CONTENTS

TABLES

PLATES

FIGURES

APPENDICES

INTRODUCTION

6.1 SLR Consulting Ireland (SLR) has been appointed by Roadstone Ltd. to prepare a hydrological and hydrogeological impact assessment for the proposed restoration of Calary Quarry at Killough Upper, Kilmacanogue, Co. Wicklow by backfilling to former ground level using imported inert soil and stone and restoring the site to a heathland / grassland habitat.

6.2 The final ground profile of the backfilled quarry will mirror the gradient on adjoining sloping lands and fall from approximately 290mOD on the eastern side of the quarry to approximately 250mOD on the western side. The total volume of soil required is estimated to be of the order of 1,830,000m^3 (1.83 million cubic metres). The nature scale and extent of the proposed development and site operations are outlined in detail in Chapter 2 of this EIS.

6.3 This chapter presents information on the local hydrology and hydrogeology of the application site and surrounding area (up to 5km radius around the site boundary) and identifies potential hydrological and hydrogeological impacts which are likely to arise from the proposed development.

6.4 Unmitigated impacts, assuming that no mitigation is in place, are considered for the initial assessment, before discussing appropriate mitigation measures and reassessing the potential impacts.

Background

6.5 Roadstone Ltd. has been operating a quarry and associated works at Killough Upper since 1973. Quarry operations were suspended in 2010 in response to the sharp downturn in the construction sector at that time.

6.6 At the time the quarry was operational, surface water run-off and groundwater inflow was collected in sumps on the quarry floor, pumped to the top of the quarry, passed through settlement tanks and discharged off-site to an end point of a tributary of the Killough River. The Killough River is located to the west of the quarry and the intervening land slopes steeply down to the river. The river is the main drainage feature in the local area.

6.7 Since the quarry suspended operations, pumping has been discontinued. Natural drainage (through rainfall and surface run-off) has resulted in the water levels in the quarry void gradually rising, from a floor level of approximately 220mOD to 245mOD at present.

6.8 It is proposed to restore the quarry to its original (pre-extraction) ground level over an extended time period using imported inert fill, principally soil and stones generated by construction and development works in the surrounding region. The proposal to restore the quarry in this fashion is technically classified as recovery of waste through deposition on land. Dewatering of the quarry void will be required prior to import of the inert material.

Scope of Work

6.9 This Chapter of the EIS presents an assessment of the environmental impact of the backfilling and restoration of the site using imported inert materials on the hydrogeological and hydrological environment. It describes the local hydrological and hydrogeological environment based on available information in the vicinity of the site and presents a qualitative assessment of the potential impacts of this activity on the local environment.

Sources of Information

6.10 The following sources of information have been consulted in order to investigate the hydrogeology and hydrology of the area surrounding the application site:

- The Environmental Protection Agency for Ireland website (www.epa.ie) for maps and environmental information;
- Environmental Protection Agency, online Envision database, http://gis.epa.ie/Envision;
- Geological Survey of Ireland (GSI) website (www.gsi.ie);
- Geological Survey of Ireland, Online Groundwater Data Viewer, http://spatial.dcenr.gov.ie/GeologicalSurvey/Groundwater/index.html:
- Groundwater Protection Scheme, Department of the Environment and Local Government, Environmental Protection Agency, and Geological Survey of Ireland, 1999, and
- Water Maps, Water Framework Directive online mapping (www.wfdireland.ie).

Contributors

6.11 This study of surface water and groundwater was undertaken and prepared by:

- Dominica Baird MSc. BSc. CGeol EurGeol MIAH, Associate Hydrogeologist, SLR Consulting Ireland

RECEIVING ENVIRONMENT

Available Information : Soil and Geology

6.12 A detailed description of the local and regional soil, subsoil and bedrock geology is provided in Chapter 5 of this EIS. A short summary is provided below for completeness.

Soils and Subsoils

6.13 Much of the soil which previously occurred across the application site has been removed / excavated by quarrying activities. The soils around the site are classified by Teagasc / EPA as *AminSRPT* (i.e. predominantly shallow soils derived from non-calcareous rock or gravel, with or without a peaty surface horizon).

6.14 Teagasc sub-soil parent material mapping indicates that the area around Calary Quarry is underlain by bedrock at, or close to, surface (refer to Figure 5-1). Within the existing quarry, overburden is well-exposed in existing quarry faces with overburden thickness varying from 2.0m to 5.0m thick. It generally consists of boulders and cobbles within a sand / gravel till matrix. The boulders are predominantly quartzitic in nature.

Regional Solid Geology

6.15 The GSI online database indicates that the application site is underlain by Cambrian Metasediments. The geological unit is identified as the Bray Head Formation, which predominantly comprises greywacke and quartzite (refer to Figure 5-2). The quartzites form the higher ground in the area, typified by the Great Sugar Loaf. These units structurally overlie the surrounding dark shales and siltstones of the Ribband Group.

Local Geology

6.16 The rocks in Calary Quarry are identified as greywackes (sandstones) underlain by green and red shales. The red shales are taken to be the transition units from the underlying Devil's Glen Formation to the overlying Bray Head Formation. Fine- to medium-grained green and red sandstones and mudstones are currently exposed in the working quarry and are overlain to the north and north-west by pale buff to off-white quartzitic sandstones. The sandstones have been interpreted by the Geological Survey of Ireland as greywackes.

6.17 Weathering of the rock shows a consistent pattern, with a zone of weathered bedrock present beneath the overburden. This zone of weathered rockhead is underlain by slightly weathered bedrock characterised by a higher fracture incidence (loosely termed "broken rock"), which is, in turn, underlain by fresh, unweathered rock. These zones are clearly visible in the face at the northern end of the quarry.

6.18 At the southern end of the quarry, the sequence dips gently to the north. Towards the centre of the quarry the sequence is monoclinally folded with increased dips to the north. The steeper dips present in the central portion of the workings reduce to a gentler dip at the northern end.

6.19 The Devil's Glen Formation (thick bedded greywackes, red and green shales and medium to thick bedded sandstones) which is the lowest geological formation of relevance to this study, outcrops over 250m to the west of the site. These rocks are overlain by Bray Head Formation, which makes up the Great Sugar Loaf.

Available Information: Hydrogeology

Aquifer Characteristics and Groundwater Vulnerability

6.20 The rocks of the Devil's Glen and Bray Head Formations generally have very low permeability and are categorised as Poor Aquifers (Pl) by the GSI i.e. bedrock which is generally unproductive except for local zones, refer to Figure 6-1.

6.21 The GSI vulnerability mapping guidelines are reproduced in Table 6-1 below.

Table 6-1
GSI Vulnerability Mapping Guidelines

Vulnerability Rating	Hydrogeological Conditions				
	Subsoil Permeability (Type) and Thickness			Unsaturated Zone	Karst Features
	High permeability (sand/gravel)	Moderate permeability (e.g. Sandy subsoil)	Low permeability (e.g. Clayey subsoil, clay, peat)	(Sand/gravel aquifers only)	(<30 m radius)
Extreme (E)	0 - 3.0m	0 - 3.0m	0 - 3.0m	0 - 3.0m	-
High (H)	>3.0m	3.0 - 10.0m	3.0 - 5.0m	>3.0m	N/A
Moderate (M)	N/A	>10.0m	5.0 - 10.0m	N/A	N/A
Low (L)	N/A	N/A	>10.0m	N/A	N/A

Notes: (1) N/A = not applicable.
(2) Precise permeability values cannot be given at present.
(3) Release point of contaminants is assumed to be 1-2 m below ground surface.

6.22 Across the quarry footprint, all overburden cover has been removed and bedrock is exposed. On this basis, groundwater vulnerability at and around the application site is classified as extreme, as shown in Figure 6-2, principally because rock occurs at or near the surface.

6.23 Calary Quarry is indicated to lie within the Wicklow Groundwater Body (GWB), for which an initial characterisation has been published by the GSI. The majority of the groundwater flow will occur in the upper few metres, mainly in the weathered zone, in a lateral direction towards rivers and springs.

6.24 The dominant recharge process is diffuse recharge from water percolating through overlying glacial till, into the weathered zone. High rates of potential recharge are often expected in hilly areas due to thin subsoils, rock exposure close to the surface and high rainfall. In this area however, a large proportion of this potential recharge is rejected because the rocks are poor aquifers (with low storage capacity) and because steeply sloping ground increases surface water run-off.

6.25 Groundwater flow occurs mostly in a shallow upper weathered zone, though deeper groundwater flow is possible along fractures, joints and major faults. Recharge occurs diffusely through subsoils and via rock outcrops. Although the presence of rock close to the surface would suggest high potential recharge, any assessment of groundwater flow must consider the effect of rejected recharge from lower permeability rocks. The aquifers within the GWB are generally unconfined, but may become locally confined where the subsoil is thicker and/or of lower permeability. Groundwater flow is considered to recharge and discharge on a local scale.

Groundwater Levels and Flow

6.26 Previously, there was two water supply boreholes GW2 and GW3 and two groundwater monitoring wells GW1 (BH3) and BH4 at or around Calary Quarry. It is understood that these wells are currently blocked or no longer intact.

6.27 Well GW2 was located at the south-west of the site, close to the R755 Regional Road and previously provided water supply to the wheel wash and the 'driver's canteen'. It was reported to be 120m deep. The pumping water level was historically dipped at 34.5m below ground level (refer to Table 6-2 below). The floor of the quarry was over 40m below the well head of Well GW2.

6.28 Well GW3 was located adjacent to the office and previously provided the water supply to the office, toilets and the canteen. It was not as deep as well GW2 and only provided a small supply. The water level was historically measured at a depth of 15m below ground level.

6.29 Water wells GW2 and GW3 were located about 20m and 40m respectively from the western quarry face. The historically measured water levels, which were higher than the quarry floor, reflected a steep cone of drawdown associated with the previous dewatering of the excavation. Groundwater levels have since recovered as dewatering has ceased at the quarry.

6.30 Two boreholes (GW1/BH3 and BH4) drilled in September 2000 were completed as monitoring wells. Borehole BH4 was not identified during recent site visits and is assumed not to be available for monitoring.

Table 6-2
Historical Groundwater Levels

BH	Top of the Inner Casing Elevation (mOD)	Total Depth (m)	Elevation of Top of Bedrock (mOD)	Date	Water Level (m bTIC*)	Reduced Water Level (mOD)
GW1/ BH3	240.45	30	237.5	08/09/00	5.72	234.73
				05/10/00	4.20	236.25
				11/10/00	4.31	236.14
BH4	260.30	38	253.2	08/09/00	4.57	255.73
				05/10/00	3.12	257.18
				11/10/00	3.47	256.53
GW2	262.4**	~122		23/6/08	~35	~228
GW3	247.6**	~54		23/6/08	15***	232.6

*bTIC: below the Top of the Inner Casing.
** Ground level at well head
*** Meters below ground level.

Groundwater Abstractions : Use and Quality

6.31 The GSI national well database (www.gsi.ie) shows a number of wells in the immediate vicinity of the site (<1km) which are principally associated with domestic dwellings in the surrounding area. Details of the wells are provided in Table 6-3 and the GSI well locations are shown on Figure 6-3. The boreholes have a yield class which is classified as *poor to moderate*. There are no Source Protection Zones in the vicinity of the existing quarry.

Table 6-3
GSI Well Database

Well Number	Well Depth (m)	Depth to Rock (mbgl)	Well Use	Yield Class	Yield (m^3/d)
3221SWW078	50.3	3	Domestic	Poor	25
3221SWW079	106.7	9.1		Poor	10
3221SWW080	45.7	19.8		Moderate	50
3221SWW081	70	3		Poor	15
3221SWW080	16.2	3.9		Moderate	55

6.32 Historical groundwater samples were taken from boreholes at or around Calary Quarry in 2000 and 2005. The locations of these wells (BH3 (GW1), GW2, and GW3) are shown in Figure 6-4.

6.33 The results of the historical groundwater sample testing are presented in Table 6-4. The water analyses show that the groundwaters in the area contain relatively low mineralisation, with hardness levels that range from moderately soft to slightly hard. These are predominantly calcium-magnesium bicarbonate waters. The water quality is good, with only ammonia slighted elevated above the Drinking Water Standard.

