database	E189850 N 243140	11 metres (overburden not recorded)
GSI Database	E190000 N 243000	15 metres (overburden not recorded)
GSI Database	E 190000 N 243000	48 metres (overburden not recorded)
GSI Database	E 190000 N 244000	8.5 metres (overburden not recorded)
GSI Database	E 190000 N 246000	6 metres (overburden not recorded)

Data Source	Location (NGR)	Depth to Bedrock
GSI Database	E 190930 N 243540	2 metres (overburden not recorded)
GSI Database	E 191000 N 243000	9 metres (overburden not recorded)
GSI Database	E 191270 N 242830	24 metres (overburden not recorded)
GSI Database	E 191300 N 242800	24 metres (overburden not recorded)

- 3.4.26 Based upon the depth to bedrock data for the site and environs its likely that over the higher ground the bedrock is less than 5 metres below the surface. In other areas depth to bedrock is generally between 5 metres and 10 metres, although it may exceed 10 metres in localised areas. The overburden type is generally relatively permeable.

Conclusions on Site Geology from a Hydrogeological Perspective

- 3.4.27 The topographical evidence, regional bedrock structure, palaeo-drainage pattern and the location of karst features suggest that the geology of the application site and its environs is controlled by two sets of faults. The primary faulting trend is north-west or north-northwest to south-east or south-southeast. The secondary fault set trends north-east to south-west. These faults may have been preferentially weathered and karstified. The primary conduits for ground water flow beneath the site will be along these conduits. The implication is that the directions of ground water flow beneath the site will be determined by a combination of topography and structural bedrock geology. Surface water catchment areas will not accurately delimit ground water catchment areas. Ground water can be transferred from one surface water catchment to another along ground water conduits. The significance of this conclusion will be demonstrated in the following sections.

HYDROLOGY

Regional Hydrology

- 3.4.28 For the purposes of this report OGE have divided the regional hydrology into three systems as shown on *Figure No. 3.4.6*:

- Killeglan System which covers the zone of contribution to the Killeglan Public Water Supply at the Tobermore Spring as well as other springs and water courses;
- Ballyglass System which includes the surface water catchment for the Ballyglass River, Coolagarry Lough and Cuilleenirwan Lough (turlough); and,
- Cross River System which includes all the land to the west of the application site and to the north-east and east of the zone of contribution to the Killeglan Public Water Supply.

3.4.29 The approximate watersheds for these surface water systems are shown on Figure No. 3.4.6.

Killeglan System

3.4.30 The hydrology of the zone of contribution to the Killeglan Public Water Supply is quoted directly from the work of Kelly and Lee (2003):

"The surface water regime is closely interconnected with the groundwater regime. There are several springs, swallow holes and numerous collapse features that are linked to the main surface water bodies in the area.

There are four main stream networks in the vicinity of Tobermore Spring. These are as follows:

- 1. Just north of Taghmaconnell, a stream rises in the townland of Bellaneeny. This stream flows west for approximately 4 km, to join the Killeglan River, which then discharges in the River Suck.*
- 2. A stream network exists to the south of Taghmaconnell, in the townlands of Knock and Sraduff. These streams flow to a turlough in the townland of Glennanea. This turlough appears to take all the flow from the stream network. Another section of stream rises east of this network and then disappears after flowing approximately 1 km to the north-east.*
- 3. An intermittent, seasonal stream is located to the east of the Tobermore Spring. This stream rises in the townland of Carrowduff and Garbally, and travels first north and then east. During wet weather the upper parts of the stream are flowing. Groundwater from the Tobermore Spring and discharge area joints this channel to form the head of the Killeglan River (Figure 1)*
- 4. A small stream network is located in the townland of Esker. This stream network is recorded as having permanent flow, but has no apparent surface outlet. It is therefore likely that this area of surface water feeds into the groundwater system.*

The majority of outflow from this area is via the Killeglan River, which includes the Tobermore Spring discharge. A second smaller outflow is through the stream at Bellaneeny, south of the springs."

3.4.31 Killeglan River flows in a west-southwesterly direction and is joined by the water from the stream emanating at Bellaneeny and then discharges to the River Suck. Feacle Lough is located within this system and is discussed later in this chapter.

Ballyglass System

- 3.4.32 The Ballyglass River rises from the Coolagarry Lough and Cuilleenirwan Lough (turlough) where the water flows south-west to discharge to the River Suck.

Cross River System

- 3.4.33 This system which includes Corkip Lough (discussed later in this chapter) drains the land to the northeast and east of the application area. The Cross River discharges to the River Shannon.

Local Hydrology

- 3.4.34 Based upon topographic considerations the majority of the site falls within the surface water catchment to the Ballyglass System. The northeast of the application area is within the surface water catchment area of the Ballyglass system above the discharge point of the Cuilleenirwan Lough to the Ballyglass River. Theoretically run-off should eventually enter either Coolagarry Lough or Cuilleenirwan Lough. The east of the site is within the surface water catchment of the Ballyglass System although surface run-off should discharge directly to the Ballyglass River, down gradient of the proposed quarry water discharge point unlike the northern part of the application site whose surface run-off should enter the Ballyglass System above the proposed discharge point. The southern part of the site is within the Killeglan System.

- 3.4.35 Kelly and Lee (2003) studying the hydrology and hydrogeology of the Killeglan Public Water Supply (Tobermore Spring) concluded that only 80% of the water available from run-off goes to ground water. Based upon the permeable nature of the overburden and the probable presence of sinkholes this figure may be an underestimate and all available water may recharge the bedrock aquifer.

Water Balance

- 3.4.36 The following water balance calculations are based on topographic considerations, i.e., based upon the surface water catchments. As previously explained the surface water catchments in karstified terrains may not accurately reflect the ground water catchments. Since most (if not all) water

available for run-off or ground water recharge probably soaks to ground water within the application site the 'actual' water balance (in terms of partition of this water to different catchments) for the site should be based on the ground water catchments and not the surface water catchments. Approximate ground water catchments below the site can be determined from the interpreted ground water flow directions. OGE will show within following sections of this chapter that the ground water catchments are indeed different to the surface water catchments of the application site and the 'true' water balance for the site is recalculated later in this chapter.

3.4.37 Rainfall and evaporation data was sourced from Met Éireann. The average annual rainfall (AAR), based on data from four rainfall stations in the area, was determined to be 950.33mm (Table No. 3.3.3). The locations of these meteorological stations are shown on Figure No.3.4.6. All the stations are now closed. Met Éireann have estimated that the climate change in the recent past is less than 1% and therefore, the data from 1941-1993 is still relevant.

3.4.38 The closest synoptic stations to the site are at Claremorris and Mullingar. The Average Potential Evaporation (PE) for Claremorris and Mullingar is 428.75mm/yr. This value is used as a best estimate of the site PE. Actual Evaporation (AE) at the site is estimated as 407.31mm/yr (0.95 PE). An ER figure of 697mm/yr is used in Groundwater Source Protection Zone assessment for the Killeglan Water Supply Scheme, Lee and Kelly, 2003. The ER determined by OGE and that used by Lee and Kelly, 2003 are different owing to a difference in assumed precipitation.

The Effective Rainfall (ER) for the site is determined from:-

$$ER = AAR - AE.$$

$$= 950.3\text{mm/yr} - 407.3\text{mm/yr}$$

$$ER = 543\text{mm/yr (OGE)}$$

$$ER = 697\text{mm/yr (Kelly and Lee, 2003 for Killeglan Spring)}$$

Table No. 3.4.3: Annual Average Rainfall Data adjacent to Site

Station		Grid Ref.		Ht (m O.D.)		Opened		Closed				
Athleague G.S.		M833576		53		1951		1988				
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Annual
101	70	78	59	66	62	59	87	86	102	96	96	961

Station		Grid Ref.		Ht (m O.D.)		Opened		Closed				
Ballyforan G.S.		M824466		50		1944		1983				
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Annual
99	68	75	56	68	65	59	88	88	100	95	97	958



Station		Grid Ref.		Ht (m O.D.)		Opened		Closed				
Taughmaconnell G.S.		M898389		59		1941		1993				
Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Annual
94	68	73	56	64	62	63	87	84	96	90	95	932
average												950.33

3.4.39 ER represents the water available for run-off and ground water recharge in a catchment. A preliminary surface water balance for the site can be determined from this data.

3.4.40 The total area of the application site 68 Ha (168 acres). Therefore the total effective precipitation falling on the site available for run-off and ground water recharge is therefore;

$$\text{Application area} = (680,000\text{m}^2)(0.543\text{m/yr})(\text{OGE figures})$$

$$\text{Application area} = (680,000\text{m}^2)(0.697\text{m/yr})(\text{Kelly and Lee, 2003})$$

$$=369,240\text{m}^3/\text{yr} (1,011\text{m}^3/\text{day})(\text{OGE})$$

$$=473,969\text{m}^3/\text{yr} (1,298\text{m}^3/\text{day})(\text{Kelly and Lee, 2003})$$

3.4.41 The surface catchment divide for the Killeglan Public Water Supply at the Tobermore Spring is located across the southernmost part of the application area. The area of the application within the Zone of Contribution to the Killeglan Public Water Supply is approximately 8.8Ha (21.8 acres) the total effective precipitation falling on area of the site with the Zone of Contribution to the Killeglan Public Water Supply is therefore estimated at:

$$\text{Application area within Killeglan ZOC} = (88,370\text{m}^2)(0.543\text{m/yr})(\text{OGE figures})$$

$$\text{Application area Killeglan ZOC} = (88,370\text{m}^2)(0.697\text{m/yr})(\text{Kelly and Lee, 2003})$$

$$=47,985\text{m}^3/\text{yr} (131.4\text{m}^3/\text{day})(\text{OGE})$$

$$=61,594\text{m}^3/\text{yr} (168.6\text{m}^3/\text{day})(\text{Kelly and Lee, 2003})$$

3.4.42 The surface water catchment contributing to (and including) the application area representing the potential source of all water infiltrating into the application has been estimated to be 982,000m²,



Figure No. 3.4.6. This is based upon the local topographic surface water catchment to the quarry area.

$$\text{Contribution to application area} = (982,000\text{m}^2)(0.543\text{m/yr})(\text{OGE figures})$$

$$\text{Contribution to application area} = (982,000\text{m}^2)(0.697\text{m/yr})(\text{Kelly and Lee, 2003})$$

$$=533,226\text{m}^3/\text{yr} (1,460\text{m}^3/\text{day})(\text{OGE})$$

$$=684,454\text{m}^3/\text{yr} (1,874\text{m}^3/\text{day})(\text{Kelly and Lee, 2003})$$

- 3.4.43 The proportion of this surface water catchment contributing to (and including) the application area representing the potential source of all water infiltrating into the application area that falls within the Zone of Contribution to the Killeglan Public Water Supply is 18% which equates to:

$$=95,981\text{m}^3/\text{yr} (263\text{m}^3/\text{day})(\text{OGE})$$

$$=123,202\text{m}^3/\text{yr} (337\text{m}^3/\text{day})(\text{Kelly and Lee, 2003})$$

- 3.4.44 The total planned extractive area is approximately 23.7 Ha. Therefore the total effective precipitation falling on the planned quarry footprint and available for run-off and ground water recharge is therefore:

$$\text{Footprint of proposed quarry} = (237,000\text{m}^2)(0.543\text{m/yr})(\text{OGE figures})$$

$$\text{Footprint of proposed quarry} = (237,000\text{m}^2)(0.697\text{m/yr})(\text{Kelly and Lee, 2003})$$

$$=128,691\text{m}^3/\text{yr} (352\text{m}^3/\text{day})(\text{OGE})$$

$$=165,189\text{m}^3/\text{yr} (452\text{m}^3/\text{day})(\text{Kelly and Lee, 2003})$$

- 3.4.45 The surface water catchment contributing to (and including) the proposed quarry footprint representing the potential source of all water infiltrating into that footprint has been estimated to be 318,000m², Figure No. 3.4.6. This is based upon the local topographic surface water catchment to the quarry area.

$$\text{Contribution to proposed quarry footprint} = (318,000\text{m}^2)(0.543\text{m/yr})(\text{OGE figures})$$

$$\text{Contribution to proposed quarry footprint} = (318,000\text{m}^2)(0.697\text{m/yr})(\text{Kelly and Lee, 2003})$$

$$=172,674\text{m}^3/\text{yr} (473\text{m}^3/\text{day})(\text{OGE})$$

=221,646m³/yr (607m³/day)(Kelly and Lee, 2003)

- 3.4.46 The zone of contribution to the Killeglan Public Water Supply at the Tobermore Spring was determined by Lee and Kelly, 2003, and the aerial extent of this zone has been estimated by OGE to cover approximately 41.7 km². Using the figures of Lee and Kelly (2003), then the average daily recharge to the zone of contribution of the Tobermore Spring is 80,000m³/day. The discharge in the vicinity of the Tobermore Spring is approximately 35,000m³/day. Kelly and Lee (2003) noted the following:

"To date, the discharge data (from the area of the Tobermore Spring) are not comprehensive enough to undertake a water balance and thus accurately estimate the catchment area for the discharge at the head of Killeglan River. However an approximation of the average discharge data and recharge data indicate that the delineated catchment is (sic) area is large enough to meet the discharge from the springs."

Designated Hydrological Sites Significant to the Hydrogeology of Site and Adjoining Areas

Corkip Lough

- 3.4.47 Corkip Lough is a turlough located approximately 2.5 kilometres (NGR E192840 N243470) to east-southeast of the application site, see Figure No. 3.4.1. The turlough is a Special Area of Conservation (SAC), Ref: 002339 and National Heritage Area (NHA), Ref: 001628. The site is described thus:

"Corkip Lough is a turlough-type lake located 2km southwest of Brideswell, County Roscommon, in low-lying agricultural land. This site is important for both its flora and fauna. As the actual area of open water has been reduced considerably in recent years due to drainage activities, this site is more appropriately termed a turlough now."

The lake retains a small area of open water in the summer and is surrounded by lowland wet grassland which is flooded in winter."

- 3.4.48 The site is significant to the hydrogeological regime of the area since a turlough is fed by ground water. Rising ground water levels in winter result in the filling of the turlough.

Feacle Lough

- 3.4.49 Feacle Lough is a turlough located some 800 metres (NGR E190790 N243390) south-east of the southern boundary of the application area, see *Figure No. 3.4.1*. The turlough is a proposed National Heritage Area (pNHA) Ref: 001634. The site is described thus:

"Feacle turlough lies approximately 12km west of Athlone in an uneven terrain of glacial deposits. The basin, which runs roughly east-west, but whose edges are sinuous because of encroaching mounds, has an even floor with a number of discrete hollows. Outcrop is visible at the western end – elsewhere there is some loose rock. A permanent pond occurs at the north-western end, but there is no apparent inflow."

- 3.4.50 OGE visited the turlough in June 2004 and found the only open water was within the pond described above. The water in this pond appears perched above the ground water table. Towards the western end of the turlough area (close to the road) is a circular depression and possible swallow-hole. A hand dug well with pump house is located on the end of this depression. Local knowledge suggested that during winter when maximum filling of the turlough occurs the pump house is just above the high water mark. OGE measured the ground water level in this well and found it to be approximately 6 metres below the pump house level. This suggests that ground water levels in the area rise by approximately 5 to 6 metres above the June level in winter.

Interim Conclusions of Hydrology

- 3.4.51 Both Feacle Lough and Corkip Lough are turloughs and by definition, fed by ground water. Significant rises in ground water levels during winter months cause these turloughs to flood. The primary conduits for ground water flow are fissures and fractures in the bedrock enhanced by karstification. The karstified conduits are generally related to structural features such as faults. Corkip Lough, as previously stated is probably located along a fault line which continues into the northern part of the application area. However, it is generally accepted that the majority of turloughs are fed by ground water from the *epikarst*. Both Corkip Lough and Feacle Lough are lower in elevation than the application area, such that the ground water table in these areas is within the *epikarst*. In the pump test, the results of which are shown in Appendix One, the permeability of the karstified areas of the bedrock below the site were tested. Within karstified aquifers 'deeper' karst features can be the primary ground water conduits. The results of the pump test carried out at the site suggest however that permeability of the karst features below the site is relatively low. As such, although the turloughs (in particular Corkip Lough) may be located above zones of deeper karstification the contribution of ground water from the deeper karst to these features is probably very limited.

Regional Surface Water Quality

3.4.52 Details of the Biological River Water Quality for two locations on the River Suck and a location on the Killeglan River are presented as *Table No. 3.4.4*; the locations of these sampling points are shown on *Figure No. 3.4.6*. The two sampling stations on the River Suck are at points up and down stream on the confluence of the Ballyglass River. As the proposed development progresses it is proposed to discharge ground water and surface run-off inflows into the quarry to the Ballyglass River. These stations would therefore represent potential up and down gradient locations to the confluence of the Ballyglass River which will be receiving the proposed quarry discharge and direct it to the River Suck.

Table No. 3.4.4: River Water Quality data from selected locations on the River Suck upstream and downstream of the site and Killeglan River (Data supplied from the Environmental Protection Agency website)

Year	Killeglan River – Bridge upstream from confluence with River Suck. Station No. 0200 (River Code 26K04)	River Suck – Bridge West of Feevagh (downstream from confluence with Ballyglass River. Station No. 1125 (River Code 26S07)	River Suck – Ballyforan Bridge (upstream from confluence with the Ballyglass River. Station No. 1100 (River Code 26S07)
1999	4	4	4
1996	4	4	4
1992	4	4	4
1987	4	4	4
1984	-	-	4
1983		4	-
1980			4
1978			4-5
1974			5
1971			5

Where a value of, 4, 4-5, 5 = Unpolluted; 3-4 = slightly polluted; 2-3, 3 = moderately polluted; 1, 1-2, 2 = seriously polluted.

3.4.53 In terms of water quality, the River Suck and Killeglan River at the three sampling locations is/has been unpolluted.

3.4.54 Chemical parameters were measured at the two above locations on the River Suck during the year 1995 to 2000 and collated by the EPA. This data is presented in *Table No 3.4.5* together with a summary of data collected by Roscommon County Council for the Killeglan Public Water Supply. Full details of the chemical analyses carried out on the pre-treatment Killeglan Public Water Supply are presented in *Appendix 3.4.4* together with abstraction data for the water supply.

Table No. 3.4.5: Hydrochemical data of river water samples from selected locations on the River Suck from 1995 to 2000 (EPA website) and from Killeglan Public Water Supply (Roscommon County Council) 2002 to 2004

Chemical Parameter	River Suck - Bridge West of Feevagh (downstream from confluence with Ballyglass River. Station No. 1125 (River Code 26S07) 1999-2000		River Suck - Ballyforan Bridge (upstream from confluence with the Ballyglass River. Station No. 1100 (River Code 26S07) 1995-1997		Killeglan Public Water Supply from date supplied by Roscommon County sample dates FEB 02 to FEB 04	
	Min	Median	Min	Median	Min	Median
B.O.D (mg/1 O ₂)	0.6	1.3	0.5	1.7	-	-
Chloride (mg/1 Cl)	-	-	15	19	-	-
Colour (Hazen)	19	76	30	70	4	21
Conductivity (µS/cm)	283	529	348	506	392	597
Dissolved Oxygen (mg/1 O ₂)	7.1	10.6	9.1	10.4	-	-
Dissolved Oxygen (% saturation)	69	93	81	90	-	-
Ortho-Phosphate (Mg/1 P)	0.00	0.02	0.01	0.03	0.002	0.005
Oxidised Nitrogen (mg/1 N)	0.1	0.8	0.2	1.0	1.414	3.184
pH	7.7	8.0	7.6	7.9	7.06	7.38
Temperature	3.3	9.0	0.3	9.5	-	-
Total Ammonia (mg/1 N)	0.0	0.02	0.01	0.03	0.002	0.007
Un-ionised Ammonia (mg/1 NH ₃)	0.000	0.000	0.000	0.001	-	-

- 3.4.55 The general chemistry indicates that, the minimum and median values of the samples generally met the European Communities (Quality of Water Intended for the Abstraction of Drinking Water) Regulations, 1989 standards, although colour may be of concern towards the upper range of the samples.

Theoretical Flows and Bankfull Capacities in the Ballyglass River at the Proposed Quarry Water Discharge Point

Dry Weather Flow (DWF)

- 3.4.56 Dry Weather Flow (DWF) is the annual minimum daily mean flow rate with a return period of 50 years.

Catchment Low Flow (q_{50})

3.4.57 There is no information available about the flow regime of the Ballyglass River at the point of the proposed quarry water discharges. The proposed discharge point is adjacent to the bridge on the R363 to Ballyforan where the road crosses the Ballyglass River. OGE estimated minimum flows in the catchment using the methodology outlined in *Analysis and Prediction of Low Flow and Drought Volumes for Selected Irish Rivers* (Martin & Cunnane, 1976).

3.4.58 Calculation of the low flow was determined as follows: The area of the catchment (A) to the bridge was calculated as being 7.97km². Using this, a value for q_{50} could be determined. q_{50} is the estimated low flow with a recurrence interval of 50 years. This is also referred to as the Dry Weather Flow (DWF).

$$q_{50} = 14.5A^{1.6} \times 10^{-6} \text{ m}^3/\text{s}$$

This equation is empirical and based upon a 'best fit' curve for modelled data from 18 catchments where the relationship between q_{50} is plotted against catchment area

$$q_{50} = 14.5(7.97)^{1.6} \times 10^{-6} \text{ m}^3/\text{s}$$

$$q_{50} = 4.02 \times 10^{-4} \text{ m}^3/\text{s} (0.402 \text{ l/s})$$

3.4.59 A 66% confidence interval for this result (derived from statistical analysis) extends an amount of 0.41 on either side of the predicted value. In other words if a value of q_{50} is estimated (by this method) the 66% confidence interval extends from $q_{50}/2.5$ to $2.5q_{50}$. Therefore we can be 66% confident that the value of q_{50} is in the range of 0.161 - 1.004 l/s.

3.4.60 This range of values represents the minimum flows in the catchment. These values are often over-conservative, and can be checked against the estimated catchment mean flow, F .

Catchment mean flow

3.4.61 Martin & Cunnane suggest that the minimum flow in a catchment with an area less than 800km² is always greater than 2 percent of F . The mean catchment flow F can be obtained in two ways:

Mean flow from rainfall and losses

3.4.62 The mean rainfall (R) for this catchment was determined to be 950mm/year (OGE) and 1039mm/year (Kelly and Lee, 2003). An evaporation loss of 450mm/year is assumed. The equation uses an evaporation rate of 450mm rather than actual evaporation rates.

$F = (R - 450) \times A / 31536$ (seconds in a year, based on 365 days divided by 1000 since rainfall is expressed in mm and needs to be converted to metres)

$$F = (950 - 450) \times 7.97 / 31536 \text{ (OGE)}$$

$$F = 0.126 \text{ m}^3/\text{s} \text{ (126.4 l/s)(OGE)}$$

$$F = (1039 - 450) \times 7.97 / 31536 \text{ (Kelly and Lee, 2003)}$$

$$F = 0.149 \text{ m}^3/\text{s} \text{ (148.9 l/s)(Kelly and Lee, 2003)}$$

Specific mean flow from rainfall

$$F = A \times (1.9R^{1.3} \times 10^{-6})$$

This equation is empirical and based upon a 'best fit' curve for modelled data where F/A (mean catchment flow/area) is plotted against R (Rainfall)

$$F = 7.97 \times (1.9 \times (950)^{1.3} \times 10^{-6}) \text{ (OGE)}$$

$$F = 0.113 \text{ m}^3/\text{s} \text{ (112.6 l/s) (OGE)}$$

$$F = 7.97 \times (1.9 \times (1039)^{1.3} \times 10^{-6}) \text{ (Kelly and Lee, 2003)}$$

$$F = 0.126 \text{ m}^3/\text{s} \text{ (126.4 l/s) (Kelly and Lee, 2003)}$$

A conservative estimate of mean flow is 112.6 l/s.

$$2\%F = (0.02) \times (0.113 \text{ m}^3/\text{s}) = 2.25 \times 10^{-3} \text{ m}^3/\text{s} \text{ or } 2.25 \text{ l/s (OGE)}$$

$$2\%F = (0.02) \times (0.126 \text{ m}^3/\text{s}) = 2.53 \times 10^{-3} \text{ m}^3/\text{s} \text{ or } 2.53 \text{ l/s (Kelly and Lee, 2003)}$$

- 3.4.63 Compared to the q_{50} values determined above this value is larger than the upper range. Martin and Cunnane point out that the equations must be used with great care in small catchments. The relationship between F and q_{50} is less well defined in smaller catchments (less than 800km²) but the estimates of flow can be generally relied upon.

- 3.4.64 So for the purposes of this EIS the conservative value $1.61 \times 10^{-4} \text{ m}^3/\text{s}$ will be used for Dry Weather Flow (DWF).

Determination of Q Mean (Annual Maximum Flood) from Catchment Characteristics of Ballyglass River at the point of proposed quarry water discharge

- 3.4.65 In the absence of flow data it is possible to determine the annual maximum flood using catchment characteristics, as outlined in the Flood Studies Report. *This is not the average flow.* The annual maximum flood is larger than the mean flow, and statistically it exceeds the one-year flood by approximately 15 percent. This flow is used as a basis for determining larger flows of a greater return period.

The equation is:

$$Q \text{ Mean} = 0.00042A^{0.95}F_s^{0.22}G^{1.18}R^{1.05}w^{-0.93}s^{0.19}$$

Where:

A = catchment area (km^2) = 7.97

F_s = channel network = 0.681

G = winter rainfall acceptance potential = 0.150

R = average annual rainfall = 1039 (worst case)

w = storage index = 1.84

s = slope of main channel = 1.23 m/km

- 3.4.66 The area of the catchment to the confluence with the unnamed stream was determined to be 7.97 km^2 . OGE used the 1:50 000 Discovery Series map (Sheet 47) to determine the area.

The values of the parameters above were determined using the methods outlined in the Flood Studies Report and the resulting equation for the area was found to be:

$$Q \text{ Mean} = (0.00042)(7.97)^{0.95}0.681^{0.22}0.150^{1.18}1039^{1.05}1.84^{-0.93}1.23^{0.19}$$

$$Q \text{ Mean} = 0.256 \text{ m}^3/\text{s} \text{ (256.4 l/s)}$$

- 3.4.67 The mean of the annual maximum flood flow of the receiving stream immediately upstream of the discharge point is only $0.256 \text{ m}^3/\text{s}$ (since the effects of the flooding are buffered by the large area of lake upstream), based on the characteristics of the catchment.

3.4.68 Coolagarry Lough is in hydraulic connectivity with the ground water table. All the run-off and ground water recharge within the surface water catchment of the lake will collect in the lake. The lake will buffer the discharge to the Ballyglass River such that there is little variation in dry weather and flood flow conditions in the river immediately downstream on the lake discharge point. A preliminary water balance for the catchment of the Ballyglass River above the proposed quarry water discharge point suggests that the maximum average discharge should be approximately 176l/s (based on the recharge figures of Kelly and Lee, 2003). Estimates of the catchment mean flow using the recharge figures of Kelly and Lee (2003) range from 126l/s to 149l/s. The average mean flood discharge for the Ballyglass River at the proposed discharge point is therefore around 85% greater than the mean discharge.

Determination of Q₅₀ and Q₁₀₀ from Q Mean of the Ballyglass River

3.4.69 A series of growth factors for flood flows of varying recurrence intervals was determined for Ireland (Cunnane & Lynn, 1976). The Q₅₀ and Q₁₀₀ multipliers are, respectively, 1.77 and 1.96. (These values are determined from the relationship between Q_T/Q Mean and the Extreme Value Type 1 Reduced Variate)

3.4.70 For the receiving stream above the discharge point, the 50-year and 100-year floods would be expected to be:

$$Q_{50} = (0.256\text{m}^3/\text{s})(1.77) = 0.454\text{m}^3/\text{s} (454 \text{ l/s})$$

$$Q_{100} = (0.256\text{m}^3/\text{s})(1.96) = 0.503\text{m}^3/\text{s} (503 \text{ l/s})$$

3.4.71 The buffering effect of the lake is marked since the predicted precipitation (based upon the *Flood Studies Report* Methodologies) within the catchment during a 24 hour duration 50 and 100 year return period storm event are 6,550l/s and 7,400l/s respectively.

