Irish Cement Ltd.
Integrated Pollution Control License Register Number P0030-04.

AQUATIC MONITORING OF THE RIVER NANNY NEAR DULEEK, CO. MEATH

2018 Report

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1. INTRODUCTION

1.1 Background

Irish Cement Ltd. operates a large limestone quarry and cement manufacturing facility at the Platin Works near Drogheda, County Louth. The trade effluent from this site is discharged into the River Nanny near Duleek, Co. Meath. This discharge is licensed by the Environmental Protection Agency (EPA) under Integrated Pollution Control (IPC) License Register Number P0030-05. This license has a number of conditions in relation to the monitoring of the receiving water. The current assessment addresses the receiving water monitoring issues in relation to the following conditions as follows:

- *Condition 6.14.1 The licensee shall annually evaluate the impact, if any, of the discharge to the River Nanny. The evaluation shall be based on the ambient sampling required under Schedule C.6 Ambient monitoring [receiving water monitoring]. In particular the evaluation shall consider the impact of fine particulate matter in the discharge*

- *Condition 6.14.2 The licensee shall, if necessary, based on the results of the evaluation incorporate additional mitigation measures for the treatment of surface water prior to discharge.*

- *Condition 6.14.3 The acute toxicity of the undiluted final effluent to at least four aquatic species from different trophic levels shall be determined by standardized and internationally accepted procedures and be carried out by a competent laboratory. The name of the laboratory and the scope of testing to be undertaken shall be subject to the agreement of the agency. The testing shall be carried out within three months of the date of grant of this license. Copies of the complete reports shall be submitted to the agency within 6 weeks of completion of the testing.*

- *Condition 6.14.4 Having identified the most sensitive species outlined in Condition 6.14.3, subsequent compliance toxicity monitoring on the two most sensitive species shall be carried out annually by the laboratory identified in Condition 6.14.3, or an alternative as may be agreed. Copies of the complete reports shall be submitted to the agency within 6 weeks of completion of the testing.*

This study provides all the required information and meets these conditions for the 2018 monitoring period. The current study was undertaken by Ecofact Environmental Consultants Ltd. and follows similar assessments completed in from 2008 to 2017 as part of the requirements of the relevant discharge license (Ecofact, 2008 to Ecofact, 2017).

1.2 The River Nanny

The River Nanny (OS Catchment No: 160; EPA code: 08N01) is located in County Meath in the Eastern River Basin District (Hydrometric Area 8 - Nanny-Delvin). It rises near Kentstown and flows east through Duleek and Julianstown. It then enters the sea on the southern side of Laytown, roughly 6 km south of Drogheda. Overall, it spans a length of approximately 28km draining a catchment area of 239 km^2 (McGinnity *et al*, 2003). Upstream of the discharge point, the catchment area of the River Nanny is approximately 200km^2. At this location, the river has a 50%ile and 95%ile flow of 1.91m^3/s and 0.323m^3/s respectively (EPA Hydrometric data system).

In Appendix 2, a summary of water quality in the River Nanny along with overall water quality in Hydrometric Area 8 during the most recently published EPA survey is presented. The most recent Q-values are from 2014 when the Environmental Protection Agency (EPA) concluded that the entire River Nanny was in an unsatisfactory ecological condition (source EPA website). Of the 7 stations sampled, five were rated 'Moderately Polluted (Q3)' and two were rated 'Slightly polluted (Q3-4)' which are both considered unsatisfactory conditions. The stations at Folistown (0400) and the east Bridge at Kentstown (0110) were both rated 'Moderately Polluted (Q3)', equivalent to Water Framework Directive (WFD) 'poor status'. The nearest EPA biological monitoring station upstream of the Irish Cement discharge is at the Bridge NE of Bellewstown House (station 0500). In 2014, this part of the river was rated 'Slightly polluted (Q3-4)' corresponding to WFD 'moderate status'. The nearest EPA biological monitoring station downstream of the discharge point is at Beaumont Bridge (0600). The River Nanny was rated ''Moderately Polluted (Q3)' by the EPA at Beaumont Bridge in 2014.

The River Nanny is in the Eastern River Basin District and is within the Nanny Water Management Unit (WMU). A WMU is a geographic area primarily defined by similar hydrology and topography. The land use is predominantly agricultural (ERBD, 2009)

2. METHODS

2.1 Site location

The locations of the six study sites (Site N1 to N6) are given in Table 1 and Figure 1. The discharge point from the Irish Cement plant is also indicated in Figure 1. The sites surveyed are at the same locations as in previous assessments (i.e. Ecofact, 2008 - Ecofact, 2017). The sampling location for the Irish Cement discharge was located at the outfall point to the Nanny River.

Table 1 Location of six biological and sediment sampling sites.

Site	N1	N2	N3	N4	N5	N6
Habitat Category	Riffle	Glide	Pool	Pool	Glide	Riffle
Sample type	Receptor	Receptor	Receptor	Reference	Reference	Reference
Location	Downstream of outfall	Downstream of outfall	Downstream of outfall	Upstream of outfall	Upstream of outfall	Upstream of outfall
NOS Grid Reference	O07976 69254	O07865 69186	O07783 69171	O07589 69186	O07537 69165	O07349 69166

2.2 Biological Assessments

2.1.1 Macroinvertebrate sampling

Semi-quantitative sampling of benthic macroinvertebrates was undertaken at the six sites listed using kick or sweep sampling (Toner *et al*, 2005). Sampling occurred on the 31st May and 1st of June 2018. Water levels were considered low at the time of the survey. Three of the sites were located within a 0.5 km section of river extending upstream of the Irish Cement discharge point (reference sites), and three sites were located over a similar distance downstream (receptor sites). Representative riffle, glide and pool habitats (EA, 2003) were sampled at both reference and receptor locations. Site 1 was located downstream of an old mill weir - while site N2 was located upstream of this impoundment. The presence of this weir on the section can be expected to influence local sedimentation rates.

The biological sampling procedure followed at each site involved the use of a 'D' shaped hand net (mesh size 0.5 mm; 350 mm diameter) which was submerged on the river bed with its mouth directed upstream. The substrate upstream of the net was then kicked for one minute to dislodge invertebrates, which were subsequently caught in the net. This was repeated at three points along/across the watercourse. Stone washings and vegetation sweeps were also undertaken over a further 1-minute period to ensure a representative sample of the fauna present at each site was collected.

All three samples of invertebrates from each substation were combined and live sorted on the river bank for 20 minutes using a headband magnifier. Identification was undertaken on site, with any unknown specimens fixed in alcohol for later identification in the laboratory.

2.1.2 Biotic Indices

2.1.2.1 The Quality Rating (Q) System

The Quality Rating (Q) System (Toner *et al*, 2005) is the standard biotic index which is used by the EPA. Invertebrates are categorised into one of five groups, depending on their sensitivity to pollution. Further details on the Q-rating system and its relationship to the European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I. 272 of 2009) are provided in Appendix 1.

2.1.2.2 BMWP (Biological Monitoring Working Party) Score

In the revised BMWP scheme (Walley and Hawkes, 1997) biotic index of water quality, each family recorded in the sample is assigned a habitat specific score. This score depends on the pollution sensitivity of the invertebrate family together with the characteristics of the study site. A site is classed as one of the following depending on substrate type: riffle (>= 70% boulders and pebbles), pool (>= 70% sand and silt) or riffle/pool (the remainder). The BMWP score is the sum of the individual scores of the families recorded at each site - a family scores if present. A higher BMWP score reflects better water quality with a score over 100 being indicative of very good water quality.

2.1.2.3 LIFE (Lotic-invertebrate Index for Flow Evaluation) Score

The LIFE (Extence *et al*., 1999) method links macroinvertebrate species and families to existing flow patterns. The LIFE score index was calculated in this assessment by assigning each individual family group a defined flow group (I to VI), then based on the macroinvertebrate estimated abundance category a score is obtained from a matrix and assigned to each taxon present in the sample. The sum of the individual family flow scores is then divided by the number of individual scoring families. Generally higher LIFE scores reflect higher flows.

2.1.2.4 PSI (Proportion of Sediment-sensitive Invertebrates)

The Proportion of Sediment-sensitive Invertebrates (PSI) index is a biomonitoring tool used to identify the degree of sedimentation in rivers and streams and was developed using a similar approach to LIFE. The methodology employed is set out in Extence *et al*. (2011). In order to calculate the PSI index, each family are assigned Fine Sediment Sensitivity Ratings (FSSR) in the form of a Sediment Sensitivity Group. Abundance weighted scores for group A and B are added and divided by the scores for all four groups A to D which is then multiplied by 100 to obtain a PSI score. The PSI scores are used to identify the impacts of deposited fine sediment and range from 0 (entirely silted river bed) to 100 (entirely silt-free river bed).

2.3 Sediment and Water Sampling

A sediment sample was obtained for analyses at each of the six sites using a large trowel. Three sub-samples were taken from undisturbed relatively homogeneous sediment deposits and combined into a composite sample for each site. Each sample was placed into a mixing bowl and objects such as sticks and leaves etc. were removed. The sample was then stirred thoroughly with a mixing spoon to homogenize and placed into a labelled container.

A water sample of the effluent, along with Sites N1 and N6, was taken on the 1st June 2018. During sampling appropriate measures to prevent contamination from other sources was undertaken and all sampling equipment had been thoroughly cleaned. Samples were labeled and placed in a cooler box and were promptly delivered to the laboratory (ALS Life Sciences) by courier.

The water sample from the effluent was analysed for Total Hydrocarbons, Heavy Metals and Petroleum Range Organics. BOD (Biochemical Oxygen Demand) and Total Hardness were analysed in samples taken from Site N1 and N6. On-site measurements of water temperature, dissolved oxygen and pH were also taken using portable meters.

2.4 Eco-toxicology testing

Condition 6.14.4 of the IPPC license requires toxicological testing to be carried out on the two most sensitive species tested in 2010. The species chosen for toxicity resting was a freshwater crustacean *Daphnia magna* which was subject to an immobilization test and a bioluminescent bacteria *Vibrio fischeri* in a Microtox - light inhibition test. The samples from the discharge were taken on the 12th of June 2018.

Toxic pollutants can be described in terms of acute and chronic toxicity. Acute toxicity is when a large dose of pollutant is released in a short period of time whereas chronic toxicity is a low dose of pollutant released over a long period of time, the former having more of a lethal effect on the biota of the receiving water. Chronic toxicity

can be lethal or sub-lethal and can result in the mal-functioning of organisms by impairing biochemical, physiological, behavioral or life-cycle functions. When toxic pollutants enter the aquatic environment they may be altered by temperature, the quality of the water, pH and hardness. It is well known that temperature influences the metabolic activity and behavior of organisms however it can also alter the physical and chemical state of pollutants. For some toxicants, increasing temperature results in increasing toxicity of the pollutant.

Toxic contaminants are rarely individual chemicals, effluents or metals; more often than not they are mixture of poisons. When two or more pollutants are present in an effluent they may exert a combined effect on an organism which is said to be *additive*, the contaminants may also interfere with one another, an antagonistic effect or the overall effect of the pollutant on an organism maybe greater than when acting alone, a synergism effect (Mason, 2002). In order to minimize the effects of pollutants on the environment toxicity tests have been developed to assess the toxicity of an effluent and to predict, in conjunction with other information e.g. available dilution, chemical characterisation, the impact it will have on the receiving waterbody. The receiving waterbody dictates the selection of the test organisms. The receiving waterbody is freshwater. Toxicity testing is essentially for environmental protection of an area, to control the wastes from animal residues and humans, to monitor industrial and manufacturing processes in order to issue discharge licences, for legal and ethical issues i.e. to protect biota in aquatic ecosystems.

2.1.1 Daphnia magna Bioassay

The *Daphnia* bioassay was carried out following standard methods as described in UK Environment Agency guidelines (2007). The effluent was tested for toxicity at the following concentrations 6.25, 12.5, 25, 50, and 100%. Twenty *Daphnia* neonates (animals less than 24 hours old) were tested for each concentration. These animals were added into 4 replicates of five animals per test chamber for each concentration. Testing was carried out in a constant temperature room at a temperature of 20ºC ± 2 throughout the test. A light regime of 16 hours light / 8 hours dark was used throughout the testing period. The test duration was 48 hours. Filtered groundwater collected locally was used as control and dilution water. The *D. magna* were obtained from in house cultures at ASU.

2.2.2 Vibrio fischeri bacteria bioassay using Microtox system

This test involves using the marine bacteria *Vibrio fischeri*. The luminescent bacteria *Vibrio fischeri* are used exclusively in the Microtox system. Testing was carried out following the ISO 113348-3 Guidelines. The concentrations of effluent tested ranged from 6.25% to 80%. Two replicates were used for each concentration tested. A concurrent reference toxicant bioassay was also carried out to determine the health and suitability of the bacteria.

2.2.3 Statistical Analyses

Statistical analyses to generate LC_{50} (Lethal Concentration to cause 50 percent mortality) or EC_{50} (Effective Concentration to cause 50 percent effect) data were performed using the ToxCalc v5.0.32 Environmental Toxicity Data Analysis System, (Tidepool Scientific 2007). Statistical analyses on the Microtox Data were performed using the proprietary Microtox Omni software (Azur Environmental, 1995).

2.5 Habitat Survey

Physical habitat assessments were undertaken at the six biological sampling sites. Habitat has a key influence on the macroinvertebrate communities, in rivers and streams. The physical habitats of the study sites were assessed in relation to macroinvertebrates using a method given by Barbour and Stribling (1991). This method assesses habitat parameters and rates each parameter as optimal, sub-optimal, marginal or poor (scores 5, 10, 15 and 20 respectively). The scores for each parameter are then added up to give an overall habitat score.

5.6 Other WQ parameters

During the current survey Conductivity (µs cm^{-1}), water temperature (^{o}C), and Dissolved Oxygen (mgl^{-1} and % saturation) were measured on-site using portable meters. These parameters, along with salinity and pH were also measured in the water sample provided to ASU for eco-toxicology testing.

