UCL

Aquatic Surveys: Glyn Rhonwy Quarries Q1 and Q6

Interim report to AECOM - May 2015

Goldsmith, B., Henderson, G., Shilland, E.M., Dowman, S., Tomlinson, M. & Harwood, A.

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ENSIS Ltd.

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ECRC Research Report 164

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Cover photo: Q1 from the lake edge © B. Goldsmith

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1. Introduction

1.1. Background

The Glyn Rhonwy Pumped Storage scheme is a proposed hydroelectric facility within Glyn Rhonwy Quarry, a disused slate quarry north-west of Llanberis, Gwynedd. The scheme requires the creation of two large water reservoirs utilising the existing quarries Q1 (SH5595060552) and Q6 (SH5665060855) which will be sealed and dammed to enable increase retention capacity. Water for the scheme will be abstracted from the adjacent Llyn Padarn, a Site of Special Scientific Interest (SSSI hereafter) to fill the upper reservoir. Both Q1 and Q6 currently hold permanent water and it is understood this may require release to Llyn Padarn during the construction phase and once operational, Llyn Padarn could also receive water from the scheme during periods of overflow.

As part of the Habitat Regulations Assessment (HRA), it is required to determine the species composition of the aquatic environments within the quarries to assess if they contain any species (native of non-native) that may threaten protected habitats (and species therein) if disturbed or released during construction or future operation of the scheme. Furthermore, it is unknown if the water and sediments within the quarries are of sufficient environmental quality for release. This applies to the Llyn Padarn SSSI to the north-east of the quarries and the Afon Gwyrfai a Llyn Cwellyn SAC to the south-west (primarily notified for Anex I habitat: Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation and Anex II species Floating water-plantain *Luronium natans* and Artic charr *Salvelinus alpinus*).

The introduction of non-native or non-representative species (plant or animal) to the protected habitats may be potentially harmful and thus threatening the integrity of the SSSI and / or SAC. Similarly, environment standards in water and sediment quality need to be met prior to release.

To this end, ENSIS has been commissioned by AECOM to undertake biological and chemical surveys of the quarry sites to include:

phytoplankton – species composition and abundance
benthic algae (diatoms) – species composition
aquatic plants – species composition and abundance
aquatic invertebrates – species composition
fish - species composition and abundance
Water quality – to meet health and environmental quality standards
Sediment quality – to meet health and environmental standards

A further assessment of the aquatic flora in Llyn Padarn has been commissioned to determine the presence and abundance of Floating water-plantain *Luronium natans* (Shedule 8 W&C act and Schedule 4 Conservation (Natural Habitats, etc.) Regulations) and Spring quillwort *Isoetes echinospora* (nationally scarce) in the area of the proposed intake pipes. Work is proposed for June.

1.2. Aims of the Project

- to undertake a survey of the aquatic plants in the Glyn Rhonwy Quarries Q1 and Q6.
- to undertake a survey of the aquatic invertebrates in the Glyn Rhonwy Quarries Q1 and Q6.
- to determine the presence of and survey the fish population in the Glyn Rhonwy Quarries Q1 and Q6.
- to collect and analyse diatom, phytoplankton and CPET samples from Q1 and Q6
- To collect water samples from Q1 and Q6 for water quality analysis
- to collect sediment samples from Q6 and Q1.
- June - to undertake a snorkel survey to provide a full species list and map of the aquatic plants within the vicinity of the proposed intake pipe at Llyn Padarn

1.3. Important considerations for the work

Unexploded ordnance

Glyn Rhonwy Quarry (Q6) was used as a munitions store and then ordnance dump during the 1940s. All survey work was therefore undertaken without the use of metal anchors and grabs and care was taken to cause minimal disturbance to the survey area.

Access

Access to Q1 was not possible without specialist rope access as defined within the Working at Height Regulations. Provided by: Remote Access Technology UK Ltd. Beacon Climbing Centre, Cibyn Industrial Estate,Caernarfon, Gwynedd LL55 2BD.

Additional sampling and analysis

Samples were collected for Chironomid Pupal Exuviae Technique (CPET) analysis. These have been preserved and archived at University College London and may be analysed if required in the future.

Licensing

ECON (fishing sub-contractor) undertook the electric fishing and gill netting under approval from Natural Resources Wales.

Work on Llyn Padarn will be carried out in June by Dr Ben Goldsmith under NRW Protected Species Licence 59401:OTH:SP:2014 (for *Luronium natans*).

Timing

In order to maximise the species information and plant identification, *the Luroniun natans* survey should be conducted during the period June – October. Invertebrates and fish can be surveyed earlier in the Q1 and Q6 quarry sites if required, and an assessment of aquatic plants also made.

2. Methods

2.1. Aquatic plant survey – Glyn Rhonwy Quarries Q1 and Q6

Due to their relatively small size, a full survey of the littoral zone was possible. Using an inflatable boat, a visual survey was made of the entire littoral zone (0 -2.5 m depth) with an underwater viewer (bathyscope). The water was sufficiently clear in both sites to give a good visual range to >3 m. Normally, a grapnel is used for detecting deeper plants, but the potential of unexploded ordnance within the Q6 site makes this unsafe. The grapnel also proved ineffective in Q1 due to the steeply sheling sides and prevalence of large boulders.