In Summary:

Table No. 3.4.6: Summary of Likely Flows in the Ballyglass River at the Proposed Quarry Water Discharge Point

Discharge Conditions in Ballyglass River	Lower Value (l/s)	Upper Value (l/s)
Dry Weather Flow	0.16	2.5
Mean Flow	113	149
Annual Maximum Flood Flow (Q)	233	256
Q ₅₀	413	454
Q ₁₀₀	458	503

Mixing Proportion of the Ballyglass River discharge and potential quarry water discharge

3.4.72 OGE have calculated the likely discharge of water from the proposed quarry when developed to a elevation of 40 metres O.D. as 2600m³/day or 30l/s. The calculations of the likely quarry water discharges are presented in the Factual Hydrogeological Report as Appendix 3.4.1. In Table No. 3.4.7 the portion of the likely total discharge in the Ballyglass River at the quarry water discharge point is shown under different flow regimes in the river. During dry flow conditions the quarry discharge water is likely to comprise between 92.3% and 99.5% of the total discharge in the Ballyglass River at the proposed discharge point. During mean flow conditions the quarry discharge water is likely to comprise between 16.6% and 21% of the total discharge in the Ballyglass River at the proposed discharge point. During average flood flow conditions the quarry discharge water is likely to comprise between 10.5% and 11.4% of the total discharge in the Ballyglass River at the proposed discharge point. If the quarry were to discharge the maximum potential of the effluent treatment system of 10Ml/day (115l/s) during a flooding event this would increase the discharge in the Ballyglass River (during a typical annual flooding event) by approximately 50%, i.e., the discharge would comprise approximate 33% of the total volume of water in the river. This figure is just above the discharge component during mean flow when the quarry discharge will be 2.6Ml/day.

Table No. 3.4.7: Relative Proportions of Proposed Quarry Discharge Water in the Ballyglass River during Different Discharge Conditions

Discharge Conditions in Ballyglass River	% of total discharge derived from potential quarry water management using lower value of river discharge (l/s)	% of total discharge derived from potential quarry water management using upper value of river discharge (l/s)
Dry Weather Flow	99.5	92.3
Mean Flow	21	16.6
Annual Maximum Flood Flow (Q)	11.4	10.5
Q ₅₀	6.8	6.2
Q ₁₀₀	6.1	5.6

Capacity of channel & Instantaneous Discharge Readings

3.4.73 OGE collected measurements of the Ballyglass River at the proposed quarry water discharge point to estimate its carrying capacity (bank-full capacity).

3.4.74 The proposed quarry water discharge point is immediately south of the bridge over the Ballyglass River on the R343 at Cuilleenirwan, see Figure No. 3.4.6. The Ballyglass River is culverted into a 1200mm diameter concrete pipe at the bridge crossing. On the 1st September 2004 the average flow rate in this pipe was measured at 0.139m/s using a hand-held impellor flow meter. The water depth in the pipe was 0.27 metres. Using a simple velocity/area calculation the discharge at the

downstream end of the culvert was approximately 271/s. This is towards the lower end of the predicted flows in the Ballyglass River and not inconsistent with expected river levels in late summer being below the predicted mean flow but above dry weather flow.

3.4.75 The dimensions of the channel were recorded at two locations, one location 8 metres downstream from the culvert and a second a further 25 metres downstream from the first measurement point. As a visual assessment the eastern bank of the Ballyglass River was found to be lower than that of the western bank. The channel appears to have two components at these locations, a lower more incised channel and a more gently sloping upper profile. As a worst case scenario of the bank full capacity only the lower more incised channel was used in the calculations. As such the actual bank full capacities of the Ballyglass River at the study locations will probably exceed that calculated. The channel is locally overgrown. The water level in the stream was approximately 0.15 metres above the bed (1st September 2004). Based upon the high tide mark on the vegetation, the average annual flood level in the stream is approximately 0.35 metres above the level recorded on the 1st September 2004. The stream bed is rough and stoney. As of 15th August 2004 OGE have been unable to clarify with the Shannon Regional Fisheries Board whether the Ballyglass River is classified as salmonid. The predicted chemistry of the Ballyglass River after the addition of the proposed quarry discharge is however compared with the required chemistry for such rivers. The information collated was processed in a channel modelling programme *Flowmaster V6.1* to determine the bank full capacities. The bank full capacities of the Ballyglass River at the study locations are as follows; the results of the *Flowmaster v6.1* analyses are presented in *Appendix 3.4.6*.

Location 1, 8 metres south of culvert bank full capacity (based on a slope of 0.00123) = 4m³/s or 4,000l/s

Location 2, 33 metres south of culvert bank full capacity (based on a slope of 0.00123) = 3.3m³/s or 3,300l/s

3.4.76 Using *Flowmaster V6.1* and the assumed annual flood level in the Ballyglass River then the predicted discharge in the channel during such events can be calculated. The predicted annual average flood discharge in the Ballyglass River at the two locations ranged from 280l/s – 295 l/s, see *Appendix 3.4.9*. These values are consistent with modelled values of the annual mean flood flow of 233l/s - 256l/s. The water depth as recorded on the 1st September 2004 was approximately 0.15 metres. Using *Flowmaster V6.1* the calculated discharge in the Ballyglass River at the two study points on the 1st September 2004 ranged from 14l/s – 16l/s. These values are consistent with the discharge as measures on the downstream end of the culvert. The predicted flows in the Ballyglass River under various conditions are compared to the bank full capacity of the stream with and without the additional load of the proposed quarry water discharge in *Table No. 3.4.8*. If the quarry were to

discharge the potential maximum from the effluent discharge system on 10MI/day, then during a flooding event of 100 year return period the Channel of the Ballyglass River would be at less than 20% capacity.

Table 3.4.8: Percentage of Bank Full Capacity of the Ballyglass River under Various Flow Conditions

Discharge Conditions in Ballyglass River	Upper Value of River Discharge without Additional Quarry Water (l/s)	% of Channel Filled at Proposed Discharge Point (worst case bank full capacity 3.3m³/s)	Upper Value of River Discharge with Additional Quarry Water at 2.6MI/d (30l/s) (l/s)	% of Channel Filled at Proposed Discharge Point with Quarry Discharge (worst case bank full capacity 3.3m³/s)
Dry Weather Flow	2.5	0.08	32.5	0.99
Mean Flow	149	4.5	179	5.4
Annual Maximum Flood Flow (Q)	256	7.6	286	8.7
Q ₅₀	454	13.6	484	14.7
Q ₁₀₀	503	15.2	533	16.2

Quarry Water Management

3.4.77 The quarry will be developed in three benches with a maximum bench height of 19.8 metres to a total estimated elevation of 40 metres O.D. Ground water levels varied across the site from around 55 metres to 70 metres O.D in February 2004 and from around 60 metres to 75 metres O.D in June 2004. Ground water levels are generally lower within the karstified bedrock and higher in the relatively unkarstified bedrock forming the central area of the site. As the quarry is developed water collecting in the quarry void will have to be managed.

3.4.78 OGE compiled a Factual Hydrogeological Report on the site to calculate the likely amount of water that will need to be managed.

3.4.79 It is proposed that water from the quarry will be pumped via a pipeline to be discharged to the Ballyglass River some 1300 metres to the west of the site. The estimated fall between the north-western corner of the site and the Ballyglass River is approximately 20 metres. The fall on the pipeline is therefore approximately 0.016. Assuming the estimated average daily discharge rate of 2,600m³/day (30l/s) at the end of the life of the quarry and a welded uPVC pipeline, then the minimum pipe diameter that is required is 150mm. In Appendix 3.4.7 the proposed settlement lagoon will have a capacity of 10MI/day. To discharge this amount of water would require a pipe of up to 255mm diameter. This pipe diameter is based upon an unpressurised system, the diameter would decrease if the system was pressurised and this would be determined in the final design. A pipe diameter of 255mm would therefore represent the maximum pipe diameter required. OGE propose that the discharge pipe is constructed to a diameter of 255mm to facilitate potential additional capacity although these levels of discharge are unlikely to ever be required. The likely

maximum daily discharges from the quarry would be 2.6ML/day. The potential impacts on the Ballyglass River are based upon these figures. Roadstone Provinces Limited will however seek a discharge licence based upon the theoretical maximum discharge from the quarry of 10ML/day. The likely impact on the river chemistry of such a discharge would however be less than those during dry flow conditions since such a level of discharge may only be required during periods of very heavy rainfall when discharges in the Ballyglass River are high. The bank full capacity of the Ballyglass River will accommodate such an increased discharge.

- 3.4.80 A discharge licence for the quarry water will be sought by Roadstone Provinces Limited from the Environment Section of Roscommon County Council.
- 3.4.81 In the above Local Hydrology section OGE have calculated the different flows in the Ballyglass River during different conditions in the river. All the calculations of likely flows within the Ballyglass River at the proposed discharge point are based on an estimate of the surface water catchment to the system above that point. In this report OGE have shown that the ground water and surface water catchments in the environs of the application site are probably not synonymous. In the Factual Hydrogeological Report that is reproduced as *Appendix 3.4.1*, OGE have calculated the likely discharges from the quarry to maintain dry working conditions as the extraction of limestone progresses. At a final bench level of 40.00m O.D. estimated discharges of ground water are likely to be of the order of 2.6 ML/day or 30 l/s based on a worst case estimate. This figure would represent the additional load on the Ballyglass River owing to the proposed quarrying activities. Within this OGE demonstrate that the ground water below the site discharges to both the Killeglan Spring catchment and that of the Cross River (Corkip Lough). The discharge of the quarry water to the Ballyglass River would therefore represent an increase in the discharge in this river. In *Table No. 3.4.7* the relative proportion of the predicted water likely to be discharged from the proposed development is compared to that of the predicted flows during different conditions in the river.
- 3.4.82 From *Table No. 3.4.7* it can be demonstrated that quarry discharges would only add an additional 6% to the total flow of the Ballyglass River (at the point of discharge) during a 100 year return period storm event. During such a storm event discharges from the quarry would remain constant as the lower parts of the working quarry would be allowed to flood owing to the volume of water accumulating in the quarry through direct precipitation. The volumes of water that would potentially accumulate in the quarry during a 50 year and 100 year return period event were calculated and the tabulated figures presented as *Appendix 3.4.5*. The mean direct precipitation to the proposed quarry over a 24 hour period during a 50 year return period storm event is estimated to be 0.559m³/s for the application area and 0.193m³/s for the quarry footprint. The mean direct

precipitation to the proposed quarry over a 24 hour period during a 100 year return period storm event is estimated to be 0.631m³/s for the application area and 0.218m³/s for the quarry footprint.

- 3.4.83 Dust suppression water will be sourced initially from ground water and surface run-off water may be utilised as the quarry develops. A production well (BH-PW2A) drilled during the hydrogeological investigation could be utilised as a water supply for the quarry operations. A safe yield of 30m³/day could currently be abstracted from this well. Water consumption for dust suppression measures is unlikely to exceed 5m³/day.
- 3.4.84 A wheel wash facility will be located within the quarry management area of the proposed development. Water to top-up the facilities to account for evaporitic losses will be sourced from ground water. OGE contend that water consumption for the wheel-wash facility would be less than 1m³/day. The site production well could be constructed to meet this need. The water used within the system will be re-cycled to minimize water usage.
- 3.4.85 Within the quarry management and concrete making areas, workshops and re-fuelling areas will be located on concrete surfaces. The drainage system for the areas of hardstanding including the block yard will be such that all run-off is collected within a central sump/reservoir and initially processed through an oil trap and klargestser system prior to being directed to the main quarry sump. In Table No. 3.4.9 OGE have calculated the likely daily mean and 1, 50, and 100 year return period storm event run-off from all areas of hardstanding (including surfaced roads) and roofs. The central sump/reservoir will have a volume of 300m³ (approximately 7 days of annual run-off) and the Klargestser oil inceptor should be capable of treating 20 l/s of water.

Table No. 3.4.9: Predicted run-off from areas of hardstanding on site

Quarry Management Area (hardstanding and roofs)	
Area of concrete slab in block yard	12,800m ²
Estimated area of hardstanding (including roads)	9,250m ²
Area of roofs (office and workshop)	534m ²
Total Area	22,584m²
Predicted run-off conditions	Volume of run-off m ³ /day (l/s)
Average daily mean	43.1m ³ (0.5l/s)
1 yr return period 24 hr event	833m ³ (9.6l/s)
50 yr return period 24 hr event	1604m ³ (18.5l/s)
100 yr return period 24 hr event	1812m ³ (21.1/s)
Maximum short duration event based on Department of the Environment guidelines (applicable to drain design and not storage lagoon)	317 l/s

- 3.4.86 Water for drinking and to service the toilet facilities (located within the site office) will be supplied from the bored supply. Water consumption for these services is unlikely to exceed 3m³/day. The chemistry of the ground water meets drinking water standards, for those parameters tested. A UV filter will be installed to treat the water prior to consumption.
- 3.4.87 Waste water from the welfare facilities will be treated via a septic tank and percolation area located within the site boundaries. A separate site assessment has been carried out for the installation of the waste treatment system. Details of the site assessment which will included the location of the proposed percolation area are included *Appendix 3.4.8*. This facility is providing for forty-five permanent and temporary site employees.
- 3.4.88 The development will also comprise concrete making facilities. It is proposed to produce 50,000m³ of readymix concrete per annum. Each 1m³ of readymix concrete requires 150-170 litres of water. This level of production would require a water consumption of 8,500m³/yr or 30m³/day based on 5.5 day working week. This water will be sourced from the treated effluent that has passed through the effluent treatment system and is available for discharge and the surface run-off central storage sump/reservoir located in the quarry management area. In addition to the readymix concrete it is proposed to produce 5 million concrete blocks per annum. This would equate to approximately 40,000m³ of blocks and require 3,200m³/yr or 8.7m³/day of water to produce.

Table No: 3.4.10: Summary of Quarry Water Management System

Water inputs and abstraction relevant to the development	Water consumption	Water discharges to ground, water courses or other losses
Surface run-off and ground inputs to quarry 2,600m ³ /day	Concrete Block Making 8.7m ³ /day	Discharge to Ballyglass River daily average following treatment by the effluent treatment system 2,561.7m ³ /day
	Readymix Concrete 30m ³ /day	
Ground water abstraction from borehole 9m ³ /day	Dust suppression measures 5m ³ /day	Evaporitic losses 6m ³ /day
	Wheel-wash facility 1m ³ /day	
	Welfare facilities 3m ³ /day	Discharges to ground through effluent treatment system 3m ³ /day
Run-off on areas of hardstanding on site including block yard	Variable dependent on availability	43.1 m ³ Discharge to quarry sump and eventual discharge to Ballyglass River

HYDROGEOLOGY

Well Data

3.4.89 Well data was available in the records of the GSI, and water levels were obtained wherever possible from the wells local to, or within the proposed quarry. Water levels recorded by OGE are tabulated in Table No. 3.4.11; the locations of the wells are shown of Figure No. 3.4.7. The majority of the residences within the study area are on public water mains supply, so there is little reliance on ground water. All the houses and farms in the local area use septic tanks. Detailed ground water observations from the site wells are included within the Factual Hydrogeological Report (Appendix 3.4.1).

Table No 3.4.11: Summary of Site and Third Party Wells

Well No. and Owner	Ground Level m O.D.	Grid Reference	Depth of Well (m bgl)	Depth to water (m bgl)	Depth to Water (m O.D.)	Date Measured	Remarks
1. Site Monitoring BH1 (Roadstone Provinces Ltd)	84.20	E 190455 N 244044	46.00	16.51	67.70	26/06/04	
2. Site Monitoring BH3 (Roadstone Provinces Ltd)	101.58	E 190099 N 244700	61.40?	46.86	54.72	26/06/04	
3. Site Monitoring BH5 (Roadstone Provinces Ltd)	95.99	E 190606 N 244222	84.50	41.85	54.14	26/06/04	
4. Site Monitoring BH6 (Roadstone Provinces Ltd)	99.48	E 190211 N 244403	60.00	28.73	70.75	26/06/04	
5. Site Monitoring BH8 (Roadstone Provinces Ltd)	91.00	E 189939 N 244576	61.40?	35.36	55.64	26/06/04	
6. Site Monitoring BH9 (Roadstone Provinces Ltd)	96.48	E 189933 N244912	62.00	28.40	68.09	26/06/04	
7. Site Monitoring BH10 (Roadstone Provinces Ltd)	96.71	E 190273 N 244912	61.80?	41.89	54.82	26/06/04	
8. Site Monitoring BH11 (Roadstone Provinces Ltd)	87.35	E 189894 N 245238	56.00	26.04	61.31	26/06/04	
9. Site Monitoring MW1 (Roadstone Provinces Ltd)	88.40	E 190056 N 244348	39.00	34.61	53.79	26/06/04	
10. Site Monitoring MW2 (Roadstone Provinces Ltd)	90.28	E 190427 N 245328	39.00	27.26	63.02	26/06/04	

11. Pumping Well PW2A (Roadstone Provinces Ltd)	96.84	E 190281 N 244897	80.00	42.60	60.40	26/06/04	
12. Mr. John-Joe Kelly	NR	E 190132 N 242893*	NR	20.21	-	29/06/04	8" steel casing still useable Mains supply
13. Mrs. Donaghue	NR	E 190275 N 242770*	NR	15.40	-	29/06/04	6" steel casing, not used - Mains supply
14. Mrs. Bulter	NR	E189816 N 245464*	NR	26.92	-	23/06/04	6" steel casing, not used - Mains supply
15. Mr. Daley	NR	E 188664 N 244819*	NR	12.45	-	23/06/04	6" steel casing, not used - Mains supply
16. Mr. Keogh	NR	E 191247 N 242831*	NR	11.40	-	29/06/04	Not used but serviceable
17. Mr. Cooney	NR	E 190690 N 243349*	NR	6.15	-	29/06/04	Old hand dug well in Feacle Turlough

Ground Water Flow Directions

3.4.90 OGE have integrated the bedrock quality map (Apex Geoservices Limited), topographic information, site karst features and the ground water contours for June 2004 to assess the likely directions of ground water flow beneath the site. This information is presented on *Figures Nos. 3.4.3 and 3.4.4*. Using this information the primary bedrock structures and therefore the main ground water conduits can be determined. This interpretative map of the ground water flow directions is presented in *Figure No. 3.4.5a*. Three ground water areas beneath the application site have been determined. Essentially ground water flow directions have two components; where the rock is relatively unfractured, the permeability of the bedrock is low and ground water directions follow topographic contours. The water levels in the unfractured rock are elevated relative to those within the main ground water conduits:

Area 1 – northern and northeastern application site

3.4.91 Below Area 1 ground water generally flows from the areas of less fractured bedrock into a central fractured and karstified zone. Ground water discharges under the site in a southeasterly direction into the Cross River catchment. Rises in ground water levels in the central fractured zone of the site during the winter appear to correspond to the maximum flood levels in Corkip Lough (turlough).



Ground water therefore flows naturally from the Ballyglass surface water catchment to that of the Cross River catchment. Since most of the water available for recharge in this part of the site soaks to ground water most of the precipitation falling on this area of site will enter the Cross River system and not the Ballyglass system which is at odds with the surface water catchments for these systems.

Area 2 –western application site

- 3.4.92 It is likely that ground water beneath this part of the site flows from the topographically higher and less fractured rock from the east and then in south-southeasterly direction along a fractured zone. Ground water flows naturally from the Ballyglass surface water catchment to that of the Killeglan Public Water Supply. Since most of the water available for recharge in this part of this site soaks to ground water most of the precipitation falling on this area of site will enter the Killeglan system and not the Ballyglass system which is at odds with the surface water catchments for these systems.

Area 3 –southern application site

- 3.4.93 Ground water beneath this area of the site flows in south-southeasterly direction. This area is within the Zone of Contribution to the Killeglan Public Water Supply. It is not planned to extract any bedrock from this area. A wayleave of approximately 50 metres is designed between the most southern part of the planned extraction and the northern boundary of this area.

Recalculated Water Balance for Application Site

- 3.4.94 OGE have shown in the proceeding sections of this chapter that between 80% and 100% of all water falling on the site and available for run-off or recharge to the aquifer will in fact soak to ground water. OGE have also demonstrated that the ground water catchments within the application site differ from the surface water catchments on site (based upon topography). In the above section OGE have delineated the probable ground water catchments of the site. Using the Effective Rainfall data determined by OGE and Kelly and Lee (2003) the water balance for the site can be recalculated to determine the average annual volume of water soaking down into each ground water catchment and run-off to surface catchment within the site. Table No. 3.4.12 shows the different ground water and surface catchment areas of the site and to which ground water and surface water system the effective rainfall for that area discharges to.

Table No. 3.4.12: Summary of Ground Water and Surface Water Catchments within Difference Sub-divisions of the Application Site

Application site area	Total Area m ²	Extractive Area m ²	Surface Water Catchment	Ground Water Catchment
Area 1 (northern site)	342,070	109,360	Ballyglass (north of discharge from Cuilleenirwan Lough)	Cross River (Corkip Lough)
Area 2 (western site)	249,560	127,640	Ballyglass (south of discharge from Cuilleenirwan Lough)	Killeglan
Area 3 (southern site)	88,370	n/a	Killeglan Public Water Supply Zone of Contribution	
	680,000	237,000		

3.4.95 The annual average effective rainfall figures for the site have been calculated as 543mm/yr (OGE) and 687mm/yr (Kelly and Lee, 2003). Assuming a 20% run-off figure, the partition of the water falling on the site to ground water and surface water within each area is calculated and presented in Table No. 3.4.13. For Areas 1 and 2 the water balance for the extractive areas within these site sub-divisions is also calculated.

Table No. 3.4.13: Revised Water Balance for the Application Site

Application site area	Average annual run-off volume and to which system (OGE ER figures) m ³	Average annual run-off volume and to which system (Kelly and Lee, 2003 ER figures) m ³	Average annual ground water recharge volume and to which system (OGE ER figures) m ³	Average annual ground water recharge volume and to which system (Kelly and Lee, 2003 ER figures) m ³
Area 1 all (northern site)	37,148 (yr) 101.7 (day) Ballyglass System	47,685 (yr) 130.5 (day) Ballyglass System	148,595 (yr) 406.8 (day) Cross River (Corkip Lough)	190,738 (yr) 522.2 (day) Cross River (Corkip Lough)
Area 1 (Extractive area)	[11,876 (yr) 32.5 (day) Ballyglass System]	[15,244 (yr) 41.7 (day) Ballyglass System]	[47,506 (yr) 130 (day) Cross River (Corkip Lough)]	[60,979 (yr) 167 (day) Cross River (Corkip Lough)]
Area 2 all (western site)	27,102 (yr) 74.2 (day) Ballyglass System	34,789 (yr) 95.2 (day) Ballyglass System	108,409 (yr) 296.8 (day) Killeglan	139,155 (yr) 381.0 (day) Killeglan
Area 2 (Extractive area)	[13,862 (yr) 38 (day) Ballyglass System]	[17,793 (yr) 48.7 (day) Ballyglass System]	55,447 (yr) 151.8 (day) Killeglan	71,172 (yr) 194.9 (day) Killeglan
Area 3 (southern site)	47,985 (yr) to 61,594 (yr) or 131.4 (day) to 168.6 (day) Killeglan			

Ground recharge and discharge

3.4.96 Recharge to the bedrock aquifer occurs at all points on the study site. In the central and western areas of the site, the bedrock aquifer is either exposed or underlain by relatively thin (< 3 metres) of overburden and highly weathered rock. There are no surface water courses either on or immediately adjacent to the site, and therefore majority of the precipitation falling on the site will recharge the bedrock aquifer. Where the overburden cover is thicker (3.00 to 10.00 metres) the permeability of the drift is such that diffuse aquifer recharge is possible. Within these areas of thicker overburden are areas of internal drainage some of which are probably related to karst collapse structures in the bedrock and thus represent swallow holes and points of discrete recharge. Kelly and Lee (2003) estimated that approximately 20% of the water available for potential run-off

within the zone of contribution to Killeglan Public Water Supply fails to recharge the aquifer. OGE would contend that this figure is probably also applicable to the application site.

3.4.97 Based upon observation taken during the constant rate pumping test during longer term monitoring of water levels in selected boreholes from the application site ground water recharge response times are rapid on the scale of a few hours.

3.4.98 As previously discussed the inferred limit of the zone of contribution to the Killeglan Public Water Supply is located within the southern part of the site. Ultimately ground water within the zone of contribution to Killeglan Public Water Supply will either discharge locally to the head of the Killeglan River or from other surface water discharge points within this ground water catchment (see Hydrology Section). Ground water below the eastern part of the application site will also discharge to the Zone of Contribution to the Killeglan Public Water Supply although this is to the north of the Zone of Contribution as defined by Lee and Kelly (2003). Ground water below the north part of the site will discharge towards Cross River catchment, although this area is located within the surface water catchment to the Ballyglass River.

Aquifer Classification

3.4.99 As discussed in Soils (and Geology) Section of this EIS, the site is underlain by Undifferentiated Visean Limestone. Rock core retrieved from the nine cored exploratory boreholes drilled on the site (and adjacent lands) do not contradict this interpretation. The County Roscommon Groundwater Protection Scheme, 2002 (Draft) classifies this aquifer as Rf - a regional important aquifer - fissure flow dominant and describes it thus:

"Overall, the Undifferentiated Visean Limestone generally comprises clean, highly karstified rocks, which are capable of sustaining significant yields, including six public water supply schemes."

3.4.100 Evidence from the site geology confirms that the bedrock is indeed 'clean', i.e., generally lacking in clastic clays and shale beds and evidence of karstification, particularly in parts of the northern and eastern parts of the site is noted. However, in the areas of the bedrock that are karstified the majority of the fractures and fissures that would provide ground water conduits are clay-filled. Therefore although the permeability of the fractured and karstified zones is higher than the unfractured bedrock they are relatively low for karstified limestones. The Killeglan Public Supply Scheme located approximately 4 kilometres south-southwest is major public water supply sourced from the Undifferentiated Visean Limestone. However, the OGE Factual Hydrogeological Report (Appendix 3.4.1) suggests that potential yields in the bedrock aquifer below the application site are not significant.

3.4.101 The overburden deposits of the study area are not considered as potential aquifers.

Ground water Vulnerability and Resource Protection

3.4.102 The vulnerability of an aquifer is dependent upon the permeability of the overlying sub-soils and their thickness. In Table No. 3.4.14 the guidelines for assessing the vulnerability of an aquifer are defined.

Table No. 3.4.14: Vulnerability Mapping Guideline (Adapted from DELG, 1999)

Unsaturated Zone Sand and gravel aquifers only	Sub-soil Thickness	Hydrogeological Conditions (Diffuse Recharge: Sub-soil Permeability and Type)		
		High Permeability (sand/gravel)	Moderate Permeability (e.g. sandy sub-soil)	Low Permeability (e.g. Clayey sub-soil, clay, peat)
Extreme	0 – 3.0 m	Extreme	Extreme	Extreme
High	3.0 – 5.0 m	High	High	High
High	5.0 – 10.0 m	High	High	Moderate
High	> 10.0 m	High	Moderate	Low

3.4.103 The vulnerability (of the bedrock aquifer) is reproduced from that of the GSI and is shown as Figure No 3.4.8 as part of a resource protection classification map. The map (as reproduced from the records of the GSI) shows that over the majority of the site the bedrock aquifer is classified of **extreme** vulnerability, i.e., bedrock is relatively shallow (< 3 metres below ground level), although the geophysical evidence from the application site suggests the overburden is thicker than this under many areas. The sections of the eastern and northeastern parts of the site would be classified of **high** vulnerability based upon the records of the GSI. This interpretation is partly co-incident with the observed site geology where the areas of the northern and eastern parts of the site are underlain by thicker overburden and more fractured bedrock.

3.4.104 Based upon the site geology alone and incorporating depth to bedrock information from this chapter the central and western areas of the application site are characterised by shallow relatively unfractured bedrock and would be classified as being of **extreme** vulnerability. All other areas of the site would be classified of **high** vulnerability, since the overburden is probably of moderate permeability and ranges in thickness from approximately 3.00 to 10.00 metres.

3.4.105 As a consequence of the proposed development the topsoil and sub-soils will be stripped from the proposed extractive areas and stored as site screening bunds. The vulnerability of the bedrock aquifer will therefore become **extreme** (within the proposed extractive areas) during the quarrying operations.

3.4.106 Based upon the classifications of the aquifer underlying the site and the vulnerability of that aquifer, a resource protection classification for the aquifer can be assigned. The bedrock aquifer below the site would therefore generally have a resource protection classification of **Rf/H - Regionally Important Aquifer - fissure flow dominant of High Vulnerability**, locally **Rf/E - Regionally Important Aquifer - fissure flow dominant of Extreme Vulnerability**. As a consequence of the proposed development the resource protection classification of the bedrock aquifer in the extractive areas would become **Rf/E - Regionally Important Aquifer - fissure flow dominant of Extreme Vulnerability**.

Bedrock Aquifer Properties

3.4.107 As part of a hydrogeological investigation a pumping test was commenced at 12:32hrs on the 28th June 2004, and completed at 12:30hrs on the 1st July 2004, a period of 71.97hrs (4318 minutes). A hydrogeological report based upon the findings of the pump test was compiled by OGE, a copy of which is enclosed as Appendix 3.4.1 to this Section of the Environmental Impact Statement.

3.4.108 The bedrock aquifer is fractured and unconfined. Hydraulic gradients in the less fractured bedrock are approximately 0.07 whereas in the fractured and karstified bedrock the hydraulic gradient falls to approximately 0.007.

3.4.109 Analyses of the time/drawdown graphs for nearest monitoring well (Borehole BH10) during the pumping test suggested a Transmissivity (T) value of 12m²/d, and a storativity value of 1.4×10^{-4} . Assuming an aquifer thickness of 38 metres, then the Hydraulic Conductivity of the aquifer in this location is 0.14m/d (1.66×10^{-6} m/s). This Hydraulic Conductivity value would be considered medium to low.