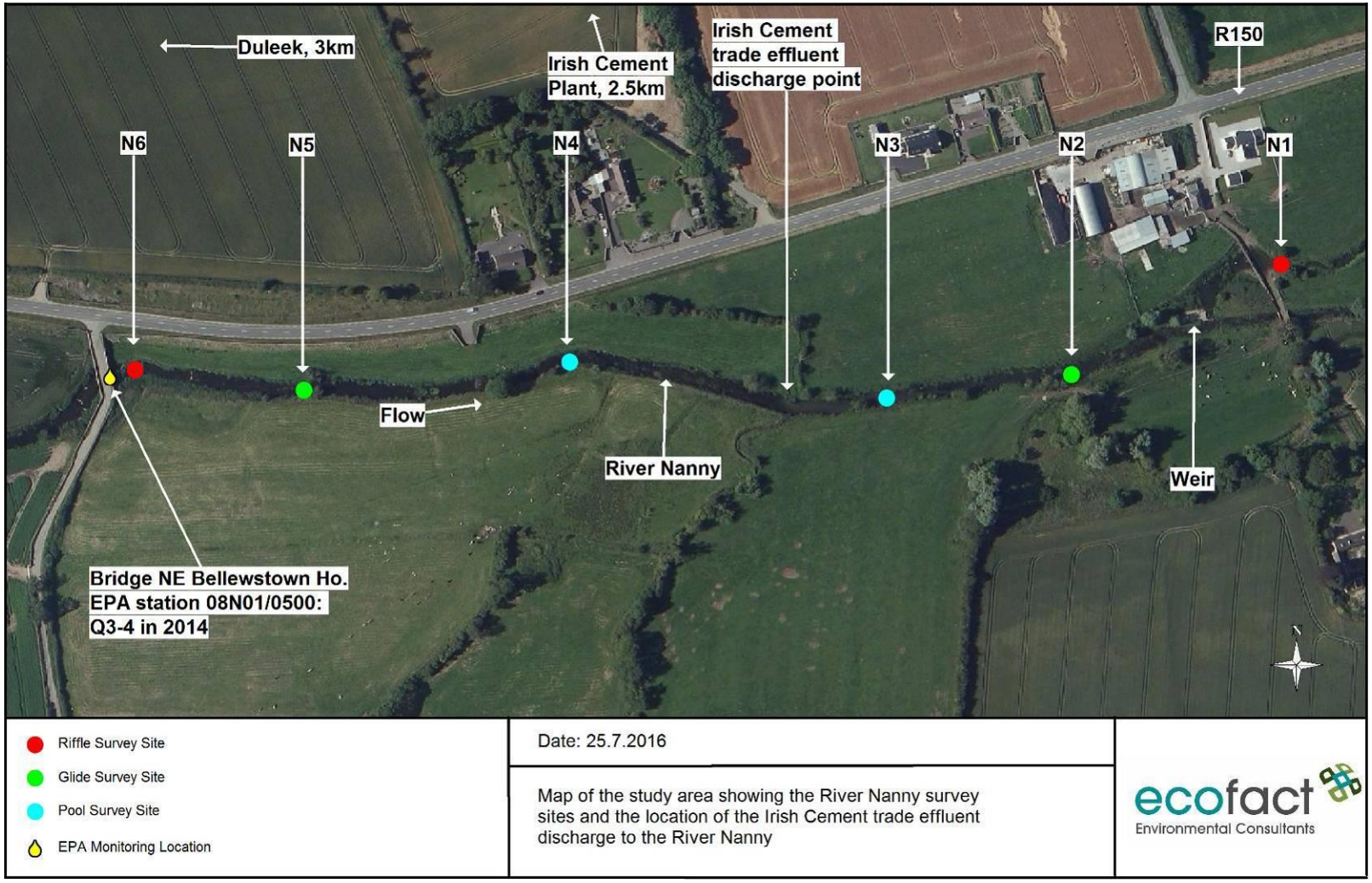

Figure 1 Map of the study area showing the location of the Irish Cement outfall to the River Nanny and river survey sit

3.0 RESULTS

3.1 Physical Habitat

The physical habitat characteristics of the six sites assessed during the June 2018 survey are presented in Table 2. The physical habitat assessment of the six sites with respect to their suitability for macroinvertebrate production is presented in Table 3. All sites were rated sub-optimal for macro-invertebrate production with generally marginal pool quality, habitat complexity and canopy cover. Siltation in the surveyed stretch of river continues to be a problem despite the unusually wet summer brought about by the high rainfall levels. In the past, the EPA has indicated that land disturbance (such as ploughing) could possibly be a cause of siltation in the river. Indeed, a large proportion of lands in the study area are used for crops such as potatoes and grains which require ground preparation and exposing bare soil, with potential for suspended solids runoff.

Table 2 Physical characteristics at the six sampling sites.

Parameter	N1	N2	N3	N4	N5	N6
Habitat Category	Riffle	Glide	Pool	Pool	Glide	Riffle
Sample type	Receptor	Receptor	Receptor	Reference	Reference	Reference
Wetted width (m)	5	5	5	5	5	6
Bank height (cm)	130	100	100	100	150	50
Bank cover (%)	95	95	100	100	95	100
Bank slope (degrees)	50	65	70	80	65	40
Canopy cover (%)	10	5	5	5	0	0
Flow (cm/s)	15	5	0	0	5	25
Riffle (%)	35	0	0	0	20	35
Glide (%)	45	10	0	0	20	35
Pool (%)	45	90	100	100	60	30
Mean depth (cm)	25	40	40	40	30	30
Maximum depth (cm)	60	60	70	70	70	75
Rock (%)	20	20	40	20	25	5
Cobble (%)	30	40	25	15	25	15
Gravel (%)	20	15	15	15	20	60
Fine (%)	30	25	20	50	30	20
In-stream vegetation (%)	25	30	35	25	25	25

Table 3 Physical habitat assessment of the six sites for their suitability for macroinvertebrate production (adapted from Barbour and Stribling, 1991).

Site **Habitat Category** **Sample type**	**N1** **Riffle** **Receptor**	**N2** **Glide** **Receptor**	**N3** **Pool** **Receptor**	**N4** **Pool** **Reference**	**N5** **Glide** **Reference**	**N6** **Riffle** **Reference**
Bottom substrate	10	5	5	5	5	10
Habitat complexity	15	10	10	10	10	15
Pool quality	5	5	5	5	5	5
Bank stability	15	15	20	20	15	20
Bank protection	15	15	20	20	15	20
Canopy	10	10	10	10	10	5
Score	**70**	**60**	**70**	**70**	**60**	**75**
Overall Assessment	**Suboptimal**	**Suboptimal**	**Suboptimal**	**Suboptimal**	**Suboptimal**	**Suboptimal**

3.2 Temperature, Conductivity, Dissolved Oxygen and other WQ parameters

3.2.1 Results of the on-site assessments

On-site water quality assessments were undertaken on the 1st of June 2018 at Sites N1 and N6 on the River Nanny. The results are provided in Table 4 below. Water temperatures were considered high during the

survey, with temperatures ranging from 19.7 at Site N1 to 20.1 at Site N6. Dissolved oxygen levels were considered suppressed based on the on-site assessment using a portable meter. This may have been due to the high-water temperatures, but both sites were also visibly polluted (eutrophication). Conductivity and pH were within a normal range at both sites.

Table 4 Results of the June 2018 on-site water quality assessments.

	Site N1	Site N6
Temperature (°C)	19.7	20.1
Dissolved Oxygen (%)	81.2	79.8
Dissolved Oxygen (mg O_2l^{-1})	7.34	7.1
Conductivity (µS cm^{-1})	641	330
pH	8.5	8.7

3.2.2 Laboratory results

Biochemical Oxygen Demand (BOD) and Total Hardness were assessed at Sites N1 and N6 on the River Nanny. BOD both upstream and downstream of the discharge was below the detectable limit (<1mg/l). Total hardness downstream (Site N1) and upstream (Site N6) of the discharge was 355mg/l and 361mg/l respectively.

Total Petroleum Hydrocarbons and Mineral Oils in the discharge sample were both below the level of detection (<1mg/l). The results of the Metals screening are provided in Table 6 and no issues were detected.

Table 5 Hydrocarbon results from the sample taken of the Irish Cement discharge on 1st June 2018. (ISO17025 Accredited).

Hydrocarbon	LOD/Units	Results	Method
TPH / Oil and Greases	<1mg/l	<1	TM235
Mineral Oil	<1mg/l	<1	TM235

Table 6 Heavy Metal results from the sample taken of the Irish Cement discharge on 1st June 2018. (ISO17025 Accredited).

Heavy Metal	Units	Results	E.Q.S S.I. No.272 of 2009	Method
Arsenic	<0.5µg/l	<0.5	<25µg/l	TM152
Cadmium	<0.08µg/l	<0.08		TM152
Chromium	<1µg/l	3.21		TM152
Copper	<0.3µg/l	<0.3	5µg/l	TM152
Lead	<0.2µg/l	<0.2	7.2µg/l	TM152
Nickel	<0.4µg/l	<0.4	20µg/l	TM152
Selenium	<0.5µg/l	1.72		TM152
Zinc	<1µg/l	<1		TM152

Table 7 BOD (Biochemical Oxygen Demand) and Total Hardness results from Sites N1 and N6 on the River Nanny, sample taken on 1st June 2018. (ISO17025 Accredited = #).

	N1	N6	Method
BOD (mg/l) #	<1	<1	TM045
Total hardness (mg/l) #	355	361	TM228
Conductivity (µS/cm)	293	467	

Based on the on-site measurements and laboratory results, there was no evidence to suggest that the River Nanny was being negatively affected by the Irish Cement discharge. The overall results obtained are similar to the previous monitoring assessments.

3.3 Sediment PSD

The results of the particle size distribution (PSD) analyses of fine sediments sampled at the six survey sites are presented in Table 8. This assessment was undertaken to assess the effect of the discharge on PSD in the river downstream of the discharge point. Fine particles in the discharge could affect aquatic ecology in the River Nanny.

The smallest particle category was very fine (silt/clay) of size 0.063mm or less. At site N1 there was mostly finer particles of silt/clay with 41.91% of all particles <0.063mm and very little gravel with 87% of particle being <5.6mm. Site N2 showed a similar trend with no gravel present and 82.9% of particles being <0.063mm (silt/clay category). Site N3 is more similar to site N1 with no particles >9.5mm and 57.67% of all particles being <0.063mm.

The same pattern is seen for the reference sites with low amounts of gravel at N4, and 100% of the sediment being <9.5mm and 98.72% being <5.6mm. There was again a large amount of silt at this site with 61.51% of particles passing through the <0.063mm filter. Site N5 also contained no gravel and 98.45% of the sample was <5.6mm. Indeed, at this site 53.38% of particles were <0.063mm in size. At Site N6, 99.47% of particles were <9.5mm however there was slightly more gravel than the other sites with just 85.92% of all particles <5.6mm. There was the lowest amount of siltation at this site with 20.53% of particles <0.063. However, this site also the only true riffle site and the river is eroding here.

Table 8 Results of the Particle Size Distribution Analysis of fine sediments sampled at the six survey sites.

Category	Particle size (mm)	% Passing in each sample					
Habitat type Sample type		N1 Riffle Receptor	N2 Glide Receptor	N3 Pool Receptor	N4 Pool Reference	N5 Glide Reference	N6 Riffle Reference
Gravel	9.5	94.99	100	100	100	100	94.47
	5.6	87.14	100	99.94	98.72	98.45	85.92
Sand	4	82.46	99.79	99.81	98.03	97.83	79.91
	2	74.10	99.50	99.12	95.44	96.06	63.28
	1	66.43	99.21	97.73	91.97	93.43	50.07
	0.6	61.04	98.43	94.10	88.67	89.58	40.76
	0.250	48.89	94.70	74.97	75.50	66.37	25.44
	0.125	45.75	90.19	66.42	69.00	59.23	22.76
Silt/Clay	0.063	41.91	82.90	57.67	61.51	53.38	20.53

Overall the silt/clay faction at the receptor sites (N1-N3) ranged from 41.91 to 82.90%, while that at the reference sites (N4-N6) ranged from 20.53 to 61.51%. Smaller particle sizes of sand (<0.125mm – <1mm) and silt/clay (<0.63) were more abundant at reference Site N1 downstream of the discharge than at N6 upstream. However, the pool sites (N3 and N4) upstream and downstream of the discharge point were very similar with respect to PSD.

In comparison to results obtain in 2017 for the six sites the percentage of gravel has decreased, and the percentage of fine particles has increased. This increased siltation is the result of background processes and the ongoing ecological deterioration of the River Nanny. The role of the weir in the receptor area of the river is also significant and is causing increased silt deposition in this area. Based on the results on onsite conservation it is considered to be highly unlikely that any differences in the PSD between sites upstream and downstream of the discharge are caused by the discharge itself.

3.4 Macroinvertebrates and Biological Water Quality

The current survey was carried out during June 2018. The abundance categories have been assigned based on the number of individuals found in each sample. Macroinvertebrate results are presented in Table 9 with biotic indices presented in Table 10.

3.4.1 Site N1 (Receptor site)

Macroinvertebrate family diversity at Site N1, the receptor riffled site was 14. Group B species were represented by cased caddisfly larvae *Sericostoma personatum* in scarce/few numbers and *Athripsodes cinereus* in small numbers. Group C species present in small numbers were the molluscs *Bithynia tentaculata* and *Planorbis Complanatus,* the mayfly larvae *Serratella ignita*, the caseless caddisfly larvae *Hydropsyche sitalai,* the cased caddisfly larvae *Athripsodes cinereus,* the damselfly larvae *Agrion splendens*, the beetle *Elmis sp.* and the bug *Gerris* sp. Other group C species *Gammerus duebini* and *Sigara dorsalis* were present in dominant and scarce/few numbers respectively. Three group D species were present including the segmented worm Lumbricidae, the leech *Erpobdella octulata* and the crustacean *Asellus aquaticus* all in scarce/few numbers. Based on the macroinvertebrates present a Q-rating of Q3 was assigned, which is a 'Moderately Polluted' rating. The BMWP and ASPT scores for the site are 67.6 and 5.2 respectively, which indicate 'Moderately Impacted' conditions. The LIFE and PSI scores are 6.5 and 51.9 respectively, which indicate 'Moderately Sedimented' conditions.