6.34 Separately, the characterisation for the Wicklow GWB includes information on the hydrochemical signature of the GWB. Samples from five Local Authority water supply wells developed in granite show that the groundwater is a calcium bicarbonate type and is soft to moderately hard (50–250 mg/l $CaCO_3$). Samples from six Local Authority supply wells in the Ordovician Rocks show these groundwaters are generally of calcium bicarbonate type, and soft to moderately soft (20–80 mg/l $CaCO_3$). Some areas in east Wicklow, around Enniskerry and Ashford, show slightly higher hardness and alkalinity, probably because overlying tills, sands and gravels include limestone clasts which chemically alter the recharge. Low conductivity values of 0.13–0.22 mS/cm are reported.

6.35 The hardness values recorded at the application site are more typical of the granite sources in terms of hardness, while the conductivity values are slightly higher than measured for the GWB.

Table 6-4
Historical Groundwater Samples

Parameter	October 2000		February 2005		Drinking Water Standard (SI 439 of 2000)
	GW1/BH3	GW2	GW2	GW3	
pH	7.20	8.20	8.07	7.98	6.5 – 9.5
Electrical Conductivity (mS/cm)	0.244	0.292	0.352	0.316	2.5
Total Hardness (mg/l)	79	112	162	120	-
Total Alkalinity (mg/l)	120	130	110	100	-
Calcium (mg/l)	15.61	17.31	21.73	20.14	-
Magnesium (mg/l)	7.33	11.29	12.37	10.93	-
Sodium (mg/l)	14.5	18	17	13.5	200
Potassium (mg/l)	0.9	0.8	0.8	1.6	-
Chloride (mg/l)	26	39	36	11	250
Sulphate (mg/l)	8	16	10	14	250
Nitrates – as NO_3 (mg/l)	11	15.9	22.4	24.3	50
Ammonium as NH_4-N (mg/l)	0.9	0.8	<0.2	<0.2	0.3
Manganese (mg/l)	<0.05	<0.05	<0.05	<0.05	0.05
Iron (mg/l)	<0.05	<0.05	<0.05	<0.05	0.2

6.36 As part of Ireland's obligations under the Water Framework Directive (2000/60/EC), the status of groundwater bodies nationally has been assessed, both on the basis of their quality and availability. The status of this particular groundwater body water was assessed in the 2010-2012 period as "Good".

Available Information: Hydrology

Local Hydrology

6.37 The Killough River rises approximately 800m south-west of Calary Quarry, at an elevation of around 280mOD. It flows northwards and collects the flow from one of its tributaries that flows to the south of the application site. It also collects discharge waters from the quarry, via a drainage ditch which runs along the eastern side of the R755 Regional Road and the western quarry boundary.

6.38 The surface water drainage regime around the application site comprises a series of drains, ditches and small streams flowing across / downslope toward the Killough River, as shown in Figure 6-5. The catchment area of the Killough River, upstream of its confluence with the tributary carrying discharge from the quarry is approximately 1.8 km^2.

6.39 Intermittent (temporary) springs can be seen along fractures on the exposed rock faces at the quarry, as shown on Plate 6-2. At the time the quarry was in operation and dewatering was ongoing, the quarry floor was generally dry, with spring flows generally only emerging on the north-eastern and southern faces of the quarry after heavy rainfall.

6.40 Surface water runoff and shallow groundwater flow entering the application site is restricted by a number of features. As well as the drain along the R755 on the western side of the application site, there is also a drain along the eastern boundary which runs south and discharges into a small stream located to the south of the quarry.

6.41 The only surface run-off and shallow groundwater flow into the application site occurs along the northern section of the eastern boundary (which extends for approximately 350m). Consequently, water management at the application site is only required to manage surface run-off generated by rainfall directly over the quarried area, the surface water inflow along the northern part of the eastern boundary and the low volume groundwater seepage into the excavation.

6.42 As the central part of the former quarry void was deepest (lowest), and is it lay below the surrounding ground level and groundwater table, most groundwater inflows and run-off collected in this part of the quarry when it was previsouly operational.

Recharge Mechanisms

6.43 The Average Annual Rainfall (AAR) in the area around Calary Quarry is c. 1,127 mm/yr for the period 1981 - 2010 (Met Eireann, 2012). The AAR monthly average rainfall values for the 1981-2010 period are shown in Table 6-5 below.

Table 6-5
Monthly Rainfall Averages (mm) 1981-2010

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AA*
117	83	85	82	78	73	62	84	92	126	128	117	1127

'* Annual Average

6.44 Annual Evaporation is assumed to be approximately 50mm/yr due to the absence of significant vegetation cover. Potential aquifer recharge at the quarry void is approximately 1,077mm/yr.

Flow Data

6.45 As part of work for the Water Framework Directive, the EPA has prepared an internet-based tool for sizing river sub-catchments and estimating flows along ungauged sections of Irish rivers (http://watermaps.wfdireland.ie/HydroTool/). .

6.46 The EPA hydrotool indicates that the catchment area for the upper stretches of the Killough River is 6.5m^2. Within this catchment, 77.7% is underlain by well drained soil, while 20.3% is underlain by poorly drained soil.

6.47 The flow duration curve for the upper Killough River generated by the EPA hydrotool is presented in Appendix 6-A. The 95%ile flow is reported at 0.032 m^3/s (with an upper 95% confidence limit of 0.048m^3/s and a lower 95% confidence limit of 0.021m^3/s).

6.48 Flow measurements were previously undertaken in the Killough River in October 2000, February 2005 and February 2007, in support of planning applications for previously planned development at Calary Quarry. The flow measurement locations FW-1 and FW-2 were situated immediately upstream of, and some distance downstream of, the confluence between the river and its tributary carrying the main quarry discharge (refer to Figure 6-4). The results obtained by previous flow monitoring are presented below in Table 6-6.

Table 6-6
Previous Flow Measurement in the Killough River

Flow Station	Flow Rates (l/s)		
	10 Oct 2000	3 February 2005	1 February 2007
FW-1	64	30	24.5*
FW-2	79.2	-	-
Discharge Stream	-	3.0	~5.0

* The location was just downstream of the confluence with the discharge stream.

Quarry Discharge and Site Water Management

6.49 Prior to the temporary suspension of quarry operations, the water management system involved collection of surface water run-off in a settlement sump on the quarry floor and pumping to a series of settlement tanks at a higher level, as shown on Plate 6-3. At the outlet from the settlement tanks there was (is) a sump area, drained by a 0.38m (15") diameter concrete drainage pipe, shown in Plate 6-4, which leads off-site.

6.50 At a point approximately 200m north of the former / proposed quarry offices, the piped quarry discharge emerges into a drainage channel which runs in the eastern verge of the R755 Regional Road. This drainage channel also collects some surface water run-off from the western flank of the Great Sugar Loaf before turning west to enter a culvert running beneath the R755, at a bend in the road.

6.51 The combined flow of the quarry discharge and the natural drainage then flows in a westerly direction for a short distance (approximately 250m) before entering the Killough River just downstream of an area where a local public road runs alongside the river. The estimated intermittent discharge rates from the quarry site at the time it was operational varied between averages of 4.6l/s in summer

and 18.6l/s in winter. This is a relatively small volume and is consistent with the low permeability and poor aquifer status of the bedrock (refer to Para 6.23).

6.52 The proposed site water management system at the application site is shown on Figure 6-5. There is an existing discharge licence in place at the quarry for discharge of treated trade effluent arising from quarrying operations (Ref. No. WPL87).

6.53 It is envisaged that dewatering of the flooded quarry void will be undertaken over an extended period of time. Ponded water in the quarry will be pumped up to the proposed infrastructure area at the top of the quarry via flexible piping. Should it be necessary to treat the ponded water to achieve discharge quality standards it will be routed through new settlement ponds and a hydrocarbon interceptor (fitted with a silt trap). Thereafter, it will flow under gravity to the existing concrete pipe and discharged off-site.

6.54 During previous dewatering at the site, the quarry floor was generally dry with seepage / spring flows only emerging at the north-eastern corner, approximately 40m above the main quarry floor level (~260mOD), at the south-eastern face and the north-western face, beside the sump in the quarry floor.

6.55 Continuous flow from the spring during wet periods and lack of seepage during drought periods was indicative of hydraulic continuity between the bedrock and the overlying deposits and a low level of storage in the bedrock. As previously noted, what groundwater storage is present in the ground is likely to be in the shallow weathered / broken zone in the upper bedrock or in any overlying Quaternary deposits.

6.56 The application site was visited by SLR personnel on 2nd May 2014, when pumping and associated water discharge had been discontinued. The water level within the quarry void was noted to have risen to the top of the access ramp leading down into the quarry, as shown in Plate 6-5. The water level (at approximately 244.5mOD) was 0.5m below the discharge outflow pipe located at the northern end of the infrastructure area at the upper level.

6.57 At the time of the visit, the former settlement tanks, small sump and 15" drainage concrete pipe were inspected and were noted to be in relatively good condition. The on-site sewage effluent system was emptied and cleaned out by a licensed waste contactor on the 19th June 2014. Any potential pollution source related to the effluent treatment system has therefore been removed from the application site.

Local Hydrology : Surface Water Quality

6.58 Calary Quarry lies within the catchment of the Killough River, a tributary of the Dargle River which enters the sea at Bray, Co. Wicklow. The River Dargle is a significant Salmon and Sea Trout fishery and has been designated a "salmonid" river in accordance with EU Directive 78/659/EEC (Quality of Fresh Waters Needing Protection or Improvement in Order to Support Fish Life).

6.59 Water quality in the Killough River is not currently monitored by the EPA. The confluence between the Killough River and the Dargle occurs near Tinnehinch Bridge. EPA water quality monitoring of the Dargle River a short distance upstream of this bridge records a River Quality Status of "High", with a 'Q rating' of 4-5. The downstream section of the Dargle River is of "Moderate" Status and has a 'Q rating' of 3-4.

6.60 As part of Ireland's obligations under the Water Framework Directive, a River Basin Management Plan (RBMP) has been prepared for the Killough River. The current plan for 2009-2015 indicates that the Killough River water body is part of the Dargle water management unit, that its status is "Moderate" and that the water body is"at risk" due to diffuse pollution inputs across the catchment. The plan notes that the water body unit is not heavily modified and sets an objective for the water body to be restored to "Good" Status by 2027.

6.61 Surface water samples have previously been taken from the Killough River downstream of the quarry discharge, at SW2 and SW3. The test results for these samples, shown in Table 6-7 below, indicated acceptable water quality standards at the time of testing.

Table 6-7
Historical Surface Water Quality Test Results

Parameter	Oct 2000		Feb 2005			Feb 2007				Surface Water Regulations SI 294 of 1989 (A1 waters)
	SW1	SW2	SW1	SW2	SW3	SW1*	SW1#	SW2	SW3	
pH	7.73	8.86	8.15	7.65	7.81					5.5 – 8.5
Electrical Conductivity (µS/cm)	195	147	291	177	180					1000
Hardness (mg/l)	52	19	154	98	46	119	111	69	30	
Phosphorous (mg/l)	0.06	< 0.05	0.05	<0.05	<0.05	<0.01	<0.01	<0.01	<0.01	
Chloride (mg/l)	31	4.3	10	13	11	13	14	13	13	250
Nitrate as NO_3 (mg/l)	7.4	8.9	16.2	11.4	10.2	22.0	20.5	15.3	9.3	50
Ammonium** (mg/l)	1.1	0.9	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.2
Suspended Solids (mg/l)	10	<10	<10	<10	<10	<10	20	18	<10	
Total Organic Carbon (mg/l)	5	8	<2	<2	<2	4	4	3	4	
BOD (mg/l)	1	<1	<2	<2	<2	<2	<2	<2	<2	5
DROs (µg/l)						29	<10	<10	<10	
Mineral Oil (µg/l)						<10	<10	<10	<10	
PROs C_5-C_9 (µg/l)						<10	<10	<10	<10	
PROs C_{10}-C_{12} (µg/l)						<10	<10	<10	<10	

SW1 Quarry Discharge: * Discharge at settlement tanks
SW2 Sampling point downstream of Calary Quarry discharge: # Discharge at R755 road verge
SW3 Sampling point upstream of Calary Quarry discharge ** Analysed as ammoniacal nitrogen
Feb 2007 analyses performed by ALcontrol Laboratories, Dublin.
DROs - Diesel Range Organics : PROs - Petrol Range Organics
Mineral Oil- A bulk type hydrocarbon (dissolved / emulsified) parameter including petroleum, oil, grease and related materials (measured by gas chromatography)

6.62 Sampling of surface water bodies was undertaken in May 2014 and February 2015. A water quality sample was taken from the water body in the quarry void on 2nd May 2014. Water quality samples were taken from the quarry void, the discharge point from the quarry and immediately upstream and downstream of the discharge to the Killough River on 10th February 2015. The water quality sampling locations are indicated on Figure 6-4. The water samples were noted to be clear, with no visual or olfactory evidence of contamination. The field quality measurements obtained are presented below in Table 6-8.