3.4.110 The Pumping Well (PW2A) is located within a zone of fractured bedrock. The value of Hydraulic Conductivity recorded is therefore likely to be at the upper range of values for the bedrock beneath the site as a whole.

Existing Potential Contamination

3.4.111 None of the houses, farms and other commercial enterprises are served by mains sewerage and waste water is treated by septic tanks. Effluent from septic tanks is a potential point source of ground water contamination. OGE have assumed that all these residences have septic tanks and provide potential point sources for contamination. Farm yard waste also provides a probable point

source of ground water contamination. The other industrial, agricultural and commercial activities also provide possible point sources of contamination from spillages of fuel or other chemicals.

3.4.112 The proposed development would provide the following additional potential sources of surface and ground water contamination

- Septic tank servicing the on-site toilet facilities, located adjacent to the office;
- A bunded diesel tank to refuel mobile plant to be located within the quarry management area;
- Waste oils from the workshop to be located within the quarry management area;
- Accidental fuel or leaks from mobile plant;
- Potentially contaminated wash-down water within the workshop yard;
- The steam cleaning of plant in the workshop area may also produce potentially contaminated surface water run-off; and
- Potential contaminated run-off from precipitation and dust suppression measures.

Site Water Chemistry

3.4.113 A sample of the ground water was collected at the end of the pumping test and sent to Alcontrol Laboratories, Ballycoolin to be analysed for the list of parameters present in Table No. 3.4.13. A water sample from the Ballyglass River was collected on the 31st August 2004 and also analysed for the same parameters. The results of these analyses are also presented in Table No. 3.4.13.

Table No.3.4.15: Hydrochemical Results of the Ground Water Sample from the site and Surface Water Sample from the Ballyglass River

Parameter	Units	Ground Water Sample at end of pump test	Surface Water Sample from the Ballyglass River	Killeglan Public Water Supply from date supplied by Roscommon County sample dates FEB 02 to FEB 04 – median value	I/PV value	IGV values
pH		7.1	8.0	7.15	5.5-8.5*	$\geq 6.5 \leq 9.5$
Conductivity	($\mu\text{S}/\text{cm}$)	537	518	597	1000	1000
Dissolved Oxygen	(mg/l)	12.8	NR	-		
Total Dissolved Solids	mg/l	383	304	-	n/a	1,000
Ammoniacal Nitrogen	mg/l N	<0.2	<0.2	0.007 (Ammonia)	n/a	n/a

Parameter	Units	Ground Water Sample at end of pump test	Surface Water Sample from the Ballyglass River	Killeglan Public Water Supply from date supplied by Roscommon County sample dates FEB 02 to FEB 04 – median value	I/PV value	IGV values
Calcium	mg/l Ca	107.7	106.6	-	n/a	200
Chloride	mg/l Cl	10	13	-	200	30
Iron	mg/l Fe	0.017	0.132	0.048	0.1	0.2
Magnesium	mg/l Mg	3.95	3.10	-	n/a	50
Manganese	mg/l Mn	0.016	0.014	0.006	0.05	0.05
Potassium	mg/l K	0.2	2.0	-	n/a	5
Sodium	mg/l Na	5.8	7.3	-	200	150
Sulphate	mg/l SO ₄	4	<3	-	250	200
Total Alkalinity	mg/l CaCO ₃	240	310	-	n/a	n/a
Nitrate as NO ₃	mg/l	3.1	1.0	3.33	50	25
Nitrite as NO ₂	mg/l	<0.05	0.47	0.002	0.5	0.1
Phosphorus	mg/l P	<0.05	<0.05	-	n/a	n/a
Orthophosphate	mg/l PO ₄	<0.03	<0.03	0.005		
Colour	Hazen	1	93	21		
Total Suspended Solids	mg/l	10	<10	-		
Minerals Oils	µg/l	<10	<10	-		
Total Phenols	mg/l	<0.01	<0.01	0.01 (G/A3)		
Total PAH's (16 EPA species)	mg/l	<0.2	0.0003	-		
Oils, Fats and Greases	mg/l	<1	<1	-		
NSO/Resins	mg/l	<1	<1			
BOD unfiltered	mg/l	<2	3	<3 (G/A1)		
COD settled	mg/l	<15	44	30 (G/A3)		

* 75/44EEC "Surface Water Directive" guideline value for A1 waters

3.4.114 surface water quality results are given relative to the I/PV values set out in 75/44/EEC Council Directive of 16 June 1975 concerning the quality required of surface water intended for the abstraction of drinking water in the Member States. This directive is informally referred to as the Surface Water Directive. The ground water results are being measured against the proposed standards for ground water as published by the EPA in the Interim Guideline Values for Groundwater.

3.4.115 The ground water and surface water samples were found to be a calcium-bicarbonate type typical of limestone terrains. The ground water sample does not exceed any of the Interim Guideline Values for Groundwater, nor since the water is intended for discharge to the Ballyglass River, does any of the parameters measured exceed the standards for surface water intended for drinking. Where the ground water sample from the site and the hydrochemical results of the on-going monitoring at the Killeglan have parameters in common the chemistry of both waters is similar.

Impact of Quarry Discharge on Killeglan Public Water Supply



3.4.116 OGE have estimated the likely daily discharges of surface run-off and ground water inflow to the quarry and proposed for discharge to the Ballyglass River is 2.6 MI/day. Higher discharges would be extremely infrequent and for short durations only. Some of this water is ground water from the Cross River system and other water would have naturally run-off to the Ballyglass River. The estimated worst case scenario of ground water inflow to the proposed development when the quarry floor is at an elevation of 40 m O.D is 1.3 MI/d. Of this worst case figure of 1.3 MI/day of ground water ingress, around 50% should be taken from the Cross River system. Therefore the worst case scenario of ground water loss and potential impact on the Killeglan source is around 650m³/day. The average daily amount of precipitation available for run-off and recharge in the zone of contribution to the Killeglan Public Water Supply is estimated as 80MI/day. The potential impact of the quarry development on the Killeglan source is therefore estimated at less than 1%.

Impact of Quarry Discharge on Corkip Lough

3.4.117 Corkip Lough was originally a turlough-type lake being feed by ground water and surface run-off. Drainage works have resulted in the lake becoming a turlough fed predominantly by ground water. As previously discussed the majority of precipitation falling within a catchment to a river or lake within this area soaks to ground water (c. 80%). Therefore the primary component of recharge to the lake will be from ground water. The majority of turloughs are fed by relatively shallow ground water emanating from the *epikarst*. Based upon the evidence presented in this report Corkip Lough lies at the down gradient end of a deep karst structure (and ground water conduit) that also underlies the northern part of the application site. Corkip Lough is therefore likely to have three recharge components:

- Ground water recharge from deeper karstified bedrock which is sourced from the north-west;
- Run-off within the surface water catchment to the lough; and,
- Shallow ground water from the *epikarst* also sourced from the surface water catchment.

3.4.118 The Working Group on Turloughs (formed as part of the Water Framework Directive) on which OGE are represented identifies the following pressures on turloughs:

- Changes to water inputs to the turlough by abstractive activities;
- Changes in drainage; and

- Changes in land use which could potential alter nutrient and/or sediment loads on the turlough.

3.4.119 Based upon the hydrogeological evidence, although Corkip Lough is probably located above an area of deep karstification, the lower karst probably provides little recharge to the turlough. The vast majority of the ground water recharge to the turlough will emanate from the *epikarst*. The quarry is only to be developed in the unfractured bedrock of the application site and the cone of depression formed as the quarry is developed to full depth is likely to be of limited extent. Furthermore, the cavities within area of fractured and karstified bedrock underlying the northern application area (and which may share a structure connection with Corkip Lough) are clay-filled and the permeability within the bedrock relatively low. It is likely therefore that the proposed quarry development will have little or no impact on Corkip Lough.

Impact of Quarry Discharge on Feacle Lough

3.4.120 Feacle Lough has been classified by the Working Group on Turloughs as a Mesotrophic turlough. This classification is based on the work of R. Goodwillie and the Duchas Ellenburgh classification. In ecological terms the turlough is therefore moderately productive but not sensitive within the terms of the Water Framework Directive. The turlough has already been impacted by other activities.

3.4.121 Most turloughs are fed by ground water from the *epikarst*. Based on the ground water levels in June 2004, Feacle Lough is up gradient from the karstified bedrock of Area 2 (Western Application Site). The ground water level in Borehole MW2 was approximately 54.00m O.D. in June 2004 whereas the water level below Feacle Lough was approximately 60.00 m O.D. The karstified bedrock below Area 2 of the Application site represents deep karst, whereas Feacle Lough is likely to be fed by shallow ground water from the *epikarst*. In general the relative ground water levels are lower in more karstified bedrock and this suggests that Feacle Lough is not fed by deep karst structures. Therefore, although ground water beneath the western and southern parts of the application site flow south-southeasterly in the general direction of Feacle Lough, the ground water that feeds this turlough is up gradient from the main ground water conduits below the site and as such the proposed quarry development will not impact the turlough.

Assimilative Capacity of Ballyglass River at the Proposed Discharge Point of the Quarry Water

3.4.122 OGE used *AquaChem v4.0* software to calculate the expected concentrations of each chemical parameter within the receiving water below the confluence with the discharge water under dry weather, mean flow and mean annual flood conditions. These mixing calculations are based upon a daily quarry discharge of 2.6Ml/day.

3.4.123 From the discharge and mixing calculations presented earlier in this chapter we can show that the receiving stream below the confluence with the discharge waters will comprise the following ratios of original receiving water and discharge water (based upon maximum discharge) under the following stream flow conditions:

- Dry Weather Conditions = 1 part original receiving water to 187.5 parts discharge water (0.00533:1 or 0.5% to 99.5%)
- Mean Flow Conditions = 3.77 part original receiving water to 1 part discharge water (1:0.265 or 79% to 21%)
- Mean Annual Flood Flow Conditions = 7.77 part receiving water to 1 part discharge water (1:0.129 or 88.6% to 11.4%)

3.4.124 The model calculates the resulting concentration by mixing the different solutions according to the equation below (*Aquachem v.4.0*, 2003):

$$C_z = \frac{\sum_{x,y} Q_x C_x + Q_y C_y}{\sum_{x,y} Q_x + Q_y}$$

Where C_z = Resultant concentration in stream (mg/l)

Q_x = Discharge rate of effluent (l/s)

C_x = Concentration of parameter in effluent (mg/l)

Q_y = Discharge rate of stream (l/s)

C_y = Concentration of parameter in stream (mg/l)

The predicted mixed waters are presented in *Table No. 3.4.16*.

Table No. 3.4.16: Predicted Hydrochemistry of Receiving Water Following Mixing with Discharge Water

Parameter		Units		Known		Predicted			Water Quality Standards		
		Discharge Water	Receiving Water above proposed discharge point	Dry Weather Conditions (lower flow limit)	Mean Flow (lower flow limit)	Mean Annual Flood Flow (lower flow limit)	Standard for surface water intended for drinking 75/440/EEC G-value	Standard for drinking water 80/778/EEC	Salmonid Waters Regulations (1988)		
Values Calculated by AquaChem 4.0											
pH		7.1	8.0	7.1	7.6	7.7	6.5-8.5 (G/A1)		≥6 and ≤9		
Electrical Conductivity	µs/cm	537	518	537	522	520	1000 (G/A1)		-		
Total Dissolved Solids	Mg/l	383	304	383	321	313	-		-		
Total Ammoniacal Nitrogen	mg/l N	<0.2	<0.2	<0.2	<0.2	<0.2	3.1 (l/A3) (as N)		≤0.821 (as N) Total Ammonium		
Calcium	mg/l Ca	107.7	106.6	107.7	106.8	106.7	-	100 (G)	-		
Chloride	mg/l Cl	10	13	10	12.4	12.6	200 (G/A1)	-	-		
Magnesium	mg/l Mg	3.95	3.1	3.94	3.27	3.19	-	30 (G)	-		
Potassium	mg/l K	0.2	2.0	0.2	1.6	1.	-	10 (G)	-		
Sodium	mg/l Na	5.8	7.3	5.8	7.0	7.1	-	20 (G)	-		
Sulphate	mg/l SO ₄	4	<3	4	3.2	3.1	150 (G/A1)		-		
Total Alkalinity	mg/l CaCO ₃	240	310	240	295	302	-	-	-		
Nitrate as NO ₃	mg/l	3.1	1.0	3.09	1.44	1.24	50 (l/A1-A3)		-		
Total Suspended Solids	mg/l	10	<10	10	10	10	25 (G/A1)		≤25		
Temperature	°C	11.1	NR	n/a	n/a	n/a	22 (G/A1)		-		
Dissolved Oxygen	mg/l	12.8	NR	n/a	n/a	n/a	>30% (G/A3)		≥9%		
Iron	mg/l Fe	0.017	0.132	0.021	0.107	0.117	0.1 (G/A1)		-		
Manganese	mg/l Mn	0.016	0.014	0.020	0.012	0.011	0.05 (G/A1)		-		

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Parameter		Known		Predicted			Water Quality Standards		
Parameter	Units	Discharge Water	Receiving Water above proposed discharge point	Dry Weather Conditions (lower flow limit)	Mean Flow (lower flow limit)	Mean Annual Flood Flow (lower flow limit)	Standard for surface water intended for drinking 75/440/EEC G-value	Standard for drinking water 80/778/EEC	Salmonid Waters Regulations (1988)
Values Calculated by AquaChem 4.0									
Nitrite as NO ₂	mg/l	<0.05	0.47	0.05	0.38	0.42	-	0.1 (l)	≤0.05
Phosphorus	mg/l P	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	-
BOD (unfiltered)	mg/l	<2	3	2	2.8	2.9	<3 (G/A1)	-	≤5
Total Phenols	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	0.01 (G/A3)	-	-
COD (settled)	mg/l	<15	44	15	38	41	30 (G/A3)	-	-
Mineral Oils Screen (Mineral Oils or Hydrocarbons of Petroleum Origin)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	1.0 (l/A3)	-	-
NSO, Resins Screen (Mineral Oils or Hydrocarbons of Petroleum Origin)	mg/l	<1	<1	<1	<1	<1	1.0 (l/A3)	-	-
Total PAH Screen (Mineral Oils or Hydrocarbons of Petroleum Origin)	mg/l	<0.2	0.0003	<0.2	<0.2	<0.2	0.001 (l/A3)	-	-
Colour	Hazen Units	1	93	2	74	83	10 (G/A1)	-	-
Oils fats and Greases	mg/l	<1	<1	<1	<1	<1	1.0 (l/A3)	-	-
Orthophosphate as PO ₄	mg/l	<0.03	<0.03	<0.03	<0.03	<0.03	0.09 (G/A1) mg/l P as P ₂ O ₅	-	-

¹ Assumes all in form of Ammonium (NH₄⁺) not Ammonia (NH₃)

Figures in italics are assumed.

Water Standards for Salmonid Rivers are quoted since the ecological status of Ballyglass River has not been confirmed

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IMPACT OF PROPOSED DEVELOPMENT

Ground Water

Negative Impacts

- 3.4.125 The local ground water table in the immediate area of the quarry will be lowered during extraction to approximately 40 metres O.D. The evidence from the Hydrogeological Report (Appendix 3.4.1) is that the permeability of the bedrock aquifer (particularly in the planned extractive area) is relatively low and that relatively steep gradients will develop on the cone of drawdown around the site. The majority of the residences in the study area have access to mains water supply. The cone of depression is unlikely to impact third party wells adjacent to the site.
- 3.4.126 The likely impact on the Killeglan source from discharges of ground water that will ingress into the quarry are negligible, probably less than 1%.
- 3.4.127 The extractive area of the quarry is located within the unfractured bedrock where the permeability is low and steep hydraulic gradient is likely to develop behind the quarry faces. Limited seepage of ground water may occur from the areas more fractured and karstified bedrock. However since Feacle Lough and Corkip Lough are fed by ground water predominantly from the *epikarst* the proposed development is unlikely to significantly impact on these.
- 3.4.128 The local ground water quality may be affected by accidental spillages on the exposed limestone within the quarry if mitigating measures are not put into place. Domestic effluent will be collected and treated on site through a septic tank system as there is no mains sewerage scheme in the area.

Neutral or Indirect Impacts

- 3.4.129 Following completion of the extraction (to an elevation of 40 metres O.D.) the central section of the site will form a large void space.
- 3.4.130 Following completion of the extraction the void space within the central section of the quarry will fill with water to a surface level of around 55 metres O.D. (summer) and 60 metres O.D. (winter). The level of the quarry lake will fluctuate seasonally not unlike the neighbouring turloughs.
- 3.4.131 In the event of storm rainfall events, the water level in the quarry would not rise significantly because of the very large storage capacity provided by the flooded quarry.

Surface Waters

Neutral or Indirect Impacts

- 3.4.132 Discharge from the site will be to the Ballyglass River located to the west of the site. The discharge of quarry water will lead to an increase in the flow of the Ballyglass River of approximately 20% during mean flow conditions. The channel of the Ballyglass River is relatively large and will accommodate this increase in discharge. During a 100 year return period storm event the discharge will represent an increase of 6% above the predicted discharge for the Ballyglass River during such an event.

MITIGATION MEASURES FOR WATER RESOURCES

Ground water

- 3.4.133 A number of ground water monitoring boreholes have been constructed in the fractured bedrock beneath the application site adjacent to the extractive area. A programme of regular monitoring will be undertaken on these boreholes, the well at Feacle Lough and surface water levels in Corkip Lough. This will ensure that these designated sites are not being impacted by the operation.
- 3.4.134 If it is discovered that the excavation at the quarry is having an adverse affect on any local wells then an alternative water supply will be provided. However, based the hydrogoeological evidence any impact on any third party well is unlikely and mains supply is available to the residences within the environs of the proposed development.
- 3.4.135 Measures will be taken at site to ensure that water entering the quarry does not become contaminated. The following procedures will be adhered to:
- All petroleum products and chemicals will be stored in paved and bunded areas. In particular all diesel tanks will be set upon concrete hardstanding and potential spillages contained within a bund wall with a minimum capacity of 110% of the total tank(s) volume. A sloping pre-fabricated galvanized roof will be added to the bund structures to prevent rainwater collecting within the bund and potentially becoming contaminated;
 - All waste oils and chemicals will be stored inside a workshop and disposed of off-site by a specialist contractor;
 - Refueling and maintenance of plant will take place in a designated facility which will be provided with a concrete surface. All run-off will be collected within a central sump/reservoir and initially processed through an oil trap and klargester system prior to being directed to the main quarry sump.

- The drainage system of the quarry management and concrete making areas will be designed so that all run-off and any potential spills will drain to a central point. This water will then pass through an oil interceptor prior to being directed to the main quarry sump.
- All other surface run-off, ground water ingress and dust suppression water (not lost through evaporation) will be discharged off site through the effluent treatment system. The settlement lagoon and klargester system will be located in the north-western part of the site as shown in the operation section of this EIS. Details of the effluent treatment system are presented in *Appendix 3.4.7*.

3.4.136 Effluent from the toilet facilities on site will be collected and treated in an on-site septic tank. A separate site suitability assessment has been carried out and this is presented as *Appendix 3.4.8*. The proposed location of the effluent percolation area is also shown on the site assessment form.

Surface Waters

3.4.137 The quality of the waters being discharged off site will be controlled by a licence to discharge trade effluent which will be sought under a separate application. The chemical compatibility of the Ballyglass River water and discharge water is assessed in this report and will also be presented in the discharge licence application. The assimilative capacity of the receiving water has also been assessed and the capacity of the channel to take the increased flow. The channel capacity of the Ballyglass River was found to be adequate to incorporate the projected increased flow. The projected quarry water discharge will not adversely impact the water chemistry of the Ballyglass River.

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Section 3.4 - Figures

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APPENDIX 3.4.1

HYDROGEOLOGICAL REPORT COMPILED BY OGE FOR ROADSTONE PROVINCES LIMITED





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HYDROGEOLOGICAL REPORT FOR PROPOSED QUARRY AT CURRY/CLOONACALTRY CO. ROSCOMMON FOR ROADSTONE PROVINCES LIMITED

Introduction

O'Neill Ground Water Engineering Limited (OGE) were engaged by Roadstone Provinces Limited to undertake a hydrogeological investigation for a proposed quarry site at Curry/Cloonacaltry, Co. Roscommon. The objective of that work was to establish the hydrogeological constraints to the full development of the proposed quarry. Essentially two questions were required to be answered.

- Can the quarry be developed to the maximum planned depth of approximately 40 to 70 metres bgl (40 metres O.D.);
- How much water would require to be managed and discharged as the quarry is deepened.

This report summarises the findings of a constant discharge rate pumping test carried out on the site between the 28th June 2004 and 1st July 2004, an Airlifting Test carried out on the 11th May 2004, and combines ground water information collected by OGE and Roadstone Provinces Limited over a six month period to provide answers to the above questions. All the data compiled during the constant discharge pumping test and ground water reading taken prior to the test is presented in tabular and graphic form in the Data Sheets at the end of this report. OGE installed pressure transducers in two boreholes (MW1 and MW2) to monitor trends within the ground water at these locations. This information is presented in tabular form within the Data Sheets at the end of this report. Ground water data from the other monitoring points compiled by OGE and Roadstone Provinces Limited is also presented within the Data Sheets at the end of this report. These two data sets are combined in graphical form with the rainfall data (sourced from Met Éireann) from the nearest weather station over this period to illustrate the medium term ground water trends below the site. This graph is also included in the Data Sheets.

Constant Discharge Pumping Test – Methodology

The pumping test was commenced at 12:32:00 on the 28th June 2004 and completed at 12:30:00 on the 1st July 2004, a period of 72 hours (4318 minutes). The recovery was measured from 12:30:00 on the 1st July 2004 to 12:35:00 on the 2nd July 2004, a period of 24 hours (1445 minutes).

Excluding the production well (PW2A) there were ten boreholes monitored during the test. The production well (PW2A) and two monitoring wells (MW1 and MW2) were drilled specifically for the undertaking of the hydrogeological investigation between March and May 2004. The production well was located within a central location of the application site within fractured bedrock probably associated with a fault zone. Details of the boreholes drilled for this investigation are contained within the appendices to the EIS Water Section. Eight other ground water monitoring boreholes previously constructed by Roadstone Provinces Limited either on the application site or in adjacent land were also monitored during the test. A location map of the site boreholes is contained within the EIS Water Section.

An Airlift test was carried out on the Production Well (PW2A) on the 11th May 2004. The maximum short term yield of the well was assessed at 0.56l/s. Details of the Airlift Test are contained within Data Sheets at the end of this report. Although the bedrock encountered within the production well was fractured the majority of these fractures appeared clay-filled. OGE assessed the predominant water making feature within the well was a cavity located at between 47.00 and 50.20 metres O.D. Only small inflows occurred from other levels.

On the basis of the observations of the Airlift Test, a pump was selected that could potentially abstract close to that of the maximum yield of the well. OGE assessed that if the water level in the production well was drawn down below the main cavity then the maximum safe yield of the well would be exceeded and the water level in the borehole would then rapidly drawdown. The initial flow rate from the production well at the start of the test was 0.265l/s, less than originally intended. The drawdown in the production well after a period of 22 hours (1344 minutes) was 1.40 metres from a rest level of 44.24 m below datum. A second pump was installed and started at 10:54:00 on the 29th June 2004. The discharge from the production well was increased to 0.41 l/s, approximately 75% of the estimated maximum yield of the well. After a period of 24.6 hours (1477 minutes) the second pump failed, however, a drawdown of 2.55 metres was achieved. The water level within the production well was therefore less than 1 metre above the main water bearing feature. The test was continued for a further 25.45 hours (1527 minutes) at the reduced pumping rate of 0.265 l/s. Details

of the data obtained during the test are presented in tabular form in the Data Sheets. A graph illustrating the drawdown in, and discharge from, the production well during the test is also shown in graphical form within the Data Sheets.

The water levels within the monitoring wells are detailed in tabular form within the Data Sheets. This information is also shown in graphical form in the Data Sheets. Maximum drawdown values within the monitoring wells are taken from the level of maximum drawdown in the production well approximately 47 hours from the start of the test. These details are summarised in Table No. 1.

Table No 1. Summary of Observed Pumping Test Results

Borehole	Static Water Level 28/06/04 prior to 12:32:00 m O.D.	Abstraction rate	Duration (minutes since start of the test)	Change in Water Level over Duration of Pumping Test (m)	Distance from Production Well (m)
Production Well PW2A	54.24	0.265 – 0.410 l/s		-2.55	-
BH1	67.70		2917	+0.730	871
BH3	54.72		2898	-0.035	268
BH5	54.14		2923	-0.085	749
BH6	70.75		2906	-0.24	499
BH8	55.64		2955	-0.055	469
BH9	68.09		2978	-0.30	354
BH10	54.82		2758	-0.89	17
BH11	61.31		2988	0.16	516
MW1	53.79		2948	-0.05	593
MW2	63.02		2736	0.04	455

Values in RED are drawdown, black values represent recovery during test

Rainfall

Periodic showers occurred during the pump test allowing limited recharge.

Hydrochemistry

The hydrochemical parameters of the discharge were monitored during the test. The results are presented with the main pump test data of the data sheet and also presented in graphical form in the Data Sheets. A water sample was taken at the end of the test and sent for analysis. The results of this analysis are presented in the EIS Water Section.

Ground Water Storage in the Bedrock

Based upon the medium term ground water monitoring results the average annual fluctuation in the ground water level below the site is approximately 10 metres. A probable upper range estimate of average interconnected porosity in the bedrock is around 4%. OGE would contend that effective porosity and storage will generally decrease with depth and in areas where the rock is less fractured.

As a first pass OGE have assumed that the average (of the whole rock mass to a final elevation of 40m O.D.) effective porosity and storativity in relatively unfractured limestone is around 1%. Karstified limestone can potentially have interconnected porosity of 15%, but the indications from the drilling work is that many of the fractures are clay filled. As a worst case scenario OGE have assumed that the highly fractured areas of limestone have interconnected porosity of approximately 10%. Moderately fractured limestones are assumed to have interconnected porosity of 2% - 5%. The quarry is to be located within the relatively unfractured bedrock. Based upon the estimates of the effective porosity of the bedrock and the planned area of extraction, OGE calculate a worst case scenario would require approximately 6,000m³ of ground water from storage to be managed per annum or 16.5m³ per day.

Ground Water Inflow and Drawdown under the Proposed Development

Based on the findings of the constant discharge rate pumping test a distance/drawdown relationship for the bedrock during the test can be constructed. A graph of the distance drawdown relationship for the pump test is shown in the Data Sheets. The regression line of the distance/drawdown curve was determined as the following:

$$y = 0.297\ln(x) - 1.85$$

The integral of the above equation is

$$= 0.297(\ln(x).x-x) - 1.85(x)$$

Since the maximum drawdown is at 0m from the pumping well and the zero drawdown point is 507m from the pumping well, the average drawdown can be estimated by integrating the above equation between the known limits. The integral of the above equation between the limits of 0 and 507 is thus



$$\begin{aligned} &= (0.297(\ln(507)507-507) -1.85(507))-(0.297(\ln(0)0-0) -1.85(0)) \\ &= (-1387.71+1675.24)-(0) \\ &= -150.65\text{m}^2 \end{aligned}$$

The average drawdown is therefore

$$150.65\text{m}^2/507\text{m} = 0.297\text{m}$$

The average calculated drawdown above is based upon a theoretical cone of drawdown with a circular plan. In reality the cone of drawdown would be elliptical and these calculations again represent a worst case scenario. The aerial extent of this theoretical cone of drawdown will be approximately 807,545m². The total rock volume within this cone of drawdown will therefore be 239,840m³.

Since an average discharge volume of 36.9m³/d, for the first 46.5 hours, produced 0.297m of drawdown over an area of an area of 807,545m², this discharge rate should therefore produce a theoretical 1 metre of drawdown over an area of 239,840m². Since the quarry footprint is believed to be 237,000m² the discharge rate to produce 1 metre of drawdown over the planned quarry area will be 36.5m³/d. Since the average summer ground water table in the proposed extractive area is 60m O.D. and therefore 20 metres of drawdown is required to maintain dry conditions in the quarry to an elevation of 40m O.D., then a discharge rate of 665m³/day should achieve this. Since the quarry is to be developed only in relatively unfractured bedrock and the there was evidence of recharge of the aquifer during the constant discharge rate pump test this figure should be considered a worst case scenario. It would be prudent however to build into any calculation of potential ground water inflow a safety margin of 100%. OGE would therefore contend that the likely ground water in flow to the quarry at a working level of 40 m O.D will be less than 1330m³/day.

Quarry Development and Discharges

Discharges from the quarry will have three components, effective rainfall, ground water released from storage and ground water inflow to retain dry conditions in the quarry. The level of effective rainfall requiring management is based upon the average daily effective rainfall falling on the application site. The amount of run-off requiring management (and discharge) as presented below is therefore the worst case scenario. Detailed water balance calculations for the site are presented in the EIS Water Section. The likely ground water discharges from the site as the quarry is developed are summarised in the *Table No. 2*.