3.4.2 Site N2 (Receptor site)

The receptor glide site (N2) contained 12 macroinvertebrate families. Group B species were represented by cased caddisfly larvae *Sericostoma personatum* in scarce/few numbers. Group C species present in small numbers were the mollusc *Bithynia tentaculata,* the cased *caddisfly Polycentropus kingi,* the beetle *Potamonectes depressus elegans* and the bug *Gerris sp.* Group C beetle *Elmis sp.* and caseless caddisfly larvae *Hydropsyche siltalai* were both common while the bugs *Sigara dorsalis* and damselfly larvae *Agrion splendens* were present in scarce/few numbers. The Group C crustacean *Gammerus duebini* were present in excessive numbers.. There was one group D species of crustacean *Asellus aquaticus* present in scarce/few. Based on the macroinvertebrates present a Q-rating of Q3 or 'Moderately Polluted'. The BMWP and ASPT scores for the site are 68.6 and 5.7 respectively. The LIFE and PSI scores are 7.2 and 61.5 respectively. These indices again point to moderate conditions

3.4.2 Site N3 (Receptor site)

At the receptor pool site (N3) 9 macroinvertebrates families were recorded. There was one Group B species recorded at this site, the cased caddisfly larvae *Sericostoma personatum* in small numbers. All Group C species were present in small numbers with the exception of the bug *Sigara dorsalis* which was present in scarce few numbers and the crustacean *Gammerus duebini* present in excessive numbers. The remainder included two molluscs *Bithynia tentaculata* and *Planorbis complanatus* and the caseless caddisfly *Hydropsyche siltalai*. Other Group C species present in small numbers include the damselfly *Agrion splendens*, the beetle *Elmis sp.* and the bug *Gerris sp.* The Q-rating for this site is Q3. There were no group D species recorded at this site. The BMWP and ASPT scores for the site are 51.3 and 5.7 respectively. The LIFE and PSI scores are 6.7 and 52.3 respectively. This site is again assessed as being 'Moderately Polluted'.

3.4.2 Site N4 (Reference site)

At the reference pool site (N4) 10 macroinvertebrates families were recorded. There were two Group B species recorded at this site, both were cased caddisfly larvae with *Sericostoma personatum* present in scarce/few numbers and *Potamophylax sp*. present in small numbers. Group C species included the molluscs *Ancylus fluviatilis*, *Bithynia tentaculata* and *Planorbis complanatus*, the caseless caddisfly larvae *Hydropsyche siltalai*, the damselfly larvae *Agrion splendens* all present in small numbers. Other group C species consisting of the beetles *Elmis sp*. and *Haliplus sp.* along with the bug *Gerris sp*. also present in small numbers. The Q-rating for this site is Q3. The BMWP and ASPT scores for the site are 58.3 and 5.8 respectively. The LIFE and PSI scores are 6.7 and 50 respectively. This site is again assessed as being 'Moderately Polluted'.

3.4.2 Site N5 (Reference site)

At Site N5 18 macroinvertebrates families were recorded. There were three species from Group B consisting of the cased caddisfly larvae *Sericostoma personatum*, *Hydroptilidae* and *Athripsodes cinereus* present in small numbers. Group C species present in small numbers include the molluscs *Ancylus fluviatilis* and *Bithynia tentaculata*, the caseless caddisfly larvae *Polycentropus kingi*, the damselfly larvae *Agrion splendens* and the beetles *Potamonectes depressus elegans*, *Haliplus sp* and the bug *Gerris sp*. Other Group C species present are the freshwater shrimp *Gammarus duebini* present in dominant numbers, the mayfly larvae *Serratella ignita*, the bug *Sigara dorsalis* and the mollusc *Planorbis complanatus* present in scarce/few numbers. The caseless caddisfly larvae *Hydropsyche siltalai* and the bug *Elmis sp* were present in common numbers. There were two group D species present including the leech *Erpobdella octoculata* and the crustacean *Asellus aquaticus* both in scarce/few numbers. This site was rated again as Q3 or 'Moderately Polluted'. The BMWP and ASPT scores for the site are 90 and 5 respectively. The LIFE and PSI scores are 6 and 60 respectively. These indices again point to moderate conditions.

3.4.2 Site N6 (Reference site)

A total of 17 different families were recorded at the reference riffle site (N6). There are three Group B species present at this site the cased caddisfly larvae *Sericostoma personatum* and *Athripsodes cinereus* present in small numbers and *Potamophylax sp.* present in common numbers. The group C species present include the bug *Gerris sp*. in common numbers and the mollucs *Planorbis complanatus* and *Bithynia tentaculata* present in small numbers. The Group C species of mayfly larvae *Serratella ignita*, caseless caddisfly larvae *Polycentropus kingi,* the true fly larvae green chironomid and the damselfly larvae *Agrion splendens* are all present in scarce/few numbers. Other group C species include *Gammarus duebeni* present in dominant numbers, the caseless caddisfly larvae *Hydropsyche siltalai* in common numbers and the truefly Simulaidae were numerous. Group D species present include the segmented worms Lumbricidae and leech *Erpobdella octoculata* present in scarce/few numbers, the mollusc *Pisidium sp.* and crustacean *Asellus aquaticus* present in scarce/few numbers. This site was rated again as Q3 or 'Moderately Polluted'. The BMWP and ASPT scores for the site are 86.9 and 5.4 respectively. The LIFE and PSI scores are 6.5 and 64.7 respectively.

Table 9 Results of the on-site macroinvertebrate survey at the six survey sites on the River Nanny during June 2018.

Habitat Category **Sample type**	**Pollution sensitivity group**	**Site N1** Riffle receptor	**Site N2** Glide receptor	**Site N3** Pool receptor	**Site N4** Pool reference	**Site N5** Glide reference	**Site N6** Riffle reference
SEGMENTED WORMS (Annelida, Clitellata)							
Aquatic earthworm (Lumbricidae)	D	Scarce/Few					Scarce/Few
LEECHES (Hirudinea)							
Erpobdellidae							
Erpobdella octoculata	D	Scarce/Few				Scarce/Few	Scarce/Few
SNAILS (Mollusca, Gastropoda)							
Ancylidae							
River limpet *Ancylus fluviatilis*	C					Small numbers	
Hydrobiidae							
Common Bithynia *Bithynia tentaculata*	C	Small numbers	Small Numbers	Small Numbers	Small Numbers	Small Numbers	Small Numbers
Planorbidae							
Planorbis Complanatus	C	Small numbers		Small numbers	Small numbers	Scarce/Few	Small numbers
MUSSELS (Mollucsa, Lamellibranchiata)							
Orb/ Pea Mussels (Sphaeridae)							
Pisidium sp.	D						Scarce/Few
CRUSTACEANS (Crustacea)							
Amphipods (Amphipoda, Gammaridae)							
Freshwater shrimp *Gammarus duebeni*	C	Dominant	Excessive	Excessive	Excessive	Dominant	Dominant
Isopods (Isopoda, Asellidae)							
Hog louse *Asellus aquaticus*	D	Scarce/Few	Scarce/Few			Scarce/Few	Scarce/Few
MAYFLIES (Uniramia, (Ephemeroptera)							
Empherellidae							
Serratella ignita	C	Scarce/Few				Scarce/Few	Scarce/Few
CASELESS CADDIS FLIES (Trichoptera)							
Grey flags (Hydropsychidae)							
Hydropsyche siltalai	C	Small numbers	Common	Small numbers	Small numbers	Common	Common

Habitat Category **Sample type**	**Pollution sensitivity group**	**Site N1** Riffle receptor	**Site N2** Glide receptor	**Site N3** Pool receptor	**Site N4** Pool reference	**Site N5** Glide reference	**Site N6** Riffle reference
Trumpet-net Caddisflies (Polycentropodidae)							
Polycentropus kingi	C		Small numbers			Small numbers	Scarce/Few
Rhyacophilidae							
Rhyacophila dorsalis	C		Scarce/Few				
CASED CADDIS FLIES (Tricoptera)							
Sericostomatidae							
Black caperer *Sericostoma personatum*	B	Scarce/Few	Scarce/Few	Small numbers	Scarce/Few	Small numbers	Small numbers
Limnephilidae							
Potamophylax sp.	B				Small numbers		Common
Microcaddisflies (Hydroptilidae)	B					Small numbers	
Leptoceridae							
Athripsodes cinereus	B	Small numbers				Small numbers	Small numbers
DAMSELFLIES (Odonata, Zygoptera)	B						
Jewelwings/Demoiselles (Calopterygidae)							
Banded jewelwing *Agrion splendens*	C	Small numbers	Scarce/Few	Small numbers	Small numbers	Small numbers	Scarce/Few
TRUE FLIES (Diptera)							
Blackfly larvae (Simulidae)	C						Numerous
Chironomidae							
Green chironomid	C						Scarce/Few
BEETLES (Coleoptera)							
Riffle beetles (Elmidae)							
Elmis sp.	C	Small numbers	Common	Small numbers	Small numbers	Common	
Diving beetles (Dytiscidae)							
Sub family Hydroporinae							
Potamonectes depressus elegans	C		Small numbers			Small numbers	
Hydrophilidae							
Haliplidae							
Haliplus sp.	C				Small numbers	Small numbers	
BUGS (Hemiptera)							
Corixidae							
Sigara dorsalis	C	Scarce/Few	Scarce/Few	Scarce/Few		Scarce/Few	

Habitat Category Sample type	Pollution sensitivity group	Site N1 Riffle receptor	Site N2 Glide receptor	Site N3 Pool receptor	Site N4 Pool reference	Site N5 Glide reference	Site N6 Riffle reference
Gerridae							
Gerris sp.	C	Small numbers	Small numbers	Small numbers	Small numbers	Small numbers	Small numbers
Family diversity		**14**	**12**	**9**	**10**	**18**	**17**
Note. Scarce/Few = <1%, Small numbers = <5%, Fair numbers = 5-10%, Common = 10-20% Numerous = 25-50%, Dominant = 50-75% and Excessive = >75%							

Table 10 Biological water quality at the six survey sites on the River Nanny during June 2017.

Site and habitat category Site type	Site N1 Riffle Receptor	Site N2 Glide Receptor	Site N3 Pool Receptor	Site N4 Pool Reference	Site N5 Glide Reference	Site N6 Riffle Reference
Number of Families	**14**	**12**	**9**	**10**	**18**	**17**
Q-Value	Q3	Q3	Q3	Q3	Q3	Q3
Q-Status	Moderately polluted	Moderately polluted	Moderately polluted	Moderately polluted	Moderately polluted	Moderately polluted
WFD status	Poor	Poor	Poor	Poor	Poor	Poor
BMWP score	67.6	68.6	51.3	58.3	90	86.9
BMWP category	Moderate	Moderate	Moderate	Moderate	Good	Good
BMWP interpretation	Moderately impacted	Moderately impacted	Moderately impacted	Moderately impacted	Clean but slightly impacted	Clean but slightly impacted
ASPT	5.2	5.7	5.7	5.8	5	5.4
LIFE score	6.5	7.2	6.7	6.7	6.8	6.5
PSI score	51.9	61.5	52.3	50	60	64.7
PSi interpretation	Moderately sedimented	Slightly sedimented	Moderately sedimented	Moderately sedimented	Moderately sedimented	Slightly sedimented

3.4.2 Overview of results

The majority of macroinvertebrates recorded during the current survey belong to Group C and are typically those associated with polluted lowland Irish limestone rivers. Crustacea, particularly *G. duebeni*, far outweighed any other group present, consistently in excessive or dominant numbers. Crustacea and Caddisflies were the most abundant groups recorded, while Molluscs were also well represented.

Compared to 2017 the results were similar, but with some variation in the numbers and groups present. The most apparent difference between 2017 and 2018 is the absence of *Baetis rhodani* and near absence of Simulidae from the kick samples. *Gammarus duebeni* was also the most abundant species recorded in 2017 but increased more so this year. There was a drop in the abundance of Diptera (Chironomids and Simulidae) compared to 2017 but an increase in Trichoptera. Despite these changes relatively similar trends are seen across the two years. Hence, there was no evidence to suggest that the macroinvertebrate community of the River Nanny is being negatively affected by the Irish Cement discharge. The variation in the results between years is likely to be down to environmental conditions. Overall, there is no evidence that the Irish Cement discharge is having a significant influence of the macroinvertebrate community along this stretch of the river.

All the sites were rated 'Slightly Polluted (Q3)' using the EPA Q-rating system (Toner *et al*. 2005), equivalent to Water Framework Directive (WFD) 'Poor' status. This rating was brought about by the small number of mayfly larvae and the absence of pollution sensitive Stonefly larvae. During the current assessment no pollution sensitive (group A) species were recorded at any of the six sites. Since the 2014 study, the Q-ratings for all sites have remained the same (Q3 - 'Moderately polluted') indicating that there has been no deterioration or improvement in water quality with respect to the EPA freshwater biological monitoring system.

All the BMWP scores were less than 100 which is indicative of unsatisfactory water quality. The reduced BMWP scores coincided with observations of filamentous algal growth and excessive siltation along the surveyed stretch of the river. Filamentous algae growth and heavy siltation was recorded at all sites. BMWP scores are proportional to family diversity and the highest score of 90 was at Site N5, corresponding to the category 'Good' and 'Clean but slightly impacted' conditions using BMWP interpretation. It is noted however those macroinvertebrate assemblages in lowland limestone rivers are usually high with respect to BMWP sometimes even in polluted circumstances. Therefore, this interpretation of macroinvertebrate diversity may be misleading. Water quality at all these locations are categorised as 'Moderate'/'Moderately impacted' with the exception of N6 which like N5 was categorised as 'Good' and 'Clean but slightly impacted'. The Average Score per Taxon (ASPT) which is a function of the BMWP score is deemed to more accurately gauge water quality. An ASPT of more than 5.5 is thought to reflect good water quality. Overall, analyzing the ASPT scores over the study area does not point to a significant decrease in water quality at Sites N1, N2 and N3 with reference to Sites N4, N5 and N6.