Table 6-8
Surface Water Quality: Field Test Results

Parameter	Quarry Void	Quarry Void	Discharge	SW1	SW2
	May 2014	February 2015			
pH	8.72	6.53	6.73	6.40	6.51
Temperature (ºC)*	10.1	4.22	4.02	3.99	3.98
Conductivity (µS/cm)	176.2	202	178	86	94
DO (mg/l)	3.78	12.7	12.94	13.2	13.24

'* Discharge Limit ≤ 25ºC or ambient

6.63 The GSI's GWB initial characterisation indicates that the groundwater hydrochemical signature in some areas in east Wicklow show slightly higher hardness and alkalinity than surrounding areas, probably because the overlying tills include limestone clasts. The conductivity is low, ranging from 130µS/cm to 200µS/cm. The field measurement for conductivity of water in the quarry void and at the discharge generally falls within this range.

6.64 The water quality results are screened against the following criteria:

- European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I. No. 272 of 2009) Environmental Quality Standards (EQS);
- European Communities Environmental Objectives (Groundwater) Regulations 2010 .(S.I. No. 9 of 2010) Environmental Quality Standards (EQS) and
- EPA Interim Report Towards Setting Guideline Values For The Protection of Groundwater in Ireland. (2003).

6.65 The relevant assessment criteria for the off-site discharge to the Killough River are Environmental Quality Standards (EQS) values. Where EQS values are not available, the results are compared with the Groundwater Regulations and EPA Interim Guideline Values (IGVs), in that order. The water samples were also compared with the discharge licence limits. The water sample results and assessment criteria are presented in Table 6-9 overleaf. Detailed laboratory reports are presented in Appendix 6-B.

Table 6-9
Water Quality Test Results

Parameter	Unit	Quarry Void May 2014	Quarry Void Feb 2015	Discharge Feb 2015	SW1 Feb 2015	SW2 Feb 2015	Water Quality Assessment Criteria	Discharge Licence Limit
pH	pH units	7.72	8.05	8.11	7.50	7.58	6.5-9.5 (EPA IGV)	6 to 9
BOD_5	≤ 5 mg/l O_2	<2	<2	<2	<2	<2	<1.3 (EQS)	≤ 5 mg/l O_2
COD	≤ 50 mg/l	9	21	14	17	23	-	≤ 50 mg/l
Suspended solids	≤ 30 mg/l	2	3	5	11	<2	-	≤ 30 mg/l
Ammonium	≤ 0.2 mg/l N	0.02	0.02	<0.01	0.03	0.02	0.04 (EQS)	≤ 0.2 mg/l N
Chloride	≤ 50 mg/l Cl	<10	<10	<10	11.67	11.99	24 (GW Regs)	≤ 50 mg/l Cl
Nitrate	≤ 30 mg/l NO_3	<8.9	<8.9	<8.9	<8.9	<8.9	37.5 (GW Regs)	≤ 30 mg/l NO_3
Phosphate as P	≤ = 0.03 mg/l MRP	0.025	<0.025	<0.025	<0.025	<0.025	0.03 (EPA IGV)	≤ 0.03 mg/l MRP
Diesel Range Organics	≤ 5 mg/l	<0.01	<0.000021	<0.000021	0.000026	0.00019	-	≤ 5 mg/l
Mineral Oil	≤ 5 mg/l	<0.01	<0.001	<0.001	<0.001	<0.001	0.01 (EPA IGV)	≤ 5 mg/l

6.66 Roadstone has undertaken water quality monitoring of the water within the quarry void on a monthly basis since February 2015. Copies of monthly monitoring results are provided in Appendix 6-C and a summary of test results is presented in Table 6-10 below. The summary results are from 11 samples, and are compared against Discharge Licence limits.

Table 6-10
Summary of Monthly Water Quality Results 2015-2016

Parameter	Unit	Discharge Licence Limit (WPL87)	Min	Average	Max
Ammonia as NH_4	mg/l	<0.2 (mg/l N)	<0.1	<0.1	<0.1
BOD	mg/l	<5 (mg/l $O_{2)}$	<2	<2	<2
COD	mg/l	<50 (mg/l)	2	5	10
Mineral Oil #	mg/l	<5 (mg/l)	<0.01	0.011	0.04
Nitrate	mg/l	<30 (mg/l)	1	2	3
pH	pH Units	6 to 9	7.9	8	8.7
Molybdate React P	mg/l	<0.03 (mg/l)	0.02	0.03	0.11
Suspended Solids	mg/l	<30 (mg/l)	1	2	3

6.67 The water quality in the quarry void is considered to be good, with all parameters monitored below the Discharge Licence Limit values, except for MRP. MRP exceeded the discharge limit value on three occasions, in September and December 2015 and in February 2016, see Appendix 6-C. The remainder of the samples were at or below the discharge licence limit of 0.03mg/l for MRP.

6.68 Ongoing monthly monitoring of the discharge will indicate if the MRP exceedances are isolated occurrences. No site activities occurred during the monitoring period between February 2015 and February 2016 which could have contributed to the elevated MRP and therefore it is considered to be a natural background reading for this parameter.

6.69 There were no activities at the application site between February 2015 and February 2016 when the monthly water quality samples were taken, and therefore the water quality results may be considered to be baseline results.

6.70 All water quality samples indicate that the water is of good quality, with no exceedences of the assessment criteria or the discharge licence limits, no evidence of hydrocarbon contamination and a low conductivity.

6.71 The quarry void and quarry discharge samples recorded concentrations of mineral oi and diesel range organics at below the detection limit. Both samples from the Killough River recorded diesel range organics at greater than detection limit. This may reflect the proximity of the sampling locations to a short section of public road nearby. That said however, the concentrations recorded were well below the assessment criteria.

Flooding

6.72 The Office of Public Works website (www.floodmaps.ie) indicates that there are no records of historic flood events on or in the vicinity of the site.

6.73 Surface water run-off and discharges at the site are managed on a continual basis so that they do not increase the risk of flooding in the surrounding area.

Limitations

6.74 The assessment of the hydrological and hydrogeological environment presented above is based on visual observations from site visits, water monitoring results and published information. It should be viewed as a largely qualitative assessment.

PROPOSED DEVELOPMENT

6.75 There are a number of key activities and working practices associated with the proposed recovery of inert waste material which may have an impact on the surface water and groundwater at the site.

Materials Quarantine Area

6.76 Any imported waste which, it is suspected, may not comply with waste acceptance criteria for the waste recovery facility, will be transferred across the application site to a proposed new covered structure to be provided at the infrastructure area at the upper level (refer to Chapter 2). This shed will serve as the waste inspection and quarantine facility for the waste recovery operation.

6.77 As the floor of the shed is sealed by a concrete slab and as no rainfall will come into contact with consignments of suspected contaminated waste, there is no requirement to install drainage infrastructure to provide for the separate collection and storage of potentially contaminated surface water run-off at the waste inspection and quarantine facility.

Dewatering of Quarry Void

6.78 Available survey data suggests that the depth of water in the pond within the quarry void is up to a maximum 25m deep. Prior to commencement of backfilling, it will be necessary to dewater the quarry void by pumping. Ponded water pumped to the surface will be routed through proposed new settlement ponds and a hydrocarbon interceptor (fitted with a silt trap), both of which have yet to be installed, prior to being discharged off-site. Thereafter, it will flow (under gravity) to the existing discharge point and via a culvert to the ditch along the R755 to the tributary stream of the Killough River.

6.79 It is envisaged that the lowering of the existing pond will be undertaken initially over an extended period following grant of planning permission and a waste licence and prior to the commencement of the quarry restoration and backfilling activities.

Surface Water Management During Quarry Backfilling

6.80 During backfilling, surface water run-off and groundwater intercepted by ongoing dewatering of the quarry void will be pumped via the proposed settlement ponds, silt trap and hydrocarbon interceptor to the existing drainage network leading to the Killough River.

6.81 During the infilling operations, the upper surface of the backfilled soil will be graded so as to ensure that surface water run-off falling over the quarry footprint falls to sumps at temporary low points within the quarry void. These temporary sumps will effectively function as primary settlement ponds and water collecting in them will be pumped (causing minimum agitation to ponded water) to the proposed new settlement ponds / mobile silt trap and oil interceptor to the existing discharge pipe.

6.82 In the longer term, toward the end of the quarry backfilling works, ground contours within and around the backfilled quarry void will be modified to ensure that surface water run-off across the area is directed to the existing discharge point. It is envisaged that the existing discharge point will effectively become a low point within the surrounding modified landform and that there will be ongoing and continued discharge of run-off from this point to the tributary of the Killough River.

IMPACT OF THE PROPOSED WASTE FACILITY

Evaluation Methodology

6.83 The impacts of the proposed inert waste recovery facility on the local surface water and groundwater environment are assessed in the following sections. The methodology applied here is a qualitative risk assessment methodology in which the probability of an impact occurring and the magnitude of the impact, if it were to occur, are considered. This approach provides a mechanism for identifying areas where mitigation measures are required, and for identifying mitigation measures appropriate to the risk presented by the development. The assessment of risk is based on the matrix outlined in Table 6-11 below.

Table 6-11
Matrix Used to Assess Significance of Potential Impacts

Probability of Occurrence	Magnitude of Potential Impacts			
	Severe	Moderate	Mild	Negligible
High	High	High	Medium	Low
Medium	High	Medium	Low	Near Zero
Low	Medium	Low	Low	Near Zero
Negligible	Low	Near Zero	Near Zero	Near Zero

6.84 The assessment of likely magnitude of potential impacts in relation to hydrogeology and hydrology is assessed in accordance with criteria detailed in Table 6-12 overleaf.

Table 6-12
Magnitude of Potential Hydrolgical and Hydrogeological Impacts

Magnitude	Potential Impact
Negligible	No alteration or very minor changes with no impact to watercourses, hydrology, hydrodynamics, erosion and sedimentation patterns; No alteration to groundwater recharge or flow mechanisms; and No pollution or change in water chemistry to either groundwater or surface water.
Mild	Minor or slight changes to the watercourse, hydrology or hydrodynamics; Changes to site resulting in slight increase in runoff well within the drainage system capacity; Minor changes to erosion and sedimentation patterns; and Minor changes to the water chemistry of surface runoff and groundwater.
Moderate	Some fundamental changes to watercourse, hydrology or hydrodynamics; Changes to site resulting in an increase in runoff within system capacity; Moderate changes to erosion and sedimentation patterns; and Moderate changes to the water chemistry of surface runoff and groundwater.
Severe	Wholesale changes to watercourse channel, route, hydrology or hydrodynamics; Changes to site resulting in an increase in runoff with flood potential Significant changes to erosion and sedimentation patterns; and Major changes to the water chemistry or hydro-ecology.

6.85 In addition to their nature and significance, the potential impacts will be assessed in terms of their duration, whether they are direct or indirect impacts, and also if the impacts will be cumulative.

6.86 The following sections identify the potential impacts of the proposed development on the hydrogeological and hydrological environments. They also assess the likelihood of occurrence of each identified impact in accordance with Table 6-11 and Table 6-12. It should be noted that the impacts are initially assessed with no mitigation or design measures incorporated to reduce the risk or magnitude of the impact.

Potential Impacts on Groundwater

6.87 The proposed inert waste recovery facility has the potential to impact on groundwater in terms of both the groundwater quality and the groundwater flow regime. The potential impacts are considered qualitatively below:

Groundwater Quality

6.88 During the development and operation of the site, there is a risk of groundwater pollution from the following potential sources:

- accidental spillage of fuels and lubricants by construction plant during placement of inert fill and other operational procedures;
- increase in suspended solids and potential for contaminated run-off entering groundwater during development of the site; and
- deposition of rogue loads of contaminated material at the site.