Table No. 2: Summary of Likely Quarry Discharges

Bench No.	Precipitation daily average		Storage		Ground Water Inflow	
	Best Case	Worst Case	Best Case	Worst Case	Best Case	Worst Case
Bench 1 80m-110m O.D.	297 m ³ /day	1,297 m ³ /day	-	-	-	-
Bench 2 60m-80m O.D.	297 m ³ /day	1,297 m ³ /day	-	Localised small quantities	-	Limited and intermittent
Bench 3 40m-60m O.D.	297 m ³ /day	1,297 m ³ /day	5.5 m ³ /day	16.5 m ³ /day	<665 m ³ /day	1330 m ³ /day

Based upon the above table the worst case scenario for quarry water management when the quarry has been developed to an elevation of 40m O.D. is approximately 2.6ML/day, i.e., precipitation, water from storage and ground water inflow.

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DATA SHEETS

O'Neill Ground Water Engineering

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Appendix : Combined Ground Water Level Data Including Daily Rainfall

Cam, Co. Roscommon for Roadstone Provinces

Contract Number: 060201/2

Compiled by : CDL 12/05/04

Date	Approximate Time of Ground Water Readings	Elapsed time days	Elapsed time hours	Rain mm/day	MW1 Ground Water Level m O.D.	MW2 Ground Water Level m O.D.	BH1 Ground Water Level m O.D.	BH3 Ground Water Level m O.D.	BH5 Ground Water Level m O.D.	BH6 Ground Water Level m O.D.	BH8 Ground Water Level m O.D.	BH9 Ground Water Level m O.D.	BH10 Ground Water Level m O.D.	BH11 Ground Water Level m O.D.
19/02/04	12:00:00	0.00	0	9.50			13.00	40.20	34.40	24.50	29.40	19.90	34.70	
20/02/04	12:00:00	1.00	24	0.0										
21/02/04	12:00:00	2.00	48	0.0										
22/02/04	12:00:00	3.00	72	0.0										
23/02/04	12:00:00	4.00	96	1.8										
24/02/04	12:00:00	5.00	120	1.8										
25/02/04	12:00:00	6.00	144	2.2										
26/02/04	12:00:00	7.00	168	0.0										
27/02/04	12:00:00	8.00	192	0.0										
28/02/04	12:00:00	9.00	216	0.0										
29/02/04	12:00:00	10.00	240	0.0										
01/03/04	12:00:00	11.00	264	0.0										
02/03/04	12:00:00	12.00	288	1.4										
03/03/04	12:00:00	13.00	312	0.3										
04/03/04	12:00:00	14.00	336	1.3										
05/03/04	12:00:00	15.00	360	0.0										
06/03/04	12:00:00	16.00	384	0.0										
07/03/04	12:00:00	17.00	408	0.0										
08/03/04	12:00:00	18.00	432	0.0										
09/03/04	12:00:00	19.00	456	0.0										
10/03/04	12:00:00	20.00	480	2.5										
11/03/04	12:00:00	21.00	504	7.0										
12/03/04	12:00:00	22.00	528	2.3										

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Date	Approximate Time of		Elapsed time days	Elapsed time hours	Rain mm/day	MW1 Ground Water Level m	MW2 Ground Water Level m	BH1 Ground Water Level m	BH3 Ground Water Level m	BH5 Ground Water Level m	BH6 Ground Water Level m	BH8 Ground Water Level m	BH9 Ground Water Level m	BH10 Ground Water Level m	BH11 Ground Water Level m
	Ground Water Readings														
13/03/04	12:00:00	23:00		552	4.9										
14/03/04	12:00:00	24:00		576	0.9										
15/03/04	12:00:00	25:00		600	2.3										
16/03/04	12:00:00	26:00		624	4.5										
17/03/04	12:00:00	27:00		648	2.5										
18/03/04	12:00:00	28:00		672	10.0										
19/03/04	12:00:00	29:00		696	9.50			13.42	41.60	35.81	24.86	31.24	23.87	36.82	20.52
20/03/04	12:00:00	30:00		720	10.00										
21/03/04	12:00:00	31:00		744	2.60										
22/03/04	15:00:00	32:13		771			27.74		41.08		23.73	30.88	20.90	36.80	18.86
22/03/04	18:30:00	32:27		774.5			27.74								
22/03/04	22:30:00	32:44		778.5	4.00		27.74								
23/03/04	2:30:00	32:60		782.5			27.74								
23/03/04	6:30:00	32:77		786.5			27.72								
23/03/04	10:30:00	32:94		790.5			27.74								
23/03/04	14:30:00	33:10		794.5			27.74								
23/03/04	18:30:00	33:27		798.5			27.72								
23/03/04	22:30:00	33:44		802.5	0.00		27.69								
24/03/04	2:30:00	33:60		806.5			27.69								
24/03/04	6:30:00	33:77		810.5			27.65								
24/03/04	10:30:00	33:94		814.5			27.62								
24/03/04	14:30:00	34:10		818.5			27.65								
24/03/04	18:30:00	34:27		822.5			27.65								
24/03/04	22:30:00	34:44		826.5	0.00		27.60								
25/03/04	2:30:00	34:60		830.5			27.57								
25/03/04	6:30:00	34:77		834.5			27.55								
25/03/04	10:30:00	34:94		838.5			27.55								
25/03/04	14:30:00	35:10		842.5			27.53								
25/03/04	18:30:00	35:27		846.5			27.53								
25/03/04	22:30:00	35:44		850.5	0.00		27.50								
26/03/04	2:30:00	35:60		854.5			27.51								
26/03/04	6:30:00	35:77		858.5			27.51								
26/03/04	10:30:00	35:94		862.5			27.53								
26/03/04	14:30:00	36:10		866.5			27.56								
26/03/04	18:30:00	36:27		870.5			27.56								
26/03/04	22:30:00	36:44		874.5	0.00		27.58								
27/03/04	2:30:00	36:60		878.5			27.61								
27/03/04	6:30:00	36:77		882.5			27.63								

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Date	Approximate Time of Ground Water Readings	Elapsed time days	Elapsed time	Rain mm/day	MW1 Ground Water Level m O.D.	MW2 Ground Water Level m O.D.	BH1 Ground Water Level m O.D.	BH3 Ground Water Level m O.D.	BH5 Ground Water Level m O.D.	BH6 Ground Water Level m O.D.	BH8 Ground Water Level m O.D.	BH9 Ground Water Level m O.D.	BH10 Ground Water Level m O.D.	BH11 Ground Water Level m O.D.
27/03/04	10:30:00	36.94	886.5			27.65								
27/03/04	14:30:00	37.10	890.5			27.66								
27/03/04	18:30:00	37.27	894.5			27.70								
27/03/04	22:30:00	37.44	898.5	0.00		27.73								
28/03/04	2:30:00	37.60	902.5			27.75								
28/03/04	6:30:00	37.77	906.5			27.75								
28/03/04	10:30:00	37.94	910.5			27.75								
28/03/04	14:30:00	38.10	914.5			27.75								
28/03/04	18:30:00	38.27	918.5			27.75								
28/03/04	22:30:00	38.44	922.5	0.00		27.75								
29/03/04	2:30:00	38.60	926.5			27.78								
29/03/04	6:30:00	38.77	930.5			27.78								
29/03/04	10:30:00	38.94	934.5			27.78								
29/03/04	14:30:00	39.10	938.5			27.81								
29/03/04	18:30:00	39.27	942.5			27.83								
29/03/04	22:30:00	39.44	946.5	0.00		27.86								
30/03/04	2:30:00	39.60	950.5			27.88								
30/03/04	6:30:00	39.77	954.5			27.93								
30/03/04	10:30:00	39.94	958.5	0.00		27.93								
30/03/04	14:30:00	40.10	962.5			27.98								
30/03/04	18:30:00	40.27	966.5			27.98								
30/03/04	22:30:00	40.44	970.5	0.00		28.00								
31/03/04	2:30:00	40.60	974.5			28.02								
31/03/04	6:30:00	40.77	978.5			28.05								
31/03/04	10:30:00	40.94	982.5			28.08								
31/03/04	14:30:00	41.10	986.5			28.08								
31/03/04	18:30:00	41.27	990.5			28.08								
31/03/04	22:30:00	41.44	994.5	0.00		28.08								
01/04/04	2:30:00	41.60	998.5			28.10								
01/04/04	6:30:00	41.77	1002.5			28.13								
01/04/04	10:30:00	41.94	1006.5			28.13								
01/04/04	14:30:00	42.10	1010.5			28.15								
01/04/04	18:30:00	42.27	1014.5			28.17								
01/04/04	22:30:00	42.44	1018.5	1.20		28.18								
02/04/04	2:30:00	42.60	1022.5			28.16								
02/04/04	6:30:00	42.77	1026.5			28.15								
02/04/04	10:30:00	42.94	1030.5			28.15								
02/04/04	14:30:00	43.10	1034.5			28.15								
02/04/04	18:30:00	43.27	1038.5			28.16								

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Date	Approximate Time of Ground Water Readings	Elapsed time days	Elapsed time hours	Rain mm/day	MW1 Ground Water Level m O.D.	MW2 Ground Water Level m O.D.	BH1 Ground Water Level m O.D.	BH3 Ground Water Level m O.D.	BH5 Ground Water Level m O.D.	BH6 Ground Water Level m O.D.	BH8 Ground Water Level m O.D.	BH9 Ground Water Level m O.D.	BH10 Ground Water Level m O.D.	BH11 Ground Water Level m O.D.
02/04/04	22:30:00	43.44	1042.5	5.40		28.15								
03/04/04	2:30:00	43.60	1046.5			28.16								
03/04/04	6:30:00	43.77	1050.5			28.18								
03/04/04	10:30:00	43.94	1054.5			28.16								
03/04/04	14:30:00	44.10	1058.5			28.13								
03/04/04	18:30:00	44.27	1062.5			28.13								
03/04/04	22:30:00	44.44	1066.5	2.90		28.09								
04/04/04	2:30:00	44.60	1070.5			28.09								
04/04/04	6:30:00	44.77	1074.5			28.09								
04/04/04	10:30:00	44.94	1078.5			28.09								
04/04/04	14:30:00	45.10	1082.5			28.09								
04/04/04	18:30:00	45.27	1086.5			28.04								
04/04/04	22:30:00	45.44	1090.5	4.60		28.07								
05/04/04	2:30:00	45.60	1094.5			28.07								
05/04/04	6:30:00	45.77	1098.5			28.07								
05/04/04	10:30:00	45.94	1102.5			28.06								
05/04/04	14:30:00	46.10	1106.5			28.04								
05/04/04	11:00:00	45.96	1103		29.63		13.24	41.70	35.99	24.57	31.12	20.68	36.47	19.00
05/04/04	15:05:00	46.13	1107.0833			28.04								
05/04/04	18:30:00	46.27	1110.5	1.50	29.63	27.98								
06/04/04	22:30:00	47.44	1138.5		29.65	27.98								
06/04/04	2:30:00	46.60	1118.5		29.65	27.98								
06/04/04	6:30:00	46.77	1122.5		29.70	27.98								
06/04/04	10:30:00	46.94	1126.5		29.70	28.01								
06/04/04	14:30:00	47.10	1130.5		29.72	27.99								
06/04/04	18:30:00	47.27	1134.5	1.40	29.75	27.99								
06/04/04	22:30:00	47.44	1138.5		29.77	27.99								
07/04/04	2:30:00	47.60	1142.5		29.77	28.00								
07/04/04	6:30:00	47.77	1146.5		29.77	28.00								
07/04/04	10:30:00	47.94	1150.5		29.79	28.00								
07/04/04	14:30:00	48.10	1154.5		29.82	27.98								
07/04/04	18:30:00	48.27	1158.5		29.84	27.93								
07/04/04	22:30:00	48.44	1162.5	0.00	29.84	27.96								
08/04/04	2:30:00	48.60	1166.5		29.86	27.96								
08/04/04	6:30:00	48.77	1170.5		29.86	27.98								
08/04/04	10:30:00	48.94	1174.5		29.89	27.98								
08/04/04	14:30:00	49.10	1178.5		29.93	27.99								
08/04/04	18:30:00	49.27	1182.5		29.93	28.01								
08/04/04	22:30:00	49.44	1186.5	2.10	29.96	28.02								

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Date	Approximate Time of		Elapsed time days	Elapsed time	Rain	MW1	MW2	BH1	BH3	BH5	BH6	BH8	BH9	BH10	BH11
09/04/04	Ground Water Readings		49.60	hours	mm/day	O.D.	O.D.	O.D.	O.D.	O.D.	O.D.	O.D.	O.D.	O.D.	O.D.
09/04/04	2:30:00		49.77	1190.5		29.93	28.04								
09/04/04	6:30:00		49.94	1194.5		29.98	28.02								
09/04/04	10:30:00		50.10	1198.5		30.00	28.02								
09/04/04	14:30:00		50.27	1202.5		30.03	28.07								
09/04/04	18:30:00		50.44	1206.5		30.05	28.07								
10/04/04	22:30:00		50.60	1210.5	0.00	30.05	28.05								
10/04/04	2:30:00		50.77	1214.5		30.05	28.08								
10/04/04	6:30:00		50.94	1218.5		30.07	28.11								
10/04/04	10:30:00		51.10	1222.5		30.10	28.08								
10/04/04	14:30:00		51.27	1226.5		30.12	28.11								
10/04/04	18:30:00		51.44	1230.5		30.14	28.11								
11/04/04	22:30:00		51.60	1234.5	0.00	30.14	28.09								
11/04/04	2:30:00		51.77	1238.5		30.16	28.12								
11/04/04	6:30:00		51.94	1242.5		30.16	28.14								
11/04/04	10:30:00		52.10	1246.5		30.19	28.12								
11/04/04	14:30:00		52.27	1250.5		30.24	28.14								
11/04/04	18:30:00		52.44	1254.5	0.60	30.21	28.15								
12/04/04	22:30:00		52.60	1258.5		30.23	28.15								
12/04/04	2:30:00		52.77	1262.5		30.26	28.15								
12/04/04	6:30:00		52.94	1266.5		30.25	28.15								
12/04/04	10:30:00		53.10	1270.5		30.28	28.15								
12/04/04	14:30:00		53.27	1272		13.35	42.90			37.25	24.80	32.37	22.72	37.51	20.48
12/04/04	18:30:00		53.44	1274.5		30.28	28.15								
13/04/04	22:30:00		53.60	1278.5		30.27	28.16								
13/04/04	2:30:00		53.77	1282.5	0.00	30.37	28.18								
13/04/04	6:30:00		53.94	1286.5		30.42	28.19								
13/04/04	10:30:00		54.10	1290.5		30.46	28.21								
13/04/04	14:30:00		54.27	1294.5		30.51	28.24								
13/04/04	18:30:00		54.44	1298.5		30.56	28.26								
14/04/04	22:30:00		54.60	1302.5	0.80	30.58	28.29								
14/04/04	2:30:00		54.77	1306.5		30.63	28.32								
14/04/04	6:30:00		54.94	1310.5		30.65	28.34								
14/04/04	10:30:00		55.10	1314.5		30.69	28.39								
14/04/04	14:30:00		55.27	1318.5		30.72	28.39								
14/04/04	18:30:00		55.44	1322.5		30.77	28.44								
15/04/04	22:30:00		55.60	1326.5	9.50	30.79	28.47								
15/04/04	2:30:00		55.77	1330.5		30.82	28.45								
15/04/04	6:30:00			1334.5		30.84	28.47								
15/04/04				1338.5		30.86	28.47								

RECEIVED: 05/12/2025

Date	Approximate Time of Ground Water Readings	Elapsed time days	Elapsed time	Rain mm/day	MW1 Ground Water Level m	MW2 Ground Water Level m	BH1 Ground Water Level m	BH3 Ground Water Level m	BH5 Ground Water Level m	BH6 Ground Water Level m	BH8 Ground Water Level m	BH9 Ground Water Level m	BH10 Ground Water Level m	BH11 Ground Water Level m
			hours		O.D.	O.D.	O.D.	O.D.	O.D.	O.D.	O.D.	O.D.	O.D.	O.D.
15/04/04	10:30:00	55.94	1342.5		30.88	28.45								
15/04/04	14:30:00	56.10	1346.5		30.90	28.48								
15/04/04	18:30:00	56.27	1350.5		30.93	28.48								
15/04/04	22:30:00	56.44	1354.5	2.70	30.93	28.51								
16/04/04	2:30:00	56.60	1358.5		30.95	28.49								
16/04/04	6:30:00	56.77	1362.5		30.97	28.51								
16/04/04	10:30:00	56.94	1366.5		30.99	28.53								
16/04/04	14:30:00	57.10	1370.5		31.02	28.56								
16/04/04	18:30:00	57.27	1374.5		31.02	28.59								
16/04/04	22:30:00	57.44	1378.5	2.40	31.07	28.59								
17/04/04	2:30:00	57.60	1382.5		31.09	28.64								
17/04/04	6:30:00	57.77	1386.5		31.14	28.71								
17/04/04	10:30:00	57.94	1390.5		31.18	28.77								
17/04/04	14:30:00	58.10	1394.5		31.23	28.82								
17/04/04	18:30:00	58.27	1398.5		31.23	28.84								
17/04/04	22:30:00	58.44	1402.5	9.60	31.25	28.84								
18/04/04	2:30:00	58.60	1406.5		31.30	28.87								
18/04/04	6:30:00	58.77	1410.5		31.30	28.89								
18/04/04	10:30:00	58.94	1414.5		31.35	28.90								
18/04/04	14:30:00	59.10	1418.5		31.39	28.87								
18/04/04	18:30:00	59.27	1422.5		31.39	28.88								
18/04/04	22:30:00	59.44	1426.5	0.00	31.39	28.88								
19/04/04	2:30:00	59.60	1430.5		31.41	28.88								
19/04/04	6:30:00	59.77	1434.5		31.46	28.93								
19/04/04	10:30:00	59.94	1438.5		31.46	28.93								
19/04/04	14:30:00	60.10	1442.5		31.48	28.96								
19/04/04	18:30:00	60.27	1446.5		31.48	28.86								
19/04/04	22:30:00	60.44	1450.5	1.90	31.48	28.84								
20/04/04	2:30:00	60.60	1454.5		31.51	28.87								
20/04/04	6:30:00	60.77	1458.5		31.53	28.89								
20/04/04	10:30:00	60.94	1462.5		31.53	28.89								
20/04/04	14:30:00	61.10	1466.5		31.55	28.94								
20/04/04	18:30:00	61.27	1470.5		31.62	28.99								
20/04/04	22:30:00	61.44	1474.5	3.50	31.62	29.02								
21/04/04	2:30:00	61.60	1478.5		31.65	29.00								
21/04/04	6:30:00	61.77	1482.5		31.67	29.02								
21/04/04	10:30:00	61.94	1486.5		31.64	29.03								
21/04/04	14:30:00	62.10	1490.5		31.65	29.00								
21/04/04	18:30:00	62.27	1494.5		31.67	29.01								

RECEIVED: 05/12/2025

Date	Approximate Time of Ground Water Readings	Elapsed time days	Elapsed time	Rain mm/day	MW1 Ground Water Level m O.D.	MW2 Ground Water Level m O.D.	BH1 Ground Water Level m O.D.	BH3 Ground Water Level m O.D.	BH5 Ground Water Level m O.D.	BH6 Ground Water Level m O.D.	BH8 Ground Water Level m O.D.	BH9 Ground Water Level m O.D.	BH10 Ground Water Level m O.D.	BH11 Ground Water Level m O.D.
21/04/04	22:30:00	62.44	1498.5	1.20	31.62	28.96								
22/04/04	23:00:00	62.60	1502.5		31.64	28.96								
22/04/04	6:30:00	62.77	1506.5		31.64	28.96								
22/04/04	10:30:00	62.94	1510.5		31.67	28.94								
22/04/04	14:30:00	63.10	1514.5		31.65	28.95								
22/04/04	18:30:00	63.27	1518.5		31.65	28.97								
22/04/04	22:30:00	63.44	1522.5	0.30	31.65	28.97								
23/04/04	2:30:00	63.60	1526.5		31.64	28.98								
23/04/04	6:30:00	63.77	1530.5		31.67	29.00								
23/04/04	10:30:00	63.94	1534.5		31.67	28.95								
23/04/04	14:30:00	64.10	1538.5		31.69	28.91								
23/04/04	18:30:00	64.27	1542.5		31.69	28.76								
23/04/04	22:30:00	64.44	1546.5	0.00	31.69	28.60								
24/04/04	2:30:00	64.60	1550.5		31.69	28.43								
24/04/04	6:30:00	64.77	1554.5		31.72	28.24								
24/04/04	10:30:00	64.94	1558.5		31.74	28.03								
24/04/04	14:30:00	65.10	1562.5		31.72	27.93								
24/04/04	18:30:00	65.27	1566.5		31.76	27.91								
24/04/04	22:30:00	65.44	1570.5	0.00	31.74	27.84								
25/04/04	2:30:00	65.60	1574.5		31.76	27.81								
25/04/04	6:30:00	65.77	1578.5		31.78	27.79								
25/04/04	10:30:00	65.94	1582.5		31.78	27.79								
25/04/04	14:30:00	66.10	1586.5		31.81	27.75								
25/04/04	18:30:00	66.27	1590.5		31.83	27.75								
25/04/04	22:30:00	66.44	1594.5	0.00	31.85	27.73								
26/04/04	2:30:00	66.60	1598.5		31.85	27.75								
26/04/04	6:30:00	66.77	1602.5		31.88	27.73								
26/04/04	10:30:00	66.94	1606.5		31.90	27.74								
26/04/04	14:30:00	67.10	1610.5		31.90	27.73								
26/04/04	18:30:00	67.27	1614.5		31.90	27.71								
26/04/04	22:30:00	67.44	1618.5	0.30	31.93	27.69								
27/04/04	2:30:00	67.60	1622.5		31.95	27.67								
27/04/04	6:30:00	67.77	1626.5		31.95	27.67								
27/04/04	10:30:00	67.94	1630.5		31.97	27.65								
27/04/04	14:30:00	68.10	1634.5		31.99	27.67								
27/04/04	18:30:00	68.27	1638.5		32.02	27.68								
27/04/04	22:30:00	68.44	1642.5	0.60	32.02	27.66								
28/04/04	2:30:00	68.60	1646.5		32.02	27.66								
28/04/04	6:30:00	68.77	1650.5		32.04	27.66								

RECEIVED: 05/12/2025

Date	Approximate Time of Ground Water Readings	Elapsed time days	Elapsed time hours	Rain mm/day	MW1 Ground Water Level m	MW2 Ground Water Level m	BH1 Ground Water Level m	BH3 Ground Water Level m	BH5 Ground Water Level m	BH6 Ground Water Level m	BH8 Ground Water Level m	BH9 Ground Water Level m	BH10 Ground Water Level m	BH11 Ground Water Level m
28/04/04	10:30:00	68.94	1654.5		32.07	27.66								
28/04/04	14:30:00	69.10	1658.5		32.09	27.66								
28/04/04	18:30:00	69.27	1662.5		32.11	27.66								
28/04/04	22:30:00	69.44	1666.5	0.00	32.13	27.67								
29/04/04	2:30:00	69.60	1670.5		32.13	27.70								
29/04/04	6:30:00	69.77	1674.5		32.16	27.70								
29/04/04	10:30:00	69.94	1678.5		32.20	27.72								
29/04/04	14:30:00	70.10	1682.5		32.20	27.75								
29/04/04	18:30:00	70.27	1686.5		32.25	27.80								
29/04/04	22:30:00	70.44	1690.5	0.00	32.25	27.80								
30/04/04	2:30:00	70.60	1694.5		32.27	27.85								
30/04/04	6:30:00	70.77	1698.5		32.30	27.85								
30/04/04	10:30:00	70.94	1702.5		32.32	27.86								
30/04/04	14:30:00	71.10	1706.5		32.32	27.83								
30/04/04	18:30:00	71.27	1710.5		32.34	27.84								
30/04/04	22:30:00	71.44	1714.5	0.00	32.34	27.81								
01/05/04	2:30:00	71.60	1718.5		32.36	27.84								
01/05/04	6:30:00	71.77	1722.5		32.37	27.84								
01/05/04	10:30:00	71.94	1726.5		32.39	27.82								
01/05/04	14:30:00	72.10	1730.5		32.41	27.84								
01/05/04	18:30:00	72.27	1734.5		32.41	27.85								
01/05/04	22:30:00	72.44	1738.5	0.0	32.43	27.82								
02/05/04	2:30:00	72.60	1742.5		32.46	27.85								
02/05/04	6:30:00	72.77	1746.5		32.46	27.85								
02/05/04	10:30:00	72.94	1750.5		32.48	27.85								
02/05/04	14:30:00	73.10	1754.5		32.51	27.85								
02/05/04	18:30:00	73.27	1758.5		32.53	27.86								
02/05/04	22:30:00	73.44	1762.5	0.0	32.55	27.86								
03/05/04	2:30:00	73.60	1766.5		32.60	27.88								
03/05/04	6:30:00	73.77	1770.5		32.60	27.89								
03/05/04	10:30:00	73.94	1774.5		32.62	27.89								
03/05/04	14:30:00	74.10	1778.5		32.65	27.94								
03/05/04	18:30:00	74.27	1782.5		32.69	27.96								
03/05/04	22:30:00	74.44	1786.5	8.9	32.74	28.06								
04/05/04	2:30:00	74.60	1790.5		32.78	28.14								
04/05/04	6:30:00	74.77	1794.5		32.83	28.19								
04/05/04	10:30:00	74.94	1798.5		32.85	28.23								
04/05/04	14:30:00	75.10	1802.5		32.90	28.24								
04/05/04	18:30:00	75.27	1806.5		32.90	28.20								

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Date	Approximate Time of		Elapsed time days	Elapsed time	Rain	MW1	MW2 Ground	BH1	BH3	BH5	BH6	BH8	BH9	BH10	BH11
	Ground Water Readings														
04/05/04	22:30:00		75.44	1810.5	8.5	32.87	O.D.	28.17	O.D.	O.D.	O.D.	O.D.	O.D.	O.D.	O.D.
05/05/04	2:30:00		75.60	1814.5		32.92		28.20							
05/05/04	6:30:00		75.77	1818.5		32.95		28.22							
05/05/04	10:30:00		75.94	1822.5		32.97		28.22							
05/05/04	14:30:00		76.10	1826.5		32.97		28.20							
05/05/04	18:30:00		76.27	1830.5		32.97		28.18							
05/05/04	22:30:00		76.44	1834.5	1.6	32.97		28.16							
06/05/04	2:30:00		76.60	1838.5		32.99		28.18							
06/05/04	6:30:00		76.77	1842.5		32.99		28.16							
06/05/04	10:30:00		76.94	1846.5		33.01		28.17							
06/05/04	14:30:00		77.10	1850.5		33.01		28.17							
06/05/04	18:30:00		77.27	1854.5		32.99		28.17							
06/05/04	22:30:00		77.44	1858.5	7.4	32.99		28.15							
07/05/04	2:30:00		77.60	1862.5		33.01		28.15							
07/05/04	6:30:00		77.77	1866.5		33.04		28.15							
07/05/04	10:30:00		77.94	1870.5		33.01		28.13							
07/05/04	14:30:00		78.10	1874.5		33.04		28.13							
07/05/04	18:30:00		78.27	1878.5		33.04		28.13							
07/05/04	22:30:00		78.44	1882.5	0.0	33.04		28.13							
08/05/04	2:30:00		78.60	1886.5		33.04		28.16							
08/05/04	6:30:00		78.77	1890.5		33.04		28.18							
08/05/04	10:30:00		78.94	1894.5		33.08		28.19							
08/05/04	14:30:00		79.10	1898.5		33.11		28.21							
08/05/04	18:30:00		79.27	1902.5		33.11		28.21							
08/05/04	22:30:00		79.44	1906.5	0.0	33.11		28.24							
09/05/04	2:30:00		79.60	1910.5		33.13		28.24							
09/05/04	6:30:00		79.77	1914.5		33.13		28.24							
09/05/04	10:30:00		79.94	1918.5		33.13		28.27							
09/05/04	14:30:00		80.10	1922.5		33.15		28.25							
09/05/04	18:30:00		80.27	1926.5		33.15		28.28							
09/05/04	22:30:00		80.44	1930.5	0.0	33.15		28.25							
10/05/04	2:30:00		80.60	1934.5		33.15		28.25							
10/05/04	6:30:00		80.77	1938.5		33.17		28.26							
10/05/04	10:30:00		80.94	1942.5		33.18		28.28							
10/05/04	14:30:00		81.10	1946.5		33.18		28.31							
10/05/04	18:30:00		81.27	1950.5		33.20		28.31							
10/05/04	22:30:00		81.44	1954.5	0.0	33.20		28.31							
11/05/04	2:30:00		81.60	1958.5		33.20		28.32							
11/05/04	6:30:00		81.77	1962.5		33.20		28.34							