2.2. Aquatic invertebrate survey – Glyn Rhonwy Quarry Q1 and Q6

Aquatic invertebrate samples were collected from 4 separate locations around the littoral zone of the quarries to maximise the detection of species and to ensure full coverage of the site. Due to the limited extend of loose material and suitable invertebrate habitat, the sampling locations were limited to the availability of habitats rather than the planned stratified sampling.

At each sample location a three minute kick / sweep samples will be conducted within the main habitats (mainly gravels and cobbles). Samples from each habitat were combined, but the samples from each sample area were analysed separately. Any free swimming or surface dwelling invertebrates observed during the survey were also recorded. Samples were preserved in alcohol and transported to the laboratories at UCL for further analysis.

In the laboratory, the samples were sorted and all invertebrates picked and identified to species level where possible. The samples have been preserved and archived at UCL.

2.3. Diatom sampling

When collecting diatoms samples for water framework directive purposes it is normal to account for seasonal variation within the population by sampling during the spring and again in the autumn as detailed within the standard Environment Agency methods (EA Operational Instruction 27_07). For the purposes of a biological species assessment however, a more complete assessment of the diatom species within a site can be gained by analysing the preserved frustules (siliceous cell walls) from the surface sediments of the deepest point of the water body. This type of sampling provides a diatom assemblage that is representative of the whole lake (not just the littoral benthos) over a period of the past few years and is therefore deemed more appropriate for this project.

Neither site had any significant sediment deposits, but small quantities of the fine sediments overlying the boulders were collected from the deepest point of both quarries (7.3 m in Q1 and 17 m in Q6) using a Renberg gravity corer. In addition samples were also collected from the littoral zone by scraping and gently brushing the surface of 5 submerged cobbles and collecting the dislodged material into sample phials. All samples were preserved with Lugol’s iodine for transport to the laboratories at UCL.

In the laboratory, the samples were are then digested using hydrogen peroxide to remove the organic components whilst leaving the siliceous diatom valves undamaged. Samples were then mounted on to microscope slides and the diatom valves identified to species level using high powered light microscopy. The surface sediment were analysed by Dr Gina Henderson, a diatom and algae specialist and member of the UK expert panel for diatom taxonomy. Preparation and enumeration follows the methods described in EA Operational Instruction 28_07. The littoral samples have been prepared and the slides archived for future analysis if required.

2.4. Phytoplankton sampling

Phytoplankon samples were collected from Q1 and Q6 sites. The samples are collected using standard methods for boat sampling as described in “Sampling lakes for water chemistry and phytoplankton” (EA Operational instruction 19_07). In summary, a single sample was taken from each site using a 25 mm diameter hose. The hose is weighted at one end and lowered to a depth of up to 5 m. The upper end is then bunged and the hose raised and bunged at the base to enclose a “column” of water. This provides a sample that integrates the phytoplankton community across a depth range. Samples are transferred to sterile sample containers and preserved with Lugol’s iodine as described in EA Operational instruction 87_07.

Samples were be analysed by Dr Gina Henderson, a diatom and algae specialist and member of the UK ring test for phytoplankton.

2.5. Chironomid Pupal Exuvial Technique (CPET): sampling and analysis

The exuviae were sampled by taking sweeps across the water surface with a fine mesh (<250 µm) net from around the lee shore of te quarry sites. The net is then rinsed into a bucket of lake water and any course debris removed and the water then poured though a flat sieve of <250 µm. The exuviae are then carefully transferred to a suitable container and preserved in denatured alcohol. A single sample was collected from each site (Q1 and Q6) and these have been archived for future analysis if required.

The adult stage of chironomids are mobile up to several kilometres and therefore there are no barriers for their dispersersal to and from the Glyn Rhonwy quarry sites and the nearby Llyn Padarn SSSI and Afon Gwyrfai a Llyn Cwellyn SAC. The value of analysing CPET is therefore limited for this project.

2.6. Water sampling and analysis

Water samples were collected from Q1 and Q6 from approximatel the cenre of the open water area. Samples were taken from sub-surface and transferred to dedicated sample containers. All samples were kept cool and refrigerated during transport to the laboratories. Neither site showed any sign of stratification (assed by temperature and dissolved oxygen profiling) and therefore a single sample taken from the lake centre was considered as being representative.

Samples were analysed for a full suite of elements and compounds, including metals, total phosphorus, organic hydrocarbons etc – see results for full list. Analysis was conducted by a UKAS accredited laboratory (NLS).

2.7. Sediment sampling – Glyn Rhonwy Quarry Q1 and Q6

Extensive efforts were made in both quarry sites to collect sediments for analysis. In Q6, the UXO restricted methods to a gravity corer (70 mm diameter) with an acrylic tube, but in Q1, an Eckman grab sampler was also used. Multiple attempts were made in both sites at a range of different depths, but no significant sediment deposits were found and insufficient fine material was recovered for analysis. The profundal areas of both quarries was dominated by large boulders with only a few millimetres of flocculent deposits overlying the hard substrate.

2.8. Fish survey – Glyn Rhonwy Quarry Q1 and Q6

The fisheries survey was conducted by Mark Tomlinson and Dr Andrew Harwood of ECON Ecological Consultancy Ltd on 29th and 30th April 2015. The main fisheries survey was restricted to Q6 only, due to unresolved access issues for Q1. In addition to initial general observations of the Q1 by the fisheries team, a further survey was carried out by ENSIS on 7th May 2015.