6.89 Without mitigation, the probability of occurrence of spillage of fuels, lubricants and other potentially contaminative liquids is '**medium**' due to the area of the site and number of vehicles that will use the site. The magnitude of such an impact, were it to occur is considered to be '**moderate**'. Therefore, the overall significance of potential groundwater impact, without mitigation, is considered to be '***medium***'.

6.90 There is a '**medium***'* risk of excessive suspended solids or contaminated run-off impacting groundwater. The magnitude of impact is assessed as '**mild**' - '**moderate**' and therefore the overall significance of surface water impact, without mitigation, is considered to be '***low***' to '***medium***'.

6.91 Without mitigation, the probability of occurrence of a rogue load which may have the potential to contaminate groundwater at the site is '**medium**'. The magnitude of impact is assessed as '**moderate**'. The overall significance of any impact on water bodies, without mitigation, is therefore considered to be '***medium***'.

Groundwater Flow / Recharge

6.92 Without mitigation, or consideration of operational procedures, infilling the site with low permeability inert fill material has the potential to create a low permeability zone. This could alter the groundwater flow pattern around the site, leading to higher groundwater levels upstream of the site and lower levels downstream of the site and/or reduce recharge to the underlying aquifer. The probability of these occurrences is '**low**' - '**moderate**'.

6.93 It is noted that the aquifer is classified as a poor aquifer, with low permeability. The magnitude of these impacts is assessed as '**mild**' and their significance is therefore considered to be '***low***'.

6.94 Groundwater levels in the aquifer surrounding the site will be lowered during dewatering. The probability of this occurrence is '**high**'. Past dewatering at the quarry did not result in an extended cone of depression and, as such, the expected impact is deemed to be '**mild**'. The significance of this particular impact is therefore considered to be '***low***'.

Potential Impacts on Surface Water

6.95 The quarry discharge enters a drain, and flows in a westerly direction for a short distance (approximately 250m) before entering the Killough River. It is considered that there is a potential short to medium-term impact that backfilling of the quarry void could result in waters contaminated with elevated suspended solids being discharged to existing watercourses. The probability of such an event occurring is considered to be '**medium**' to '**high**' and the magnitude of

impact is '**moderate**'. The overall significance of this impact on surface waters is therefore assessed as '***medium***' to '***high***' if mitigation measures are not in place.

6.96 In the longer term, it is likely that only a minor proportion of the run-off from the completed landform will recharge to ground within the application site. The surface water run-off could potentially carry some suspended solids toward the Killough River. The probability of such an event occurring is considered to be '**medium**' to '**high**' and the magnitude of impact is '**moderate**'. The overall significance of this impact on surface waters is therefore assessed as '***medium***' to '***high***' if mitigation measures are not in place.

6.97 It is considered that initial dewatering will take place at rates permitted by the existing discharge licence which stipulates a typical rate of 805m^3/day (and a maximum rate of 1600m^3/day in summer and 2000m^3/day in winter) permitted by the existing discharge licence.

6.98 Thereafter, the potential impact of the proposed waste recovery activity on surface water flow quantities is negligible. Almost all water managed at the facility will be surface water run-off arising either within the site footprint or from surrounding land. Any groundwater inflows to the quarry void are likely to be low. There is likely to be little or no change in the volume of surface water discharged off-site to the Killough River via the existing land drain and as such, this particular impact is not considered any further.

Summary of Potential Impacts

6.99 A summary of potential impacts *without mitigation* is presented in Table 6-13 below:

Table 6-13
Unmitigated Risk, Magnitude and Significance of Potential Impacts

Potential Impact	Spatial Impact, Duration, Direct/Indirect	Probability of Occurrence	Magnitude of Impact	Significance of Impact	Mitigation Required?
Groundwater Quality					
Spillages of fuel	Local, Short Term, Direct	Medium	Moderate	Medium	Yes
Release of suspended solids and contaminants	Local, Short Term, Direct	Medium	Mild to Moderate	Low to medium	Yes
Rogue load of contaminated material	Local, Long Term, Direct	Medium	Moderate	Medium	Yes

Potential Impact	Spatial Impact, Duration, Direct/Indirect	Probability of Occurrence	Magnitude of Impact	Significance of Impact	Mitigation Required?
Groundwater Flow / Recharge to Aquifer					
Impermeable barrier to groundwater flow	Local, Long Term, Direct	Low - Medium	Mild	Low	No
Reduction in recharge to aquifer	Local, Long Term and Direct	Low - Medium	Mild	Low	No
Lowering of groundwater levels	Local, Short Term and Direct	High	Mild	Low	No
Surface Water Quality					
Release of suspended solids	Local, Short and Long Term, Direct	Medium to High	Moderate	Medium to High	Yes

6.100 Table 6-13 indicates that if no mitigation measures are incorporated into the quarry backfilling operation, there is potential for the proposed development to cause direct impacts to the aquifer by locally polluting groundwater. The impacts are local to regional, and range from short term to long term. If the identified potential impacts on groundwater quality were all to occur there would be a cumulative effect, which would increase the significance of the impact.

6.101 Similarly, in the absence of an effective surface water management system, the quarry backfilling operation at the site has the potential to cause detrimental and direct impacts to the water at the discharge point and in the Killough River which in turn flows into the Dargle River.

6.102 It is therefore recommended that the mitigation measures outlined in the following section are incorporated into the development proposal to reduce the potential impacts.

Do-Nothing Scenario

6.103 Since extraction activity at the quarry was suspended, dewatering, pumping and associated water discharge has been discontinued. Natural drainage (through rainfall and surface run-off) has resulted in the water levels in the quarry void gradually rising, to the point that all surface water arising within the quarry and flowing into it from the surrounding catchment is currently discharged off-site via the existing land drain.

6.104 If the proposed development does not proceed, the existing water level in the quarry void would need to be controlled and managed on an ongoing basis to ensure that off-site discharge is unimpeded, that there is no uncontrolled rise in groundwater level and that no potentially contaminating activities occur in the quarry or on lands within the surrounding catchment.

Interactions

6.105 Surface water discharges and diffuse pollution from surface water run-off arising at the proposed recovery facility has the potential to impact on local ecology through a reduction in water quality at local surface water bodies. Contamination of groundwater through the direct recharge at the recovery site can also impact surface waters (where there is a potential ground and surface water hydraulic connectivity).

6.106 The potential impacts of changes in surface water and/or groundwater quality on habitats and aquatic species are assessed in Chapter 4 of this EIS (Ecology).

MITIGATION MEASURES

6.107 Proposed mitigation measures required to reduce the potential impacts to acceptable levels are identified in the following sections. These measures either reduce the likelihood of an event occurring, or reduce the magnitude of the consequences if the event does occur. It should be noted that several of the mitigation measures proposed would have a positive effect on more than one potential impact.

Proposed Mitigation Measures

6.108 In order to mitigate against the risk of pollution to groundwater and surface water occurring during backfilling and restoration activity at the application site, the following management measures are envisaged:

Soil Management

- Imported material will be placed and compacted as soon as possible after importation in order to minimise erosion and inclusion of particulates (silt and clay) and suspended solids in surface water run-off.
- Final restoration and seeding will take place at the earliest opportunity. If stockpiles (eg. topsoil) are left in place over extended time periods, they will be seeded with grass to minimise erosion.
- The slope of the topsoil and overburden storage areas will be designed to ensure short-term stability and to minimise surface erosion (refer to Chapter 5, Soils and Geology).

Water Management Systems

- The establishment and operations of settlement ponds as proposed will reduce the suspended solids content of surface water run-off prior to discharge and will ensure that discharged waters are of the appropriate water quality standard.
- All surface water run-off arising within the facility will be passed through the settlement ponds. Surface water drainage will be installed around the upper infrastructure area to collect surface water run-off. All site drainage from this area will be routed via a silt trap and hydrocarbon interceptor prior to its discharge off-site. All surface water ponding on the quarry floor / top of backfill areas will also be pumped to settlement ponds at the upper level and passed through the hydrocarbon interceptor prior to discharge off site;

- Any ponded water over the quarry floor / backfilling area will be drained prior to any waste being deposited. This is to minimise the potential mobilisation of fines and suspended solids in water pumped to settlement tanks at the upper level;
- A traffic management system will be put in place to reduce the potential conflicts between vehicles, thereby reducing the risk of a collision and resulting fuel spills;
- A site speed limit would be enforced to further reduce the likelihood and significance of collisions;
- Existing perimeter drains / ditches shall be maintained and cleaned out regularly. In addition the integrity of the existing off-site discharge pipe should be checked at regular intervals to ensure that there are no blockages along the pipe that may impede or prevent flow through it.
- All petroleum based products and chemicals shall be stored in containers and drums stored over bunded pallets in a storage container which is itself placed over a drained concrete slab;
- Refuelling of vehicles to be either be undertaken at over the proposed concrete slab adjacent to the bunded fuel tank(s) or from a mobile double skinned fuel bowser in order to minimise the risk of uncontrolled release of polluting liquids / liquors;
- An emergency response kit will be kept at the application site to minimise the potential migration of any spillages / leaks of petroleum based products;
- All plant to be regularly maintained and inspected daily for leaks of fuels, lubricating oil or other contaminating liquids/liquors;
- Routine maintenance of plant and machinery would be undertaken over the concrete slab adjacent to the bunded fuel tanks to minimise the risk of uncontrolled release of polluting liquids. Any non-routine servicing or maintenance would be undertaken at off-site facilities;
- All fuel, chemicals, petroleum based products, mechanical and electrical equipment shall be removed prior to closure of the site.

Inspection of Imported Material

- Loads of imported material will be screened and inspected in line with an approved waste acceptance plan to confirm they are inert prior to deposition at the application site.

Monitoring

- The quality of the any off-site discharge will be monitored at the application site and upstream and downstream of the confluence between the Killough River and the tributary stream leading from Calary Quarry. Water quality monitoring will be undertaken on at least a six monthly basis. Surface water samples will be analysed for pH, temperature, BOD, COD, suspended solids, ammonium, chloride, nitrate, phosphate as P, diesel range organics and mineral oil.
- Groundwater monitoring will be required. Previous groundwater wells and monitoring well GW1/BH3, GW2, GW3 and BH4 are believed to be blocked / partially collapsed and will be redrilled prior to commencement of soil importation at the proposed waste facility. Some further baseline

groundwater monitoring will also be undertaken prior to commencement. Groundwater quality monitoring will then be undertaken on at least a six monthly basis.

- The results of all monitoring undertaken will be recorded and submitted for its records and review to the EPA in an Annual Environmental Report;
- It is currently envisaged that the surface water and groundwater monitoring regime will remain in place for the duration of the quarry backfilling and restoration works. Sampling and monitoring will continue as long as backfilling activities continue and for a short period thereafter.

6.109 Taken together, it is considered that these measures would reduce the potential impact of

- spillage of fuels and lubricants from '*medium*' to '*low*';
- release of suspended solids / contaminants to groundwater from '*medium*' to '*low';*
- contamination from rogue loads from '*medium'* to '*low*', and
- release of suspended solids to surface water from '*medium*' to '*low'.*

RESIDUAL IMPACTS

6.110 A summary of the proposed mitigation methods, together with the predicted effects and residual impacts is presented in Table 6-14 overleaf.

6.111 Examination of Table 6-14 indicates that there are no significant residual impacts with respect to groundwater and/or surface water, provided the appropriate mitigation measures are undertaken.

CONCLUSIONS

6.112 The groundwater and surface water regimes at the application site have been assessed with reference to information held by the Geological Survey of Ireland, the Environmental Protection Agency and others. This information has been supplemented with site specific water quality information.

6.113 The potential impacts of the proposed development upon hydrogeological and hydrological environment have been identified and assessed, and where appropriate, mitigation measures have been incorporated into the design of the development.