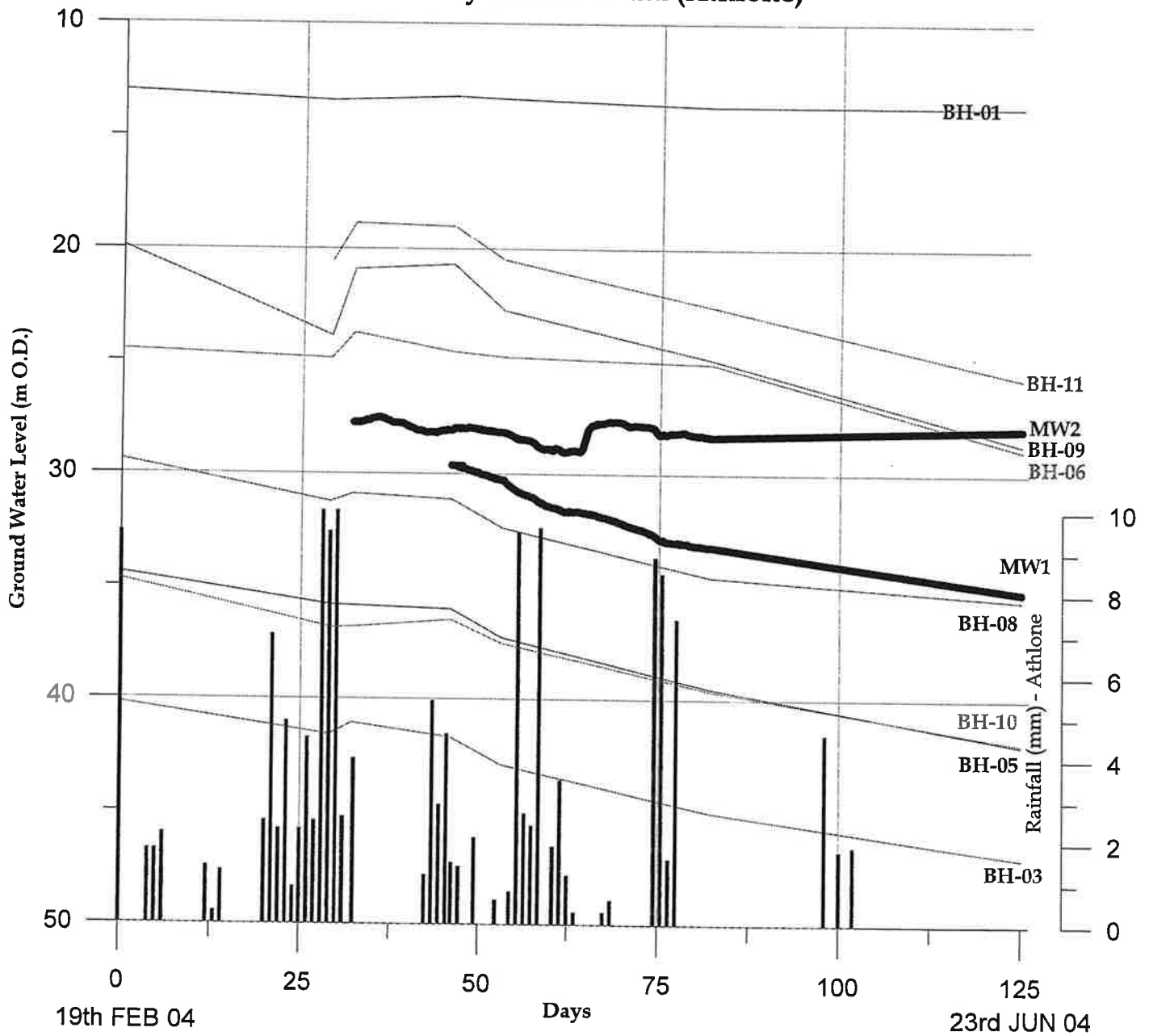
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Date	Approximate Time of Ground Water Readings	Elapsed time days	Elapsed time hours	Rain mm/day	MW1 Ground Water Level m O.D.	MW2 Ground Water Level m O.D.	BH1 Ground Water Level m O.D.	BH3 Ground Water Level m O.D.	BH5 Ground Water Level m O.D.	BH6 Ground Water Level m O.D.	BH8 Ground Water Level m O.D.	BH9 Ground Water Level m O.D.	BH10 Ground Water Level m O.D.	BH11 Ground Water Level m O.D.
11/05/04	10:30:00	81.94	1966.5		33.20	28.34	13.66	45.01	39.51	25.09	34.55	24.89	39.60	22.54
11/05/04	13:00:00	82.04	1969	0.0	33.20	28.34								
12/05/04	12:00:00	83.0	1992	0.0										
13/05/04	12:00:00	84.0	2016	0.0										
14/05/04	12:00:00	85.0	2040	0.0										
15/05/04	12:00:00	86.0	2064	0.0										
16/05/04	12:00:00	87.0	2088	0.0										
17/05/04	12:00:00	88.0	2112	0.0										
18/05/05	12:00:00	454.0	10896	0.0										
19/05/04	12:00:00	90.0	2160	0.0										
20/05/04	12:00:00	91.0	2184	0.0										
21/05/04	12:00:00	92.0	2208	0.0										
22/05/04	12:00:00	93.0	2232	0.0										
23/05/04	12:00:00	94.0	2256	0.0										
24/05/04	12:00:00	95.0	2280	0.0										
25/05/04	12:00:00	96.0	2304	0.0										
26/05/04	12:00:00	97.0	2328	0.0										
27/05/04	12:00:00	98.0	2352	4.6										
28/05/04	12:00:00	99.0	2376	0.0										
29/05/04	12:00:00	100.0	2400	1.8										
30/05/04	12:00:00	101.0	2424	0.0										
31/05/04	12:00:00	102.0	2448	1.9										
23/06/04	12:00:00	125.0	3000		35.21	27.98	13.68	47.03	42.02	28.91	35.56	28.66	41.94	25.74

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Long Term Ground Water Level and Daily Rainfall Data (Athlone)



O'Neill Ground Water Engineering

7, South Main Street, Naas, Co. Kildare.

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Appendix : Pumping Test Data (MW1 long term monitoring)

Cam, Co. Roscommon for Roadstone Provinces

Contract Number: 060201/2

Compiled by : CDL 12/05/04

Date and Time	Elapsed		Elapsed		Elapsed		Logger reading bar	Logger Temp °C	Total Pressure Head	Manual	Corrected for drop	Water level m bd	Drift Correction	Water Level Corrected for drift
	Hours	Days	Mins	Seconds	Seconds	Seconds								
05.04.2004 11:48:00										29.63				
05.04.2004 18:35:25	336	14.00	20160.00		1209600.00		0.6961	9.7607	7.11		7.11	29.63	0.00	29.63
05.04.2004 22:35:25	340	14.17	20400.00		1224000.00		0.694	9.7759	7.09		7.09	29.65	0.00	29.65
06.04.2004 02:35:25	344	14.33	20640.00		1238400.00		0.6938	9.7607	7.09		7.09	29.65	0.00	29.65
06.04.2004 06:35:25	348	14.50	20880.00		1252800.00		0.6896	9.79	7.04		7.04	29.70	0.00	29.70
06.04.2004 10:35:25	352	14.67	21120.00		1267200.00		0.6894	9.7759	7.04		7.04	29.70	0.00	29.70
06.04.2004 14:35:25	356	14.83	21360.00		1281600.00		0.6871	9.7759	7.02		7.02	29.72	0.00	29.72
06.04.2004 18:35:25	360	15.00	21600.00		1296000.00		0.6847	9.7607	6.99		6.99	29.75	0.00	29.75
06.04.2004 22:35:25	364	15.17	21840.00		1310400.00		0.6826	9.7759	6.97		6.97	29.77	0.00	29.77
07.04.2004 02:35:25	368	15.33	22080.00		1324800.00		0.6824	9.7607	6.97		6.97	29.77	0.00	29.77
07.04.2004 06:35:25	372	15.50	22320.00		1339200.00		0.6826	9.7759	6.97		6.97	29.77	0.00	29.77
07.04.2004 10:35:25	376	15.67	22560.00		1353600.00		0.68	9.7451	6.95		6.95	29.79	0.00	29.79
07.04.2004 14:35:25	380	15.83	22800.00		1368000.00		0.6779	9.7607	6.92		6.92	29.82	0.00	29.82
07.04.2004 18:35:25	384	16.00	23040.00		1382400.00		0.6758	9.7759	6.90		6.90	29.84	0.00	29.84
07.04.2004 22:35:25	388	16.17	23280.00		1396800.00		0.6759	9.79	6.90		6.90	29.84	0.00	29.84
08.04.2004 02:35:25	392	16.33	23520.00		1411200.00		0.6735	9.7759	6.88		6.88	29.86	0.00	29.86
08.04.2004 06:35:25	396	16.50	23760.00		1425600.00		0.6731	9.7451	6.87		6.87	29.87	0.00	29.86

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05/12/2004

Date and Time	Elapsed		Elapsed		Elapsed		Logger reading	Logger Temp °C	Total Pressure Head	Manual	Corrected for drop	Water level m bd	Drift Correction	Water Level Corrected for drift
	Hours	Days	Mins	Seconds	bar	Seconds								
08.04.2004 10:35:25	400	16.67	24000.00	1440000.00	0.671	1440000.00	9.7607	6.85	6.85		6.85	29.89	0.00	29.89
08.04.2004 14:35:25	404	16.83	24240.00	1454400.00	0.6663	1454400.00	9.7451	6.81	6.81		6.81	29.93	0.00	29.93
08.04.2004 18:35:25	408	17.00	24480.00	1468800.00	0.6663	1468800.00	9.7451	6.81	6.81		6.81	29.93	0.00	29.93
08.04.2004 22:35:25	412	17.17	24720.00	1483200.00	0.6642	1483200.00	9.7607	6.78	6.78		6.78	29.96	0.00	29.96
09.04.2004 02:35:25	416	17.33	24960.00	1497600.00	0.6663	1497600.00	9.7451	6.81	6.81		6.81	29.93	0.00	29.93
09.04.2004 06:35:25	420	17.50	25200.00	1512000.00	0.6621	1512000.00	9.7759	6.76	6.76		6.76	29.98	0.00	29.98
09.04.2004 10:35:25	424	17.67	25440.00	1526400.00	0.6598	1526400.00	9.7759	6.74	6.74		6.74	30.00	0.00	30.00
09.04.2004 14:35:25	428	17.83	25680.00	1540800.00	0.6572	1540800.00	9.7451	6.71	6.71		6.71	30.03	0.00	30.03
09.04.2004 18:35:25	432	18.00	25920.00	1555200.00	0.6549	1555200.00	9.7451	6.69	6.69		6.69	30.05	0.00	30.05
09.04.2004 22:35:25	436	18.17	26160.00	1569600.00	0.6549	1569600.00	9.7451	6.69	6.69		6.69	30.05	0.00	30.05
10.04.2004 02:35:25	440	18.33	26400.00	1584000.00	0.6553	1584000.00	9.7759	6.69	6.69		6.69	30.05	0.00	30.05
10.04.2004 06:35:25	444	18.50	26640.00	1598400.00	0.6528	1598400.00	9.7607	6.67	6.67		6.67	30.07	0.00	30.07
10.04.2004 10:35:25	448	18.67	26880.00	1612800.00	0.6504	1612800.00	9.7451	6.64	6.64		6.64	30.10	0.00	30.10
10.04.2004 14:35:25	452	18.83	27120.00	1627200.00	0.6484	1627200.00	9.7759	6.62	6.62		6.62	30.12	0.00	30.12
10.04.2004 18:35:25	456	19.00	27360.00	1641600.00	0.6458	1641600.00	9.7451	6.60	6.60		6.60	30.14	0.00	30.14
10.04.2004 22:35:25	460	19.17	27600.00	1656000.00	0.646	1656000.00	9.7607	6.60	6.60		6.60	30.14	0.00	30.14
11.04.2004 02:35:25	464	19.33	27840.00	1670400.00	0.6437	1670400.00	9.7607	6.57	6.57		6.57	30.17	0.00	30.16
11.04.2004 06:35:25	468	19.50	28080.00	1684800.00	0.6436	1684800.00	9.7451	6.57	6.57		6.57	30.17	0.00	30.16
11.04.2004 10:35:25	472	19.67	28320.00	1699200.00	0.6414	1699200.00	9.7607	6.55	6.55		6.55	30.19	0.00	30.19
11.04.2004 14:35:25	476	19.83	28560.00	1713600.00	0.6367	1713600.00	9.7451	6.50	6.50		6.50	30.24	0.00	30.24
11.04.2004 18:35:25	480	20.00	28800.00	1728000.00	0.6392	1728000.00	9.7607	6.53	6.53		6.53	30.21	0.00	30.21
11.04.2004 22:35:25	484	20.17	29040.00	1742400.00	0.6369	1742400.00	9.7607	6.51	6.51		6.51	30.23	0.00	30.23
12.04.2004 02:35:25	488	20.33	29280.00	1756800.00	0.6346	1756800.00	9.7607	6.48	6.48		6.48	30.26	0.00	30.26
12.04.2004 06:35:25	492	20.50	29520.00	1771200.00	0.6349	1771200.00	9.79	6.48	6.48		6.48	30.26	0.00	30.25
12.04.2004 10:35:25	496	20.67	29760.00	1785600.00	0.6324	1785600.00	9.7607	6.46	6.46		6.46	30.28	0.00	30.28
12.04.2004 14:35:25	500	20.83	30000.00	1800000.00	0.6324	1800000.00	9.7607	6.46	6.46		6.46	30.28	0.00	30.28
12.04.2004 18:35:25	504	21.00	30240.00	1814400.00	0.8805	1814400.00	9.7759	8.99	8.99		6.46	30.28	0.00	30.27
12.04.2004 22:35:25	508	21.17	30480.00	1828800.00	0.8709	1828800.00	9.73	8.90	8.90		6.37	30.37	0.00	30.37
13.04.2004 02:35:25	512	21.33	30720.00	1843200.00	0.8664	1843200.00	9.73	8.85	8.85		6.32	30.42	0.00	30.42
13.04.2004 06:35:25	516	21.50	30960.00	1857600.00	0.8622	1857600.00	9.7607	8.81	8.81		6.28	30.46	0.00	30.46
13.04.2004 10:35:25	520	21.67	31200.00	1872000.00	0.8576	1872000.00	9.7607	8.76	8.76		6.23	30.51	0.00	30.51

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03/12/2025

Date and Time	Elapsed	Elapsed	Elapsed	Elapsed	Logger reading	Logger	Total Pressure	Manual	Corrected	Water level m	Drift	Water Level
	Hours	Days	Mins	Seconds	bar	Temp °C	Head		for drop	bd	Correction	Corrected for drift
13.04.2004 14:35:25	524	21.83	31440.00	1886400.00	0.8529	9.7451	8.71		6.18	30.56	0.00	30.56
13.04.2004 18:35:25	528	22.00	31680.00	1900800.00	0.8506	9.7451	8.69		6.16	30.58	0.00	30.58
13.04.2004 22:35:25	532	22.17	31920.00	1915200.00	0.8461	9.7451	8.64		6.11	30.63	0.00	30.63
14.04.2004 02:35:25	536	22.33	32160.00	1929600.00	0.8439	9.7607	8.62		6.09	30.65	0.00	30.65
14.04.2004 06:35:25	540	22.50	32400.00	1944000.00	0.8396	9.7759	8.58		6.05	30.69	0.00	30.69
14.04.2004 10:35:25	544	22.67	32640.00	1958400.00	0.837	9.7451	8.55		6.02	30.72	0.00	30.72
14.04.2004 14:35:25	548	22.83	32880.00	1972800.00	0.8324	9.7451	8.50		5.97	30.77	0.00	30.77
14.04.2004 18:35:25	552	23.00	33120.00	1987200.00	0.83	9.73	8.48		5.95	30.79	0.00	30.79
14.04.2004 22:35:25	556	23.17	33360.00	2001600.00	0.8275	9.7168	8.45		5.92	30.82	0.00	30.82
15.04.2004 02:35:25	560	23.33	33600.00	2016000.00	0.8254	9.73	8.43		5.90	30.84	0.00	30.84
15.04.2004 06:35:25	564	23.50	33840.00	2030400.00	0.8236	9.7759	8.41		5.88	30.86	0.00	30.86
15.04.2004 10:35:25	568	23.67	34080.00	2044800.00	0.8212	9.7607	8.39		5.86	30.88	0.00	30.88
15.04.2004 14:35:25	572	23.83	34320.00	2059200.00	0.8189	9.7607	8.36		5.83	30.91	0.00	30.91
15.04.2004 18:35:25	576	24.00	34560.00	2073600.00	0.8167	9.7607	8.34		5.81	30.93	0.00	30.93
15.04.2004 22:35:25	580	24.17	34800.00	2088000.00	0.8167	9.7607	8.34		5.81	30.93	0.00	30.93
16.04.2004 02:35:25	584	24.33	35040.00	2102400.00	0.8144	9.7607	8.32		5.79	30.95	0.00	30.95
16.04.2004 06:35:25	588	24.50	35280.00	2116800.00	0.8121	9.7607	8.29		5.76	30.98	0.00	30.97
16.04.2004 10:35:25	592	24.67	35520.00	2131200.00	0.8102	9.79	8.28		5.75	30.99	0.00	30.99
16.04.2004 14:35:25	596	24.83	35760.00	2145600.00	0.8077	9.7759	8.25		5.72	31.02	0.00	31.02
16.04.2004 18:35:25	600	25.00	36000.00	2160000.00	0.8074	9.7451	8.25		5.72	31.02	0.00	31.02
16.04.2004 22:35:25	604	25.17	36240.00	2174400.00	0.803	9.7607	8.20		5.67	31.07	0.00	31.07
17.04.2004 02:35:25	608	25.33	36480.00	2188800.00	0.8006	9.7451	8.18		5.65	31.09	0.00	31.09
17.04.2004 06:35:25	612	25.50	36720.00	2203200.00	0.796	9.7451	8.13		5.60	31.14	0.00	31.14
17.04.2004 10:35:25	616	25.67	36960.00	2217600.00	0.7918	9.7759	8.09		5.56	31.18	0.00	31.18
17.04.2004 14:35:25	620	25.83	37200.00	2232000.00	0.7872	9.7759	8.04		5.51	31.23	0.00	31.23
17.04.2004 18:35:25	624	26.00	37440.00	2246400.00	0.7871	9.7607	8.04		5.51	31.23	0.00	31.23
17.04.2004 22:35:25	628	26.17	37680.00	2260800.00	0.7846	9.7451	8.01		5.48	31.26	0.00	31.25
18.04.2004 02:35:25	632	26.33	37920.00	2275200.00	0.7802	9.7607	7.97		5.44	31.30	0.00	31.30
18.04.2004 06:35:25	636	26.50	38160.00	2289600.00	0.7802	9.7607	7.97		5.44	31.30	0.00	31.30
18.04.2004 10:35:25	640	26.67	38400.00	2304000.00	0.7755	9.7451	7.92		5.39	31.35	0.00	31.35
18.04.2004 14:35:25	644	26.83	38640.00	2318400.00	0.771	9.7451	7.87		5.34	31.40	0.00	31.39

RECEIVED: 05/12/2025

Date and Time	Elapsed		Elapsed		Elapsed		Logger reading bar	Logger Temp °C	Total Pressure Head	Manual	Corrected for drop	Water level m bd	Drift Correction	Water Level Corrected for drift
	Hours	Days	Mins	Seconds	bar	Temp °C								
18.04.2004 18:35:25	648	27.00	38880.00	2332800.00	0.771	9.7451	7.87				5.34	31.40	0.00	31.39
18.04.2004 22:35:25	652	27.17	39120.00	2347200.00	0.771	9.7451	7.87				5.34	31.40	0.00	31.39
19.04.2004 02:35:25	656	27.33	39360.00	2361600.00	0.7689	9.7607	7.85				5.32	31.42	0.00	31.41
19.04.2004 06:35:25	660	27.50	39600.00	2376000.00	0.7645	9.7759	7.81				5.28	31.46	0.00	31.46
19.04.2004 10:35:25	664	27.67	39840.00	2390400.00	0.7643	9.7607	7.81				5.28	31.46	0.00	31.46
19.04.2004 14:35:25	668	27.83	40080.00	2404800.00	0.762	9.7607	7.78				5.25	31.49	0.00	31.48
19.04.2004 18:35:25	672	28.00	40320.00	2419200.00	0.7619	9.7451	7.78				5.25	31.49	0.00	31.48
19.04.2004 22:35:25	676	28.17	40560.00	2433600.00	0.7622	9.7759	7.78				5.25	31.49	0.00	31.48
20.04.2004 02:35:25	680	28.33	40800.00	2448000.00	0.7598	9.7607	7.76				5.23	31.51	0.00	31.51
20.04.2004 06:35:25	684	28.50	41040.00	2462400.00	0.7573	9.7451	7.73				5.20	31.54	0.00	31.53
20.04.2004 10:35:25	688	28.67	41280.00	2476800.00	0.7575	9.7607	7.74				5.21	31.53	0.00	31.53
20.04.2004 14:35:25	692	28.83	41520.00	2491200.00	0.7552	9.7607	7.71				5.18	31.56	0.00	31.55
20.04.2004 18:35:25	696	29.00	41760.00	2505600.00	0.7484	9.7607	7.64				5.11	31.63	0.00	31.62
20.04.2004 22:35:25	700	29.17	42000.00	2520000.00	0.7484	9.7607	7.64				5.11	31.63	0.00	31.62
21.04.2004 02:35:25	704	29.33	42240.00	2534400.00	0.7461	9.7607	7.62				5.09	31.65	0.00	31.65
21.04.2004 06:35:25	708	29.50	42480.00	2548800.00	0.7438	9.7607	7.60				5.07	31.67	0.00	31.67
21.04.2004 10:35:25	712	29.67	42720.00	2563200.00	0.7463	9.7759	7.62				5.09	31.65	0.00	31.64
21.04.2004 14:35:25	716	29.83	42960.00	2577600.00	0.7458	9.73	7.62				5.09	31.65	0.00	31.65
21.04.2004 18:35:25	720	30.00	43200.00	2592000.00	0.7438	9.7607	7.60				5.07	31.67	0.00	31.67
21.04.2004 22:35:25	724	30.17	43440.00	2606400.00	0.7484	9.7607	7.64				5.11	31.63	0.00	31.62
22.04.2004 02:35:25	728	30.33	43680.00	2620800.00	0.7461	9.7607	7.62				5.09	31.65	0.00	31.64
22.04.2004 06:35:25	732	30.50	43920.00	2635200.00	0.7461	9.7607	7.62				5.09	31.65	0.00	31.64
22.04.2004 10:35:25	736	30.67	44160.00	2649600.00	0.7437	9.7451	7.60				5.07	31.67	0.00	31.67
22.04.2004 14:35:25	740	30.83	44400.00	2664000.00	0.7459	9.7451	7.62				5.09	31.65	0.00	31.65
22.04.2004 18:35:25	744	31.00	44640.00	2678400.00	0.7459	9.7451	7.62				5.09	31.65	0.00	31.65
22.04.2004 22:35:25	748	31.17	44880.00	2692800.00	0.7459	9.7451	7.62				5.09	31.65	0.00	31.65
23.04.2004 02:35:25	752	31.33	45120.00	2707200.00	0.7461	9.7607	7.62				5.09	31.65	0.00	31.64
23.04.2004 06:35:25	756	31.50	45360.00	2721600.00	0.7438	9.7607	7.60				5.07	31.67	0.00	31.67
23.04.2004 10:35:25	760	31.67	45600.00	2736000.00	0.7437	9.7451	7.60				5.07	31.67	0.00	31.67
23.04.2004 14:35:25	764	31.83	45840.00	2750400.00	0.7414	9.7451	7.57				5.04	31.70	-0.01	31.69
23.04.2004 18:35:25	768	32.00	46080.00	2764800.00	0.7414	9.7451	7.57				5.04	31.70	-0.01	31.69

RECEIVED
05/12/2025

Date and Time	Elapsed		Elapsed		Elapsed	Logger reading	Logger Temp °C	Total Pressure Head	Manual	Corrected	Water level m	Drift	Water Level Corrected for drift
	Hours	Days	Mins	Seconds									
23.04.2004 22:35:25	772	32.17	46320.00	2779200.00	0.7414	9.7451	7.57			5.04	31.70	-0.01	31.69
24.04.2004 02:35:25	776	32.33	46560.00	2793600.00	0.7412	9.73	7.57			5.04	31.70	-0.01	31.69
24.04.2004 06:35:25	780	32.50	46800.00	2808000.00	0.739	9.73	7.55			5.02	31.72	-0.01	31.72
24.04.2004 10:35:25	784	32.67	47040.00	2822400.00	0.737	9.7607	7.53			5.00	31.74	-0.01	31.74
24.04.2004 14:35:25	788	32.83	47280.00	2836800.00	0.739	9.73	7.55			5.02	31.72	-0.01	31.72
24.04.2004 18:35:25	792	33.00	47520.00	2851200.00	0.7344	9.73	7.50			4.97	31.77	-0.01	31.76
24.04.2004 22:35:25	796	33.17	47760.00	2865600.00	0.7368	9.7451	7.53			5.00	31.74	-0.01	31.74
25.04.2004 02:35:25	800	33.33	48000.00	2880000.00	0.7346	9.7451	7.50			4.97	31.77	-0.01	31.76
25.04.2004 06:35:25	804	33.50	48240.00	2894400.00	0.7323	9.7451	7.48			4.95	31.79	-0.01	31.78
25.04.2004 10:35:25	808	33.67	48480.00	2908800.00	0.7323	9.7451	7.48			4.95	31.79	-0.01	31.78
25.04.2004 14:35:25	812	33.83	48720.00	2923200.00	0.73	9.7451	7.46			4.93	31.81	-0.01	31.81
25.04.2004 18:35:25	816	34.00	48960.00	2937600.00	0.7279	9.7607	7.43			4.90	31.84	-0.01	31.83
25.04.2004 22:35:25	820	34.17	49200.00	2952000.00	0.7256	9.7607	7.41			4.88	31.86	-0.01	31.85
26.04.2004 02:35:25	824	34.33	49440.00	2966400.00	0.7255	9.7451	7.41			4.88	31.86	-0.01	31.85
26.04.2004 06:35:25	828	34.50	49680.00	2980800.00	0.7232	9.7451	7.39			4.86	31.88	-0.01	31.88
26.04.2004 10:35:25	832	34.67	49920.00	2995200.00	0.7207	9.73	7.36			4.83	31.91	-0.01	31.90
26.04.2004 14:35:25	836	34.83	50160.00	3009600.00	0.7211	9.7607	7.37			4.84	31.90	-0.01	31.90
26.04.2004 18:35:25	840	35.00	50400.00	3024000.00	0.7209	9.7451	7.36			4.83	31.91	-0.01	31.90
26.04.2004 22:35:25	844	35.17	50640.00	3038400.00	0.7185	9.73	7.34			4.81	31.93	-0.01	31.93
27.04.2004 02:35:25	848	35.33	50880.00	3052800.00	0.7164	9.7451	7.32			4.79	31.95	-0.01	31.95
27.04.2004 06:35:25	852	35.50	51120.00	3067200.00	0.7165	9.7607	7.32			4.79	31.95	-0.01	31.95
27.04.2004 10:35:25	856	35.67	51360.00	3081600.00	0.7143	9.7607	7.30			4.77	31.97	-0.01	31.97
27.04.2004 14:35:25	860	35.83	51600.00	3096000.00	0.7118	9.7451	7.27			4.74	32.00	-0.01	31.99
27.04.2004 18:35:25	864	36.00	51840.00	3110400.00	0.7095	9.7451	7.25			4.72	32.02	-0.01	32.02
27.04.2004 22:35:25	868	36.17	52080.00	3124800.00	0.7097	9.7607	7.25			4.72	32.02	-0.01	32.02
28.04.2004 02:35:25	872	36.33	52320.00	3139200.00	0.7095	9.7451	7.25			4.72	32.02	-0.01	32.02
28.04.2004 06:35:25	876	36.50	52560.00	3153600.00	0.7073	9.7451	7.22			4.69	32.05	-0.01	32.04
28.04.2004 10:35:25	880	36.67	52800.00	3168000.00	0.7047	9.7168	7.20			4.67	32.07	-0.01	32.07
28.04.2004 14:35:25	884	36.83	53040.00	3182400.00	0.7027	9.7451	7.18			4.65	32.09	-0.01	32.09
28.04.2004 18:35:25	888	37.00	53280.00	3196800.00	0.7006	9.7607	7.16			4.63	32.11	-0.01	32.11
28.04.2004 22:35:25	892	37.17	53520.00	3211200.00	0.6983	9.7607	7.13			4.60	32.14	-0.01	32.13