The LIFE scores across the suite of sites surveyed ranged from 6.5-7.2. Site N1 and N6 received the lowest LIFE scores while the highest LIFE score was obtained in Site N2. Higher LIFE scores are associated with higher flow rates. The LIFE scores are greatly affected by the number of individual species and the variety of macroinvertebrate families supported in each analysed sample. The PSI score reflects the percentage of fine sediment-sensitive taxa present in a sample with higher percentages (61-100%) associated with 'Slightly sedimented' to 'Minimally sedimented/unsedimented' river bed conditions. The PSI scores derived for the sites assessed range from 50 to 64.7%%. Sites N1, N3, N4 and N5 were rated 'moderately sedimented', while sites N2 and N6 were 'Slightly sedimented'. 'Moderately sensitive' (Group B) and 'Highly insensitive' (Group D) were

the two major contributing groups to the FSSR in all six sites. Lower water levels prior to sampling are likely to reflect high levels of sedimentation along the river channel.

There was no discernible difference in water quality between the sites upstream and downstream of the Irish Cement discharge. Overall, the results confirm that biological water quality in the River Nanny is the same upstream and downstream of the Irish Cement discharge. All sites followed the same trend with the exception of Site N2 having scored a higher BMWP but a relatively average PSI compared to the other sites which can be explained by the higher family diversity. Compared to 2014, 2015, 2016 and 2017 there has been no significant change in biological water quality in the surveyed stretch of river i.e. both upstream and downstream of the discharge location. Based on the relative abundance of macroinvertebrate and biotic indices, it is considered that the River Nanny continues to be under considerable ecological pressure as signified by the absence of pollution sensitive indicators, low relative abundance of Group B indicators and domination by pollution tolerant taxa (Group D). As observed from year to year in previous surveys, the macroinvertebrate community in the surveyed stretch of river is variable, indicating ecological instability brought about apparently by pressures in the catchment.

3.5 Toxicology

The toxicity results indicate that the discharge from the Irish Cement Plant is non-toxic to two trophic levels. The results of the *Daphnia magna* bioassay and the Microtox system are outlined below.

3.5.1 Daphnia magna Bioassay

This test was deemed to be valid given that there was greater than 90% survival in the controls indicating that the animals and testing conditions were satisfactory (UK Environment Agency, 2007). Survival across the concentration series of effluent was between 95 and 100% demonstrating that the effluent is non-toxic to *D. magna*. No LC_{50} value was generated for this bioassay due to the non-toxic nature of the effluent. Results of this bioassay are displayed in Figure 2. Water quality measurements in the test chambers remained within normal limits for the duration of the bioassay. These data are presented in Appendix 4. The Daphnia magna 48 h EC_{50} test is shown in Plate 23.

3.5.2 Vibrio fischeri bacteria bioassay using Microtox system

The Microtox bioassay carried out was deemed to be valid. A reference toxicant test was carried out before actual testing of samples took place to ensure that the bacterium and reagents were suitable for testing. The reference toxicant using the Zinc++ ion determined an EC_{50} of 1.3 mg Zn++/L after 15 minutes exposure. This is within the guideline range of 0.6-2.2 mg Zn++/L as specified by the Microtox manufacturer (Azur Environmental, 1995). These data are presented in Appendix 5. Equipment used for this test is shown in Plate 24.

No toxicity was observed between the controls and throughout the effluent concentration series. No significant decrease in light production was observed in any of the concentrations during the test. Some minor light stimulation was observed in all of the concentrations tested. Similar light stimulation has been shown to occur in other non-toxic samples and is an artefact of testing method. ASU have tested non-toxic blank samples (containing de-ionized water and osmotic adjusting solution) and recorded similar results. Based on the supporting data from the other bioassay it appears that this sample is also non-toxic using the Microtox system. The data for the effluent test are presented in Figure 3.

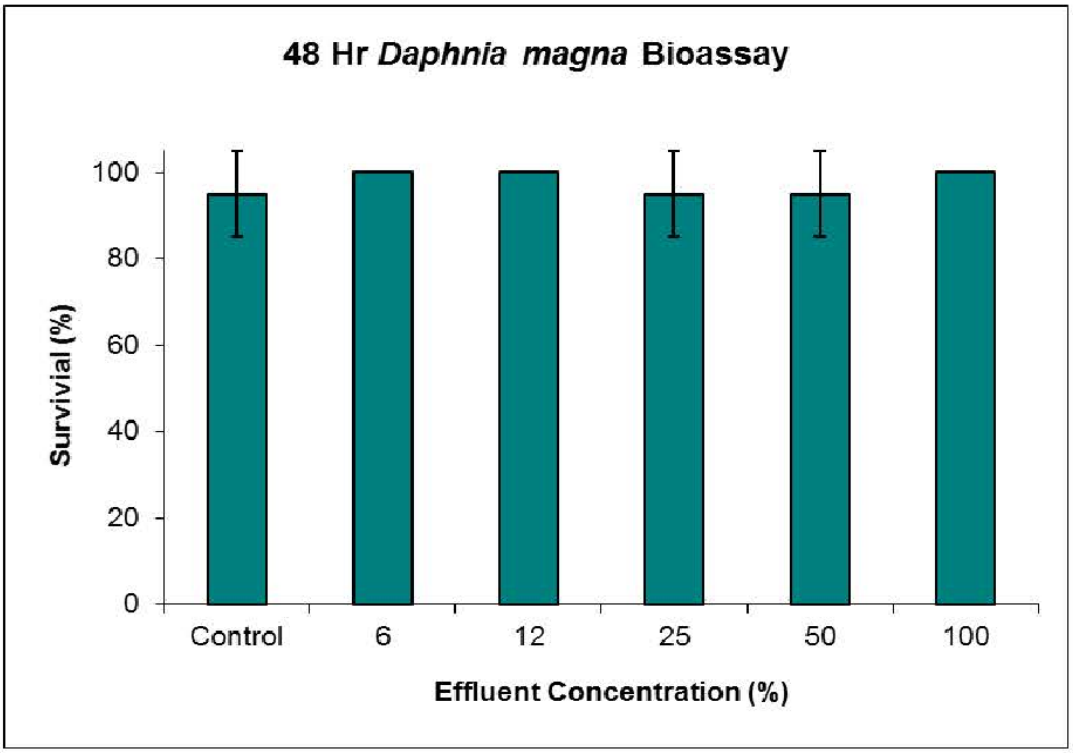

Figure 2 Average survival of *Daphnia magna* after 48 hours in a concentration series of the Irish Cement trade effluent.

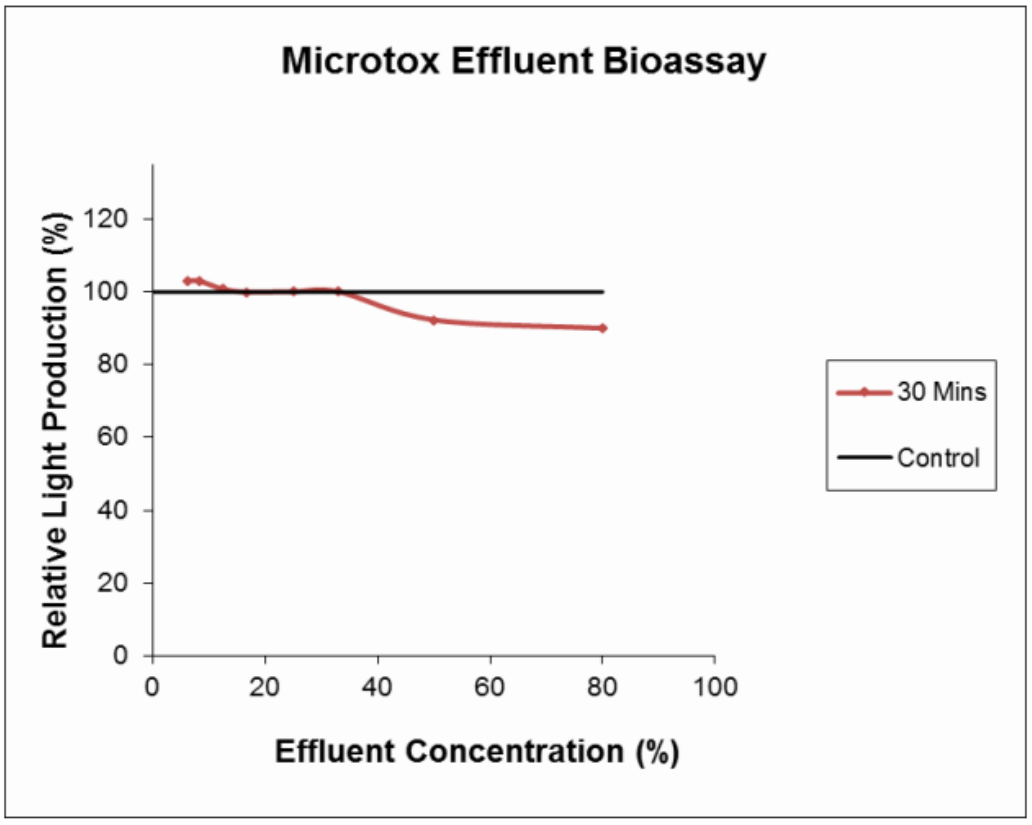

Figure 3 Plot of the Microtox results for Ecofact Nanny effluent sample on 13/06/18. Values represent light production relative to the controls. The highest concentration of effluent tested was 80%.

4.0 SUMMARY AND CONCLUSIONS

Six sites were sampled within 500m upstream and downstream of the Irish Cement trade discharge outflow during June 2018. This is part of a continuous monitoring programme of the treated effluent being discharged from the quarry and manufacturing facility to River Nanny near Duleek, Co. Meath.

The latest biological monitoring completed by the EPA of the River Nanny indicates that the entire river is in an unsatisfactory ecological condition. The nearest EPA biological monitoring stations to the discharge point along the Nanny catchment received either a 'Poor' or 'Moderate' status. The low ecological rating is as a result of high nutrient concentration (Phosphorus, Ammonia, issues with level of oxygen in water). The causes of these pressures have been identified as agriculture, wastewater and industrial discharges, and septic tanks (ERDB, 2009).

Based on the current observations and during analysis of the data collected during 2018, there was no evidence to imply that the Irish Cement trade effluent was impacting on the substrate composition in the River Nanny, particular with reference to smaller sized materials. The primary concern with respect to the Irish Cement trade effluent is fine particles such as fine sands and silt/clay. Sites N3 and N4 above and below the discharge point show no considerable differences when compared with the other sites. Of these six sites, site N2 was composed of greater amounts of finer particles but this can be attributed to the artificial ponding from a downstream impoundment which have all contributed to increasing siltation along the entire stretch of river - which is extremely silted. The percentage of gravel is very high at each site. The subsequent ponding is evident in Plate 6 which shows excessive reed growth. Overall it is concluded that the trade effluent from the Irish Cement Plant is not negatively impacting on the composition of the substrate in the river.

Macroinvertebrate analysis in 2018 resulted in all sites returning a Q3 rating, equivalent to a WFD status 'Moderately polluted'. This again similar to the status of the river found in previous assessments. The most recent EPA biological water quality monitoring results available are from 2014. The nearest EPA biological monitoring station upstream of the discharge point is the Bridge NE of Bellewstown House (station 0500) which was rated ‘Slightly polluted (Q3-4)’ corresponding to WFD ‘moderate status’ in 2014. This site corresponds to site N6. The nearest EPA biological monitoring station downstream of the discharge point is at Beaumont Bridge (0600) was rated ‘Moderately Polluted (Q3)’ corresponding to WFD ‘moderate status’ in 2014.

However, it is clear from the Irish cement surveys that the macroinvertebrate community and structure along the surveyed stretch of river changes from year to year with only pollution tolerant indicators continuing to become more abundant in most recent surveys. This changing state of the river is indicative of background pressures on aquatic ecology, and not directly related to the Irish Cement discharge.

The high BMWP scores and family abundances at sites N5 and N6 can be attributed to the high quality of physical habitat present here with a pronounced riffle and complex substrate that is not present in the other sites due to several reasons one of which is the presence of a weir between sites N2 and N1 with causes artificial ponding around sites N2 and N3 and an increase in emergent vegetation. Also due to the weir, site N1 doesn't receive the full flow of the river and at the time of sampling due to low water levels was only receiving half flow. This difference in physical habitat makes the sites less comparable. In and around the discharge point there was no algal growth and no siltation. Thousands of *Gammarus deubini* were attempting to migrate up the discharge pipe which can be seen from Plate 21. There were also good numbers of Caddisfly larvae on

+rocks in the outflow stream which can be seen in Plate 20. This is indicative of better water quality in the discharge then what was currently in the river. This difference in water quality can be seen in Plates 7 and 19. The absence of B*aetis rhodani* larvae is a possible limitation of one time kick-net sampling and most likely due to the characteristics of its lifecycle. The larvae are generally in low numbers this time of year as most have emerged (Fahy, 1973) so perhaps *B. rhodani* were not in a detectable stage of their lifecycle.

Overall the entirety of the study area showed extreme siltation. This is made worse at sites N2 and N3 due to the presence of the weir which causes ponding increasing siltation even more at these sites. Previous wet years have brought silt down the river which during the drought when samples were taken had settle along this stretch and river flow was not enough to dislodge it. Toxicology testing was carried out on two different aquatic species both from trophic levels using trade effluent from the Irish Cement plant. Toxicology test results showed that the effluent is non-toxic to the organisms tested. It is considered therefore that the discharge from the Irish Cement plant to the River Nanny does not adversely affect the aquatic ecology within the River Nanny. This is supported by the results of the macroinvertebrate analyses.