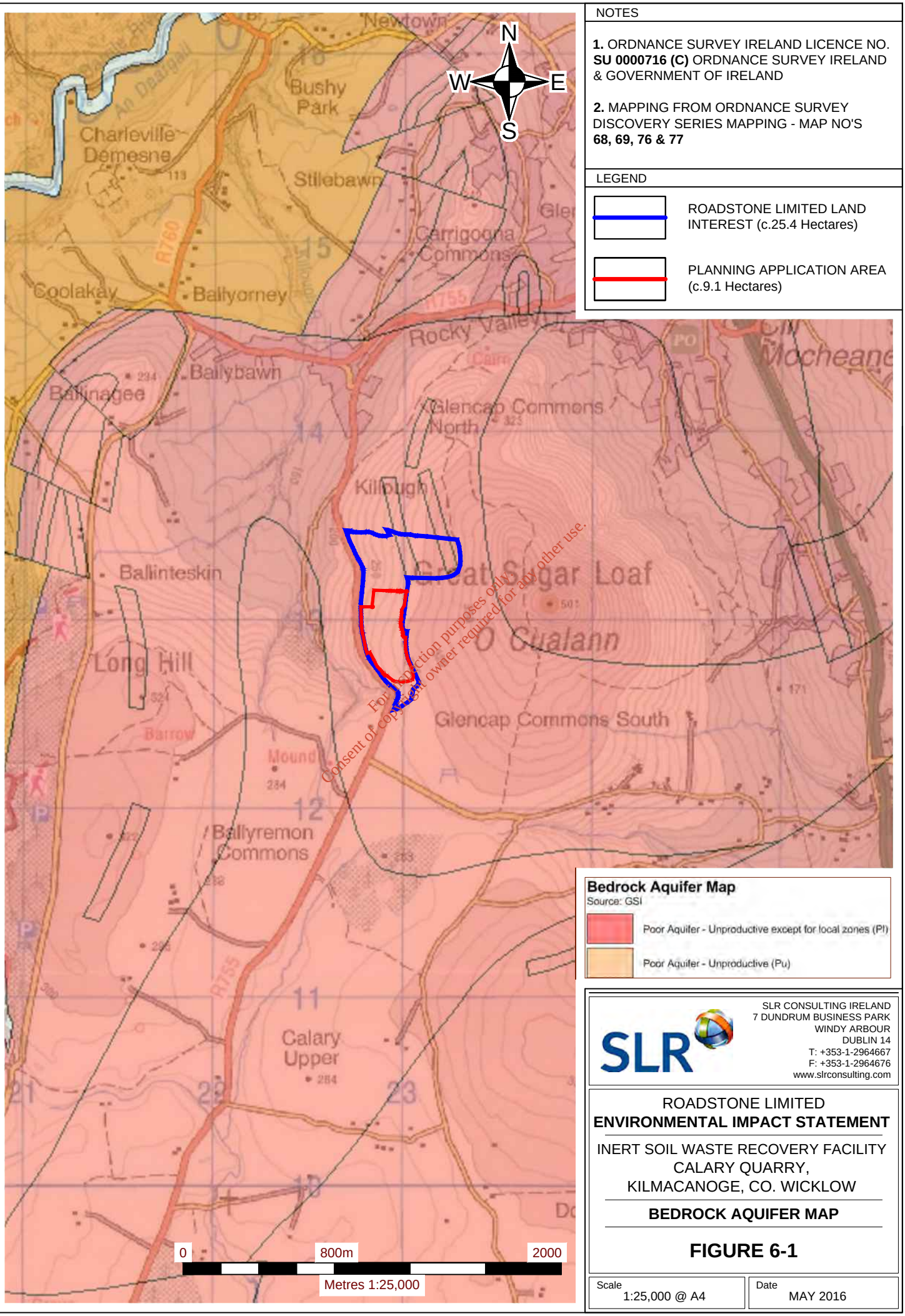
6.114 Implementation of mitigation measures will ensure that the magnitude of residual impacts with respect to groundwater and/or surface water is "low".

6.115 It is therefore concluded that the siting of an inert waste recovery facility in this location is acceptable and it has been shown that there will be no significant impact on groundwater and/or surface water.

Table 6-14
Mitigated Risk, Magnitude and Significance of Potential Impacts

Potential Impact	Spatial Impact, Duration, Direct/ Indirect	Probability of Occurrence	Magnitude of Impact	Significance of Impact	Mitigation Required?	Mitigation Measures	Mitigated Probability of Occurrence	Mitigated Magnitude of Impact	Residual Magnitude of Impact
Groundwater Quality									
Spillages of fuel	Local, Short Term, Direct	Medium	Moderate	Medium	Yes	Maintenance, bunding and spill kits	Low	Moderate	Low
Release of suspended solids and contaminants	Local, Short Term, Direct	Medium	Mild to Moderate	Low to Medium	Yes	Minimise erosion potential; implement waste acceptance procedures	Low	Mild	Low
Rogue load of contaminated material	Local, Long Term, Direct	Medium	Moderate	Medium	Yes	Inspection and testing of waste loads	Low	Mild to Moderate	Low
Groundwater Flow / Recharge to Aquifer									
Impermeable barrier to groundwater flow	Local, Long Term, Direct	Low - Medium	Mild	Low	No				
Reduction in recharge to aquifer	Local, Long Term and Direct	Low - Medium	Mild	Low	No				
Lowering of groundwater levels	Local, Short Term and Direct	High	Mild	Low	No				
Surface Water Quality									
Release of suspended solids	Local, Short and Long Term, Direct	Medium to High	Moderate	Medium to High	Yes	Surface water management measures	Low	Moderate	Low

FIGURES



NOTES

1. ORDNANCE SURVEY IRELAND LICENCE NO. **SU 0000716 (C)** ORDNANCE SURVEY IRELAND & GOVERNMENT OF IRELAND

2. MAPPING FROM ORDNANCE SURVEY DISCOVERY SERIES MAPPING - MAP NO'S **68, 69, 76 & 77**

LEGEND

ROADSTONE LIMITED LAND INTEREST (c.25.4 Hectares)

PLANNING APPLICATION AREA (c.9.1 Hectares)

Bedrock Aquifer Map
Source: GSI

Poor Aquifer - Unproductive except for local zones (Pl)

Poor Aquifer - Unproductive (Pu)

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ROADSTONE LIMITED

ENVIRONMENTAL IMPACT STATEMENT

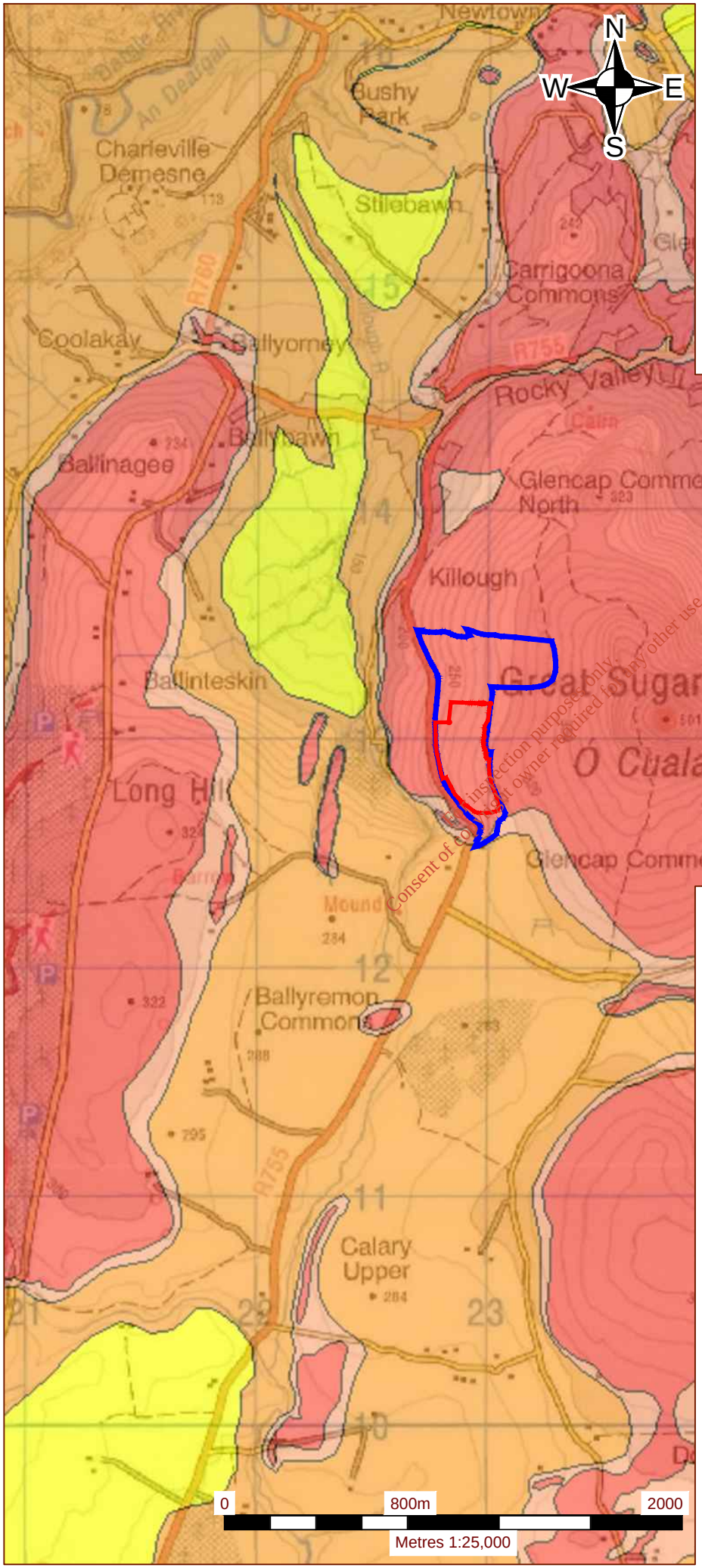
INERT SOIL WASTE RECOVERY FACILITY
CALARY QUARRY,
KILMACANOGE, CO. WICKLOW

BEDROCK AQUIFER MAP

FIGURE 6-1

Scale	Date
1:25,000 @ A4	MAY 2016

00180.00109.0.FIG_6-1.Bedrock Aquifer.dwg



NOTES

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2. MAPPING FROM ORDNANCE SURVEY DISCOVERY SERIES MAPPING - MAP NO'S **68, 69, 76 & 77**

LEGEND

ROADSTONE LIMITED LAND INTEREST (c.25.4 Hectares)

PLANNING APPLICATION AREA (c.9.1 Hectares)

GW Vulnerability Classification
Source: GSI 2013

- Rock near surface or karst - X
- Extreme - E
- High - H
- Medium - M
- Low - L

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ROADSTONE LIMITED
ENVIRONMENTAL IMPACT STATEMENT

INERT SOIL WASTE RECOVERY FACILITY
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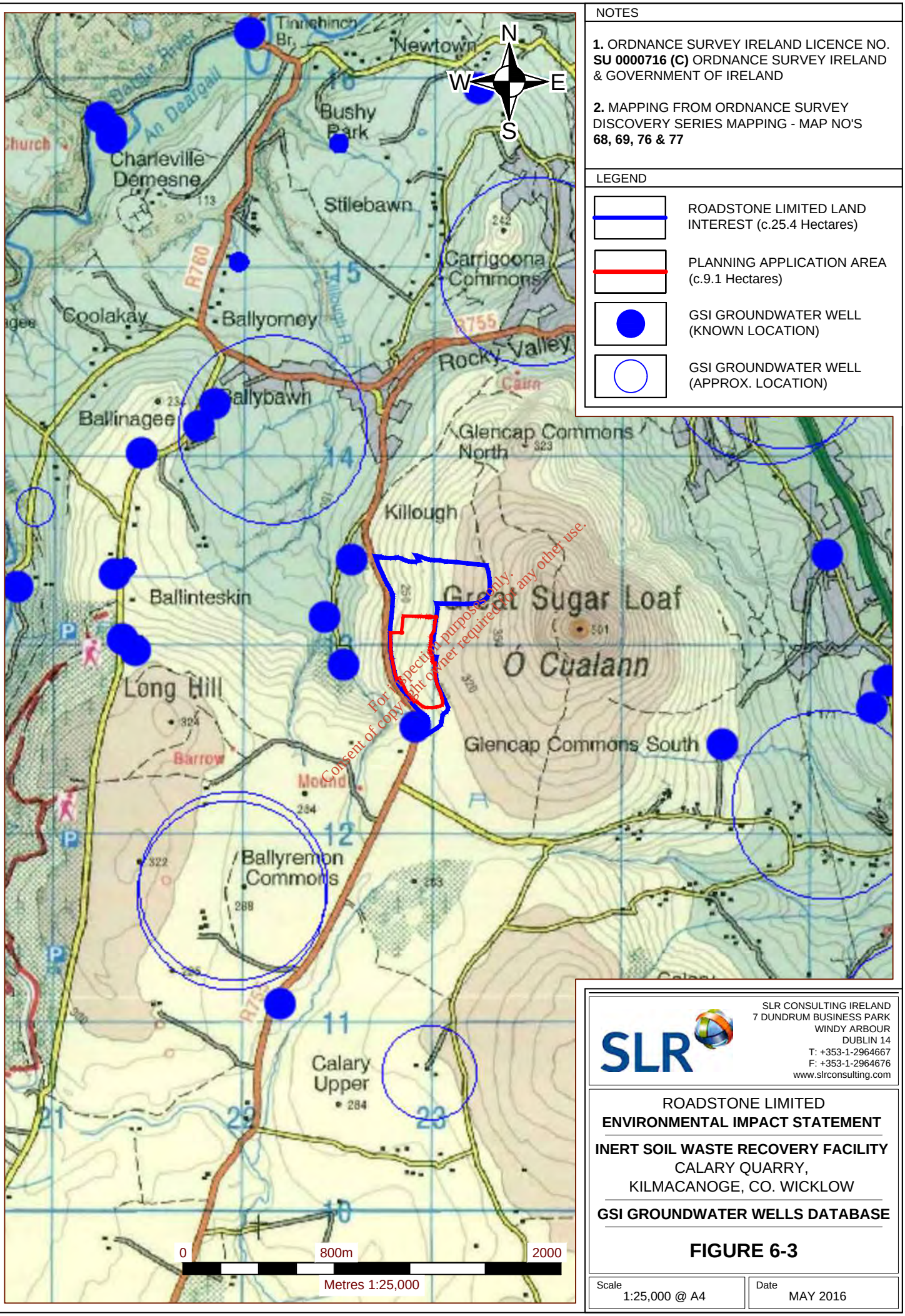
AQUIFER VULNERABILITY MAP