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Date and Time	Elapsed		Elapsed		Elapsed Seconds	Logger reading bar	Logger Temp °C	Total Pressure Head	Manual	Corrected for drop	Water level m bd	Drift Correction	Water Level Corrected for drift
	Hours	Days	Mins	Seconds									
29.04.2004 02:35:25	896	37.33	53760.00	3225600.00	0.6982	9.7451	7.13			4.60	32.14	-0.01	32.13
29.04.2004 06:35:25	900	37.50	54000.00	3240000.00	0.6959	9.7451	7.11			4.58	32.16	-0.01	32.16
29.04.2004 10:35:25	904	37.67	54240.00	3254400.00	0.6913	9.7451	7.06			4.53	32.21	-0.01	32.20
29.04.2004 14:35:25	908	37.83	54480.00	3268800.00	0.6913	9.7451	7.06			4.53	32.21	-0.01	32.20
29.04.2004 18:35:25	912	38.00	54720.00	3283200.00	0.6887	9.7607	7.02			4.49	32.25	-0.01	32.25
29.04.2004 22:35:25	916	38.17	54960.00	3297600.00	0.6887	9.7607	7.02			4.49	32.25	-0.01	32.25
30.04.2004 02:35:25	920	38.33	55200.00	3312000.00	0.6845	9.7451	6.99			4.46	32.28	-0.01	32.27
30.04.2004 06:35:25	924	38.50	55440.00	3326400.00	0.6822	9.7451	6.97			4.44	32.30	-0.01	32.30
30.04.2004 10:35:25	928	38.67	55680.00	3340800.00	0.6797	9.7168	6.94			4.41	32.33	-0.01	32.32
30.04.2004 14:35:25	932	38.83	55920.00	3355200.00	0.68	9.7451	6.95			4.42	32.32	-0.01	32.32
30.04.2004 18:35:25	936	39.00	56160.00	3369600.00	0.6779	9.7607	6.92			4.39	32.35	-0.01	32.34
30.04.2004 22:35:25	940	39.17	56400.00	3384000.00	0.6779	9.7607	6.92			4.39	32.35	-0.01	32.34
01.05.2004 02:35:25	944	39.33	56640.00	3398400.00	0.6754	9.7451	6.90			4.37	32.37	-0.01	32.36
01.05.2004 06:35:25	948	39.50	56880.00	3412800.00	0.6752	9.73	6.90			4.37	32.37	-0.01	32.37
01.05.2004 10:35:25	952	39.67	57120.00	3427200.00	0.6728	9.7168	6.87			4.34	32.40	-0.01	32.39
01.05.2004 14:35:25	956	39.83	57360.00	3441600.00	0.6709	9.7451	6.85			4.32	32.42	-0.01	32.41
01.05.2004 18:35:25	960	40.00	57600.00	3456000.00	0.6707	9.73	6.85			4.32	32.42	-0.01	32.41
01.05.2004 22:35:25	964	40.17	57840.00	3470400.00	0.6686	9.7451	6.83			4.30	32.44	-0.01	32.43
02.05.2004 02:35:25	968	40.33	58080.00	3484800.00	0.6663	9.7451	6.81			4.28	32.46	-0.01	32.46
02.05.2004 06:35:25	972	40.50	58320.00	3499200.00	0.6662	9.73	6.80			4.27	32.47	-0.01	32.46
02.05.2004 10:35:25	976	40.67	58560.00	3513600.00	0.6637	9.7168	6.78			4.25	32.49	-0.01	32.48
02.05.2004 14:35:25	980	40.83	58800.00	3528000.00	0.6616	9.73	6.76			4.23	32.51	-0.01	32.51
02.05.2004 18:35:25	984	41.00	59040.00	3542400.00	0.6595	9.7451	6.74			4.21	32.53	-0.01	32.53
02.05.2004 22:35:25	988	41.17	59280.00	3556800.00	0.6572	9.7451	6.71			4.18	32.56	-0.01	32.55
03.05.2004 02:35:25	992	41.33	59520.00	3571200.00	0.6525	9.73	6.66			4.13	32.61	-0.01	32.60
03.05.2004 06:35:25	996	41.50	59760.00	3585600.00	0.6525	9.73	6.66			4.13	32.61	-0.01	32.60
03.05.2004 10:35:25	1000	41.67	60000.00	3600000.00	0.6502	9.73	6.64			4.11	32.63	-0.01	32.62
03.05.2004 14:35:25	1004	41.83	60240.00	3614400.00	0.6478	9.7168	6.62			4.09	32.65	-0.01	32.65
03.05.2004 18:35:25	1008	42.00	60480.00	3628800.00	0.6436	9.7451	6.57			4.04	32.70	-0.01	32.69
03.05.2004 22:35:25	1012	42.17	60720.00	3643200.00	0.6388	9.73	6.52			3.99	32.75	-0.01	32.74
04.05.2004 02:35:25	1016	42.33	60960.00	3657600.00	0.6345	9.7451	6.48			3.95	32.79	-0.01	32.78

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Date and Time	Elapsed		Elapsed		Logger reading	Logger Temp °C	Total Pressure Head	Manual	Corrected for drop	Water level m	Drift Correction	Water Level Corrected for drift
	Hours	Days	Mins	Seconds								
04.05.2004 06:35:25	1020	42.50	61200.00	3672000.00	0.6299	9.7451	6.43		3.90	32.84	-0.01	32.83
04.05.2004 10:35:25	1024	42.67	61440.00	3686400.00	0.6275	9.73	6.41		3.88	32.86	-0.01	32.85
04.05.2004 14:35:25	1028	42.83	61680.00	3700800.00	0.6231	9.7451	6.36		3.83	32.91	-0.01	32.90
04.05.2004 18:35:25	1032	43.00	61920.00	3715200.00	0.6229	9.73	6.36		3.83	32.91	-0.01	32.90
04.05.2004 22:35:25	1036	43.17	62160.00	3729600.00	0.6255	9.7607	6.39		3.86	32.88	-0.01	32.87
05.05.2004 02:35:25	1040	43.33	62400.00	3744000.00	0.6206	9.73	6.34		3.81	32.93	-0.01	32.92
05.05.2004 06:35:25	1044	43.50	62640.00	3758400.00	0.6184	9.73	6.32		3.79	32.95	-0.01	32.95
05.05.2004 10:35:25	1048	43.67	62880.00	3772800.00	0.6161	9.73	6.29		3.76	32.98	-0.01	32.97
05.05.2004 14:35:25	1052	43.83	63120.00	3787200.00	0.616	9.7168	6.29		3.76	32.98	-0.01	32.97
05.05.2004 18:35:25	1056	44.00	63360.00	3801600.00	0.616	9.7168	6.29		3.76	32.98	-0.01	32.97
05.05.2004 22:35:25	1060	44.17	63600.00	3816000.00	0.6163	9.7451	6.29		3.76	32.98	-0.01	32.97
06.05.2004 02:35:25	1064	44.33	63840.00	3830400.00	0.614	9.7451	6.27		3.74	33.00	-0.01	32.99
06.05.2004 06:35:25	1068	44.50	64080.00	3844800.00	0.614	9.7451	6.27		3.74	33.00	-0.01	32.99
06.05.2004 10:35:25	1072	44.67	64320.00	3859200.00	0.6117	9.7451	6.25		3.72	33.02	-0.01	33.01
06.05.2004 14:35:25	1076	44.83	64560.00	3873600.00	0.6117	9.7451	6.25		3.72	33.02	-0.01	33.01
06.05.2004 18:35:25	1080	45.00	64800.00	3888000.00	0.614	9.7451	6.27		3.74	33.00	-0.01	32.99
06.05.2004 22:35:25	1084	45.17	65040.00	3902400.00	0.614	9.7451	6.27		3.74	33.00	-0.01	32.99
07.05.2004 02:35:25	1088	45.33	65280.00	3916800.00	0.6117	9.7451	6.25		3.72	33.02	-0.01	33.01
07.05.2004 06:35:25	1092	45.50	65520.00	3931200.00	0.6094	9.7451	6.22		3.69	33.05	-0.01	33.04
07.05.2004 10:35:25	1096	45.67	65760.00	3945600.00	0.6117	9.7451	6.25		3.72	33.02	-0.01	33.01
07.05.2004 14:35:25	1100	45.83	66000.00	3960000.00	0.6093	9.73	6.22		3.69	33.05	-0.01	33.04
07.05.2004 18:35:25	1104	46.00	66240.00	3974400.00	0.6093	9.73	6.22		3.69	33.05	-0.01	33.04
07.05.2004 22:35:25	1108	46.17	66480.00	3988800.00	0.6094	9.7451	6.22		3.69	33.05	-0.01	33.04
08.05.2004 02:35:25	1112	46.33	66720.00	4003200.00	0.6093	9.73	6.22		3.69	33.05	-0.01	33.04
08.05.2004 06:35:25	1116	46.50	66960.00	4017600.00	0.6093	9.73	6.22		3.69	33.05	-0.01	33.04
08.05.2004 10:35:25	1120	46.67	67200.00	4032000.00	0.605	9.7607	6.18		3.65	33.09	-0.01	33.08
08.05.2004 14:35:25	1124	46.83	67440.00	4046400.00	0.6026	9.7451	6.15		3.62	33.12	-0.01	33.11
08.05.2004 18:35:25	1128	47.00	67680.00	4060800.00	0.6023	9.7168	6.15		3.62	33.12	-0.01	33.11
08.05.2004 22:35:25	1132	47.17	67920.00	4075200.00	0.6024	9.73	6.15		3.62	33.12	-0.01	33.11
09.05.2004 02:35:25	1136	47.33	68160.00	4089600.00	0.6002	9.73	6.13		3.60	33.14	-0.01	33.13
09.05.2004 06:35:25	1140	47.50	68400.00	4104000.00	0.6002	9.73	6.13		3.60	33.14	-0.01	33.13

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Date and Time	Elapsed		Elapsed	Elapsed	Logger reading	Logger	Total Pressure	Manual	Corrected	Water level m	Drift	Water Level Corrected for drift
	Hours	Days	Mins	Seconds	bar	Temp °C	Head					
09.05.2004 10:35:25	1144	47.67	68640.00	4118400.00	0.6002	9.73	6.13		3.60	33.14	-0.01	33.13
09.05.2004 14:35:25	1148	47.83	68880.00	4132800.00	0.5981	9.7451	6.11		3.58	33.16	-0.01	33.15
09.05.2004 18:35:25	1152	48.00	69120.00	4147200.00	0.5981	9.7451	6.11		3.58	33.16	-0.01	33.15
09.05.2004 22:35:25	1156	48.17	69360.00	4161600.00	0.5979	9.73	6.11		3.58	33.16	-0.01	33.15
10.05.2004 02:35:25	1160	48.33	69600.00	4176000.00	0.5979	9.73	6.11		3.58	33.16	-0.01	33.15
10.05.2004 06:35:25	1164	48.50	69840.00	4190400.00	0.5959	9.7607	6.09		3.56	33.18	-0.01	33.17
10.05.2004 10:35:25	1168	48.67	70080.00	4204800.00	0.5956	9.73	6.08		3.55	33.19	-0.01	33.18
10.05.2004 14:35:25	1172	48.83	70320.00	4219200.00	0.5956	9.73	6.08		3.55	33.19	-0.01	33.18
10.05.2004 18:35:25	1176	49.00	70560.00	4233600.00	0.5935	9.7451	6.06		3.53	33.21	-0.01	33.20
10.05.2004 22:35:25	1180	49.17	70800.00	4248000.00	0.5932	9.7168	6.06		3.53	33.21	-0.01	33.20
11.05.2004 02:35:25	1184	49.33	71040.00	4262400.00	0.5933	9.73	6.06		3.53	33.21	-0.01	33.20
11.05.2004 06:35:25	1188	49.50	71280.00	4276800.00	0.5932	9.7168	6.06		3.53	33.21	-0.01	33.20
11.05.2004 10:35:25	1192	49.67	71520.00	4291200.00	0.5933	9.73	6.06		3.53	33.21	-0.01	33.20
11.05.2004 14:11:00								33.20				

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Appendix : Pumping Test Data (MW2 long term monitoring)

Cam, Co. Roscommon for Roadstone Provinces

Contract Number: 060201/3

Compiled by : CDL 12/05/04

Date and Time	Elapsed Hours	Elapsed Days	Elapsed Mins	Elapsed Seconds	Logger reading bar	Logger Temp °C	Total Pressure Head	Manual	Water level m bd	Drift Correction	Water Level Corrected for drift
22.03.2004 15:28:00								27.74			
22.03.2004 18:35:00	0	0.00	0.00	0.00	0.5693	10.0127	5.81		27.74	0.00	27.74
22.03.2004 22:36:23	4	0.17	240.00	14400.00	0.5692	9.998	5.81		27.74	0.00	27.74
23.03.2004 02:36:23	8	0.33	480.00	28800.00	0.569	9.9834	5.81		27.74	0.00	27.74
23.03.2004 06:36:23	12	0.50	720.00	43200.00	0.5712	9.9688	5.83		27.72	0.00	27.72
23.03.2004 10:36:23	16	0.67	960.00	57600.00	0.569	9.9834	5.81		27.74	0.00	27.74
23.03.2004 14:36:23	20	0.83	1200.00	72000.00	0.5689	9.9688	5.81		27.74	0.00	27.74
23.03.2004 18:36:23	24	1.00	1440.00	86400.00	0.5712	9.9688	5.83		27.72	0.00	27.72
23.03.2004 22:36:23	28	1.17	1680.00	100800.00	0.5737	9.9834	5.86		27.69	0.00	27.69
24.03.2004 02:36:23	32	1.33	1920.00	115200.00	0.5739	9.998	5.86		27.69	0.00	27.69
24.03.2004 06:36:23	36	1.50	2160.00	129600.00	0.5785	9.9834	5.91		27.64	0.00	27.65
24.03.2004 10:36:23	40	1.67	2400.00	144000.00	0.581	9.998	5.93		27.62	0.00	27.62
24.03.2004 14:36:23	44	1.83	2640.00	158400.00	0.5783	9.9688	5.91		27.64	0.01	27.65
24.03.2004 18:36:23	48	2.00	2880.00	172800.00	0.5785	9.9834	5.91		27.64	0.01	27.65
24.03.2004 22:36:23	52	2.17	3120.00	187200.00	0.5832	9.9834	5.96		27.59	0.01	27.60
25.03.2004 02:36:23	56	2.33	3360.00	201600.00	0.5857	9.998	5.98		27.57	0.01	27.57
25.03.2004 06:36:23	60	2.50	3600.00	216000.00	0.5878	9.9688	6.00		27.55	0.01	27.55
25.03.2004 10:36:23	64	2.67	3840.00	230400.00	0.5879	9.9834	6.00		27.55	0.01	27.55
25.03.2004 14:36:23	68	2.83	4080.00	244800.00	0.5903	9.9834	6.03		27.52	0.01	27.53
25.03.2004 18:36:23	72	3.00	4320.00	259200.00	0.5903	9.9834	6.03		27.52	0.01	27.53
25.03.2004 22:36:23	76	3.17	4560.00	273600.00	0.5928	9.998	6.05		27.50	0.01	27.50

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Date and Time	Elapsed		Elapsed		Elapsed		Logger reading bar	Logger Temp °C	Total Pressure Head	Manual	Water level m bd	Drift Correction	Water Level Corrected <i>for drift</i>
	Hours	Days	Mins	Seconds	bar	Temp °C							
26.03.2004 02:36:23	80	3.33	4800.00	288000.00	0.5926	9.9834	6.05				27.50	0.01	27.51
26.03.2004 06:36:23	84	3.50	5040.00	302400.00	0.5928	9.998	6.05				27.50	0.01	27.51
26.03.2004 10:36:23	88	3.67	5280.00	316800.00	0.5905	10.0127	6.03				27.52	0.01	27.53
26.03.2004 14:36:23	92	3.83	5520.00	331200.00	0.5879	9.9834	6.00				27.55	0.01	27.56
26.03.2004 18:36:23	96	4.00	5760.00	345600.00	0.5878	9.9688	6.00				27.55	0.01	27.56
26.03.2004 22:36:23	100	4.17	6000.00	360000.00	0.5855	9.9834	5.98				27.57	0.01	27.58
27.03.2004 02:36:23	104	4.33	6240.00	374400.00	0.583	9.9688	5.95				27.60	0.01	27.61
27.03.2004 06:36:23	108	4.50	6480.00	388800.00	0.5807	9.9688	5.93				27.62	0.01	27.63
27.03.2004 10:36:23	112	4.67	6720.00	403200.00	0.5788	10.0127	5.91				27.64	0.01	27.65
27.03.2004 14:36:23	116	4.83	6960.00	417600.00	0.5785	9.9834	5.91				27.64	0.01	27.66
27.03.2004 18:36:23	120	5.00	7200.00	432000.00	0.5739	9.998	5.86				27.69	0.01	27.70
27.03.2004 22:36:23	124	5.17	7440.00	446400.00	0.5714	9.9834	5.84				27.71	0.01	27.73
28.03.2004 02:36:23	128	5.33	7680.00	460800.00	0.5689	9.9688	5.81				27.74	0.02	27.75
28.03.2004 06:36:23	132	5.50	7920.00	475200.00	0.5692	9.998	5.81				27.74	0.02	27.75
28.03.2004 10:36:23	136	5.67	8160.00	489600.00	0.569	9.9834	5.81				27.74	0.02	27.75
28.03.2004 14:36:23	140	5.83	8400.00	504000.00	0.5692	9.998	5.81				27.74	0.02	27.75
28.03.2004 18:36:23	144	6.00	8640.00	518400.00	0.5692	9.998	5.81				27.74	0.02	27.75
28.03.2004 22:36:23	148	6.17	8880.00	532800.00	0.5692	9.998	5.81				27.74	0.02	27.75
29.03.2004 02:36:23	152	6.33	9120.00	547200.00	0.5668	9.998	5.79				27.76	0.02	27.78
29.03.2004 06:36:23	156	6.50	9360.00	561600.00	0.5668	9.998	5.79				27.76	0.02	27.78
29.03.2004 10:36:23	160	6.67	9600.00	576000.00	0.5667	9.9834	5.79				27.76	0.02	27.78
29.03.2004 14:36:23	164	6.83	9840.00	590400.00	0.5642	9.9688	5.76				27.79	0.02	27.81
29.03.2004 18:36:23	168	7.00	10080.00	604800.00	0.5618	9.9688	5.74				27.81	0.02	27.83
29.03.2004 22:36:23	172	7.17	10320.00	619200.00	0.5594	9.9688	5.71				27.84	0.02	27.86
30.03.2004 02:36:23	176	7.33	10560.00	633600.00	0.5574	9.998	5.69				27.86	0.02	27.88
30.03.2004 06:36:23	180	7.50	10800.00	648000.00	0.5524	9.9688	5.64				27.91	0.02	27.93
30.03.2004 10:36:23	184	7.67	11040.00	662400.00	0.5525	9.9834	5.64				27.91	0.02	27.93
30.03.2004 14:36:23	188	7.83	11280.00	676800.00	0.5478	9.9834	5.60				27.95	0.02	27.98
30.03.2004 18:36:23	192	8.00	11520.00	691200.00	0.5478	9.9834	5.60				27.95	0.02	27.98
30.03.2004 22:36:23	196	8.17	11760.00	705600.00	0.5456	9.998	5.57				27.98	0.02	28.00
31.03.2004 02:36:23	200	8.33	12000.00	720000.00	0.5434	10.0127	5.55				28.00	0.02	28.02
31.03.2004 06:36:23	204	8.50	12240.00	734400.00	0.5407	9.9834	5.52				28.03	0.02	28.05
31.03.2004 10:36:23	208	8.67	12480.00	748800.00	0.5382	9.9688	5.50				28.05	0.03	28.08
31.03.2004 14:36:23	212	8.83	12720.00	763200.00	0.5384	9.9834	5.50				28.05	0.03	28.08

RECEIVED: 05/12/2025

Date and Time	Elapsed Hours	Elapsed Days	Elapsed Mins	Elapsed Seconds	Logger reading bar	Logger Temp °C	Total Pressure Head	Manual	Water level m bd	Drift Correction	Water Level Corrected $\rho_{\text{cor}} \Delta \text{drift}$
31.03.2004 18:36:23	216	9.00	12960.00	777600.00	0.5384	9.9834	5.50		28.05	0.03	28.08
31.03.2004 22:36:23	220	9.17	13200.00	792000.00	0.5382	9.9688	5.50		28.05	0.03	28.08
01.04.2004 02:36:23	224	9.33	13440.00	806400.00	0.5359	9.9688	5.47		28.08	0.03	28.10
01.04.2004 06:36:23	228	9.50	13680.00	820800.00	0.5336	9.9834	5.45		28.10	0.03	28.13
01.04.2004 10:36:23	232	9.67	13920.00	835200.00	0.5335	9.9688	5.45		28.10	0.03	28.13
01.04.2004 14:36:23	236	9.83	14160.00	849600.00	0.5314	9.998	5.43		28.12	0.03	28.15
01.04.2004 18:36:23	240	10.00	14400.00	864000.00	0.5291	9.998	5.40		28.15	0.03	28.17
01.04.2004 22:36:23	244	10.17	14640.00	878400.00	0.5288	9.9688	5.40		28.15	0.03	28.18
02.04.2004 02:36:23	248	10.33	14880.00	892800.00	0.5311	9.9688	5.42		28.13	0.03	28.16
02.04.2004 06:36:23	252	10.50	15120.00	907200.00	0.5313	9.9834	5.43		28.12	0.03	28.15
02.04.2004 10:36:23	256	10.67	15360.00	921600.00	0.5313	9.9834	5.43		28.12	0.03	28.15
02.04.2004 14:36:23	260	10.83	15600.00	936000.00	0.5314	9.998	5.43		28.12	0.03	28.15
02.04.2004 18:36:23	264	11.00	15840.00	950400.00	0.5311	9.9688	5.42		28.13	0.03	28.16
02.04.2004 22:36:23	268	11.17	16080.00	964800.00	0.5314	9.998	5.43		28.12	0.03	28.15
03.04.2004 02:36:23	272	11.33	16320.00	979200.00	0.5311	9.9688	5.42		28.13	0.03	28.16
03.04.2004 06:36:23	276	11.50	16560.00	993600.00	0.5286	9.9536	5.40		28.15	0.03	28.18
03.04.2004 10:36:23	280	11.67	16800.00	1008000.00	0.5313	9.9834	5.43		28.12	0.03	28.16
03.04.2004 14:36:23	284	11.83	17040.00	1022400.00	0.5336	9.9834	5.45		28.10	0.03	28.13
03.04.2004 18:36:23	288	12.00	17280.00	1036800.00	0.5338	9.998	5.45		28.10	0.03	28.13
03.04.2004 22:36:23	292	12.17	17520.00	1051200.00	0.5382	9.9688	5.50		28.05	0.04	28.09
04.04.2004 02:36:23	296	12.33	17760.00	1065600.00	0.5379	9.9399	5.49		28.06	0.04	28.09
04.04.2004 06:36:23	300	12.50	18000.00	1080000.00	0.5382	9.9688	5.50		28.05	0.04	28.09
04.04.2004 10:36:23	304	12.67	18240.00	1094400.00	0.5381	9.9536	5.50		28.05	0.04	28.09
04.04.2004 14:36:23	308	12.83	18480.00	1108800.00	0.5384	9.9834	5.50		28.05	0.04	28.09
04.04.2004 18:36:23	312	13.00	18720.00	1123200.00	0.5431	9.9834	5.55		28.00	0.04	28.04
04.04.2004 22:36:23	316	13.17	18960.00	1137600.00	0.5407	9.9834	5.52		28.03	0.04	28.07
05.04.2004 02:36:23	320	13.33	19200.00	1152000.00	0.5406	9.9688	5.52		28.03	0.04	28.07
05.04.2004 06:36:23	324	13.50	19440.00	1166400.00	0.5407	9.9834	5.52		28.03	0.04	28.07
05.04.2004 10:36:23	328	13.67	19680.00	1180800.00	0.541	10.0127	5.53		28.02	0.04	28.06
05.04.2004 14:36:23	332	13.83	19920.00	1195200.00	0.5431	9.9834	5.55		28.00	0.04	28.04
05.04.2004 15:05:00	332.5							28.58			28.04
05.04.2004 18:36:23	336	14.00	20160.00	1209600.00	0.5454	9.9834	5.57		27.98	0.00	27.98
05.04.2004 22:36:23	340	14.17	20400.00	1224000.00	0.5453	9.9688	5.57		27.98	0.00	27.98
06.04.2004 02:36:23	344	14.33	20640.00	1238400.00	0.5454	9.9834	5.57		27.98	0.00	27.98

RECEIVED: 05/12/2025

Date and Time	Elapsed		Elapsed		Elapsed		Logger reading	Logger Temp °C	Total Pressure Head	Manual	Water level m	Drift	Water Level Corrected
	Hours	Days	Mins	Seconds	bar	Seconds							
06.04.2004 06:36:23	348	14.50	20880.00	1252800.00	0.5456	1252800.00	9.998	5.57			27.98	0.01	27.98
06.04.2004 10:36:23	352	14.67	21120.00	1267200.00	0.5429	1267200.00	9.9688	5.55			28.00	0.01	28.01
06.04.2004 14:36:23	356	14.83	21360.00	1281600.00	0.5454	1281600.00	9.9834	5.57			27.98	0.01	27.99
06.04.2004 18:36:23	360	15.00	21600.00	1296000.00	0.5453	1296000.00	9.9688	5.57			27.98	0.01	27.99
06.04.2004 22:36:23	364	15.17	21840.00	1310400.00	0.5453	1310400.00	9.9688	5.57			27.98	0.01	27.99
07.04.2004 02:36:23	368	15.33	22080.00	1324800.00	0.5452	1324800.00	9.9536	5.57			27.98	0.02	28.00
07.04.2004 06:36:23	372	15.50	22320.00	1339200.00	0.5454	1339200.00	9.9834	5.57			27.98	0.02	28.00
07.04.2004 10:36:23	376	15.67	22560.00	1353600.00	0.5454	1353600.00	9.9834	5.60			27.98	0.02	28.00
07.04.2004 14:36:23	380	15.83	22800.00	1368000.00	0.5478	1368000.00	9.9834	5.60			27.95	0.02	27.98
07.04.2004 18:36:23	384	16.00	23040.00	1382400.00	0.5524	1382400.00	9.9688	5.64			27.91	0.02	27.93
07.04.2004 22:36:23	388	16.17	23280.00	1396800.00	0.5499	1396800.00	9.9536	5.62			27.93	0.02	27.96
08.04.2004 02:36:23	392	16.33	23520.00	1411200.00	0.5502	1411200.00	9.9834	5.62			27.93	0.03	27.96
08.04.2004 06:36:23	396	16.50	23760.00	1425600.00	0.5478	1425600.00	9.9834	5.60			27.95	0.03	27.98
08.04.2004 10:36:23	400	16.67	24000.00	1440000.00	0.5479	1440000.00	9.998	5.60			27.95	0.03	27.98
08.04.2004 14:36:23	404	16.83	24240.00	1454400.00	0.5477	1454400.00	9.9688	5.59			27.96	0.03	27.99
08.04.2004 18:36:23	408	17.00	24480.00	1468800.00	0.5457	1468800.00	10.0127	5.57			27.98	0.03	28.01
08.04.2004 22:36:23	412	17.17	24720.00	1483200.00	0.5454	1483200.00	9.9834	5.57			27.98	0.04	28.02
09.04.2004 02:36:23	416	17.33	24960.00	1497600.00	0.5432	1497600.00	9.998	5.55			28.00	0.04	28.04
09.04.2004 06:36:23	420	17.50	25200.00	1512000.00	0.5454	1512000.00	9.9834	5.57			27.98	0.04	28.02
09.04.2004 10:36:23	424	17.67	25440.00	1526400.00	0.5454	1526400.00	9.9834	5.57			27.98	0.04	28.02
09.04.2004 14:36:23	428	17.83	25680.00	1540800.00	0.5407	1540800.00	9.9834	5.52			28.03	0.04	28.07
09.04.2004 18:36:23	432	18.00	25920.00	1555200.00	0.5406	1555200.00	9.9688	5.52			28.03	0.05	28.07
09.04.2004 22:36:23	436	18.17	26160.00	1569600.00	0.5431	1569600.00	9.9834	5.55			28.00	0.05	28.05
10.04.2004 02:36:23	440	18.33	26400.00	1584000.00	0.5406	1584000.00	9.9688	5.52			28.03	0.05	28.08
10.04.2004 06:36:23	444	18.50	26640.00	1598400.00	0.5379	1598400.00	9.9999	5.49			28.06	0.05	28.11
10.04.2004 10:36:23	448	18.67	26880.00	1612800.00	0.5406	1612800.00	9.9688	5.52			28.03	0.05	28.08
10.04.2004 14:36:23	452	18.83	27120.00	1627200.00	0.5381	1627200.00	9.9536	5.50			28.05	0.06	28.11
10.04.2004 18:36:23	456	19.00	27360.00	1641600.00	0.5382	1641600.00	9.9688	5.50			28.05	0.06	28.11
10.04.2004 22:36:23	460	19.17	27600.00	1656000.00	0.5406	1656000.00	9.9688	5.52			28.03	0.06	28.09
11.04.2004 02:36:23	464	19.33	27840.00	1670400.00	0.5379	1670400.00	9.9999	5.49			28.06	0.06	28.12
11.04.2004 06:36:23	468	19.50	28080.00	1684800.00	0.5357	1684800.00	9.9536	5.47			28.08	0.06	28.14
11.04.2004 10:36:23	472	19.67	28320.00	1699200.00	0.5385	1699200.00	9.998	5.50			28.05	0.07	28.12
11.04.2004 14:36:23	476	19.83	28560.00	1713600.00	0.5359	1713600.00	9.9688	5.47			28.08	0.07	28.14
11.04.2004 18:36:23	480	20.00	28800.00	1728000.00	0.5357	1728000.00	9.9536	5.47			28.08	0.07	28.15