A single multimesh gill net (CEN standard) was set across the lake on the evening of 29th April and retrieved the following morning, being in the water for approximately 14 hours. The gill net used was 30 m in length, with a stretched depth of 1.5 m. The net is comprised of 12 monofilament panels, each 2.5 m long, with mesh sizes in the following order: 43.0, 19.5, 6.25, 10.0, 55.0, 8.0, 12.5, 24.0, 15.5, 5.0, 35.0 and 29.0 mm. The net was positioned using 6 mm polypropylene rope from bank to bank and anchored in place using weighted ropes, such that it effectively sampled the upper 1.5 m of the limnetic zone.

The survey of the littoral margin was conducted on 30th April using a Point Abundance Sampling by Electrofishing (PASE) method. The electric fishing equipment used is detailed in Table 1. The equipment, powered by a 1 KVa generator, produces pulsed direct current (DC). The anode was equipped with a relatively large (380 mm) ring, which aims to reduce the danger zone close to the anode and thus potential fish mortality (Novotny 1990).

Unit	Input amps (A)	Frequency (Hz)	Output volts (V)	Area of influence (m^2)
Electrafish FC1000	<1.0	50	c. 25	0.91

Table 1 Details of the electric fishing equipment used for the PASE survey

The equipment induces effective galvanotaxis of fish towards the anode within its associated sphere of influence. Fish may react slightly differently to the anode, depending on size and species, but will generally move toward the anode and become incapacitated allowing them to be caught in a long-handled net. The area of the sphere of influence was determined to be at a distance of around 35 cm (determined using a volt meter on site), equating to an area of influence of 0.91 m^2.

The PASE survey was conducted using a small boat with two operators, one controlling the boat by ‘push-rowing’ from the bow, keeping the electric fishing operator in sight at all times. Points were sampled systematically, approximately 5 m apart, covering the entire margin. A total of 30 points were sampled.

At each point the 2.5 m long anode was rapidly immersed and a lightweight, long handled net was swept through the point, thereby collecting stunned fish even if none were seen. All fish caught were identified to species level, measured to the nearest mm (fork length) and any particular characteristics of individual fish are noted including any ailments or obvious parasites. Weight estimates (grammes – g) are calculated from length-weight regression relationships for each species compiled and held by ECON. Fish density estimates for the littoral margin were calculated using the following formula:

Total individuals (ind.) or biomass of fish / Number of points / Effective area

In addition to the standard PASE surveys, continuous electric fishing patrols were also undertake of all suitable habitat using the same equipment and principles detailed above. Habitat was deemed as suitable where any non-vertical littoral zone was present. Continuous patrols are a practical means of achieving the most thorough coverage of a site and work particularly well for smaller sites such as these quarries.

3. Results

3.1. Aquatic plants – Glyn Rhonwy Quarries Q1 and Q6

Despite the very clear water and ample light, there were no submerged aquatic (higher) plants recorded growing in Q1 or Q6.

Water quality in both sites (see below) was good, and typical of oligotrophic lakes within the region which support *Isoëto-Nanojuncetea* and / or *Littorelletea unifloriae* floras (e.g. Llyn Padarn, Llyn Cwellyn). The lack of plants is more likely to be due to the poor substrates into which plants need to take root. Much of the littoral zone in both sites was steeply shelving and lacked any significant fine sediment suitable for plant growth. Furthermore, the substrates were relatively mobile which also inhibits plants from becoming established.

In Q6, the waterline along the west and east margin had growths of moss on the solid rocks and larger boulders. All sample specimens of the moss were *Brachythecium plumosum*, a species common throughout the UK in damp shaded environments, and particularly on lake and streamsides.

In Q1, the flatter areas around the western and south shore were relatively rich in bryophytes. Of these only 2 species of liverwort were recorded growing in the water below the splash zone: *Nardia scalaris* (ladder flapwort) and *Pellia* sp. (identified as *P. epiphylla,* but lacking fruiting bodies and therefore not possible to confirm). These are common within Wales and the UK.

In summary, there were no rare or protected species of aquatic plants recorded within either quarry, and no species of aquatic plant that poses any risk to protected environments if caused to be released from the site.

The maximum recorded water depths were:
Q1 = 7.3 m
Q6 = 17.1 m

3.2. Aquatic invertebrates – Glyn Rhonwy Quarry Q1 and Q6

Generally the habitat in both quarries was restricted to loose gravels, cobbles and boulders with some overhanging shrubs and trees providing additional habitat dynamics. Neither site had any significant deposits of organic material or leaf litter. Some species were observed on the water surface (e.g. Whirlygig beetles and river skaters), but the majority were associated with the substrates where they sheltered either on or under stones.

A total of 26 different taxa were recorded from the 2 sites, 18 in Q1 and 17 in Q6, only 9 of which were common to both sites (Table 2). The assemblages are typical of still water oligotrophic sites and there were no rare or nuisance species recorded.