FIGURE 6-2

Scale	Date
1:25,000 @ A4	MAY 2016

00180.00109.0.FIG_6-2.Aquifer Vulnerability.dwg



NOTES

1. ORDNANCE SURVEY IRELAND LICENCE NO. **SU 0000716 (C)** ORDNANCE SURVEY IRELAND & GOVERNMENT OF IRELAND

2. MAPPING FROM ORDNANCE SURVEY DISCOVERY SERIES MAPPING - MAP NO'S **68, 69, 76 & 77**

LEGEND

- ROADSTONE LIMITED LAND INTEREST (c.25.4 Hectares)
- PLANNING APPLICATION AREA (c.9.1 Hectares)
- GSI GROUNDWATER WELL (KNOWN LOCATION)
- GSI GROUNDWATER WELL (APPROX. LOCATION)

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ROADSTONE LIMITED

ENVIRONMENTAL IMPACT STATEMENT

INERT SOIL WASTE RECOVERY FACILITY
CALARY QUARRY,
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GSI GROUNDWATER WELLS DATABASE

FIGURE 6-3

Scale	Date
1:25,000 @ A4	MAY 2016

00180.00109.0.FIG_6-3.GSI GW Wells.dwg

SW1 (2015)
SW2 HISTORICAL

SW2 (2015)
SW3 HISTORICAL

N
W
E
S

GW1

DISCHARGE POINT (2015)

SW1 (HISTORICAL)

GW3

QUARRY VOID
(2014 + 2015)

GW2

0 80m 200
Metres 1:2500

NOTES

1. ORDNANCE SURVEY IRELAND LICENCE NO. SU 0000716 (C) ORDNANCE SURVEY IRELAND & GOVERNMENT OF IRELAND

2. TOPOGRAPHIC / AERIAL SURVEY SUPPLIED BY SLR CONSULTING IRELAND

LEGEND

- ROADSTONE LIMITED LAND INTEREST (c.25.4 Hectares)
- PLANNING APPLICATION AREA (c.9.1 Hectares)
- GW1 — GROUNDWATER MONITORING LOCATION
- SW1 — SURFACE WATER MONITORING LOCATION

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ROADSTONE LIMITED
ENVIRONMENTAL IMPACT STATEMENT

INERT SOIL WASTE RECOVERY FACILITY
CALARY QUARRY,
KILMACANOGE, CO. WICKLOW

SURFACE WATER & GROUNDWATER MONITORING LOCATIONS

FIGURE 6-4

Scale	Date
1:2,500 @ A3	MAY 2016

00180.00109.0.FIG_6-4.SW and GW Monitoring Locations.dwg

N
W
E
S

INTERMITTENT SPRING

CONNECTION TO OFFSITE DISCHARGE

HYDROCARBON INTERCEPTOR

SETTLEMENT POND

CLEARWATER POND

CULVERT

SURFACE WATER PUMPED FROM QUARRY / BACKFILL FLOOR

INTERMITTENT SPRING

R755 REGIONAL ROAD

0 20 40 60 80m 120 160 200

Metres 1:2000

NOTES

1. ORDNANCE SURVEY IRELAND LICENCE NO. SU 0000716 (C) ORDNANCE SURVEY IRELAND & GOVERNMENT OF IRELAND

2. TOPOGRAPHIC / AERIAL SURVEY SUPPLIED BY SLR CONSULTING IRELAND

LEGEND

- PLANNING APPLICATION AREA (c.9.1 Hectares)
- EX-PIT STREAM / DRAIN
- TEMPORARY SPRING
- DIRECTION OF DRAINAGE

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ROADSTONE LIMITED

ENVIRONMENTAL IMPACT STATEMENT

INERT SOIL WASTE RECOVERY FACILITY

CALARY QUARRY,
KILMACANOGE, CO. WICKLOW

SITE WATER MANAGEMENT SYSTEM

FIGURE 6-5

Scale	Date
1:2,000 @ A3	MAY 2016

00180.00109.0.FIG_6-5.Site Water Management System.dwg

PLATES

Plate 6-1
View of Calary Quarry from West

Plate 6-2
Evidence of Temporary Springs at North-Eastern Corner of Quarry

Plate 6-3
Former Settlement Tank System (now disbanded)

Plate 6-4
Existing High Level Sump and Discharge Pipe

Plate 6.5
View North Showing Water Filled Quarry Void (May 2014)

APPENDICES

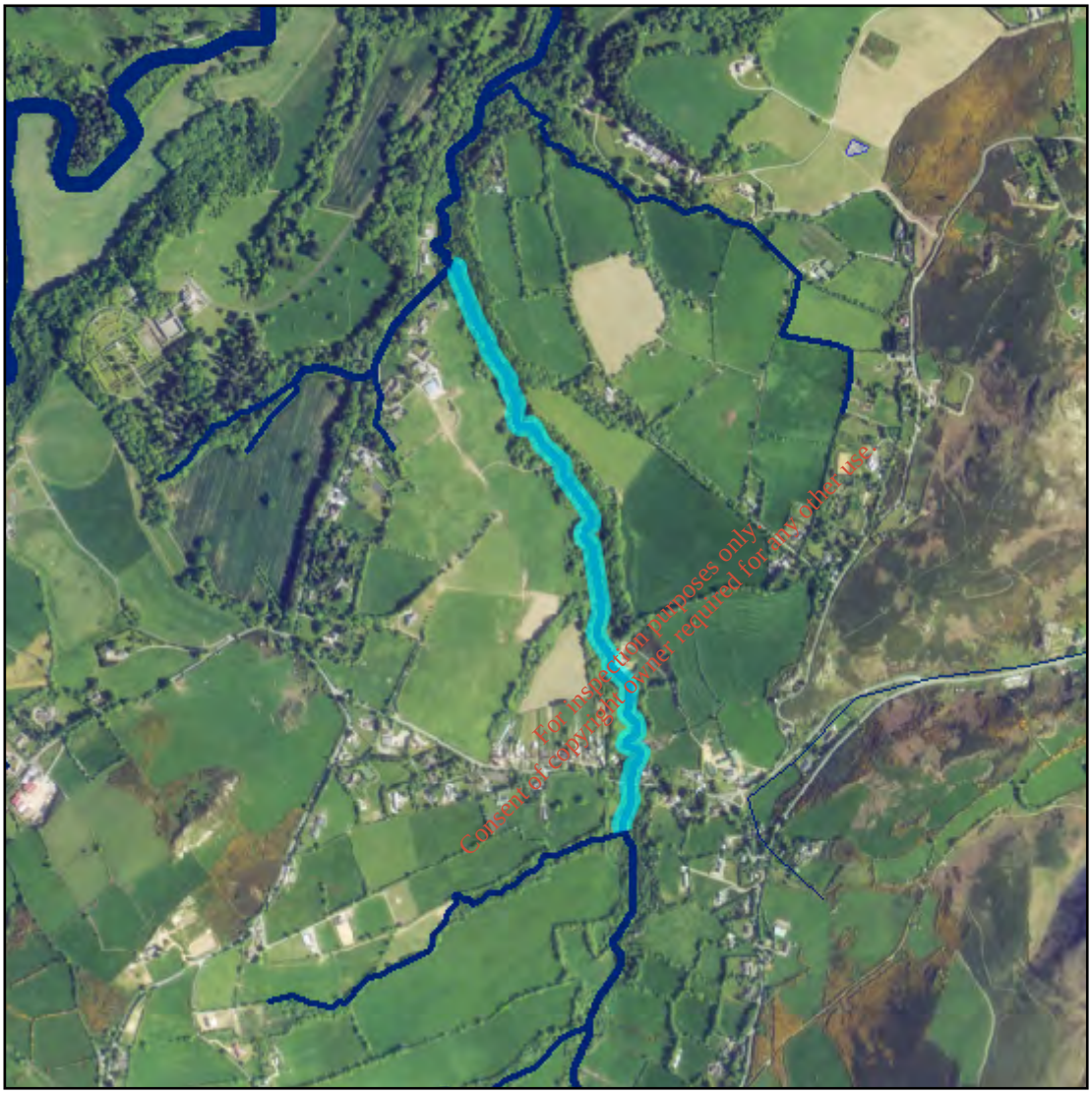
APPENDIX 6-A
EPA Flow Duration Curve Report

Environmental Protection Agency

Estimation of Flow Duration Curve for Ungauged Catchment

River Name	Killough(10_1351)
XY Location	322390,214864 (ING)

River Segment Map



Disclaimer

The source of hydrometric data used to estimate the flow duration curve ordinates for ungauged catchments was obtained from (1) water level data and (2) the rating curve(s) generated for each hydrometric station. The Environmental Protection Agency and the Office of Public Works used these data, respectively, to calculate daily mean flows. The daily mean flows were then used by the Environmental Protection Agency to prepare flow duration curves for each station. Neither body accepts any liability for the subsequent handling of the data.

The user should familiarise himself/herself with the catchment being studied and confirm that the ungauged site is in a natural catchment where flows conditions are suitable for the use of the model.

It is strongly recommended that the user examine the catchment descriptors contained in the report produced and confirm that the percentages of the various constituent elements are comparable to a natural catchment.

If the flow in a catchment is not entirely natural, the estimation of flows using the model in these catchments could be affected due to:

- existence of local conduit karst within the catchment;
- the selected location itself is on local conduit karst;
- regulation of the river flow on the river channel (e.g. power station, sluice gates etc)
- impacts of abstractions upstream of the selected location or the impact of the discharge associated with the abstraction into the same/different catchment;
- estimates of flow being sought at locations effected by storage effects at, or near, lake outfalls;
- lack of similar catchments with observed flows, ie where catchment descriptors lie outside the range of available gauging station catchments (e.g. the catchment area is under 5 km²);
- any other special circumstances that may affect river flows.

Expert judgement will be required to ensure that the estimate of flow is not unduly affected by any of these influences.

Please note that the model does not provide estimates of flood peaks and, specifically, should not be used for that purpose.

The EPA has also prepared estimates of DWF and long term 95 percentile flows which are also presented on the EPA web site. These data are presented at http://www.epa.ie/whatwedo/monitoring/water/hydrometrics/data/

The data produced by the model for specific stations should be compared to the data contained in this file of DWF and long term 95percentile flows.