RECEIVED: 05/12/2025

Date and Time	Elapsed Hours	Elapsed Days	Elapsed Mins	Elapsed Seconds	Logger reading bar	Logger Temp °C	Total Pressure Head	Manual	Water level m bd	Drift Correction	Water Level Corrected <i>for drift</i>
11.04.2004 22:36:23	484	20.17	29040.00	1742400.00	0.5356	9.9399	5.47		28.08	0.07	28.15
12.04.2004 02:36:23	488	20.33	29280.00	1756800.00	0.5359	9.9688	5.47		28.08	0.07	28.15
12.04.2004 06:36:23	492	20.50	29520.00	1771200.00	0.5356	9.9399	5.47		28.08	0.07	28.15
12.04.2004 10:36:23	496	20.67	29760.00	1785600.00	0.536	9.9834	5.47		28.08	0.08	28.15
12.04.2004 12:00:00	497.5	20.73	29850.00	1791000.00				28.54			
12.04.2004 14:36:23	500	20.83	30000.00	1800000.00	0.5359	9.9688	5.47		28.08	0.08	28.15
12.04.2004 18:36:23	504	21.00	30240.00	1814400.00	0.536	9.9834	5.47		28.08	0.08	28.16
12.04.2004 22:36:23	508	21.17	30480.00	1828800.00	0.5334	9.9536	5.45		28.10	0.08	28.18
13.04.2004 02:36:23	512	21.33	30720.00	1843200.00	0.5334	9.9536	5.45		28.10	0.08	28.19
13.04.2004 06:36:23	516	21.50	30960.00	1857600.00	0.531	9.9536	5.42		28.13	0.09	28.21
13.04.2004 10:36:23	520	21.67	31200.00	1872000.00	0.5288	9.9688	5.40		28.15	0.09	28.24
13.04.2004 14:36:23	524	21.83	31440.00	1886400.00	0.5264	9.9688	5.38		28.17	0.09	28.26
13.04.2004 18:36:23	528	22.00	31680.00	1900800.00	0.5239	9.9536	5.35		28.20	0.09	28.29
13.04.2004 22:36:23	532	22.17	31920.00	1915200.00	0.5217	9.9688	5.33		28.22	0.09	28.32
14.04.2004 02:36:23	536	22.33	32160.00	1929600.00	0.5195	9.9834	5.31		28.24	0.10	28.34
14.04.2004 06:36:23	540	22.50	32400.00	1944000.00	0.5145	9.9536	5.26		28.29	0.10	28.39
14.04.2004 10:36:23	544	22.67	32640.00	1958400.00	0.5146	9.9688	5.26		28.34	0.10	28.44
14.04.2004 14:36:23	548	22.83	32880.00	1972800.00	0.5098	9.9536	5.21		28.37	0.10	28.47
14.04.2004 18:36:23	552	23.00	33120.00	1987200.00	0.5076	9.9688	5.18		28.34	0.11	28.45
14.04.2004 22:36:23	556	23.17	33360.00	2001600.00	0.5099	9.9688	5.21		28.36	0.11	28.47
15.04.2004 02:36:23	560	23.33	33600.00	2016000.00	0.5077	9.9834	5.19		28.36	0.11	28.47
15.04.2004 06:36:23	564	23.50	33840.00	2030400.00	0.5077	9.9834	5.19		28.34	0.11	28.45
15.04.2004 10:36:23	568	23.67	34080.00	2044800.00	0.5101	9.9834	5.21		28.37	0.11	28.48
15.04.2004 14:36:23	572	23.83	34320.00	2059200.00	0.5076	9.9688	5.18		28.37	0.11	28.48
15.04.2004 18:36:23	576	24.00	34560.00	2073600.00	0.5074	9.9536	5.18		28.39	0.12	28.51
15.04.2004 22:36:23	580	24.17	34800.00	2088000.00	0.5051	9.9536	5.16		28.37	0.12	28.49
16.04.2004 02:36:23	584	24.33	35040.00	2102400.00	0.5074	9.9536	5.18		28.39	0.12	28.51
16.04.2004 06:36:23	588	24.50	35280.00	2116800.00	0.5052	9.9688	5.16		28.41	0.12	28.53
16.04.2004 10:36:23	592	24.67	35520.00	2131200.00	0.5031	9.998	5.14		28.43	0.12	28.56
16.04.2004 14:36:23	596	24.83	35760.00	2145600.00	0.5008	9.998	5.12		28.46	0.13	28.59
16.04.2004 18:36:23	600	25.00	36000.00	2160000.00	0.4981	9.9688	5.09		28.46	0.13	28.59
16.04.2004 22:36:23	604	25.17	36240.00	2174400.00	0.498	9.9536	5.09		28.51	0.13	28.64
17.04.2004 02:36:23	608	25.33	36480.00	2188800.00	0.4933	9.9536	5.04		28.58	0.13	28.71
17.04.2004 06:36:23	612	25.50	36720.00	2203200.00	0.4866	9.998	4.97				

RECEIVED: 05/12/2025

Date and Time	Elapsed		Elapsed		Elapsed		Logger reading bar	Logger Temp °C	Total Pressure Head	Manual	Water level m bd	Drift Correction	Water Level Corrected <i>for drift</i>
	Hours	Days	Mins	Seconds	Seconds	Seconds							
17.04.2004 10:36:23	616	25.67	36960.00	2217600.00	0.4816	9.9688	4.92	0.13	28.63		28.77		
17.04.2004 14:36:23	620	25.83	37200.00	2232000.00	0.4769	9.9688	4.87	0.14	28.68		28.82		
17.04.2004 18:36:23	624	26.00	37440.00	2246400.00	0.4745	9.9688	4.85	0.14	28.70		28.84		
17.04.2004 22:36:23	628	26.17	37680.00	2260800.00	0.4748	9.998	4.85	0.14	28.70		28.84		
18.04.2004 02:36:23	632	26.33	37920.00	2275200.00	0.472	9.9536	4.82	0.14	28.73		28.87		
18.04.2004 06:36:23	636	26.50	38160.00	2289600.00	0.47	9.9834	4.80	0.14	28.75		28.89		
18.04.2004 10:36:23	640	26.67	38400.00	2304000.00	0.47	9.9834	4.80	0.15	28.75		28.90		
18.04.2004 14:36:23	644	26.83	38640.00	2318400.00	0.4723	9.9834	4.82	0.15	28.73		28.87		
18.04.2004 18:36:23	648	27.00	38880.00	2332800.00	0.472	9.9536	4.82	0.15	28.73		28.88		
18.04.2004 22:36:23	652	27.17	39120.00	2347200.00	0.4723	9.9834	4.82	0.15	28.73		28.88		
19.04.2004 02:36:23	656	27.33	39360.00	2361600.00	0.4723	9.9834	4.82	0.15	28.73		28.88		
19.04.2004 06:36:23	660	27.50	39600.00	2376000.00	0.4678	9.998	4.78	0.16	28.77		28.93		
19.04.2004 10:36:23	664	27.67	39840.00	2390400.00	0.4676	9.9834	4.78	0.16	28.77		28.93		
19.04.2004 14:36:23	668	27.83	40080.00	2404800.00	0.4652	9.9834	4.75	0.16	28.80		28.96		
19.04.2004 18:36:23	672	28.00	40320.00	2419200.00	0.4747	9.9834	4.85	0.16	28.70		28.86		
19.04.2004 22:36:23	676	28.17	40560.00	2433600.00	0.477	9.9834	4.87	0.16	28.68		28.84		
20.04.2004 02:36:23	680	28.33	40800.00	2448000.00	0.4748	9.998	4.85	0.16	28.70		28.87		
20.04.2004 06:36:23	684	28.50	41040.00	2462400.00	0.4725	9.998	4.83	0.17	28.72		28.89		
20.04.2004 10:36:23	688	28.67	41280.00	2476800.00	0.4723	9.9834	4.82	0.17	28.73		28.89		
20.04.2004 14:36:23	692	28.83	41520.00	2491200.00	0.4678	9.998	4.78	0.17	28.77		28.94		
20.04.2004 18:36:23	696	29.00	41760.00	2505600.00	0.4629	9.9834	4.73	0.17	28.82		28.99		
20.04.2004 22:36:23	700	29.17	42000.00	2520000.00	0.4605	9.9834	4.70	0.17	28.85		29.02		
21.04.2004 02:36:23	704	29.33	42240.00	2534400.00	0.4629	9.9834	4.73	0.18	28.82		29.00		
21.04.2004 06:36:23	708	29.50	42480.00	2548800.00	0.4605	9.9834	4.70	0.18	28.85		29.02		
21.04.2004 10:36:23	712	29.67	42720.00	2563200.00	0.4604	9.9688	4.70	0.18	28.85		29.03		
21.04.2004 14:36:23	716	29.83	42960.00	2577600.00	0.4629	9.9834	4.73	0.18	28.82		29.00		
21.04.2004 18:36:23	720	30.00	43200.00	2592000.00	0.4629	9.9834	4.73	0.18	28.82		29.01		
21.04.2004 22:36:23	724	30.17	43440.00	2606400.00	0.4676	9.9834	4.78	0.19	28.77		28.96		
22.04.2004 02:36:23	728	30.33	43680.00	2620800.00	0.4676	9.9834	4.78	0.19	28.77		28.96		
22.04.2004 06:36:23	732	30.50	43920.00	2635200.00	0.4675	9.9688	4.77	0.19	28.78		28.96		
22.04.2004 10:36:23	736	30.67	44160.00	2649600.00	0.4697	9.9536	4.80	0.19	28.75		28.94		
22.04.2004 14:36:23	740	30.83	44400.00	2664000.00	0.4698	9.9688	4.80	0.19	28.75		28.95		
22.04.2004 18:36:23	744	31.00	44640.00	2678400.00	0.4675	9.9688	4.77	0.20	28.78		28.97		
22.04.2004 22:36:23	748	31.17	44880.00	2692800.00	0.4678	9.998	4.78	0.20	28.77		28.97		

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Date and Time	Elapsed		Elapsed		Elapsed		Logger reading bar	Logger Temp °C	Total Pressure Head	Manual	Water level m		Drift Correction	Water Level Corrected for drift
	Hours	Days	Mins	Seconds	bar	Temp °C					bd	Correction		
23.04.2004 02:36:23	752	31.33	45120.00	2707200.00	0.4673	9.9536	4.77	28.78	0.20		28.98			
23.04.2004 06:36:23	756	31.50	45360.00	2721600.00	0.4654	9.998	4.75	28.80	0.20		29.00			
23.04.2004 10:36:23	760	31.67	45600.00	2736000.00	0.47	9.9834	4.80	28.75	0.20		28.95			
23.04.2004 14:36:23	764	31.83	45840.00	2750400.00	0.4747	9.9834	4.85	28.70	0.21		28.91			
23.04.2004 18:36:23	768	32.00	46080.00	2764800.00	0.4888	9.9834	4.99	28.56	0.21		28.76			
23.04.2004 22:36:23	772	32.17	46320.00	2779200.00	0.5053	9.9834	5.16	28.39	0.21		28.60			
24.04.2004 02:36:23	776	32.33	46560.00	2793600.00	0.5219	9.9834	5.33	28.22	0.21		28.43			
24.04.2004 06:36:23	780	32.50	46800.00	2808000.00	0.5409	9.998	5.52	28.03	0.21		28.24			
24.04.2004 10:36:23	784	32.67	47040.00	2822400.00	0.5618	9.9688	5.74	27.81	0.21		28.03			
24.04.2004 14:36:23	788	32.83	47280.00	2836800.00	0.5714	9.9834	5.84	27.71	0.22		27.93			
24.04.2004 18:36:23	792	33.00	47520.00	2851200.00	0.5737	9.9834	5.86	27.69	0.22		27.91			
24.04.2004 22:36:23	796	33.17	47760.00	2865600.00	0.5808	9.9834	5.93	27.62	0.22		27.84			
25.04.2004 02:36:23	800	33.33	48000.00	2880000.00	0.5833	9.998	5.96	27.59	0.22		27.81			
25.04.2004 06:36:23	804	33.50	48240.00	2894400.00	0.5855	9.9834	5.98	27.57	0.22		27.79			
25.04.2004 10:36:23	808	33.67	48480.00	2908800.00	0.5857	9.998	5.98	27.57	0.23		27.79			
25.04.2004 14:36:23	812	33.83	48720.00	2923200.00	0.5903	9.9834	6.03	27.52	0.23		27.75			
25.04.2004 18:36:23	816	34.00	48960.00	2937600.00	0.5903	9.9834	6.03	27.52	0.23		27.75			
25.04.2004 22:36:23	820	34.17	49200.00	2952000.00	0.5926	9.9834	6.05	27.50	0.23		27.73			
26.04.2004 02:36:23	824	34.33	49440.00	2966400.00	0.5903	9.9834	6.03	27.52	0.23		27.75			
26.04.2004 06:36:23	828	34.50	49680.00	2980800.00	0.5926	9.9834	6.05	27.50	0.24		27.73			
26.04.2004 10:36:23	832	34.67	49920.00	2995200.00	0.5925	9.9688	6.05	27.50	0.24		27.74			
26.04.2004 14:36:23	836	34.83	50160.00	3009600.00	0.5928	9.998	6.05	27.50	0.24		27.73			
26.04.2004 18:36:23	840	35.00	50400.00	3024000.00	0.595	9.9834	6.08	27.47	0.24		27.71			
26.04.2004 22:36:23	844	35.17	50640.00	3038400.00	0.5975	9.998	6.10	27.45	0.24		27.69			
27.04.2004 02:36:23	848	35.33	50880.00	3052800.00	0.5997	9.9834	6.13	27.42	0.25		27.67			
27.04.2004 06:36:23	852	35.50	51120.00	3067200.00	0.5997	9.9834	6.13	27.42	0.25		27.67			
27.04.2004 10:36:23	856	35.67	51360.00	3081600.00	0.6021	9.9834	6.15	27.40	0.25		27.65			
27.04.2004 14:36:23	860	35.83	51600.00	3096000.00	0.5998	9.998	6.13	27.42	0.25		27.67			
27.04.2004 18:36:23	864	36.00	51840.00	3110400.00	0.5997	9.9834	6.13	27.42	0.25		27.68			
27.04.2004 22:36:23	868	36.17	52080.00	3124800.00	0.6021	9.9834	6.15	27.40	0.25		27.66			
28.04.2004 02:36:23	872	36.33	52320.00	3139200.00	0.6022	9.998	6.15	27.40	0.26		27.66			
28.04.2004 06:36:23	876	36.50	52560.00	3153600.00	0.6018	9.9536	6.15	27.40	0.26		27.66			
28.04.2004 10:36:23	880	36.67	52800.00	3168000.00	0.6019	9.9688	6.15	27.40	0.26		27.66			
28.04.2004 14:36:23	884	36.83	53040.00	3182400.00	0.6021	9.9834	6.15	27.40	0.26		27.66			

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Date and Time	Elapsed		Elapsed		Elapsed		Logger reading bar	Logger Temp °C	Total Pressure Head	Manual	Water level m bd	Drift Correction	Water Level Corrected <i>for drift</i>
	Hours	Days	Mins	Seconds	Seconds	Seconds							
28.04.2004 18:36:23	888	37.00	53280.00	3196800.00	0.6021	9.9834	6.15	27.40	0.26	27.66			
28.04.2004 22:36:23	892	37.17	53520.00	3211200.00	0.6018	9.9536	6.15	27.40	0.27	27.67			
29.04.2004 02:36:23	896	37.33	53760.00	3225600.00	0.5995	9.9688	6.12	27.43	0.27	27.70			
29.04.2004 06:36:23	900	37.50	54000.00	3240000.00	0.5993	9.9399	6.12	27.43	0.27	27.70			
29.04.2004 10:36:23	904	37.67	54240.00	3254400.00	0.597	9.9536	6.10	27.45	0.27	27.72			
29.04.2004 14:36:23	908	37.83	54480.00	3268800.00	0.5944	9.9243	6.07	27.48	0.27	27.75			
29.04.2004 18:36:23	912	38.00	54720.00	3283200.00	0.5901	9.9688	6.03	27.52	0.28	27.80			
29.04.2004 22:36:23	916	38.17	54960.00	3297600.00	0.5904	9.998	6.03	27.52	0.28	27.80			
30.04.2004 02:36:23	920	38.33	55200.00	3312000.00	0.5854	9.9688	5.98	27.57	0.28	27.85			
30.04.2004 06:36:23	924	38.50	55440.00	3326400.00	0.5855	9.9834	5.98	27.57	0.28	27.85			
30.04.2004 10:36:23	928	38.67	55680.00	3340800.00	0.5853	9.9536	5.98	27.57	0.28	27.86			
30.04.2004 14:36:23	932	38.83	55920.00	3355200.00	0.5876	9.9536	6.00	27.55	0.29	27.83			
30.04.2004 18:36:23	936	39.00	56160.00	3369600.00	0.5876	9.9536	6.00	27.55	0.29	27.84			
30.04.2004 22:36:23	940	39.17	56400.00	3384000.00	0.59	9.9536	6.03	27.52	0.29	27.81			
01.05.2004 02:36:23	944	39.33	56640.00	3398400.00	0.5878	9.9688	6.00	27.55	0.29	27.84			
01.05.2004 06:36:23	948	39.50	56880.00	3412800.00	0.5878	9.9688	6.00	27.55	0.29	27.84			
01.05.2004 10:36:23	952	39.67	57120.00	3427200.00	0.5901	9.9688	6.03	27.52	0.30	27.82			
01.05.2004 14:36:23	956	39.83	57360.00	3441600.00	0.5878	9.9688	6.00	27.55	0.30	27.84			
01.05.2004 18:36:23	960	40.00	57600.00	3456000.00	0.5878	9.9688	6.00	27.55	0.30	27.85			
01.05.2004 22:36:23	964	40.17	57840.00	3470400.00	0.59	9.9536	6.03	27.52	0.30	27.82			
02.05.2004 02:36:23	968	40.33	58080.00	3484800.00	0.5876	9.9536	6.00	27.55	0.30	27.85			
02.05.2004 06:36:23	972	40.50	58320.00	3499200.00	0.5878	9.9688	6.00	27.55	0.30	27.85			
02.05.2004 10:36:23	976	40.67	58560.00	3513600.00	0.5876	9.9536	6.00	27.55	0.30	27.85			
02.05.2004 14:36:23	980	40.83	58800.00	3528000.00	0.588	9.998	6.01	27.55	0.31	27.85			
02.05.2004 18:36:23	984	41.00	59040.00	3542400.00	0.5879	9.9834	6.00	27.54	0.31	27.85			
02.05.2004 22:36:23	988	41.17	59280.00	3556800.00	0.5878	9.9688	6.00	27.55	0.31	27.86			
03.05.2004 02:36:23	992	41.33	59520.00	3571200.00	0.5855	9.9834	5.98	27.57	0.31	27.88			
03.05.2004 06:36:23	996	41.50	59760.00	3585600.00	0.5853	9.9536	5.98	27.57	0.32	27.89			
03.05.2004 10:36:23	1000	41.67	60000.00	3600000.00	0.5857	9.998	5.98	27.57	0.32	27.89			
03.05.2004 14:36:23	1004	41.83	60240.00	3614400.00	0.5805	9.9536	5.93	27.62	0.32	27.94			
03.05.2004 18:36:23	1008	42.00	60480.00	3628800.00	0.5785	9.9834	5.91	27.64	0.32	27.96			
03.05.2004 22:36:23	1012	42.17	60720.00	3643200.00	0.569	9.9834	5.81	27.74	0.32	28.06			
04.05.2004 02:36:23	1016	42.33	60960.00	3657600.00	0.5618	9.9688	5.74	27.81	0.33	28.14			
04.05.2004 06:36:23	1020	42.50	61200.00	3672000.00	0.5571	9.9688	5.69	27.86	0.33	28.19			

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Date and Time	Elapsed Hours	Elapsed Days	Elapsed Mins	Elapsed Seconds	Logger reading bar	Logger Temp °C	Total Pressure Head	Manual	Water level m bd	Drift Correction	Water Level Corrected for Drift
04.05.2004 10:36:23	1024	42.67	61440.00	3686400.00	0.5527	9.998	5.65		27.90	0.33	28.23
04.05.2004 14:36:23	1028	42.83	61680.00	3700800.00	0.5525	9.9834	5.64		27.91	0.33	28.24
04.05.2004 18:36:23	1032	43.00	61920.00	3715200.00	0.5569	9.9536	5.69		27.86	0.33	28.20
04.05.2004 22:36:23	1036	43.17	62160.00	3729600.00	0.5596	9.9834	5.72		27.83	0.34	28.17
05.05.2004 02:36:23	1040	43.33	62400.00	3744000.00	0.5571	9.9688	5.69		27.86	0.34	28.20
05.05.2004 06:36:23	1044	43.50	62640.00	3758400.00	0.5549	9.9834	5.67		27.88	0.34	28.22
05.05.2004 10:36:23	1048	43.67	62880.00	3772800.00	0.5549	9.9834	5.67		27.88	0.34	28.22
05.05.2004 14:36:23	1052	43.83	63120.00	3787200.00	0.5572	9.9834	5.69		27.86	0.34	28.20
05.05.2004 18:36:23	1056	44.00	63360.00	3801600.00	0.5592	9.9399	5.71		27.84	0.34	28.18
05.05.2004 22:36:23	1060	44.17	63600.00	3816000.00	0.5618	9.9688	5.74		27.81	0.35	28.16
06.05.2004 02:36:23	1064	44.33	63840.00	3830400.00	0.5599	10.0127	5.72		27.83	0.35	28.18
06.05.2004 06:36:23	1068	44.50	64080.00	3844800.00	0.5618	9.9688	5.74		27.81	0.35	28.16
06.05.2004 10:36:23	1072	44.67	64320.00	3859200.00	0.5615	9.9399	5.74		27.81	0.35	28.17
06.05.2004 14:36:23	1076	44.83	64560.00	3873600.00	0.5618	9.9688	5.74		27.81	0.35	28.17
06.05.2004 18:36:23	1080	45.00	64800.00	3888000.00	0.5618	9.9688	5.74		27.81	0.36	28.17
06.05.2004 22:36:23	1084	45.17	65040.00	3902400.00	0.5642	9.9688	5.76		27.79	0.36	28.15
07.05.2004 02:36:23	1088	45.33	65280.00	3916800.00	0.5642	9.9688	5.76		27.79	0.36	28.15
07.05.2004 06:36:23	1092	45.50	65520.00	3931200.00	0.5643	9.9834	5.76		27.79	0.36	28.15
07.05.2004 10:36:23	1096	45.67	65760.00	3945600.00	0.5665	9.9688	5.79		27.76	0.36	28.13
07.05.2004 14:36:23	1100	45.83	66000.00	3960000.00	0.5665	9.9688	5.79		27.76	0.37	28.13
07.05.2004 18:36:23	1104	46.00	66240.00	3974400.00	0.5667	9.9834	5.79		27.76	0.37	28.13
07.05.2004 22:36:23	1108	46.17	66480.00	3988800.00	0.567	10.0127	5.79		27.76	0.37	28.13
08.05.2004 02:36:23	1112	46.33	66720.00	4003200.00	0.5643	9.9834	5.76		27.79	0.37	28.16
08.05.2004 06:36:23	1116	46.50	66960.00	4017600.00	0.562	9.9834	5.74		27.81	0.37	28.18
08.05.2004 10:36:23	1120	46.67	67200.00	4032000.00	0.5618	9.9688	5.74		27.81	0.38	28.19
08.05.2004 14:36:23	1124	46.83	67440.00	4046400.00	0.5593	9.9536	5.71		27.84	0.38	28.21
08.05.2004 18:36:23	1128	47.00	67680.00	4060800.00	0.5596	9.9834	5.72		27.83	0.38	28.21
08.05.2004 22:36:23	1132	47.17	67920.00	4075200.00	0.5572	9.9834	5.69		27.86	0.38	28.24
09.05.2004 02:36:23	1136	47.33	68160.00	4089600.00	0.5574	9.998	5.69		27.86	0.38	28.24
09.05.2004 06:36:23	1140	47.50	68400.00	4104000.00	0.5574	9.998	5.69		27.86	0.39	28.24
09.05.2004 10:36:23	1144	47.67	68640.00	4118400.00	0.555	9.998	5.67		27.88	0.39	28.27
09.05.2004 14:36:23	1148	47.83	68880.00	4132800.00	0.5571	9.9688	5.69		27.86	0.39	28.25
09.05.2004 18:36:23	1152	48.00	69120.00	4147200.00	0.5547	9.9688	5.67		27.88	0.39	28.28
09.05.2004 22:36:23	1156	48.17	69360.00	4161600.00	0.5572	9.9834	5.69		27.86	0.39	28.25

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Date and Time	Elapsed		Elapsed		Elapsed Seconds	Logger reading bar	Logger Temp °C	Total Pressure Head	Manual	Water level m bd	Drift Correction	Water Level Corrected eas drift
	Hours	Days	Mins									
10.05.2004 02:36:23	1160	48.33	69600.00		4176000.00	0.5574	9.998	5.69		27.86	0.39	28.25
10.05.2004 06:36:23	1164	48.50	69840.00		4190400.00	0.5569	9.9536	5.69		27.86	0.40	28.26
10.05.2004 10:36:23	1168	48.67	70080.00		4204800.00	0.5549	9.9834	5.67		27.88	0.40	28.28
10.05.2004 14:36:23	1172	48.83	70320.00		4219200.00	0.5524	9.9688	5.64		27.91	0.40	28.31
10.05.2004 18:36:23	1176	49.00	70560.00		4233600.00	0.5525	9.9834	5.64		27.91	0.40	28.31
10.05.2004 22:36:23	1180	49.17	70800.00		4248000.00	0.5524	9.9688	5.64		27.91	0.40	28.31
11.05.2004 02:36:23	1184	49.33	71040.00		4262400.00	0.5522	9.9536	5.64		27.91	0.41	28.32
11.05.2004 06:36:23	1188	49.50	71280.00		4276800.00	0.55	9.9688	5.62		27.93	0.41	28.34
11.05.2004 10:36:23	1192	49.67	71520.00		4291200.00	0.5503	9.998	5.62		27.93	0.41	28.34
11.05.2004 10:36:23									28.34			

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Project No: 060201

Project Name: Proposed Quarry Cam, Co. Roscommon

Ground Water Readings

Borehole	Datum	Easting	Northing	Ground lvl	Casing lvl	Stick-up	19th February 2004			19th March 2004			22nd March 2004			5th April 2004			12th April 2004			11th May 2004			
							Time	level b.c	level O.D	Time	level b.c	level O.D	Time	level b.c	level O.D	Time	level b.c	level O.D	Time	level b.c	level O.D	Time	level b.c	level O.D	Time
BH1	top casing	190455	244044	84.20	84.37	0.17	NR	13.00	71.37	NR	13.42	70.95	NR	13:37	13.24	71.13	NR	13:35	71.02	NR	13:35	71.02	13:48	13.66	70.71
BH3	top casing	190099	244700	101.58	101.75	0.17	NR	40.20	61.55	NR	41.6	60.15	NR	11:12	41.70	60.05	NR	42.90	58.85	NR	42.90	58.85	13:32	45.01	56.74
BH5	top casing	190606	244222	95.99	96.16	0.17	NR	34.40	61.76	NR	35.81	60.35	NR	14:05	35.99	60.17	NR	37.25	58.91	NR	37.25	58.91	13:53	39.51	56.65
BH6	top casing	190211	244403	99.48	99.66	0.18	NR	24.50	75.16	NR	24.86	74.80	NR	14:08	23.73	75.09	NR	24.80	74.86	NR	24.80	74.86	13:39	25.09	74.57
BH8	top casing	189939	244576	91.00	91.20	0.20	NR	29.40	61.80	NR	31.24	59.96	NR	11:56	31.12	60.08	NR	32.37	58.83	NR	32.37	58.83	14:24	34.55	56.65
BH9	top casing	189933	244961	96.48	96.74	0.26	NR	19.90	76.84	NR	23.87	72.87	NR	13:45	20.68	76.06	NR	22.72	74.02	NR	22.72	74.02	14:45	24.89	71.85
BH10	top casing	190273	244912	96.71	96.84	0.13	NR	34.70	62.14	NR	36.82	60.02	NR	13:52	36.80	60.04	NR	37.51	59.33	NR	37.51	59.33	10:39	39.60	57.24
BH11	top casing	189894	245238	87.35	87.48	0.13	NR	NR	NR	NR	20.52	66.96	NR	13:57	18.86	68.62	NR	20.48	67.00	NR	20.48	67.00	14:51	22.54	64.94
BHMMW1	top casing	190056	244348			NR							BH filled with sludge			11:48	29.63		NR	NR		14:11	33.20		
BHMMW2	top casing	190427	245328			NR							15:28	27.74		15:05	28.04		NR	28.54		15:03	28.34		
PW2A	top casing																					10:34	40.16		