		7th May 2015				29th April 2015					
Common Name	**Taxa**	**Q1(1)**	**Q1(2)**	**Q1(3)**	**Q1(4)**	**Q6(a)**	**Q6(b)**	**Q6(c)**	**Q6(d)**	**Q1 Totals**	**Q6 Totals**
Stonefly	*Amphinemura sulcicollis*	2								2	0
Freshwater Limpet	*Ancylus fluviatilis*	10	4	2	3	2			1	19	3
River Skater	*Aquarius najas*	2								2	0
Mayfly	*Caenis luctuosa*					50	20	15	10	0	95
Non-biting Midge	Chironomidae	10	20	4	3	20	10	20	5	37	55
Mayfly	*Electrogena lateralis*	50	40	60	30	30			3	180	33
Freshwater Shrimp	*Gammarus pulex*	30	15	20	15					80	0
Cased Caddis	Glossosomatidae (pupa)	1	1							2	0
Whirlygig Beetle	*Gyrinus sp.*	10	1		3					14	0
Leech	*Helobdella stagnalis*					2				0	2
Mayfly	*Leptophlebia marginata*					10	8	30	10	0	58
Cased Caddis	*Limnephilus lunatus*					2		3		0	5
Stonefly	*Nemoura* sp.					3		5		0	8
Freshwater Worm	Oligochaeta	10		5		20			2	15	22
Riffle Beetle	*Oulimnius tuberculatus*	15	1	1		10		6		17	16
Mayfly	*Paraleptophlebia* sp.	3	1	1	7					12	0
Pea Mussel	*Pisidium sp.*					2				0	2
Flatworm	*Polycelis nigra/tenuis*					2				0	2
Caseless Caddis	*Polycentropus flavomaculatus*	3		4	1					8	0
Caseless Caddis	*Polycentropus irroratus*					5	20		5	0	30
Snail	*Radix balthica*		5	6	1	15	1		2	12	18
Cased Caddis	*Sericostoma personatum*			5		30			1	5	31
Lesser Water Boatman	*Sigara (Sigara) dorsalis*	1	2							3	0
Stonefly	*Siphonoperla torrentium*	4		10		20				14	20
Beetle	*Stictotarsus duodecimpustulatus*			1						1	0
Caseless Caddis	*Tinodes waeneri*	30	20	6	7	16			2	63	18

Table 2 Invertebrate species recorded in the Glyn Rhonwy quarry sites, Q1 and Q6

3.3. Diatoms - Glyn Rhonwy Quarry Q1 and Q6

The diatom assemblages are typical of nutrient poor, circum-neutral lakes with clear water. The majority of species recorded in both sites are benthic species which is indicative of the high water clarity; Fragilariaceae being the most represented family (Table 3).

The results are typical for clear, nutrient poor, circum-neutral lakes and give no cause for concern.

Species name	**Q1 7 May 15**	**Q6 29 April 15**
Achnanthidium minutissimum	38	37
Amphora ovalis		20
Amphora pediculus	3	2
Cocconeis placentula (raphe valves)	2	
Cocconeis placentula var. euglypta	9	
Cocconeis placentula var. pseudolineata	4	
Cyclotella cf stelligera		1
Cymbella cymbiformis		4
Cymbella sp (central section only)	3	
Diatoma mesodon	2	
Diploneis ovalis		2
Diploneis parma	1	
Diploneis sp	1	
Encyonema silesiacum	2	
Encyonopsis microcephala		2
Eunotia rhynchocephala var satelles	1	
Fragilaria capucina		3
Fragilaria capucina var. distans		5
Fragilaria microstriata	71	
Gomphonema sp.	4	2
Navicula cryptocephala	2	2
Nitzschia denticula	39	2
Nitzschia frustulum		1
Nitzschia sp.	2	2
Pseudostaurosira brevistriata	2	79
Staurosira construens var. binodis	25	34
Staurosira construens var. construens		5
Staurosira pseudoconstruens		10
Staurosira robusta	148	224
Synedra nanana		13
Synedra ulna	1	
Total valves	**360**	**450**

Table 3 Diatom species recorded in the Glyn Rhonwy quarry sites, Q1 and Q6

3.4. Phytoplankton - Glyn Rhonwy Quarry Q1 and Q6

Phytoplankton concentrations were low in both sites, which is typical for nutrient poor waters. Q1 was particularly dilute and dominated (in numbers) by picoplankton; tiny single-celled algae, the size and lack of any differentiation being insufficient to identify. Q6 was slightly more diverse and in addition to picoplankton had relatively high numbers of the colonial chrysophyte *Dinobryon sociale*. This species often blooms in the spring and is common in UK lakes (Henderson, *pers. comm.*). There were no cyanobacteria (blue-green) recorded in either site, and no "nuisance" species.

	Q1 7 May 15		Q6 29 April 15	
Species name	**Conc. No's per ml**	**Biovol. µm³ per ml**	**Conc. No's per ml**	**Biovol. µm³ per ml**
Aulacoseira	1	808		
Cryptomonas (medium) Length 20-30 µm	2	3,260	55	129,155
Cryptomonas (small) Length <20 µm	2	2,445	51	62,885
Dictyosphaerium pulchellum	1	958		
Dinobryon sociale			1602	157,869
Glenodinium sp.	1	10,150	5	15,857
Gonium sp.	1	468	0.4	295
Mallomonas akrokomos	7	450		
Mallomonas caudata	31	3,130		
Medium centric diatom (10-20 µm diam.)	7	10,139	9	5,560
Monoraphidium contortum			36	209
Monoraphidium griffithii			27	1,255
Nanoplankton - unidentified single cells 2–20 µm diameter			18	1,674
Oocystis sp.	1	299		
Peridinium sp.	1	5,321		
Picoplankton - unidentified single cells <2 µm diam.	1244	651	1456	763
Rhodomonas lacustris var. nannoplanctica	176	9,438	91	11,228
Small centric diatom (5 - <10 µm diam.)			27	3,575
Synedra sp.			10	6,229
Synedra ulna			7	5,044
Tetraedron minimum			127	5,729
Totals	**1474**	**47520**	**3524**	**407327**

Table 4 Phytoplankton species recorded in the Glyn Rhonwy quarry sites, Q1 and Q6

3.5. Water quality - Glyn Rhonwy Quarry Q1 and Q6

Summary data for water quality are given in Table 5 and the full analytical results in Appendix I. Both lakes were slightly alkaline with respect to pH, and fall within the low (Q1) to moderate (Q6) alkalinity class, which is typical for surface waters on slate geology.