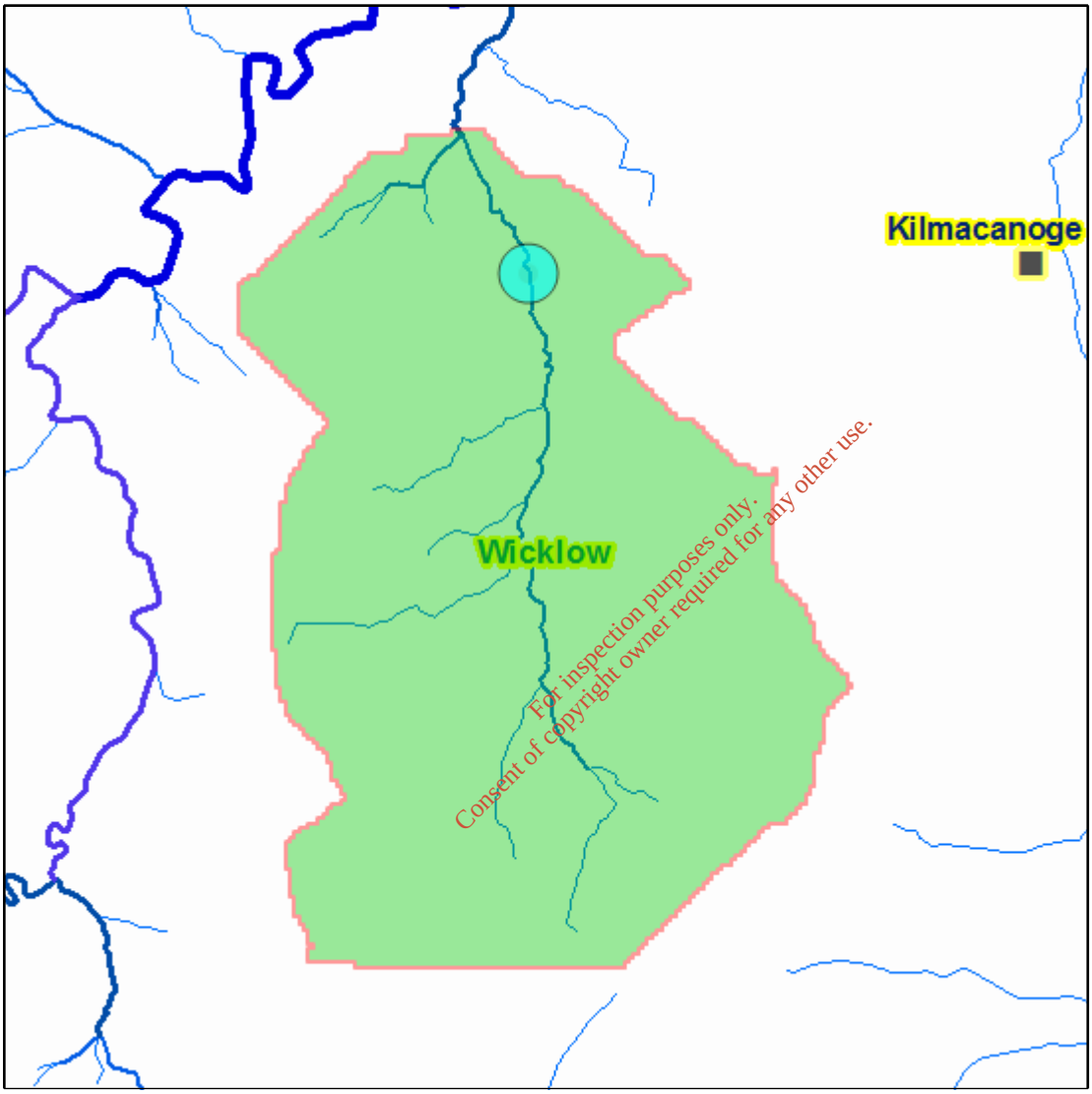
Disclaimer
The source hydrometric data used to estimate the flow duration curve ordinates for ungauged catchments was obtained from (1) water level data and (2) the rating curve(s) generated for each hydrometric station. The Environmental Protection Agency and the Office of Public Works used these data, respectively, to calculate daily mean flows. The daily mean flows were then used by the Environmental Protection Agency to prepare flow duration curves for each station. Neither body accepts any liability for the subsequent handling of the data.

Environmental Protection Agency

Estimation of Flow Duration Curve for Ungauged Catchment

River Name	Killough(10_1351)
XY Location	322390,214864 (ING)

Nested Catchment Map

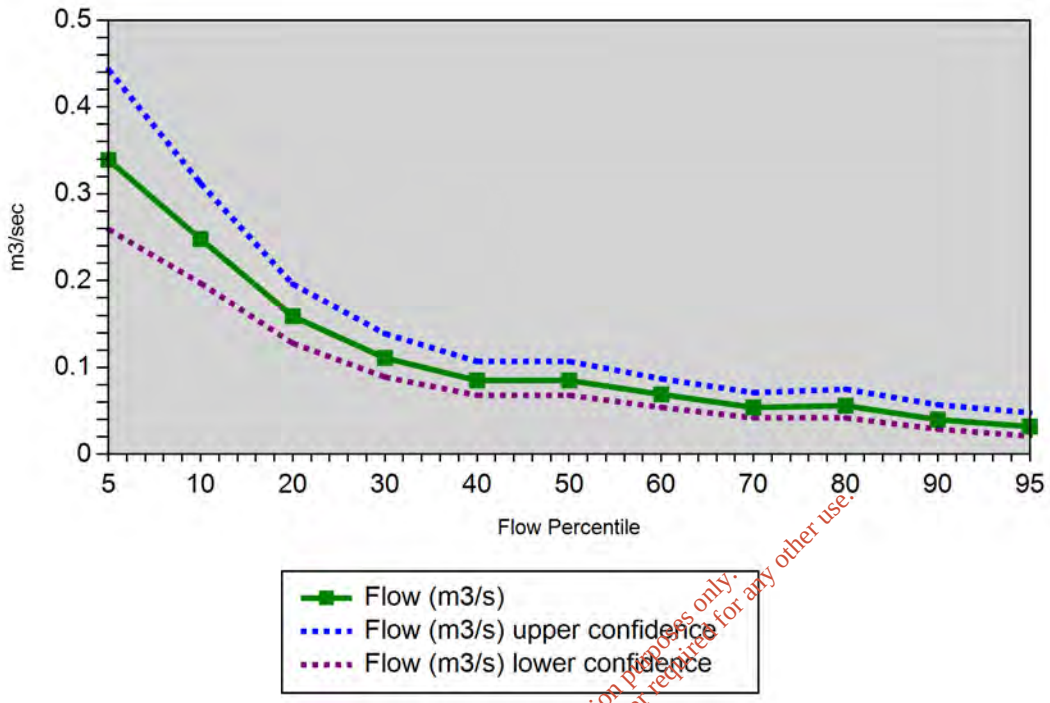


Disclaimer
The source hydrometric data used to estimate the flow duration curve ordinates for ungauged catchments was obtained from (1) water level data and (2) the rating curve(s) generated for each hydrometric station. The Environmental Protection Agency and the Office of Public Works used these data, respectively, to calculate daily mean flows. The daily mean flows were then used by the Environmental Protection Agency to prepare flow duration curves for each station. Neither body accepts any liability for the subsequent handling of the data.

Estimation of Flow Duration Curve for Ungauged Catchment

Environmental Protection Agency

Flow Duration Curve (Flow in m3/sec)



%ile	flow(m3/sec)	upper 95% confidence limit m3/sec	lower 95% confidence limit m3/sec
5	0.339	0.443	0.259
10	0.248	0.312	0.197
20	0.159	0.196	0.128
30	0.111	0.139	0.089
40	0.085	0.107	0.068
50	0.085	0.107	0.068
60	0.069	0.087	0.054
70	0.054	0.071	0.042
80	0.056	0.075	0.042
90	0.04	0.057	0.029
95	0.032	0.048	0.021

Environmental Protection Agency

Estimation of Flow Duration Curve for Ungauged Catchment

Catchment Descriptors		
General		
Descriptor	**Unit**	**Value**
Area	sq km	6.5
Average Annual Rainfall (61-90)	mm/yr	850
Stream Length	km	7.8
Drainage Density	Channel length (km)/catchment area (sqkm)	1.2
Slope	Percent Slope	13
FARL	Index (range 0:1)	1

Soil	
Code	**% of Catchment**
Poorly Drained	20.3
Well Drained	77.7
Alluvmin	0.7
Peat	1.3
Water	0
Made	0

Disclaimer
The source hydrometric data used to estimate the flow duration curve ordinates for ungauged catchments was obtained from (1) water level data and (2) the rating curve(s) generated for each hydrometric station. The Environmental Protection Agency and the Office of Public Works used these data, respectively, to calculate daily mean flows. The daily mean flows were then used by the Environmental Protection Agency to prepare flow duration curves for each station. Neither body accepts any liability for the subsequent handling of the data.

Environmental Protection Agency

Estimation of Flow Duration Curve for Ungauged Catchment

Subsoil Permeability		
Code	**Explanation**	**% of Catchment**
H	High	10.5
M	Moderate	18.9
L	Low	11.1
ML	Moderate/Low	0
NA	No Subsoil/Bare Rock	59.5

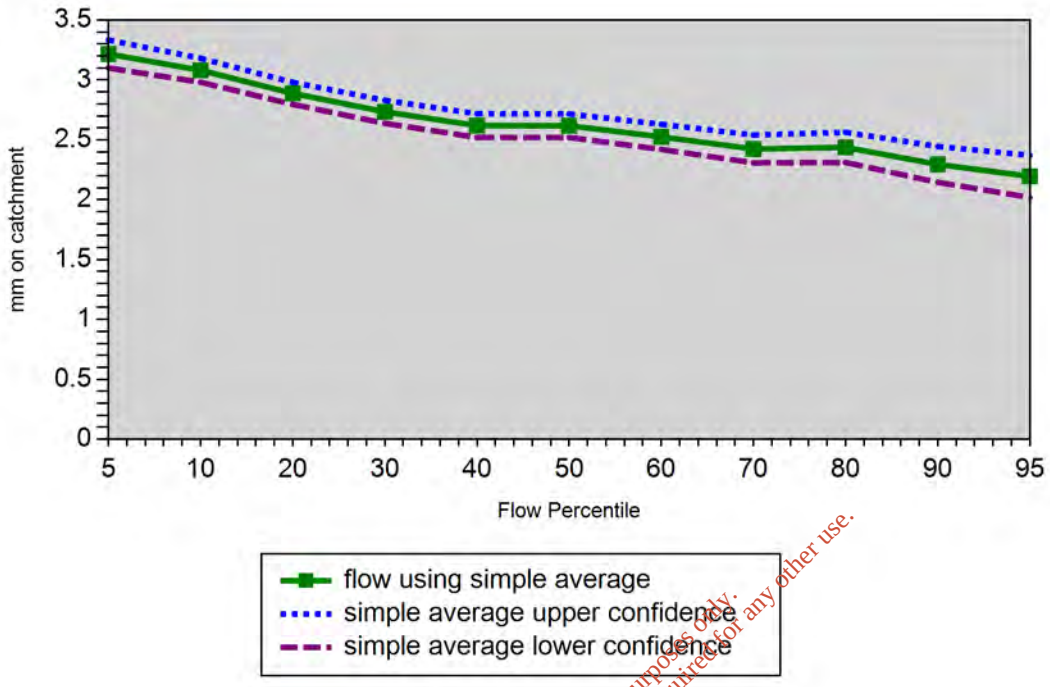
Aquifer		
Code	**Explanation**	**% of Catchment**
LG_RG	LG:Locally important sand-gravel aquifer RG: Regionally important sand-gravel aquifer	6.8
LL	Locally important aquifer which is moderately productive only in local zones	8.4
LM_RF	LM: Locally important aquifer which is generally moderately productive RF: Regionally important fissured bedrock aquifer	0
PU_PL	PU: Poor aquifer which is generally unproductive PL: Poor aquifer which is generally unproductive except for local zones	84.9
RKC_RK	Regionally important karstified aquifer dominated by conduit flow	0
RKD_LK	Regionally important karstified aquifer dominated by diffuse flow	0

Stations in Pooling group			
%ile Flow	**Station 1**	**Station 2**	**Station 3**
5	07001	25040	25107
10	07001	25040	25107
20	07001	25040	25107
30	07001	25040	25107
40	07001	25040	25107
50	10021	09009	12001
60	10021	09009	12001
70	10021	09009	12001
80	12001	10028	09009
90	12001	10028	09009
95	12001	10028	09009

Estimation of Flow Duration Curve for Ungauged Catchment

Environmental Protection Agency

Flow Duration Curve (mm on catchment)



Log Flow (mm on catchment)			
%ile	mm	upper 95% confidence limit	lower 95% confidence limit
5	3.217	3.334	3.1
10	3.081	3.181	2.981
20	2.888	2.98	2.796
30	2.734	2.83	2.638
40	2.619	2.718	2.52
50	2.618	2.716	2.52
60	2.525	2.63	2.42
70	2.424	2.54	2.308
80	2.437	2.563	2.311
90	2.295	2.445	2.145
95	2.195	2.371	2.019

APPENDIX 6-B
Water Quality Results

City Analysts Limited
Environmental Laboratories

City Analysts Limited,
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Ringsend,
Dublin 4.