The trade effluent from the Irish Cement plant does not appear to be adversely affecting BOD, hardness, or D.O. in the River Nanny, as indicated by water quality results from samples taken upstream and downstream of the discharge. The D.O. concentration was slightly lower immediately downstream of the discharge (N3) point however, began to increase to over 100%, the ideal saturation concentration. Thus, showing the water is oxygen rich and is not been adversely affected by the discharge from Irish Cement. Organic compounds and Heavy Metals were not present in the sample of the discharge at a level considered harmful to the aquatic environment.

Overall, the results confirm that macroinvertebrate communities, biological water quality and sediment levels in the River Nanny are not significantly different upstream and downstream of the trade effluent from the Irish Cement plant. The discharge is considered to be having a neutral impact on the aquatic ecology of local areas of the River Nanny.

5.0 RECOMMENDATIONS

Biological monitoring of the River Nanny upstream and downstream of the discharge should be maintained in order to monitor the impact of the discharge on aquatic ecology. Similarly, the composition of substrates in the river should be monitored and Irish Cement Ltd. should continue monitoring chemical water quality upstream and downstream of trade effluent discharge on the River Nanny.

REFERENCES

Azur Environmental (1995) Microtox Acute Basic Test Procedures. Azur Environmental,. Carlsbad, California, USA.

Barbour, M.T. and J.B. Stribling. 1991. Use of Habitat Assessment in Evaluating the Biological Integrity of Stream Communities. *Biological Criteria: Research and Regulation: 25-38. EPA-440/5-91-005. Washington, DC: Office of Water, US EPA*

Central and Regional Fisheries Boards (2009). Sampling fish for the Water Framework Directive - Eastern River Basin District Rivers.

DOEHLG (2009) European Communities Environmental Objectives (Surface Waters) Regulations 2009. S.I. 272 of 2009.

Ecofact (2008) Aquatic Monitoring of the River Nanny near Duleek, Co. Meath. Prepared on behalf of Irish Cement Ltd.

Ecofact (2009) Aquatic Monitoring of the River Nanny near Duleek, Co. Meath. Prepared on behalf of Irish Cement Ltd.

Ecofact (2010) Aquatic Monitoring of the River Nanny near Duleek, Co. Meath. Prepared on behalf of Irish Cement Ltd.

Ecofact (2011) Aquatic Monitoring of the River Nanny near Duleek, Co. Meath. Prepared on behalf of Irish Cement Ltd.

Ecofact (2012) Aquatic Monitoring of the River Nanny near Duleek, Co. Meath. Prepared on behalf of Irish Cement Ltd.

Ecofact (2013) Aquatic Monitoring of the River Nanny near Duleek, Co. Meath. Prepared on behalf of Irish Cement Ltd.

Ecofact (2014) Aquatic Monitoring of the River Nanny near Duleek, Co. Meath. Prepared on behalf of Irish Cement Ltd.

Ecofact (2015) Aquatic Monitoring of the River Nanny near Duleek, Co. Meath. Prepared on behalf of Irish Cement Ltd.

Ecofact (2016) Aquatic Monitoring of the River Nanny near Duleek, Co. Meath. Prepared on behalf of Irish Cement Ltd.

Ecofact (2017) Aquatic Monitoring of the River Nanny near Duleek, Co. Meath. Prepared on behalf of Irish Cement Ltd.

Environment Agency EA (2003) River Habitat Survey in Britain and Ireland: Field Survey Guidance Manual. River Habitat Survey Manual: 2003 version, Environment Agency, 136 pp

EA (2007) The direct toxicity assessment of aqueous environmental samples using the juvenile Daphnia magna immobilisation test. *Methods for the Examination of Waters and Associated Materials.* Environment Agency, UK.

Environmental Protection Agency EPA (2017) EPA Map Viewer. [ONLINE] Available at: http://gis.epa.ie/Envision.

ERBD (2009) Nanny Water Management Unit - Final Programme of Measures. Document Reference: 39325/ERBD40/DG134 – S.

Extence C.A., Balbi D.M. & Chadd R.P. (1999) River flow indexing using British benthic macroinvertebrates: a framework for setting hydroecological objectives. *Regulated Rivers-Research & Management,* 15, 543–574.

Extence, C.A., Chadd R.P., England J., Dunbar M.J., Wood P.J. & Taylor E.D. (2011) The assessment of fine sediment accumulation in rivers using macro-invertebrate community response. *River Research and Applications*, 29, 17–55.

Fahy, E. (1973) Observations on the growth of Ephemeroptera in fluctuating and constant temperature conditions. Proceedings of the Royal Irish Academy. Section B: Biological, geological, and chemical science. Royal Irish Academy. 133-149

ISO 11348-3:2007. Water quality-Determination of the inhibitory effect of water samples on the light emission of *Vibrio fischeri* (Luminescent bacteria test)—Part 3: method using freeze dried bacteria. International Standards Organisation.

McGarrigle, M.L., Bowman, J.J., Clabby, K.J., Lucy, P., Cunningham, M., MacCarthaigh, M., Keegan, M., Cantrell, B., Lehane, M., Clenaghan, C., Toner, P.F. (2002) *Water Quality in Ireland 1998-2000*. Second (Revised) Edition. Environmental Protection Agency.

Mason, C.F. (2002) Biology of Freshwater Pollution, Aquatic toxicology, 21-45.

Toner, P., Bowman, K., Clabby, K., Lucey, J., McGarrigle, M, Concannon, C., Clenaghan, C., Cunningham, P., Delaney, J., O' Boyle, S., MaCarthaigh, M., Craig, M., and Quinn, R. (2005) *Water Quality in Ireland 2001-2003*. Environmental Protection Agency, Wexford

Walley W.J. and Hawkes H.A. (1997) A computer-based development of the Biological Monitoring Working Party score system incorporating abundance rating, biotope type and indicator value. *Water Research*, 31 (2), 201-210.

PLATES

Plate 1 Kick sampling at Site N1: receptor riffle site. Site was heavily silted with excessive algae growths.

Plate 2 River Nanny was visibly polluted at all sites; excessive algae growths and siltation at Site N1.

Plate 3 Kick sampling at Site N6: reference riffle site. Note plume of silt.

Plate 4 Weir upstream of Site N1 ponds water and also reduces the flow at Site N1.

Plate 5 River Nanny old headrace which diverts water around site N1.

Plate 6 River Nanny at Site N2 which is partially ponded by weir. Excessive instream growth of reeds apparent. Site was also heavily silted with excessive algae growths.

Plate 7 Irish Cement trade effluent outfall to the River Nanny. The outfall stream was visibly cleaner than the receiving water.

Plate 8 River Nanny, Site N5. There was less reed growth upstream of the outfall, but it was considered that this was related to flows and depths (and the ponding influence of the weir).

Plate 9 River Nanny, Site N4. Again, note the plume of silt

Plate 10 Excessive filamentous algae growth was recorded at all sites.

Plate 11 *Gammarus* spp. were the most common macroinvertebrate recorded.

Plate 12 Minnows *Poxinus phoxinus* were common at every site.

Plate 13 Banded jeweling *Agrion splendens larve.* This Class C indicator species remains common in the study area.

Plate 14 Pondweeds in the deeper water at Site N5.

Plate 15 Liverworts growing on rocks at Site N6.

Plate 16 Typical river substrate at Site N3, downstream of the outfall.

Plate 17 Typical river substrate at Site N4, upstream of the outfall.

Plate 18 The outfall stream was visibly cleaner than the receiving water.

Plate 19 The outfall had clearly better water quality than the River Nanny with relatively clean substrate and no excessive siltation and algal growths present. Good numbers of caddisfly larvae on the stones.

Plate 20 Numerous cased caddisfly larve present on rocks in the outflow stream.

Plate 21 Significant numbers of *Gammarus spp.* on the wall of the outfall. They were trying to migrate upstream into the pipe – presumably due to the better water quality in the outfall – but the flow from the pipe was too high for them to enter so they accumulated downstream like this.

Plate 22 Bank maintenance works on the River Nanny upstream of Site N6.

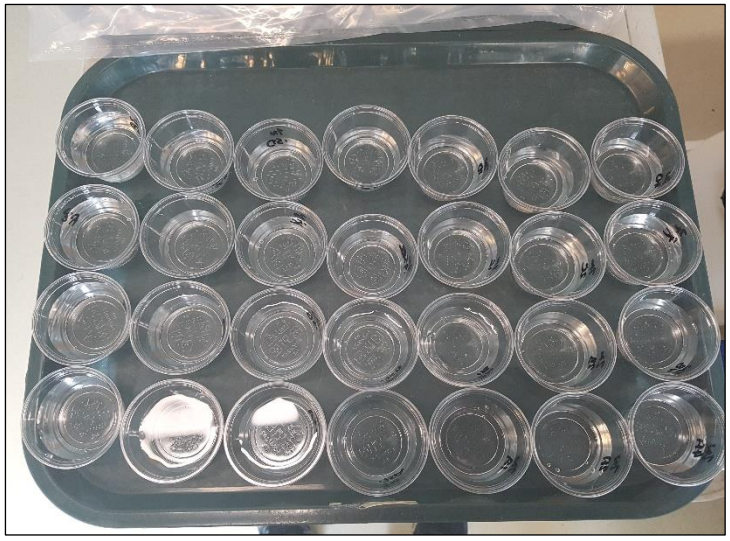

Plate 23 *Daphnia magna* 48 h EC_{50} test

Plate 24 Temperature controlled photometer apparatus used to test for bioluminescence of *Vibrio fischeri* in the 30 min EC_{50} test.

Appendix 1 Biotic Indices.

Table A1.1 Biological River Quality Classification (Q-Values).

'Q' value	Community Diversity	Water Quality	Condition*	Status	Quality
Q5	High	Good	Satisfactory	Unpolluted	Class A
Q4	Reduced	Fair	Satisfactory	Unpolluted	Class A
Q3	Much Reduced	Doubtful	Unsatisfactory	Slightly Polluted	Class B
Q2	Low	Poor	Unsatisfactory	Moderately Polluted	Class C
Q1	Very Low	Bad	Unsatisfactory	Seriously Polluted	Class D

* *'Condition' refers to the likelihood of interference with beneficial or potential beneficial use.*

The connection between the Q-rating system and the European Communities Environmental Objectives (Surface Waters) Regulations 2009 (S.I. 272 of 2009) is given in Table A1.2 below.

Table A1.2 Water Framework Directive (WFD) ecological status classification and corresponding Q-rating.

Ecological status classification	Corresponding Q-rating
High	Q5, Q4-5
Good	Q4
Moderate	Q3-4
Poor	Q3, Q2-3
Bad	Q2, Q1

Table A1.3 BMWP Scoring System.

BMWP score	Category	Interpretation
0-10	Very poor	Heavily polluted
11-40	Poor	Polluted or impacted
41-70	Moderate	Moderately impacted
71-100	Good	Clean but slightly impacted
>100	Very good	Unpolluted, unimpacted

Table A1.4 Standard estimated macroinvertebrate abundance categories used for LIFE calculation (Extence *et al*., 1999).

Category	Estimated abundance
A	1-9
B	10-99
C	100-999
D	1000-9999
E	10000+

Table A1.5 LIFE calculation scores matrix for difference abundance categories of taxa associated with flow groups I - VI (Extence *et al*., 1999).

Flow Groups		Abundance categories			
		A	B	C	D/E
I	Rapid	9	10	11	12
II	Moderate/fast	8	9	10	11
III	Slow/sluggish	7	7	7	7
IV	Flowing/standing	6	5	4	3
V	Standing	5	4	3	2
VI	Drought resistant	4	3	2	1

Table A1.6 Summary of Fine Sediment Sensitivity Rating and abundance weighted scores for PSI calculation (Extence *et al*., 2011).

Group	Fine Sediment Sensitivity Rating (FSSR)	Log abundance			
		1-9	10-99	100-999	1000+
A	Highly sensitive	2	3	4	5
B	Moderately sensitive	1	2	3	4
C	Moderately insensitive	1	2	3	4

D	Highly insensitive	2	3	4	5

Table A1.7 Summary of PSI score interpretation (Extence *et al*., 2011).

PSI Scoring (%)	River bed condition
81 - 100	Minimally sedimented/unsedimented
61 - 80	Slightly sedimented
41 - 60	Moderately sedimented
21 - 40	Sedimented
0 - 20	Heavily sedimented

Appendix 2 EPA Water Quality Data for the River Nanny

Table A2.1 Water quality in the River Nanny along with overall water quality in hydrometric area 8 (adapted from Clabby *et al.* 2008).

Catchment	Class A	Class B	Class C	Class D	Total (km)
Hydrometric Area 8 (km)	22.5	23	70	6.5	122
Hydrometric Area 8 (%)	18.4	18.9	57.4	5.3	100
Nanny (km)	6.5	12	9.5	-	28
Nanny (%)	23.2	42.9	33.9	-	100

Table A2.2 Biological Water Quality in the River Nanny (EPA Code 08N01) (EPA, 2017).

Station No.	Station location	Biological water quality ratings (Q-value)											
		1980	1982	1986	1988	1991	1996	1998	2001	2005	2008	2010	2014
0040	Folistown Br	-	-	-	-	-	2-3	2-3	2	2-3	3	3	3
0090	East Bridge, S. of Brownstown	-	-	-	2-3	2-3	-	-	-	-	-	-	-
0100	West Br Kentstown	-	-	-	-	-	-	-	-	-	-	-	-
0110	East Bridge, Kentstown	-	-	-	3	3	3	2-3	2-3	2-3	2-3	3	3
0200	Br just S. of Balrath X-Roads	3-4	2-3	3	3-4	3-4	-	-	-	-	-	-	-
0280	Bridge d/s Nanny Bridge	-	-	-	3	3	3	3-4	3-4	4	4	3-4	3
0300	Bridge near Deenes	3	1-2	2	-	3	-	-	-	-	-	-	-
0400	Upstream Bridge, Duleek	3-4	4	3-4	2-3	3	-	-	-	-	-	-	-
0500	Bridge N.E. of Bellewstown Ho	3	3-4	3-4	3	3-4	3	3-4	3-4	3-4	3	3-4	3-4
0600	Beaumont Bridge	3-4	3	3-4	3	-	-	-	-	-	-	-	-
0650	Dardistown Bridge	-	-	3-4	3-4	3-4	4	4	3	-	-	-	-
0700	Bridge at Julianstown	3	3-4	3-4	3-4	3	3-4	3-4	3	3-4	3-4	3	3-4

2014 EPA Assessment of the River Nanny: The Nanny River is unsatisfactory along the entire length surveyed. Since the 2010 survey, there has been a slight improvement at Station 0700, but a slight decline in quality at Station 0280.