Notes:

Weather 19th March 2004 fine locally heavy showers

Weather 22nd March 2004 fine locally heavy showers

Weather 11th May 2004 cool and overcast

Logger installed BH MW2 15:30 22/03/04

Logger installed BH MW1 15:00 05/04/04

Logger out MW1 14:07 11/05/04

Logger out MW2 15:01 11/05/04

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O'Neill Ground Water Engineering

7, South Main Street, Naas, Co. Kildare.
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email: info@groundwatereng.ie



Appendix One : Pumping Test Data (Monitoring Wells)
Proposed Quarry, Cam, Co. Roscommon
Contract Number: 060201/3
Compiled by : CDL 06/07/04
Date of Test: 28/06/04

BH1

Time and Date	Elapsed Time (seconds)	Elapsed Time (minutes)	Water Level below Datum (metres)	Drawdown (metres)	Reduced Level (m .O.D)	
23/06/2004 10:33			13.675		70.695	
28/06/2004 10:41			14.650		69.720	
28/06/2004 12:32	0	0	14.650	0.000	69.720	Pump on
29/06/2004 18:25	107580	1793	14.670	-0.020	69.700	
30/06/2004 13:09	175020	2917	13.920	0.730	70.450	
30/06/2004 19:56	199440	3324	14.625	0.025	69.745	
01/07/2004 10:45	252780	4213	14.540	0.110	69.830	
02/07/2004 13:17	348300	5805	14.660	-0.010	69.710	Pump off

Ground Level = 84.20

Stick-up = 0.17

Datum Level = 84.37

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Appendix One : Pumping Test Data (Monitoring Wells)

Proposed Quarry, Cam, Co. Roscommon

Contract Number: 060201/3

Compiled by : CDL 05/07/04

Date of Test: 28/06/04

BH3

Time and Date	Elapsed Time (seconds)	Elapsed Time (minutes)	Water Level below Datum (metres)	Drawdown (metres)	Reduced Level (m .O.D)	
23/06/2004 09:51			47.030		54.720	
28/06/2004 09:51			47.020		54.730	
28/06/2004 12:32	0	0	47.020	0.000	54.730	Pump on
28/06/2004 16:37	14700	245	47.040	-0.020	54.710	
29/06/2004 10:21	78540	1309	47.020	0.000	54.730	
29/06/2004 13:07	88500	1475	47.020	0.000	54.730	
29/06/2004 18:05	106380	1773	47.050	-0.030	54.700	
30/06/2004 12:50	173880	2898	47.055	-0.035	54.695	
30/06/2004 19:35	198180	3303	47.050	-0.030	54.700	
01/07/2004 10:10	250680	4178	47.040	-0.020	54.710	
02/07/2004 09:50	335880	5598	47.060	-0.040	54.690	Pump off

Ground Level = 101.58

Stick-up = 0.14

Datum Level = 101.75

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Appendix One : Pumping Test Data (Monitoring Wells)

Proposed Quarry, Cam, Co. Roscommon

Contract Number: 060201/3

Compiled by : CDL 06/07/04

Date of Test: 28/06/04

BH5

Time and Date	Elapsed Time (seconds)	Elapsed Time (minutes)	Water Level below Datum (metres)	Drawdown (metres)	Reduced Level (m .O.D)	
23/06/2004 10:44			42.020		54.140	
28/06/2004 11:15			42.130		54.030	
28/06/2004 12:32	0	0	42.130	0.000	54.030	Pump on
29/06/2004 18:43	108660	1811	42.020	0.110	54.140	
30/06/2004 13:15	175380	2923	42.215	-0.085	53.945	
30/06/2004 20:02	199800	3330	42.210	-0.080	53.950	
01/07/2004 11:15	254580	4243	42.235	-0.105	53.925	
02/07/2004 13:12	348000	5800	42.270	-0.140	53.890	Pump off

Ground Level = 95.99

Stick-up = 0.17

Datum Level = 96.16

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Appendix One : Pumping Test Data (Monitoring Wells)

Proposed Quarry, Cam, Co. Roscommon

Contract Number: 060201/3

Compiled by : CDL 05/07/04

Date of Test: 28/06/04

BH6

Time and Date	Elapsed Time (seconds)	Elapsed Time (minutes)	Water Level below Datum (metres)	Drawdown (metres)	Reduced Level (m .O.D)	
23/06/2004 09:58			28.910		70.750	
28/06/2004 10:02			29.890		69.770	
28/06/2004 12:32	0	0	29.890	0.000	69.770	Pump on
28/06/2004 16:05	12780	213	29.900	-0.010	69.760	
29/06/2004 13:17	89100	1485	30.030	-0.140	69.630	
29/06/2004 18:13	106860	1781	30.025	-0.135	69.635	
30/06/2004 12:58	174360	2906	30.130	-0.240	69.530	
30/06/2004 19:43	198660	3311	30.160	-0.270	69.500	
01/07/2004 10:20	251280	4188	30.300	-0.410	69.360	
02/07/2004 09:59	336420	5607	30.350	-0.460	69.310	Pump off

Ground Level = 99.48

Stick-up = 0.18

Datum Level = 99.66

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O'Neill Ground Water Engineering

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Appendix One : Pumping Test Data (Monitoring Wells)

Proposed Quarry, Cam, Co. Roscommon

Contract Number: 060201/3

Compiled by : CDL 06/07/04

Date of Test: 28/06/04

BH8

Time and Date	Elapsed Time (seconds)	Elapsed Time (minutes)	Water Level below Datum (metres)	Drawdown (metres)	Reduced Level (m .O.D)	
23/06/2004 10:16			35.560		55.640	
28/06/2004 10:17			36.650		54.550	
28/06/2004 12:32	0	0	36.650	0.000	54.550	Pump on
28/06/2004 16:19	13620	227	36.640	0.010	54.560	
29/06/2004 13:53	91260	1521	36.675	-0.025	54.525	
29/06/2004 18:25	107580	1793	36.655	-0.005	54.545	
30/06/2004 13:47	177300	2955	36.705	-0.055	54.495	
30/06/2004 20:34	201720	3362	36.695	-0.045	54.505	
01/07/2004 11:38	255960	4266	36.730	-0.080	54.470	
02/07/2004 10:11	337140	5619	36.745	-0.095	54.455	Pump off

Ground Level = 91.00

Stick-up = 0.20

Datum Level = 91.20

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O'Neill Ground Water Engineering

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Appendix One : Pumping Test Data (Monitoring Wells)

Proposed Quarry, Cam, Co. Roscommon

Contract Number: 060201/3

Compiled by : CDL 05/07/04

Date of Test: 28/06/04

BH9

Time and Date	Elapsed Time (seconds)	Elapsed Time (minutes)	Water Level below Datum (metres)	Drawdown (metres)	Reduced Level (m .O.D)	
23/06/2004 09:09			28.655		68.085	
28/06/2004 09:16			29.260		67.480	
28/06/2004 12:32	0	0	29.260	0.000	67.480	Pump on
28/06/2004 17:51	19140	319	29.240	0.020	67.500	
29/06/2004 09:23	75060	1251	29.295	-0.035	67.445	
29/06/2004 15:39	97620	1627	29.255	0.005	67.485	
29/06/2004 17:28	104160	1736	29.260	0.000	67.480	
30/06/2004 14:10	178680	2978	29.290	-0.030	67.450	
30/06/2004 20:48	202560	3376	29.285	-0.025	67.455	
01/07/2004 11:59	257220	4287	29.345	-0.085	67.395	
02/07/2004 12:40	346080	5768	29.380	-0.120	67.360	Pump off

Ground Level = 96.48

Stick-up = 0.26

Datum Level = 96.74

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O'Neill Ground Water Engineering

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Appendix One : Pumping Test Data (Monitoring Wells)

Proposed Quarry, Cam, Co. Roscommon

Contract Number: 060201/3

Compiled by : CDL 05/07/04

Date of Test: 28/06/04

BH10

Time and Date	Elapsed Time (seconds)	Elapsed Time (minutes)	Water Level below Datum (metres)	Drawdown (metres)	Reduced Level (m .O.D)
23/06/2004 09:21			41.940		54.900
23/06/2004 12:36			41.940		54.900
23/06/2004 12:55			41.970		54.870
23/06/2004 14:23			42.050		54.790
28/06/2004 09:26			41.990		54.850
28/06/2004 12:18			42.020		54.820
28/06/2004 12:32	0	0	42.020	0.000	54.820
28/06/2004 13:50	4680	78	42.100	-0.080	54.740
28/06/2004 13:55	4980	83	42.110	-0.090	54.730
28/06/2004 14:00	5280	88	42.115	-0.095	54.725
28/06/2004 14:05	5580	93	42.120	-0.100	54.720
28/06/2004 14:10	5880	98	42.120	-0.100	54.720
28/06/2004 14:22	6600	110	42.130	-0.110	54.710
28/06/2004 14:27	6900	115	42.130	-0.110	54.710
28/06/2004 14:57	8700	145	42.150	-0.130	54.690
28/06/2004 15:02	9000	150	42.150	-0.130	54.690
28/06/2004 15:13	9660	161	42.170	-0.150	54.670
28/06/2004 15:22	10200	170	42.170	-0.150	54.670
28/06/2004 15:27	10500	175	42.170	-0.150	54.670
28/06/2004 15:32	10800	180	42.180	-0.160	54.660
28/06/2004 17:03	16260	271	42.235	-0.215	54.605
28/06/2004 17:34	18120	302	42.250	-0.230	54.590
28/06/2004 18:39	22020	367	42.280	-0.260	54.560
28/06/2004 23:55	40980	683	42.405	-0.385	54.435
29/06/2004 06:12	63600	1060	42.490	-0.470	54.350
29/06/2004 09:28	75360	1256	42.505	-0.485	54.335
29/06/2004 10:07	77700	1295	42.510	-0.490	54.330
29/06/2004 10:39	79620	1327	42.515	-0.495	54.325
29/06/2004 10:55	80580	1343	42.515	-0.495	54.325
29/06/2004 10:56	80640	1344	42.520	-0.500	54.320
29/06/2004 10:57	80700	1345	42.520	-0.500	54.320
29/06/2004 10:58	80760	1346	42.520	-0.500	54.320
29/06/2004 10:59	80820	1347	42.520	-0.500	54.320
29/06/2004 11:00	80880	1348	42.520	-0.500	54.320
29/06/2004 11:01	80940	1349	42.530	-0.510	54.310
29/06/2004 11:02	81000	1350	42.530	-0.510	54.310
29/06/2004 11:03	81060	1351	42.535	-0.515	54.305
29/06/2004 11:04	81120	1352	42.535	-0.515	54.305
29/06/2004 11:05	81180	1353	42.535	-0.515	54.305
29/06/2004 11:06	81240	1354	42.535	-0.515	54.305
29/06/2004 11:07	81300	1355	42.535	-0.515	54.305
29/06/2004 11:08	81360	1356	42.535	-0.515	54.305
29/06/2004 11:09	81420	1357	42.535	-0.515	54.305
29/06/2004 11:14	81720	1362	42.535	-0.515	54.305
29/06/2004 11:19	82020	1367	42.535	-0.515	54.305
29/06/2004 11:24	82320	1372	42.535	-0.515	54.305

Pump on

2nd Pump

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Time and Date	Elapsed Time (seconds)	Elapsed Time (minutes)	Water Level below Datum (metres)	Drawdown (metres)	Reduced Level (m O.D)
29/06/2004 11:29	82620	1377	42.540	-0.520	54.300
29/06/2004 11:38	83160	1386	42.545	-0.525	54.295
29/06/2004 12:00	84480	1408	42.560	-0.540	54.280
29/06/2004 12:11	85140	1419	42.565	-0.545	54.275
29/06/2004 12:22	85800	1430	42.570	-0.550	54.270
29/06/2004 12:32	86400	1440	42.570	-0.550	54.270
29/06/2004 12:57	87900	1465	42.585	-0.565	54.255
29/06/2004 13:58	91560	1526	42.615	-0.595	54.225
29/06/2004 16:03	99060	1651	42.650	-0.630	54.190
29/06/2004 16:33	100860	1681	42.660	-0.640	54.180
29/06/2004 17:03	102660	1711	42.675	-0.655	54.165
29/06/2004 18:59	109620	1827	42.705	-0.685	54.135
29/06/2004 21:44	119520	1992	42.785	-0.765	54.055
30/06/2004 00:48	130560	2176	42.835	-0.815	54.005
30/06/2004 03:59	142020	2367	42.875	-0.855	53.965
30/06/2004 07:38	155160	2586	42.915	-0.895	53.925
30/06/2004 10:30	165480	2758	42.910	-0.890	53.930
30/06/2004 12:24	172320	2872	42.775	-0.755	54.065
30/06/2004 14:01	178140	2969	42.735	-0.715	54.105
30/06/2004 14:36	180240	3004	42.720	-0.700	54.120
30/06/2004 19:19	197220	3287	42.640	-0.620	54.200
30/06/2004 21:35	205380	3423	42.615	-0.595	54.225
01/07/2004 04:11	229140	3819	42.565	-0.545	54.275
01/07/2004 09:41	248940	4149	42.540	-0.520	54.300
01/07/2004 12:17	258300	4305	42.525	-0.505	54.315
01/07/2004 12:31	259140	4319	42.530	-0.510	54.310
01/07/2004 12:33	259260	4321	42.520	-0.500	54.320
01/07/2004 12:35	259380	4323	42.515	-0.495	54.325
01/07/2004 12:37	259500	4325	42.500	-0.480	54.340
01/07/2004 12:39	259620	4327	42.490	-0.470	54.350
01/07/2004 12:41	259740	4329	42.485	-0.465	54.355
01/07/2004 12:50	260280	4338	42.480	-0.460	54.360
01/07/2004 13:00	260880	4348	42.475	-0.455	54.365
01/07/2004 13:15	261780	4363	42.455	-0.435	54.385
01/07/2004 13:30	262680	4378	42.440	-0.420	54.400
01/07/2004 16:48	274560	4576	42.340	-0.320	54.500
02/07/2004 09:43	335460	5591	42.125	-0.105	54.715

Ground Level = 96.71
Stick-up = 0.13
Datum Level = 96.84

O'Neill Ground Water Engineering

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Appendix One : Pumping Test Data (Monitoring Wells)

Proposed Quarry, Cam, Co. Roscommon

Contract Number: 060201/3

Compiled by : CDL 05/07/04

Date of Test: 28/06/04

BH11

Time and Date	Elapsed Time (seconds)	Elapsed Time (minutes)	Water Level below Datum (metres)	Drawdown (metres)	Reduced Level (m .O.D)	
23/06/2004 09:05			25.740		61.740	
28/06/2004 08:49			26.170		61.310	
28/06/2004 12:32	0	0	26.170	0.000	61.310	Pump on
28/06/2004 17:57	19500	325	26.150	0.020	61.330	
29/06/2004 09:19	74820	1247	26.245	-0.075	61.235	
29/06/2004 15:29	97020	1617	26.235	-0.065	61.245	
29/06/2004 17:35	104580	1743	26.235	-0.065	61.245	
30/06/2004 14:20	179280	2988	26.330	-0.160	61.150	
30/06/2004 20:55	202980	3383	26.280	-0.110	61.200	
01/07/2004 12:05	257580	4293	26.395	-0.225	61.085	
02/07/2004 12:44	346320	5772	26.460	-0.290	61.020	Pump off

Ground Level = 87.35

Stick-up = 0.13

Datum Level = 87.48

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O'Neill Ground Water Engineering

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Appendix One : Pumping Test Data (Monitoring Wells)

Proposed Quarry, Cam, Co. Roscommon

Contract Number: 060201/3

Compiled by : CDL 06/07/04

Date of Test: 28/06/04 (Start 2)

MW1

Time and Date	Elapsed Time (seconds)	Elapsed Time (minutes)	Water Level below Datum (metres)	Drawdown (metres)	Reduced Level (m .O.D)	
23/06/2004 10:09			35.215		53.935	
28/06/2004 10:08			35.360		53.790	
28/06/2004 12:32	0	0	35.360	0.000	53.790	Pump on
28/06/2004 16:10	13080	218	35.380	-0.020	53.770	
29/06/2004 13:26	89640	1494	35.385	-0.025	53.765	
29/06/2004 18:18	107160	1786	35.335	0.025	53.815	
30/06/2004 13:40	176880	2948	35.410	-0.050	53.740	
30/06/2004 20:23	201060	3351	35.410	-0.050	53.740	
01/07/2004 11:32	255600	4260	35.440	-0.080	53.710	
02/07/2004 10:04	336720	5612	35.450	-0.090	53.700	Pump off

Ground Level = 88.40

Stick-up = 0.75

Datum Level = 89.15

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Appendix One : Pumping Test Data (Monitoring Wells)

Proposed Quarry, Cam, Co. Roscommon

Contract Number: 060201/3

Compiled by : CDL 05/07/04

Date of Test: 28/06/04

MW2

Time and Date	Elapsed Time (seconds)	Elapsed Time (minutes)	Water Level below Datum (metres)	Drawdown (metres)	Reduced Level (m .O.D)	
23/06/2004 08:38			27.980		63.070	
28/06/2004 08:20			28.030		63.020	
28/06/2004 12:32	0	0	28.030	0.000	63.020	Pump on
28/06/2004 18:11	20340	339	28.040	-0.010	63.010	
29/06/2004 15:39	97620	1627	28.015	0.015	63.035	
29/06/2004 17:48	105360	1756	28.015	0.015	63.035	
30/06/2004 10:08	164160	2736	27.990	0.040	63.060	
30/06/2004 22:23	208260	3471	28.080	-0.050	62.970	
01/07/2004 09:10	247080	4118	28.150	-0.120	62.900	
01/07/2004 16:35	273780	4563	28.280	-0.250	62.770	Pump off
02/07/2004 12:51	346740	5779	28.380	-0.350	62.670	

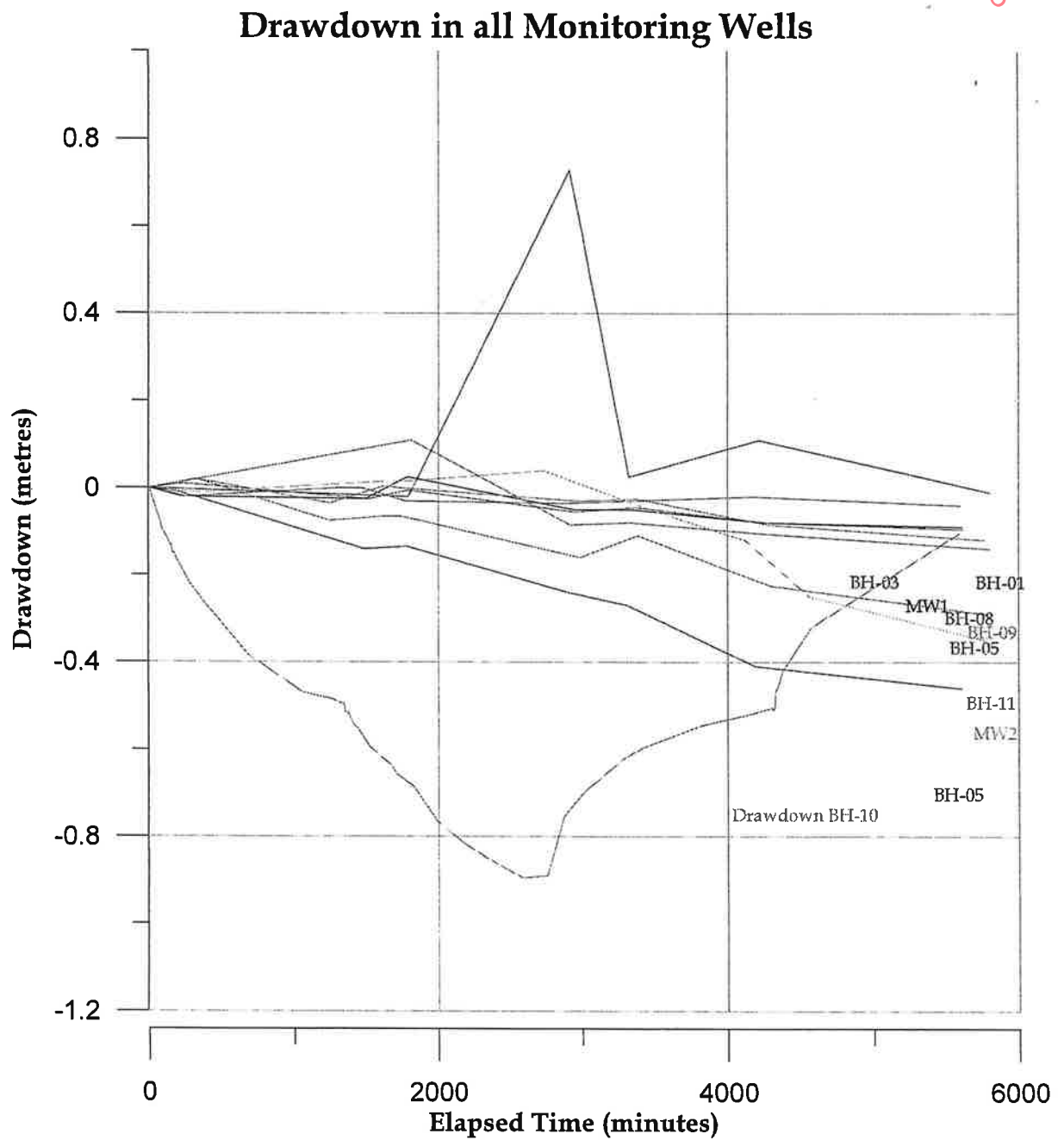
Ground Level = 90.28

Stick-up = 0.77

Datum Level = 91.05

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113	200	813	152.7	WALLIS COTTON ROAD, LUGDA
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RECEIVED: 05/12/2023

Month	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446	2447	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479	2480	2481	2482	2483	2484	2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495	2496	2497	2498	2499	2500	2501	2502	2503	2504	2505	2506	2507	2508	2509	2510	2511	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525	2526	2527	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687	2688	2689	2690	2691	2692	2693	2694	2695	2696	2697	2698	2699	2700	2701	2702	2703	2704	2705	2706	2707	2708	2709	2710	2711	2712	2713	2714	2715	2716	2717	2718	2719	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731	2732	2733	2734	2735	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750	2751	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783	2784	2785	2786	2787	2788	2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799	2800	2801	2802	2803	2804	2805	2806	2807	2808	2809	2810	2811	2812	2813	2814	2815	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826	2827	2828	2829	2830	2831	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845	2846	2847	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863	2864	2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879	2880	2881	2882	2883	2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895	2896	2897	2898	2899	2900	2901	2902	2903	2904	2905	2906	2907	2908	2909	2910	2911	2912	2913	2914	2915	2916	2917	2918	2919	2920	2921	2922	2923	2924	2925	2926	2927	2928	2929	2930	2931	2932	2933	2934	2935	2936	2937	2938	2939	2940	2941	2942	2943	2944	2945	2946	2947	2948	2949	2950	2951	2952	2953	2954	2955	2956	2957	2958	2959	2960	2961	2962	2963	2964	2965	2966	2967	2968	2969	2970	2971	2972	2973	2974	2975	2976	2977	2978	2979	2980	2981	2982	2983	2984	2985	2986	2987	2988	2989	2990	2991	2992	2993	2994	2995	2996	2997	2998	2999	3000
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14520-2085	20231125	535975	468138	11180	5453
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14520-2087	20231125	536000	468138	12420	5453
14520-2088	20231125	536012	468138	13040	5453
14520-2089	20231125	536025	468138	13660	5453
14520-2090	20231125	536037	468138	14280	5453
14520-2091	20231125	536050	468138	14900	5453
14520-2092	20231125	536062	468138	15520	5453
14520-2093	20231125	536075	468138	16140	5453
14520-2094	20231125	536087	468138	16760	5453
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14520-2103	20231125	536200	468138	22340	5453
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14520-2108	20231125	536262	468138	25440	5453
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14520-2111	20231125	536300	468138	27300	5453
14520-2112	20231125	536312	468138	27920	5453
14520-2113	20231125	536325	468138	28540	5453
14520-2114	20231125	536337	468138	29160	5453
14520-2115	20231125	536350	468138	29780	5453
14520-2116	20231125	536362	468138	30400	5453
14520-2117	20231125	536375	468138	31020	5453
14520-2118	20231125	536387	468138	31640	5453
14520-2119	20231125	536400	468138	32260	5453
14520-2120	20231125	536412	468138	32880	5453
14520-2121	20231125	536425	468138	33500	5453
14520-2122	20231125	536437	468138	34120	5453
14520-2123	20231125	536450	468138	34740	5453
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14520-2128	20231125	536512	468138	37840	5453
14520-2129	20231125	536525	468138	38460	5453
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14520-2132	20231125	536562	468138	40320	5453
14520-2133	20231125	536575	468138	40940	5453
14520-2134	20231125	536587	468138	41560	5453
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14520-2136	20231125	536612	468138	42800	5453
14520-2137	20231125	536625	468138	43420	5453
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14520-2164	20231125	536962	468138	60160	5453
14520-2165	20231125	536975	468138	60780	5453
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14520-2181	20231125	537175	468138	70700	5453
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14520-2184	20231125	537212	468138	72560	5453
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14520-2187	20231125	537250	468138	74420	5453
14520-2188	20231125	537262	468138	75040	5453
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14520-2190	20231125	537287	468138	76280	5453
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14520-2194	20231125	537337	468138	78760	5453
14520-2195	20231125	537350	468138	79380	5453
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14520-2197	20231125	537375	468138	80620	5453
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14520-2199	20231125	537400	468138	81860	5453
14520-2200	20231125	537412	468138	82480	5453
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14520-2202	20231125	537437	468138	83720	5453
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14520-2204	20231125	537462	468138	84960	5453
14520-2205	20231125	537475	468138	85580	5453
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14520-2212	20231125	537562	468138	89920	5453
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14520-2215	20231125	537600	468138	91780	5453
14520-2216	20231125	537612	468138	92400	5453
14520-2217	20231125	537625	468138	93020	5453
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14520-2219	20231125	537650	468138	94260	5453
14520-2220	20231125	537662	468138	94880	5453
14520-2221	20231125	537675	468138	95500	5453
14520-2222	20231125	537687	468138	96120	5453
14520-2223	20231125	537700	468138	96740	5453
14520-2224	20231125	537712	468138	97360	5453
14520-2225	20231125	537725	468138	97980	5453
14520-2226	20231125	537737	468138	98600	5453
14520-2227	20231125	537750	468138	99220	5453
14520-2228	20231125	537762	468138	99840	5453
14520-2229	20231125	537775	468138	100460	5453
14520-2230	20231125	537787	468138	101080	5453
14520-2231	20231125	537800	468138	101700	5453
14520-2232	20231125	537812	468138	102320	5453
14520-2233	20231125	537825	468138	102940	5453
14520-2234	20231125	537837	468138	103560	5453
14520-2235	20231125	537850	468138	104180	5453
14520-2236	20231125	537862	468138	104800	5453
14520-2237	20231125	537875	468138	105420	5453
14520-2238	20231125	537887	468138	106040	5453
14520-2239	20231125	537900	468138	106660	5453
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14520-2245	20231125	537975	468138	110380	5453
14520-2246	20231125	537987	468138	111000	5453
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14520-2248	20231125	538012	468138	112240	5453
14520-2249	20231125	538025	468138	112860	5453
14520-2250	20231125	538037	468138	113480	5453
14520-2251	20231125	538050	468138	114100	5453
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14520-2253	20				

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September	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
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November	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
December	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

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1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446	2447	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479	2480	2481	2482	2483	2484	2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495	2496	2497	2498	2499	2500	2501	2502	2503	2504	2505	2506	2507	2508	2509	2510	2511	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525	2526	2527	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687	2688	2689	2690	2691	2692	2693	2694	2695	2696	2697	2698	2699	2700	2701	2702	2703	2704	2705	2706	2707	2708	2709	2710	2711	2712	2713	2714	2715	2716	2717	2718	2719	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731	2732	2733	2734	2735	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750	2751	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783	2784	2785	2786	2787	2788	2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799	2800	2801	2802	2803	2804	2805	2806	2807	2808	2809	2810	2811	2812	2813	2814	2815	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826	2827	2828	2829	2830	2831	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845	2846	2847	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863	2864	2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879	2880	2881	2882	2883	2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895	2896	2897	2898	2899	2900	2901	2902	2903	2904	2905	2906	2907	2908	2909	2910	2911	2912	2913	2914	2915	2916	2917	2918	2919	2920	2921	2922	2923	2924	2925	2926	2927	2928	2929	2930	2931	2932	2933	2934	2935	2936	2937	2938	2939	2940	2941	2942	2943	2944	2945	2946	2947	2948	2949	2950	2951	2952	2953	2954	2955	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