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Fax:(01) 613 6008
Email:info@cityanalysts.ie

www.cityanalysts.ie

Customer Contact: Dominica Baird

Customer: SLR Consulting

Customer Address: 7 Dundrum Business Pk
Windy Arbour
Dublin 14

Report Reference: 14-02241-
Report Version: 3
Reason for report re-issue: Provisional report issued

Report Date: 12/05/2014

Customer PO No.: Dominica Baird

Chain of Custody No.:

Certificate Of Analysis

Analysis of 1 sample(s) submitted on 02/05/2014 is now complete.
We have the pleasure of enclosing your certificate of analysis.

Should you have any queries regarding the report or require any further services, we would be happy to discuss your requirements. For additional information about the company please log-on to our web site at the above address.

Thank you for choosing City Analysts Limited. We look forward to assisting you again.

Authorised By: Laura Walsh **Date:** 12/05/2014

Note: Information on methods of analysis and performance characteristics is available on request.

Note: Results relate only to the items tested.
Test report shall not be reproduced except in full or with written approval of City Analysts Ltd .

Template 1146
Revision 017

City Analysts Limited
Environmental Laboratories

City Analysts Limited,
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Ringsend,
Dublin 4.

Tel:(01) 613 6003 /6 /9
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Email:info@cityanalysts.ie

www.cityanalysts.ie

Certificate of Analysis

Customer Contact: Dominica Baird

Customer: SLR Consulting

Customer Address: 7 Dundrum Business Pk
Windy Arbour
Dublin 14

Report Reference: 14-02241-
Report Version: 3

Sample Description: SW 1
Sample Type: Surface Water
Date Sampled: 02/05/2014
Lab Reference Number: 176206

Site/Method Ref.	Analysis Start Date	Parameter	Result	Units	PV Value	Accreditation Status
D/3000	06/05/2014	Ammonia as N	0.02	mg/l	-	INAB
D/1003	02/05/2014	CBOD5	<2	mg/l	-	INAB
D/3000	06/05/2014	Chloride	<10	mg/l	-	INAB
D/1009	06/05/2014	COD	9	mg/l	-	INAB
SUB C		Diesel Range Organics	<0.010	mg/l	-	NON
SUB C		Mineral Oil	<0.010	mg/l	-	UKAS
D/3000	06/05/2014	Nitrate as NO3	<8.9	mg/l	-	INAB
D/3000	06/05/2014	Ortho-phosphate as P	0.025	mg/l	-	INAB
D/1041	02/05/2014	pH	7.72	pH Units	-	INAB
D/1005	02/05/2014	Temperature	15.5	ºC	-	NON
D/1049	03/05/2014	TSS	2	mg/l	-	INAB

Note:

NAC & ATC - No abnormal change and acceptable to customers.
TVC - Total Viable Count
PV Value is the parametric value, taken from European Communities, (Drinking Water) (No. 2) Regulations, 2007. S.I. No. 278 of 2007, and relates only to drinking water samples.
Site D = Analysed at City Analysts Dublin. Site L = Analysed at City Analysts Limerick. Site SUBC= Analysed at a subcontracted lab

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Customer Contact: Dominica Baird

Customer: SLR Consulting

Customer Address: 7 Dundrum Business Pk
Windy Arbour
Dublin 14

Report Reference: 15-00644-
Report Version: 1

Report Date: 25/02/2015

Customer PO No.: Q15-00149
Chain of Custody No.:

Certificate Of Analysis

Analysis of 4 sample(s) submitted on 11/02/2015 is now complete.
We have the pleasure of enclosing your certificate of analysis.

Should you have any queries regarding the report or require any further services, we would be happy to discuss your requirements. For additional information about the company please log-on to our web site at the above address.

Thank you for choosing City Analysts Limited. We look forward to assisting you again.

Authorised By: Melissa Brady

Date: 25/02/2015

Note: Information on methods of analysis and performance characteristics is available on request.

Note: Results relate only to the items tested.
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Revision 018

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Certificate of Analysis

Customer Contact: Dominica Baird

Customer: SLR Consulting

Customer Address: 7 Dundrum Business Pk
Windy Arbour
Dublin 14

Report Reference: 15-00644-
Report Version: 1

Sample Description: SW1
Sample Type: Surface Water
Date Sampled: 10/02/2015
Lab Reference Number: 200457

Site/Method Ref.	Analysis Start Date	Parameter	Result	Units	PV Value	Accreditation Status
D/3000	18/02/2015	Ammonia as N	0.03	mg/l	-	INAB
D/1003	11/02/2015	CBOD5	<2	mg/l	-	INAB
D/3000	18/02/2015	Chloride	11.67	mg/l	-	INAB
D/1009	12/02/2015	COD	17	mg/l	-	INAB
D/3000	18/02/2015	Nitrate as NO3	<8.9	mg/l	-	INAB
SUB C		Diesel Range Organics	0.026	ug/l	-	NON
L/3071		Mineral Oil	<0.001	mg/l	-	NON
D/3000	18/02/2015	Ortho-phosphate as P	<0.025	mg/l	-	INAB
D/1041	12/02/2015	pH	7.50	pH Units	-	INAB
D/1049	14/02/2015	TSS	11	mg/l	-	INAB

Note:

NAC & ATC - No abnormal change and acceptable to customers.
TVC - Total Viable Count
PV Value is the parametric value, taken from European Communities, (Drinking Water) Regulations, 2014. S.I. No. 122 of 2014, and relates only to drinking water samples.
Site D = Analysed at City Analysts Dublin. Site L = Analysed at City Analysts Shannon. Site SUBC= Analysed at a subcontracted lab

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Certificate of Analysis

Customer Contact: Dominica Baird

Customer: SLR Consulting

Customer Address: 7 Dundrum Business Pk
Windy Arbour
Dublin 14

Report Reference: 15-00644-
Report Version: 1

Sample Description: SW2
Sample Type: Surface Water
Date Sampled: 10/02/2015
Lab Reference Number: 200458

Site/Method Ref.	Analysis Start Date	Parameter	Result	Units	PV Value	Accreditation Status
D/1041	12/02/2015	pH	7.58	pH Units	-	INAB
D/1049	14/02/2015	TSS	<2	mg/l	-	INAB
SUB C		Diesel Range Organics	0.19	ug/l	-	NON
L/3071		Mineral Oil	<1.00	ug/l	-	NON
D/3000	18/02/2015	Nitrate as NO3	<8.9	mg/l	-	INAB
D/3000	18/02/2015	Ortho-phosphate as P	<0.025	mg/l	-	INAB
D/1009	12/02/2015	COD	23	mg/l	-	INAB
D/3000	18/02/2015	Chloride	11.99	mg/l	-	INAB
D/3000	18/02/2015	Ammonia as N	0.02	mg/l	-	INAB
D/1003	11/02/2015	CBOD5	<2	mg/l	-	INAB

Note:

NAC & ATC - No abnormal change and acceptable to customers.
TVC - Total Viable Count
PV Value is the parametric value, taken from European Communities, (Drinking Water) Regulations, 2014. S.I. No. 122 of 2014, and relates only to drinking water samples.
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Certificate of Analysis

Customer Contact: Dominica Baird

Customer: SLR Consulting

Customer Address: 7 Dundrum Business Pk
Windy Arbour
Dublin 14

Report Reference: 15-00644-
Report Version: 1

Sample Description: Anarry Void
Sample Type: Surface Water
Date Sampled: 10/02/2015
Lab Reference Number: 200459

Site/Method Ref.	Analysis Start Date	Parameter	Result	Units	PV Value	Accreditation Status
D/3000	18/02/2015	Ammonia as N	0.02	mg/l	-	INAB
D/1003	11/02/2015	CBOD5	<2	mg/l	-	INAB
D/3000	18/02/2015	Chloride	<10	mg/l	-	INAB
D/1009	12/02/2015	COD	21	mg/l	-	INAB
D/3000	18/02/2015	Nitrate as NO3	<8.9	mg/l	-	INAB
L/3071		Mineral Oil	<1.00	ug/l	-	NON
D/3000	18/02/2015	Ortho-phosphate as P	<0.025	mg/l	-	INAB
SUB C		Diesel Range Organics	<0.021	ug/l	-	NON
D/1049	14/02/2015	TSS	3	mg/l	-	INAB
D/1041	12/02/2015	pH	8.05	pH Units	-	INAB

Note:

NAC & ATC - No abnormal change and acceptable to customers.
TVC - Total Viable Count
PV Value is the parametric value, taken from European Communities, (Drinking Water) Regulations, 2014. S.I. No. 122 of 2014, and relates only to drinking water samples.
Site D = Analysed at City Analysts Dublin. Site L = Analysed at City Analysts Shannon. Site SUBC= Analysed at a subcontracted lab

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Certificate of Analysis

Customer Contact: Dominica Baird

Customer: SLR Consulting

Customer Address: 7 Dundrum Business Pk
Windy Arbour
Dublin 14

Report Reference: 15-00644-
Report Version: 1

Sample Description: Anarry Discharge
Sample Type: Surface Water
Date Sampled: 10/02/2015
Lab Reference Number: 200460

Site/Method Ref.	Analysis Start Date	Parameter	Result	Units	PV Value	Accreditation Status
D/1049	14/02/2015	TSS	5	mg/l	-	INAB
L/3071		Mineral Oil	<1.00	ug/l	-	NON
D/1041	12/02/2015	pH	8.11	pH Units	-	INAB
D/3000	18/02/2015	Ortho-phosphate as P	<0.025	mg/l	-	INAB
D/3000	18/02/2015	Nitrate as NO3	<8.9	mg/l	-	INAB
D/1009	12/02/2015	COD	14	mg/l	-	INAB
SUB C		Diesel Range Organics	<0.021	ug/l	-	NON
D/3000	18/02/2015	Ammonia as N	<0.01	mg/l	-	INAB
D/3000	18/02/2015	Chloride	<10	mg/l	-	INAB
D/1003	11/02/2015	CBOD5	<2	mg/l	-	INAB

Note:

NAC & ATC - No abnormal change and acceptable to customers.
TVC - Total Viable Count
PV Value is the parametric value, taken from European Communities, (Drinking Water) Regulations, 2014. S.I. No. 122 of 2014, and relates only to drinking water samples.
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Template 1146
Revision 018

APPENDIX 6-C

Discharge Water Quality Results (2015-2016)

Calary Quarry Discharge Water Quality Monitoring Results

	Sample Date	03/02/2015	03/03/2015	14/04/2015	18/05/2015	03/06/2015	07/07/2015	14/08/2015	16/09/2015	06/10/2015		01/12/2015		02/02/2016
Parameter	**Lab ID**	**119695**	**120241**	**121090**	**121757**	**122140**	**122836**	**123442**	**124205**	**124649**		**125834**		**127024**
Ammonia as NH_4	mg/l	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10		<0.10		<0.10
BOD	mg/l	<2	<2	<2	<2	<2	<2	<2	<2	<2		<2		<2
COD	mg/l	<4	<4	7	6	10	<4	6	7	5		8		<4
Mineral Oil #	mg/l	<0.01	0.017	0.040	<0.010	<0.010	<0.010	<0.010	<0.010	0.023		<0.010		<0.010
Nitrate	mg/l	3	3	3	2	2	1	2	1	1		2		2
pH	pH Units	8.1	8.1	7.9	8.3	8.3	8.6	8.5	8.7	8.4		7.9		7.9
Molybdate React P	mg/l	0.03	<0.03	0.03	0.02	0.02	<0.03	<0.03	0.11	<0.03		0.05		0.05
Suspended solids	mg/l	3	<1	3	2	1	2	2	2	<1		3		<1