Appendix 3 ALS Certs / Sediment PSD result

Unit 7-8 Hawarden Business Park
Manor Road (off Manor Lane)
Hawarden
Deeside
CH5 3US
Tel: (01244) 528700
Fax: (01244) 528701
email: hawardencustomerservices@alsglobal.com
Website: www.alsenvironmental.co.uk

Ecofact Environmental Consultants Ltd
Tait Business Centre
Limerick

Attention: William O'Connor

CERTIFICATE OF ANALYSIS

Date:	11 June 2018
Customer:	D_ECOFACT_LIM
Sample Delivery Group (SDG):	180602-24
Your Reference:	
Location:	River Nanny
Report No:	459751

This report has been revised and directly supersedes 459589 in its entirety.

We received 9 samples on Saturday June 02, 2018 and 9 of these samples were scheduled for analysis which was completed on Monday June 11, 2018. Accredited laboratory tests are defined within the report, but opinions, interpretations and on-site data expressed herein are outside the scope of ISO 17025 accreditation.

Should this report require incorporation into client reports, it must be used in its entirety and not simply with the data sections alone.

Chemical testing (unless subcontracted) performed at ALS Life Sciences Ltd Hawarden (Method codes TM) or ALS Life Sciences Ltd Aberdeen (Method codes S).

Approved By:

Sonia McWhan
Operations Manager

Validated

CERTIFICATE OF ANALYSIS

SDG:	180602-24	**Client Reference:**		**Report Number:**	459751
Location:	River Nanny	**Order Number:**		**Superseded Report:**	459589

Received Sample Overview

Lab Sample No(s)	Customer Sample Ref.	AGS Ref.	Depth (m)	Sampled Date
17670191	N0			01/06/2018
17670180	N1			01/06/2018
17670182	N1			01/06/2018
17670183	N2			01/06/2018
17670184	N3			01/06/2018
17670185	N4			01/06/2018
17670186	N5			01/06/2018
17670188	N6			01/06/2018
17670189	N6			01/06/2018

Maximum Sample/Coolbox Temperature (°C) : **18**

ISO5667-3 Water quality - Sampling - Part3 -
During Transportation samples shall be stored in a cooling device capable of maintaining a temperature of (5±3)°C.

ALS have data which show that a cool box with 4 frozen icepacks is capable of maintaining pre-chilled samples at a temperature of (5±3)°C for a period of up to 24hrs.

Only received samples which have had analysis scheduled will be shown on the following pages.

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CERTIFICATE OF ANALYSIS

SDG: 180602-24	**Client Reference:**	**Report Number:**	459751
Location: River Nanny	**Order Number:**	**Superseded Report:**	459589

Results Legend

- X Test
- N No Determination Possible

Sample Types -

- S - Soil/Solid
- UNS - Unspecified Solid
- GW - Ground Water
- SW - Surface Water
- LE - Land Leachate
- PL - Prepared Leachate
- PR - Process Water
- SA - Saline Water
- TE - Trade Effluent
- TS - Treated Sewage
- US - Untreated Sewage
- RE - Recreational Water
- DW - Drinking Water Non-regulatory
- UNL - Unspecified Liquid
- SL - Sludge
- G - Gas
- OTH - Other

Lab Sample No(s)				1670191	1670180	1670182	1670183	1670184	1670185	1670186	1670188	1670189
Customer Sample Reference				N0	N1	N1	N2	N3	N4	N5	N6	N6
AGS Reference												
Depth (m)												
Container			0.5l glass bottle (ALE227)	HNO3 Filtered (ALE204)	250ml BOD (ALE212)	1kg TUB	1kg TUB	1kg TUB	1kg TUB	1kg TUB	1kg TUB	250ml BOD (ALE212)
Sample Type			UNL	UNL	UNL	S	S	S	S	S	S	UNL
Asbestos ID in Solid Samples	All	NDPs: 0 Tests: 5				X	X	X	X		X	
BOD True Total	All	NDPs: 0 Tests: 2			X							X
Dissolved Metals by ICP-MS	All	NDPs: 0 Tests: 1		X								
Mercury Dissolved	All	NDPs: 0 Tests: 1		X								
Passing Through >63µm sieve	All	NDPs: 0 Tests: 6				X	X	X	X	X	X	
Sample description	All	NDPs: 0 Tests: 6				X	X	X	X	X	X	
Total Metals by ICP-MS	All	NDPs: 0 Tests: 2			X							X
TPH by IR Oils and Greases	All	NDPs: 0 Tests: 1	X									

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CERTIFICATE OF ANALYSIS

SDG:	180602-24	**Client Reference:**		**Report Number:**	459751
Location:	River Nanny	**Order Number:**		**Superseded Report:**	459589

Sample Descriptions

Grain Sizes

very fine	<0.063mm	fine	0.063mm - 0.1mm	medium	0.1mm - 2mm	coarse	2mm - 10mm	very coarse	>10mm

Lab Sample No(s)	Customer Sample Ref.	Depth (m)	Colour	Description	Inclusions	Inclusions 2
17670182	N1		Black	Loamy Sand	Crushed Brick	Stones
17670183	N2		Dark Brown	Loamy Sand	Crushed Brick	Stones
17670184	N3		Dark Brown	Loamy Sand	Crushed Brick	Stones
17670185	N4		Dark Brown	Loamy Sand	Crushed Brick	Stones
17670186	N5		Black	Loamy Sand	Stones	Vegetation
17670188	N6		Dark Brown	Loamy Sand	Crushed Brick	Stones

These descriptions are only intended to act as a cross check if sample identities are questioned, and to provide a log of sample matrices with respect to MCERTS validation. They are not intended as full geological descriptions.

We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally ocurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample.

Other coarse granular materials such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

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CERTIFICATE OF ANALYSIS

SDG:	180602-24	**Client Reference:**		**Report Number:**	459751
Location:	River Nanny	**Order Number:**		**Superseded Report:**	459589

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	N0	N1	N1	N2	N3	N4
			Depth (m)						
			Sample Type	Unspecified Liquid (UNL)	Unspecified Liquid (UNL)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)
			Date Sampled	01/06/2018	01/06/2018	01/06/2018	01/06/2018	01/06/2018	01/06/2018
			Sample Time						
			Date Received	02/06/2018	02/06/2018	02/06/2018	02/06/2018	02/06/2018	02/06/2018
			SDG Ref	180602-24	180602-24	180602-24	180602-24	180602-24	180602-24
			Lab Sample No.(s)	17670191	17670180	17670182	17670183	17670184	17670185
			AGS Reference						
Moisture Content Ratio (% of as received sample)	%	PM024				38	18	56	27
BOD, unfiltered	<1 mg/l	TM045			<1				
Arsenic (diss.filt)	<0.5 µg/l	TM152		<0.5					
Cadmium (diss.filt)	<0.08 µg/l	TM152		<0.08					
Chromium (diss.filt)	<1 µg/l	TM152		3.21					
Copper (diss.filt)	<0.3 µg/l	TM152		<0.3					
Lead (diss.filt)	<0.2 µg/l	TM152		<0.2					
Nickel (diss.filt)	<0.4 µg/l	TM152		<0.4					
Selenium (diss.filt)	<1 µg/l	TM152		1.72					
Zinc (diss.filt)	<1 µg/l	TM152		<1					
Hardness, Total as CaCO3 unfiltered	<0.35 mg/l	TM152			355				
Mercury (diss.filt)	<0.01 µg/l	TM183		<0.01					
TPH / Oil & Greases	<1 mg/l	TM235		<1					
Mineral Oil	<1 mg/l	TM235		<1					

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CERTIFICATE OF ANALYSIS

SDG:	180602-24	**Client Reference:**		**Report Number:**	459751
Location:	River Nanny	**Order Number:**		**Superseded Report:**	459589

Results Legend

#	ISO17025 accredited.
M	*m*CERTS accredited.
aq	Aqueous / settled sample.
diss.filt	Dissolved / filtered sample.
tot.unfilt	Total / unfiltered sample.
*	Subcontracted test.
**	% recovery of the surrogate standard to check the efficiency of the method. The results of individual compounds within samples aren't corrected for the recovery
(F)	Trigger breach confirmed
1-5&+§@	Sample deviation (see appendix)

Component	LOD/Units	Method	Customer Sample Ref.	N5	N6	N6			
			Depth (m)						
			Sample Type	Soil/Solid (S)	Soil/Solid (S)	Unspecified Liquid (UNL)			
			Date Sampled	01/06/2018	01/06/2018	01/06/2018			
			Sample Time						
			Date Received	02/06/2018	02/06/2018	02/06/2018			
			SDG Ref	180602-24	180602-24	180602-24			
			Lab Sample No.(s)	17670186	17670188	17670189			
			AGS Reference						
Moisture Content Ratio (% of as received sample)	%	PM024		33	26				
BOD, unfiltered	<1 mg/l	TM045				<1			
Hardness, Total as CaCO3 unfiltered	<0.35 mg/l	TM152				361			

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CERTIFICATE OF ANALYSIS

SDG:	180602-24	**Client Reference:**	**Report Number:** 459751
Location:	River Nanny	**Order Number:**	**Superseded Report:** 459589

Asbestos Identification - Solid Samples

		Date of Analysis	Analysed By	Comments	Amosite (Brown) Asbestos	Chrysotile (White) Asbestos	Crocidolite (Blue) Asbestos	Fibrous Actinolite	Fibrous Anthophyllite	Fibrous Tremolite	Non-Asbestos Fibre
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Receieved SDG Original Sample Method Number	N1 SOLID 01/06/2018 00:00:00 05/06/2018 19:51:49 180602-24 17670182 TM048	07/06/2018	James Richards	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Receieved SDG Original Sample Method Number	N2 SOLID 01/06/2018 00:00:00 05/06/2018 18:31:38 180602-24 17670183 TM048	07/06/2018	James Richards	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Receieved SDG Original Sample Method Number	N3 SOLID 01/06/2018 00:00:00 05/06/2018 18:34:21 180602-24 17670184 TM048	07/06/2018	Marcin Magdziarek	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Receieved SDG Original Sample Method Number	N4 SOLID 01/06/2018 00:00:00 05/06/2018 18:28:06 180602-24 17670185 TM048	07/06/2018	Marcin Magdziarek	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected
Cust. Sample Ref. Depth (m) Sample Type Date Sampled Date Receieved SDG Original Sample Method Number	N6 SOLID 01/06/2018 00:00:00 05/06/2018 18:36:44 180602-24 17670188 TM048	07/06/2018	Marcin Magdziarek	-	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected (#)	Not Detected

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SDG:	180602-24	**Client Reference:**		**Report Number:**	459751
Location:	River Nanny	**Order Number:**		**Superseded Report:**	459589

Table of Results - Appendix

Method No	Reference	Description
PM024	Modified BS 1377	Soil preparation including homogenisation, moisture screens of soils for Asbestos Containing Material
TM008	BS 1377:Part 1977	Particle size distribution of solid samples
TM045	MEWAM BOD5 2nd Ed.HMSO 1988 / Method 5210B, AWWA/APHA, 20th Ed., 1999; SCA Blue Book 130	Determination of BOD5 (ATU) Filtered by Oxygen Meter on liquids
TM048	HSG 248, Asbestos: The analysts' guide for sampling, analysis and clearance procedures	Identification of Asbestos in Bulk Material
TM152	Method 3125B, AWWA/APHA, 20th Ed., 1999	Analysis of Aqueous Samples by ICP-MS
TM183	BS EN 23506:2002, (BS 6068-2.74:2002) ISBN 0 580 38924 3	Determination of Trace Level Mercury in Waters and Leachates by PSA Cold Vapour Atomic Fluorescence Spectrometry
TM235	The Determination of Hydrocarbon Oils in Waters by Solvent Extraction, Infra red Absorption and Gravimetry 1983, HMSO, London	Determination of Total Petroleum Hydrocarbons (TPH) in Waters By Infra-Red Spectroscopy

NA = not applicable.
Chemical testing (unless subcontracted) performed at ALS Life Sciences Ltd Hawarden (Method codes TM) or ALS Life Sciences Ltd Aberdeen (Method codes S).