Nutrient concentrations are relatively low with total phosphorus (TP) in Q1 being below the target value of 10 μgl^{-1} set for oligotrophic waters under the Habitats Directive quality guidance (JNCC 2015). Q6 had slightly higher TP, but again, this is within the limits for oligo-mesotrophic standing waters where alkalinity is above 50 $mgl^{-1.}$ (JNCC 2015). Nitrates were low in both sites and the nutrient chemistry gives no cause for concern.

Analyte	Units	Q1 Concentration	Q6 Concentration
General quality			
pH	pH Units	8.04	8.26
Alkalinity to pH 4.5 : Grans Plot	mg/l	31.9	65
Conductivity at 20C	uS/cm	99	158
BOD 5 Day ATU	mg/l	<2.92	<2.92
Chemical Oxygen Demand :- {COD}	mg/l	<10.0	<10.0
Nutrients			
Phosphorus : Total as P	ug/l	15	<10
Orthophosphate, reactive as P	ug/l	1.7	1.2
Nitrogen : Total Oxidised as N	mg/l	0.233	0.3
Nitrate as N	mg/l	0.231	0.299
Nitrite as N	mg/l	0.00179	0.00102
Ammoniacal Nitrogen as N	mg/l	<0.00200	<0.00200
Metals			
Aluminium	ug/l	<10	<10
Antimony	ug/l	<1	<1
Arsenic	ug/l	<1	3.16
Barium	ug/l	28.5	556
Boron	ug/l	<100	<100
Cadmium	ug/l	<0.1	<0.1
Calcium	mg/l	13.9	20.8
Chromium	ug/l	<0.5	1.06
Cobalt	ug/l	<1	<1
Copper	ug/l	1.95	3.27
Iron	ug/l	<30	<30
Lead	ug/l	<2	<2
Lithium	ug/l	<100	<100
Magnesium	mg/l	1.23	5.13
Manganese	ug/l	<10	<10
Mercury	ug/l	<0.01	<0.01
Molybdenum	ug/l	<3	<3
Nickel	ug/l	<1	<1
Potassium	mg/l	0.206	0.39
Selenium	ug/l	<1	<1
Sodium	mg/l	4.66	4.76
Strontium	ug/l	<20	81.8
Sulphate as SO4	mg/l	<10	<10
Zinc	ug/l	<5	<5
Organic chemistry			
Carbon, Organic : Total as C :- {TOC}	mg/l	<0.7	0.7
Phenol	ug/l	0.0598	0.153

Table 5 Water quality summary for the Glyn Rhonwy quarry sites, Q1 and Q6

Metal concentrations were relatively low in most cases, with the majority of toxic elements being below detection. The **annual mean** limits for copper are 1 μgl^{-1} for waters below 50 mgl^{-1} alkalinity (Q1) and 6 μgl^{-1} for waters in the range 50-100 mgl^{-1} total alkalinity (Q6) (EUDirective 76/464/EEC). The spot sample taken at Q1therefore exceeds the permissible environmental quality standard (EQS) for levels of copper. The implications for this should be investigated further with respect to any proposed release of water from Q1 and for Q6 where any receiving water is <50 mgl^{-1} alkalinity. The upper limits for short term concentrations are less stringent.

Levels of total organic compounds were low with the majority of analytes being below detection limits. Detectable levels of phenol were measured, but these were well within the legislative EQS and also below the more stringent limits recommended by UKTAG for WFD compliance (7.7 μgl^{-1} Lepper *et al.* 2007).

3.6. Sediment sampling – Glyn Rhonwy Quarry Q1 and Q6

No significant sediment deposits were found and no samples taken.

The negative sampling attempts from multiple locations within both sites suggest that there is only very limited fine sediments within the sites.

3.7. Fish survey – Glyn Rhonwy Quarry Q1 and Q6

Q6

The fisheries techniques employed in Q6, revealed a very limited fish community of three-spined stickleback *Gasterosteus aculeatus* and European eel *Anguilla anguilla* (eel hereafter).

A total of six three-spined sticklebacks were captured in the PASE survey of the littoral margin resulting in an abundance estimate of 0.22 individuals m^{-2} and a biomass of 0.16 g m^{-2} for the littoral margin. Assuming a perimeter of 375 m (estimated from satellite images and tools in Google Earth Pro) and an average width of 1 m, this equates to 83 fish. In reality, this is likely to be an underestimate as the area of suitable habitat may be much greater than this and that the sampling efficiency may have been compromised slightly by the abundance of crevices within the slate substrate acting as refuges.

A further nine three-spined sticklebacks were captured in the electric fishing patrols of the littoral margin. A large eel measuring approximately 1 m in length and estimated to weigh 2 kg (based on national length-weight regressions), was also encountered at the south-west end of the lake.

The three-spined sticklebacks captured ranged from 29 to 42 mm in fork length. A number of the fish captured were identified as males displaying breeding colours (red undersides).

No fish were captured in the survey gill net.