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CERTIFICATE OF ANALYSIS

SDG:	180602-24	**Client Reference:**		**Report Number:**	459751
Location:	River Nanny	**Order Number:**		**Superseded Report:**	459589

Test Completion Dates

Lab Sample No(s)	17670191	17670180	17670182	17670183	17670184	17670185	17670186	17670188	17670189
Customer Sample Ref.	N0	N1	N1	N2	N3	N4	N5	N6	N6
AGS Ref.									
Depth									
Type	Unspecified Liq	Unspecified Liq	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Soil/Solid (S)	Unspecified Liq
Asbestos ID in Solid Samples			07-Jun-2018	07-Jun-2018	07-Jun-2018	07-Jun-2018		07-Jun-2018	
BOD True Total		08-Jun-2018							08-Jun-2018
Dissolved Metals by ICP-MS	08-Jun-2018								
Mercury Dissolved	07-Jun-2018								
Passing Through >63µm sieve			08-Jun-2018	08-Jun-2018	11-Jun-2018	08-Jun-2018	06-Jun-2018	08-Jun-2018	
Sample description			04-Jun-2018	04-Jun-2018	04-Jun-2018	04-Jun-2018	04-Jun-2018	04-Jun-2018	
Total Metals by ICP-MS		07-Jun-2018							07-Jun-2018
TPH by IR Oils and Greases	05-Jun-2018								

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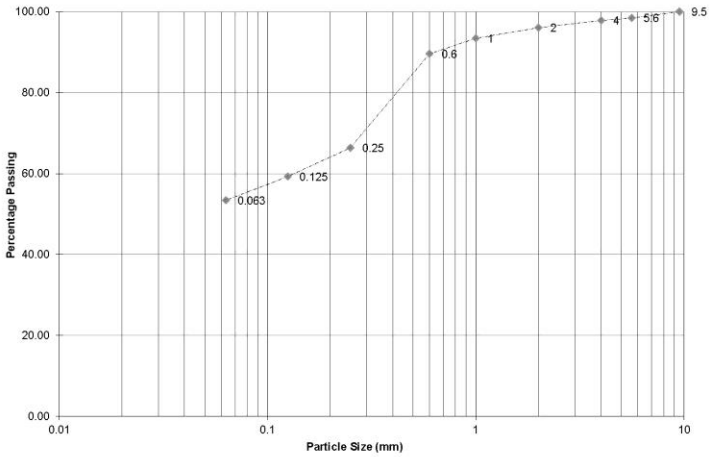
WS-701_2 Issue date: 26/01/17

Particle Size Distribution

Particle Size (mm)	% Passing
9.5	100.00
5.6	98.45
4	97.83
2	96.06
1	93.43
600um	89.58
250um	66.37
125um	59.23
63um	53.38

Sample Number 17674832
Client D_ECOFACT_LIM
Sample ID N5
depth 0.00-0.00



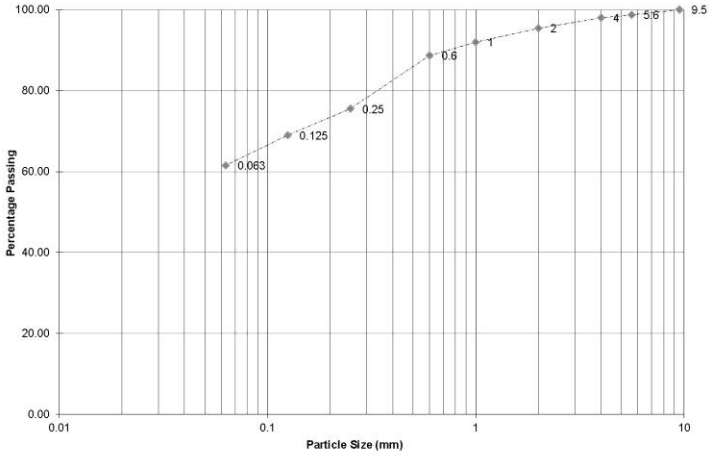
ALS Laboratories

WS-701_2 Issue date: 26/01/17

Particle Size Distribution

Particle Size (mm)	% Passing
9.5	100.00
5.6	98.72
4	98.03
2	95.44
1	91.97
600um	88.67
250um	75.50
125um	69.00
63um	61.51

Sample Number 17675038
Client D_ECOFACT_LIM
Sample ID N4
depth 0.00-0.00



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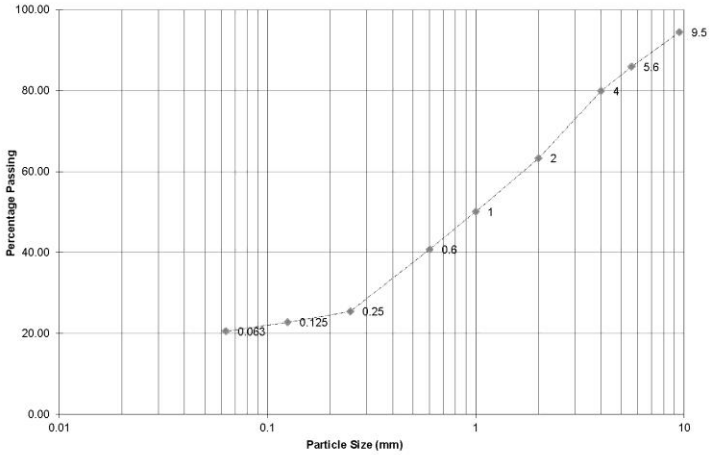
WS-701_2 Issue date: 26/01/17

Particle Size Distribution

Particle Size (mm)	% Passing
9.5	94.47
5.6	85.92
4	79.91
2	63.28
1	50.07
600um	40.76
250um	25.44
125um	22.76
63um	20.53

Sample Number 17674958
Client D_ECOFACT_LIM
Sample ID N6
depth 0.00-0.00



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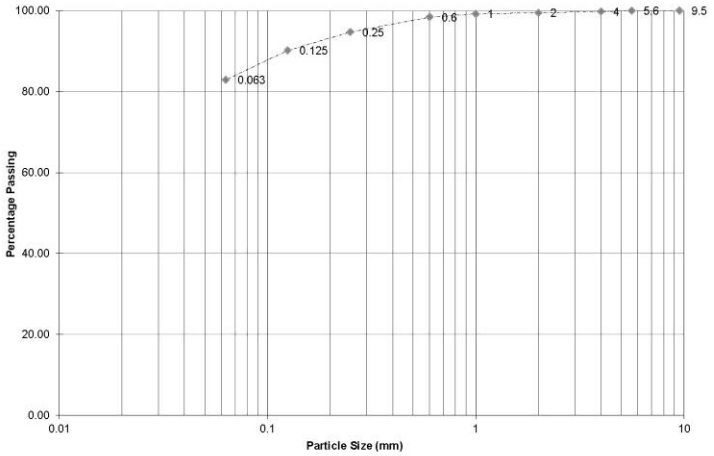
Particle Size Distribution

Particle Size (mm)	% Passing
9.5	100.00
5.6	100.00
4	99.79
2	99.50
1	99.21
600um	98.43
250um	94.70
125um	90.19
63um	82.90

Sample Number 17675028
Client D_ECOFACT_LIM
Sample ID N2
depth 0.00-0.00



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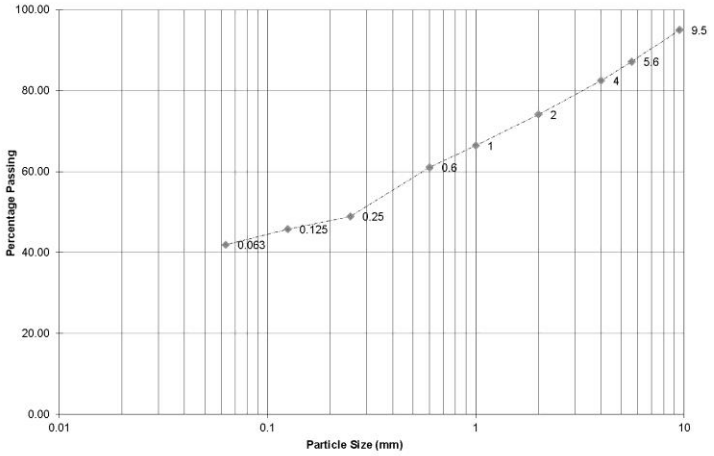
WS-701_2 Issue date: 26/01/17

Particle Size Distribution

Particle Size (mm)	% Passing
9.5	94.99
5.6	87.14
4	82.46
2	74.10
1	66.43
600um	61.04
250um	48.89
125um	45.75
63um	41.91

Sample Number 17674799
Client D_ECOFACT_LIM
Sample ID N1
depth 0.00-0.00



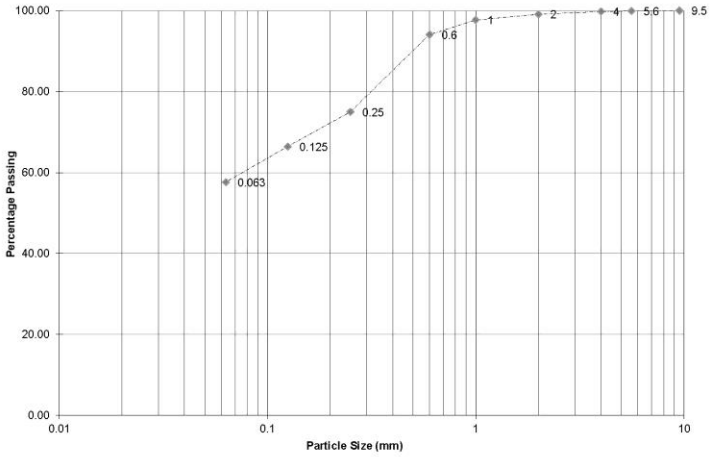
ALS Laboratories

WS-701_2 Issue date: 26/01/17

Particle Size Distribution

Particle Size (mm)	% Passing
9.5	100.00
5.6	99.94
4	99.81
2	99.12
1	97.73
600um	94.10
250um	74.97
125um	66.42
63um	57.61

Sample Number 17674965
Client D_ECOFACT_LIM
Sample ID N3
depth 0.00-0.00



ALS Laboratories

CERTIFICATE OF ANALYSIS

SDG:	180602-24	**Client Reference:**		**Report Number:**	459751
Location:	River Nanny	**Order Number:**		**Superseded Report:**	459589

Appendix

1. Results are expressed on a dry weight basis (dried at 35ºC) for all soil analyses except for the following: NRA and CEN Leach tests, flash point LOI, pH, ammonium as NH4 by the BRE method, VOC TICs and SVOC TICs.

2. Samples will be run in duplicate upon request, but an additional charge may be incurred.

3. If sufficient sample is received a sub sample will be retained free of charge for 30 days after analysis is completed (e-mailed) for all sample types unless the sample is destroyed on testing. The prepared soil sub sample that is analysed for asbestos will be retained for a period of 6 months after the analysis date. All bulk samples will be retained for a period of 6 months after the analysis date. All samples received and not scheduled will be disposed of one month after the date of receipt unless we are instructed to the contrary. Once the initial period has expired, a storage charge will be applied for each month or part thereof until the client cancels the request for sample storage. ALS reserve the right to charge for samples received and stored but not analysed.

4. With respect to turnaround, we will always endeavour to meet client requirements wherever possible, but turnaround times cannot be absolutely guaranteed due to so many variables beyond our control.

5. We take responsibility for any test performed by sub-contractors (marked with an asterisk). We endeavour to use UKAS/MCERTS Accredited Laboratories, who either complete a quality questionnaire or are audited by ourselves. For some determinands there are no UKAS/MCERTS Accredited Laboratories, in this instance a laboratory with a known track record will be utilised.

6. When requested, the individual sub sample scheduled will be analysed in house for the presence of asbestos fibres and asbestos containing material by our documented in house method TM048 based on HSG 248 (2005), which is accredited to ISO17025. If a specific asbestos fibre type is not found this will be reported as "Not detected". If no asbestos fibre types are found all will be reported as "Not detected" and the sub sample analysed deemed to be clear of asbestos. If an asbestos fibre type is found it will be reported as detected (for each fibre type found). Testing can be carried out on asbestos positive samples, but, due to Health and Safety considerations, may be replaced by alternative tests or reported as No Determination Possible (NDP). The quantity of asbestos present is not determined unless specifically requested.

7. If no separate volatile sample is supplied by the client, or if a headspace or sediment is present in the volatile sample, the integrity of the data may be compromised. This will be flagged up as an invalid VOC on the test schedule and the result marked as deviating on the test certificate.

8. If appropriate preserved bottles are not received preservation will take place on receipt. However, the integrity of the data may be compromised.

9. NDP - No determination possible due to insufficient/unsuitable sample.

10. Metals in water are performed on a filtered sample, and therefore represent dissolved metals - total metals must be requested separately.

11. Results relate only to the items tested.

12. LoDs (Limit of Detection) for wet tests reported on a dry weight basis are not corrected for moisture content.

13. **Surrogate recoveries** - Surrogates are added to your sample to monitor recovery of the test requested. A % recovery is reported, results are not corrected for the recovery measured. Typical recoveries for organics tests are 70-130%, they are generally wider for volatiles analysis, 50-150%. Recoveries in soils are affected by organic rich or clay rich matrices. Waters can be affected by remediation fluids or high amounts of sediment. Test results are only ever reported if all of the associated quality checks pass; it is assumed that all recoveries outside of the values above are due to matrix affect.

14. **Product analyses** - Organic analyses on products can only be semi-quantitative due to the matrix effects and high dilution factors employed.

15. Phenols monohydric by HPLC include phenol, cresols (2-Methylphenol, 3-Methylphenol and 4-Methylphenol) and Xylenols (2,3 Dimethylphenol, 2,4 Dimethylphenol, 2,5 Dimethylphenol, 2,6 Dimethylphenol, 3,4 Dimethyphenol, 3,5 Dimethylphenol).

16. Total of 5 speciated phenols by HPLC includes Phenol, 2,3,5-Trimethyl Phenol, 2-Isopropylphenol, Cresols and Xylenols (as detailed in 15).

17. Stones/debris are not routinely removed. We always endeavour to take a representative sub sample from the received sample.

18. In certain circumstances the method detection limit may be elevated due to the sample being outside the calibration range. Other factors that may contribute to this include possible interferences. In both cases the sample would be diluted which would cause the method detection limit to be raised.

19. Mercury results quoted on soils will not include volatile mercury as the analysis is performed on a dried and crushed sample.

20. For leachate preparations other than Zero Headspace Extraction (ZHE) volatile loss may occur.

General

21. For the BSEN 12457-3 two batch process to allow the cumulative release to be calculated, the volume of the leachate produced is measured and filtered for all tests. We therefore cannot carry out any unfiltered analysis. The tests affected include volatiles GCFID/GCMS and all subcontracted analysis.

22. We are accredited to MCERTS for sand, clay and loam/topsoil, or any of these materials - whether these are derived from naturally occurring soil profiles, or from fill/made ground, as long as these materials constitute the major part of the sample. Other coarse granular material such as concrete, gravel and brick are not accredited if they comprise the major part of the sample.

23. Analysis and identification of specific compounds using GCFID is by retention time only, and we routinely calibrate and quantify for benzene, toluene, ethylbenzenes and xylenes (BTEX). For total volatiles in the C5-C12 range, the total area of the chromatogram is integrated and expressed as ug/kg or ug/l. Although this analysis is commonly used for the quantification of gasoline range organics (GRO), the system will also detect other compounds such as chlorinated solvents, and this may lead to a falsely high result with respect to hydrocarbons only. It is not possible to specifically identify these non-hydrocarbons, as standards are not routinely run for any other compounds, and for more definitive identification, volatiles by GCMS should be utilised.

24. **Tentatively Identified Compounds (TICs)** are non-target peaks in VOC and SVOC analysis. All non-target peaks detected with a concentration above the LoD are subjected to a mass spectral library search. Non-target peaks with a library search confidence of >75% are reported based on the best mass spectral library match. When a non-target peak with a library search confidence of <75% is detected it is reported as "mixed hydrocarbons". Non-target compounds identified from the scan data are semi-quantified relative to one of the deuterated internal standards, under the same chromatographic conditions as the target compounds. This result is reported as a semi-quantitative value and reported as Tentatively Identified Compounds (TICs). TICs are outside the scope of UKAS accreditation and are not moisture corrected.

Sample Deviations

If a sample is classed as deviated then the associated results may be compromised.

1	**Container with Headspace provided for volatiles analysis**
2	**Incorrect container received**
3	**Deviation from method**
4	**Holding time exceeded before sample received**
5	**Samples exceeded holding time before presevation was performed**
§	**Sampled on date not provided**
♦	**Sample holding time exceeded in laboratory**
@	**Sample holding time exceeded due to sampled on date**
&	**Sample Holding Time exceeded - Late arrival of instructions.**

Asbestos

Identification of Asbestos in Bulk Materials & Soils

The results for identification of asbestos in bulk materials are obtained from supplied bulk materials which have been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

The results for identification of asbestos in soils are obtained from a homogenised sub sample which has been examined to determine the presence of asbestos fibres using ALS (Hawarden) in-house method of transmitted/polarised light microscopy and central stop dispersion staining, based on HSG 248 (2005).

Asbestos Type	Common Name
Chrysotile	White Asbestos
Amosite	Brown Asbestos
Crocidolite	Blue Asbestos
Fibrous Actinolite	-
Fibrous Anthophyllite	-
Fibrous Tremolite	-

Visual Estimation Of Fibre Content

Estimation of fibre content is not permitted as part of our UKAS accredited test other than: - Trace - Where only one or two asbestos fibres were identified.

Further guidance on typical asbestos fibre content of manufactured products can be found in HSG 264.

The identification of asbestos containing materials and soils falls within our schedule of tests for which we hold UKAS accreditation, however opinions, interpretations and all other information contained in the report are outside the scope of UKAS accreditation.

Appendix 5 Toxicology results

Report on the Toxicity Testing of the
Platin Water Sample
June 2018

Report prepared by

Aquatic Services Unit,
Environmental Research Institute.
Lee Road.
Cork

Introduction

Toxicity testing was requested by Ecofact for the water sample labelled Platin. Two aquatic species from different trophic levels were selected for the testing, namely the waterflea (*Daphnia magna*) and the bacteria (*Vibrio fischeri*). Testing commenced on June 13th, 2018 and finished on June 15th, 2018.

Methodology

The effluent sample was collected on June 12th, 2018 and transported to the Aquatic Services Unit (ASU) laboratory by courier service. The Platin sample had temperature of 3.1°C on arrival to the laboratory; the sample was then immediately placed in a refrigerator at 4 °C until required for testing.

Daphnia magna Bioassay

The *Daphnia* bioassay was carried out following standard methods as described in UK Environment Agency guidelines (2007). The sample was tested for toxicity at the following concentrations 6.25, 12.5, 25, 50, and 100% following the pH adjustment. Twenty *Daphnia* neonates (animals less than 24 hours old) were tested for each concentration. These animals were added into 4 replicates of five animals per test chamber for each concentration. Testing was carried out in a constant temperature room at a temperature of 20 °C ± 2 throughout the test. A light regime of 16 hours light/8 hours dark was used throughout the testing period. The test duration was 48 hours. Filtered groundwater collect locally was used as control and dilution water. The *D. magna* were obtained from in house cultures at ASU.

Vibrio fischeri bacteria bioassay using Microtox system.

The luminescent bacteria *Vibrio fischeri* are used exclusively in the Microtox system. Testing was carried out following the ISO 11348-3 Guidelines. The concentrations of effluent tested ranged from 6.25% to 80%. Two replicates were used for each concentration tested. A concurrent reference toxicant bioassay was also carried out to determine the health and suitability of the bacteria.

Statistical Analyses

Statistical analyses to generate LC_{50} (Lethal Concentration to cause 50 percent mortality) or EC_{50} (Effective Concentration to cause 50 percent effect) data were performed using the ToxCalc v5.0.32 Environmental Toxicity Data Analysis System, (Tidepool Scientific 2007). Statistical analyses on the Microtox Data were performed using the proprietary Microtox Omni software (Azur Environmental 1995).

Results and Discussion

Daphnia magna bioassay results

This test was deemed to be valid given that there was greater than 90% survival in the controls indicating that the animals and testing conditions were satisfactory (UK Environment Agency, 2007). Survival across the concentration series of effluent was between 95 and 100% demonstrating that the sample is non-toxic to *D. magna*. No LC_{50} value was generated for this bioassay due to the non-toxic nature of the effluent. Results of this bioassay are displayed in Figure 1. Water quality measurements in the test chambers remained within normal limits for the duration of the bioassay. These data are presented in Appendix 1.

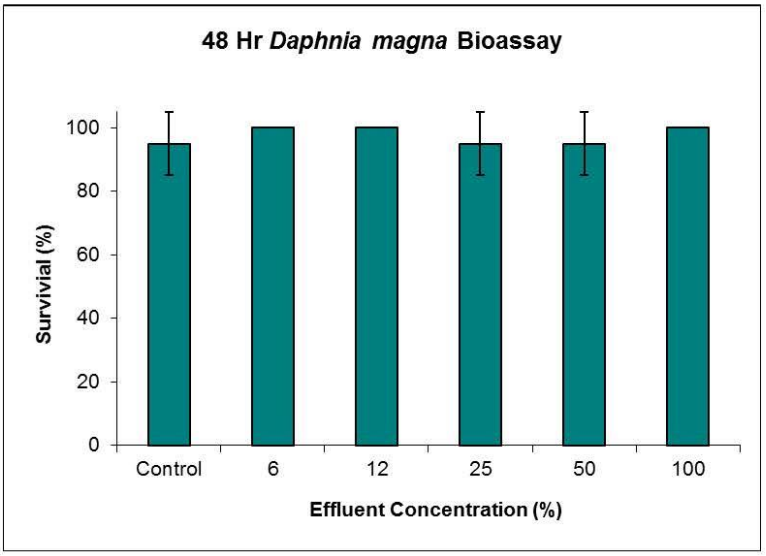


Figure 1 Average survival of *Daphnia magna* after 48 hours in a concentration series of the Platin sample.

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Microtox results.

The Microtox bioassay carried out on June 13th, 2018 was deemed to be valid. A reference toxicant test was carried out before actual testing of samples took place to ensure that the bacterium and reagents were suitable for testing. The reference toxicant using the $Zinc^{++}$ ion determined an EC_{50} of 1.3 mg Zn^{++}/L after 15 minutes exposure. This is within the guideline range of 0.6-2.2 mg Zn^{++}/L as specified by the Microtox manufacturer (Azur Environmental, 1995). These data are presented in Appendix 2.

No significant toxicity was observed between the controls and throughout the effluent concentration series. No significant decrease in light production was observed in any of the concentrations during the test. Based on the supporting data from the other bioassay the Platin Discharge sample is also non-toxic using the Microtox system. The data for the effluent test are presented in Figure 2.

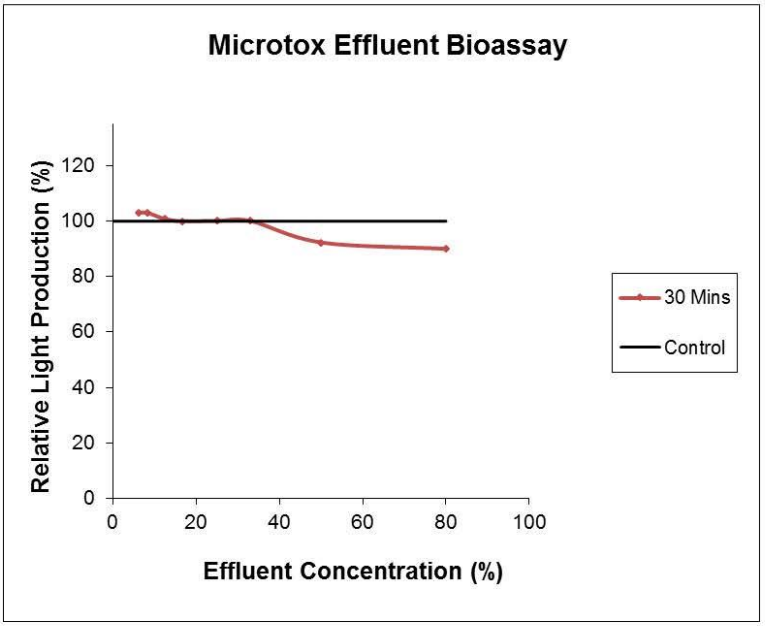

Figure 2 Plot of the Microtox results for Platin sample. Values represent light production relative to the controls. The highest concentration of effluent tested was 80%.

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Summary and Conclusions

The results from the 2 bioassays performed on the Platin sample indicate that the sample was non-toxic to both species tested. All of the bioassays performed were deemed to be valid as they meet all of the criteria as specified in the guidelines.

References

Azur Environmental, 1995. Microtox Acute Basic Test Procedures. Azur Environmental ,. Carlsbad, California, USA.

Environment Agency 2007, The direct toxicity assessment of aqueous environmental samples using the juvenile *Daphnia magna* immobilisation test. Methods for the Examination of Waters and Associated Materials. www.environment-agency.gov.uk.

ISO 11348-3:2007. Water quality-Determination of the inhibitory effect of water samples on the light emission of Vibrio fischeri (Luminescent bacteria test)—Part 3: method using freeze dried bacteria. International Standards Organisation.

U.S EPA, 2007. ECOTOX User Guide: ECOTOXicology Database System. Version 4. http:/www.epa.gov/ecotox.

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Appendix 1- Water Quality Measurements for *Daphnia magna* Bioassay

48 Hour Daphnia Bioassay
Ecofact Platin Eff 13/06/18

Concentration (%)	Survival			D.O (mg/L)			pH			Conductivity(µS/cm)			Temp (°C)		
	0hrs	24hrs	48hrs	0hrs	24hrs	48hrs	0hrs	24hrs	48hrs	0hrs	24hrs	48hrs	0hrs	24hrs	48hrs
Control A	5	4	4	9.7		9.5	8.25		8.19	351		498	19.5	19.2	19.3
Control B	5	5	5												
Control C	5	5	5												
Control D	5	5	5												
6.25A	5	5	5	9.7		9.5	8.29		8.21	374		421	19.3	19.2	19.3
6.25B	5	5	5												
6.25C	5	5	5												
6.25D	5	5	5												
12.5A	5	5	5	9.7		9.4	8.27		8.31	396		479	19.2	19.2	19.3
12.5B	5	5	5												
12.5C	5	5	5												
12.5D	5	5	5												
25A	5	5	5	9.8		9.4	8.22		8.29	440		482	19.1	19.2	19.3
25B	5	5	5												
25C	5	5	5												
25D	5	4	4												
50A	5	5	5	9.8		9.4	8.12		8.27	541		615	19.2	19.2	19.3
50A	5	5	5												
50A	5	5	5												
50B	5	4	4												
100A	5	5	5	10.0		9.4	7.97		8.05	739		788	19.3	19.2	19.3
100B	5	5	5												
100C	5	5	5												
100D	5	5	5												

Notes
Day 0 Initiated at 14.00 , animals less than 24hrs old in initiation
24hrs 10.30
48hrs Terminated test at 12.10

Testing performed by Aquatic Services Unit, ERI Building, Lee Rd., Cork

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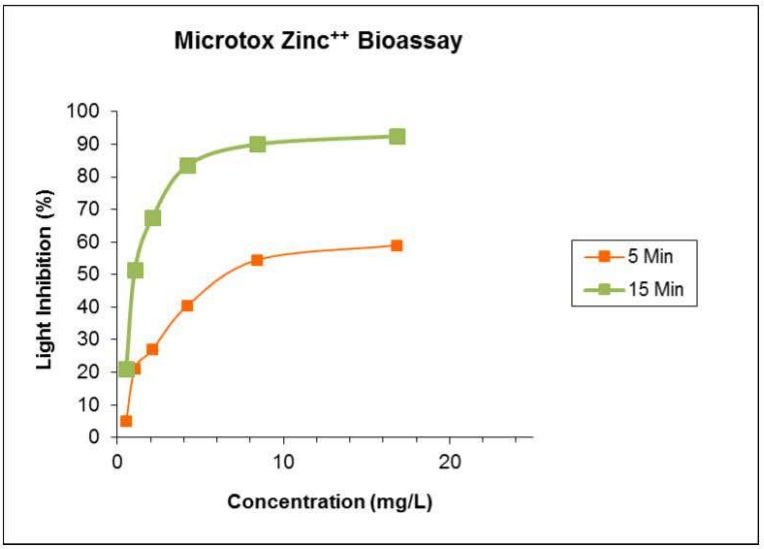
Appendix 2- Microtox Reference Toxicant Bioassay



Plot of light inhibition relative to the controls versus zinc sulphate concentration after 5 and 15 minutes exposure.

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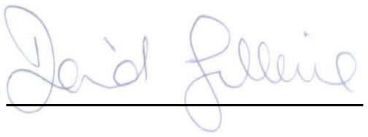
The toxicity testing carried out for this report complies with internationally accepted guidelines. The results of these toxicity tests contained in this report are deemed valid under these guidelines.

Signed: 

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