Q1

Unlike in Q6 where three-spined sticklebacks were very evident during the electric fishing and visual surveys, none were recorded in Q1 and no other fish species were seen.

Q1 is much smaller than Q6, with a perimeter of c.100 m, and is very isolated, and without public access to the water and hence less likely to have been inoculated with fish. The site also has rather limited littoral habitat due to the near vertical sides of much of the basin.

The absence of fish in Q1 is further supported by the occurrence and behaviour of some invertebrate species. In Q1, the mayfly *Electrogena lateralis* was very visible on the upper surface of rocks within the littoral zone (Figure 1). This is a species that could easily be taken as prey by fish (including three-spined sticklebacks) if they were present. There is evidence to suggest that similar species of mayfly adjust their behaviour to avoid predation where fish are present, whereas in fishless lakes (and streams) they remain and feed in more open habitat (Tikkanen *et al* 1996) as observed in Q1. In summary there was no evidence found of any fish in Q1.

Figure 1 Mayfly (*Electrogena lateralis*) and freshwater limpet (*Ancylus fluviatilis*) grazing on the upper surface of a rock in Q1.

3.8. Other notable species

Newts

Although apparently fishless, palmate newts *Lissotriton helveticus* were abundant in Q1, with both males and females present (Figure 2). Where littoral habitat was available, there were estimated to be as many as 10 newts present per m^2.

A single specimen of newt was seen in Q6, although not captured, it is likely to have been a palmate newt *Lissotriton helveticus*.

Non-native species

Although not part of the commissioned survey, it was noted that as well as the non-native *Buddleja* sp. (Buddleia) which was common on the approach to Q6, both Q1 and Q6 have *Cotoneaster* shrubs growing on outcropping rocks. *Cotoneaster* is listed within under Schedule 9 to the Wildlife and Countryside Act 1981 with respect to England and Wales and it is an offence to knowingly cause these species to grow in the wild.

Care should therefore be exercised to ensure all vegetation is disposed of in a manner compliant with the Wildlife and Countryside Act 1981 to avoid spread of this plant.

Figure 2 Palmate newt (*Lissotriton helveticus*) recorded in Q1.

4. Summary of findings

4.1. Q1 quarry lake

The lake in Q1 appears typical of an isolated upland site in terms of its biology. The diatom and phytoplankton floras are characteristic of clear-water, circum-neutral waters.

The aquatic invertebrate population is similarly typical and the species therein pose no ecological threat if transferred to nearby protected sites as a result of the works.

No higher plants were recorded growing in the lakes. The lack of suitable substrate and steeply shelving sides present poor habitat for aquatic plants and this along with the isolation of the site has prevented colonisation. The terrestrial habitat is relatively rich in bryophytes, and 2 commonly occurring liverworts were recorded growing below the waterline and in the splash-zone of the lake. These are common throughout the region and pose no ecological threat to nearby sites.

The lake substrate is dominated by large boulders and solid rock, with some finer gavels in the littoral zone. No significant accumulations of fine sediments were found.

No fish were recorded in the site. The steep sides of the quarry largely prevent public access and therefore seeding by potential anglers (see below). The prevalence of invertebrates is also indicative of the site having no fish.

The water quality is excellent in terms nutrients (N & P) and has no elevated levels of hydrocarbons. The only concern raised is the concentration of dissolved copper in Q1 which although relatively low, nonetheless exceeds the environmental quality standard for low alkalinity waters and we recommend this be clarified prior to release.

The terrestrial habitat was not surveyed, but the presence of *Cotoneaster* sp. was noted. Under Schedule 9 to the Wildlife and Countryside Act 1981 England and Wales it is an offence to knowingly cause these species to grow in the wild and therefore due care should be taken to control these plants during the proposed works.

4.2. Q6 quarry lake

The Q6 lake is larger than Q1 and significantly deeper (17.1 m) and has long been open to public access making the possible introduction of species to the site more likely.

The diatom and phytoplankton floras are typical of clear, circum-neutral waters.

The aquatic invertebrate population is similarly typical and the species therein pose no ecological threat if transferred to nearby protected sites as a result of the works.

No higher plants were recorded growing in the lakes. The lack of suitable substrate and steeply shelving sides present poor habitat for aquatic plants, and will have prevented plants becoming established even if they were able to reach the site. A single species of moss was common growing on rocks around the waterline and

splash. This species is common throughout the region and poses no ecological threat to nearby sites.

The lake substrate is dominated by large boulders and solid rock, with some finer gavels in the littoral zone. No significant accumulations of fine sediments were found.

Fish were recorded in Q6, but the community was species poor and of low abundance, which is typical of such a water. Indeed the colonisation of newly formed lakes by both sticklebacks and eels has been noted in flooded gravel pits (Milne 1974). Three-spined stickleback are one of the most widespread species throughout the UK capable of maintaining populations in various habitats, including brackish and salt water, have a varied diet and are tolerant of a wide range of water qualities.

These characteristics contribute to the species being early colonising species within new waterbodies (described by Maitland & Campbell 1992; Maitland 2000 for review). In the case of Q6, the three-spined stickleback are likely to have arrived via eggs or as juveniles or adults within plant matter carried by birds. Whilst the lake is not connected to other waterbodies, Llyn Padarn is within 400 m (in a straight line) from the quarry. Thus, it is likely the lake was seeded by fish from here and a viable population then developed.

Three-spined sticklebacks are heavily preyed upon by fish, birds and mammals, but as primary colonisers, their populations can rapidly increase in numbers. Other than the large eel, there was little evidence of potential predation pressure on three-spined stickleback in Q6, therefore the population may be limited due to resources and habitat. In regard to habitat, whilst the interstitial spaces within the lake would provide ideal refugia for the fish, male sticklebacks require fibrous plant material or detritus to construct nests on soft substrate. Therefore spawning potential of the species, and ultimately the population, may be limited through the habitat of the quarry lake.

Like sticklebacks, eels are also often early colonisers due to their ability to cross ground between waterbodies. However, such a colonisation route from Llyn Padarn and the Aefon Seiont would appear unlikely as the direct distance and vertical elevation between the waterbodies is approximately 400 m and 50 m respectively. The fish may have instead been introduced as a very young fish, again through an avian introduction. Whatever the pathway, once inside the quarry basin escape was unlikely and if the water remains as is, the fish will be unlikely to ever undergo migration to the sea.

In general, eels in excess of 450 mm in length are usually female fish, as males have generally migrated from their freshwater environment by that size. However, due to the fish being essentially landlocked, the sex of the captured eel is unclear. Eels usually reach this size and migrate to sea after 10 years, but a fish of this size is likely to be considerably older. Interestingly, this is not the first record of an eel in the quarry; a large adult eel was recorded in the old bomb store (assumed to be Q6) in 2009 (Appendix 6.5 of the Environmental Statement for the Glyn Rhonwy Pumped Storage Scheme).

Whilst the deep areas of the quarry lake were not sampled, there is confidence in the findings of the fisheries survey. The lake is truly isolated from other water sources and illegal introductions of fish by anglers would be the main potential source of further fish species being introduced. Transporting fish into the quarry would also pose a considerable challenge which would likely prevent any casual attempts to introduce fish. In addition, there was no evidence of any angling activity on the water (e.g. discarded or snagged line or floats), whereas there was other evidence of recreational use including small dinghies, oars and lilos that had been discarded.

The water quality is relatively good in terms of nutrients (N & P) and typical for mesotrophic waters. Total phosphorus was slightly above the upper limit for oligotrophic waters (10 μgl^{-1}), but this should pose no problem unless the proposed receiving waters are very nutrient poor. At time of writing we do not have the nutrient chemistry for Llyn Padarn, but it is likely that TP levels are similar: this should be checked.

All other water quality parameters fall within the EQS for this lake type. Dissolved copper concentrations are higher than in Q1, but the upper limit for more alkaline lakes (Q6 is within the 50-100 mgl^{-1} range) is higher (6ugl^{-1} of copper). We recommend that further clarification is sought with regards to the potential impact on the receiving waterbody.

The terrestrial habitat was not surveyed, but the presence of *Cotoneaster* sp. was noted. Under Schedule 9 to the Wildlife and Countryside Act 1981 England and Wales it is an offence to knowingly cause these species to grow in the wild and therefore due care should be taken to control these plants during the proposed works.

5. References

Copp, G.H. &, Peñáz, M. (1988). Ecology of fish spawning and nursery zones in the flood plain, using a new sampling approach. *Hydrobiologia*, **169**: 209-224.

JNCC (2015). Common Standards Monitoring Guidance for Freshwater Lakes. Version March 2015. ISSN 1743-8160 (online): http://jncc.defra.gov.uk/pdf/0315_CSM_Freshwater_lakes.pdf [Accessed May 2015]

Lepper, P., Sorokin, N., Atkinson, C., Rule, K., Hope, S-J., Maycock, D. & Comber, S. (2007). *Proposed EQS for Water Framework Directive Annex VIII substances: phenol*. Science Report: SC040038/SR12. Environment Agency, Bristol

Maitland, P.S. (2000). *Guide to Freshwater Fish of Britain and Europe*. Hamlyn, London. 256p.

Maitland, P.S. & Campbell, R.N. (1992). *Freshwater Fishes*. Harper Collins, London. 368p.

Milne, B.S. (1974). Ecological Succession and Bird-life at a Newly Excavated Gravel-pit, *Bird Study*, **21:4**, 263-278.

Novotny, D.W. (1990). Electric Fishing Apparatus and Electric Fields. In *Fishing with Electricity-Applications in Freshwater Fisheries Management*, eds. I.G. Cowx & P. Lamarque, pp. 34-88. Fishing News Books, Blackwell Scientific Publications, Oxford, UK.

Phillips, G. (2003). *Reporting Typology for Ecoregion 18, Great Britain – UKTAG.* Lakes Task Team Internal Report TAG/LTT 43, March 2003

Tikkanen, P., Muotka, T. & Huhta, A. (1996). Fishless-stream mayflies express behavioural flexibility in response to predatory fish. *Animal Behaviour*, **51:** 1391–1399.

6. Appendix I – Full water quality analysis

Analyte	***Units***	**Q1 Concentration 07/05/2015**	**Q6 Concentration 29/04/2015**
General quality			
pH	pH Units	8.04	8.26
Alkalinity to pH 4.5 : Grans Plot	mg/l	31.9	65
Conductivity at 20C	uS/cm	99	158
BOD 5 Day ATU	mg/l	<2.92	<2.92
Chemical Oxygen Demand :- {COD}	mg/l	<10.0	<10.0
Nutrients			
Phosphorus : Total as P	ug/l	15	<10
Orthophosphate, reactive as P	ug/l	1.7	1.2
Nitrogen : Total Oxidised as N	mg/l	0.233	0.3
Nitrate as N	mg/l	0.231	0.299
Nitrite as N	mg/l	0.00179	0.00102
Ammoniacal Nitrogen as N	mg/l	<0.00200	<0.00200
Metals			
Aluminium	ug/l	<10	<10
Antimony	ug/l	<1	<1
Arsenic	ug/l	<1	3.16
Barium	ug/l	28.5	556
Boron	ug/l	<100	<100
Cadmium	ug/l	<0.1	<0.1
Calcium	mg/l	13.9	20.8
Chromium	ug/l	<0.5	1.06
Cobalt	ug/l	<1	<1
Copper	ug/l	1.95	3.27
Iron	ug/l	<30	<30
Lead	ug/l	<2	<2
Lithium	ug/l	<100	<100
Magnesium	mg/l	1.23	5.13
Manganese	ug/l	<10	<10
Mercury	ug/l	<0.01	<0.01
Molybdenum	ug/l	<3	<3
Nickel	ug/l	<1	<1
Potassium	mg/l	0.206	0.39
Selenium	ug/l	<1	<1
Sodium	mg/l	4.66	4.76
Strontium	ug/l	<20	81.8
Sulphate as SO4	mg/l	<10	<10
Zinc	ug/l	<5	<5
Organic chemistry			
Carbon, Organic : Total as C :- {TOC}	mg/l	<0.7	0.7
Phenol	ug/l	0.0598	0.153
Hydrocarbons >C10 - C12, Aliphatic Fraction	mg/l	<0.003	<0.003
Hydrocarbons >C10 - C12, Aromatic Fraction	mg/l	<0.007	<0.007
Hydrocarbons >C10 - C35, Aliphatic Fraction	mg/l	<0.02	<0.02
Hydrocarbons >C10 - C35, Aromatic Fraction	mg/l	<0.05	<0.05
Hydrocarbons >C12 - C16, Aliphatic Fraction	mg/l	<0.01	<0.01
Hydrocarbons >C12 - C16, Aromatic Fraction	mg/l	<0.006	<0.006

Analyte	***Units***	**Q1 Concentration 07/05/2015**	**Q6 Concentration 29/04/2015**
Hydrocarbons >C16 - C21, Aliphatic Fraction	mg/l	<0.005	<0.005
Hydrocarbons >C16 - C21, Aromatic Fraction	mg/l	<0.03	<0.03
Hydrocarbons >C16 - C35, Aliphatic Fraction	mg/l	<0.02	<0.02
Hydrocarbons >C16 - C35, Aromatic Fraction	mg/l	<0.05	<0.05
Hydrocarbons >C21 - C35, Aliphatic Fraction	mg/l	<0.02	<0.02
Hydrocarbons >C21 - C35, Aromatic Fraction	mg/l	<0.03	<0.03
Hydrocarbons > C7 - C8, Aliphatic Fraction	mg/l	<0.05	<0.05
Hydrocarbons > C7 - C8, Aromatic Fraction	mg/l	<0.05	<0.05
Hydrocarbons > C8 - C10, Aliphatic Fraction	mg/l	<0.1	<0.1
Hydrocarbons > C8 - C10, Aromatic Fraction	mg/l	<0.05	<0.05
Hydrocarbons >C 5 - C6, Aliphatic Fraction	mg/l	<0.05	<0.05
Hydrocarbons >C5 - C10, Aliphatic Fraction	mg/l	<0.2	<0.2
Hydrocarbons >C5 - C10, Aromatic Fraction	mg/l	<0.1	<0.1
Hydrocarbons >C6 - C7, Aliphatic Fraction	mg/l	<0.1	<0.1
Hydrocarbons >C6 - C7, Aromatic Fraction	mg/l	<0.05	<0.05
Acenaphthene	ug/l	<0.03	<0.01
Acenaphthylene	ug/l	<0.03	<0.01
Anthracene	ug/l	<0.03	<0.01
Benzo(a)anthracene	ug/l	<0.03	<0.01
Benzo(a)pyrene	ug/l	<0.03	<0.01
Benzo(b)fluoranthene	ug/l	<0.03	<0.01
Benzo(e)pyrene	ug/l	<0.03	<0.01
Benzo(ghi)perylene	ug/l	<0.03	<0.01
Benzo(k)fluoranthene	ug/l	<0.03	<0.01
Chrysene	ug/l	<0.03	<0.01
Cyanide as CN	mg/l	<0.00500	<0.00500
Dibenzo(ah)anthracene	ug/l	<0.03	<0.01
Fluorene	ug/l	<0.03	<0.01
Fluoranthene	ug/l	<0.03	<0.01
Indeno(1,2,3-cd)pyrene	ug/l	<0.03	<0.01
Naphthalene	ug/l	<0.03	<0.01
Perylene	ug/l	<0.03	<0.01
Phenanthrene	ug/l	<0.03	<0.01
Pyrene	ug/l	<0.03	<0.01
2,3,5,6-Tetrachlorophenol	ug/l	<0.02	<0.02
2,3-Dichlorophenol	ug/l	<0.02	<0.02
2,3-Dimethylphenol :- {2,3-Xylenol}	ug/l	<0.02	<0.02
2,4,5-Trichlorophenol	ug/l	<0.02	<0.02
2,4,6-Trichlorophenol	ug/l	<0.02	<0.02
2,4-Dichlorophenol	ug/l	<0.02	<0.02
2,4-Dimethylphenol :- {2,4-Xylenol}	ug/l	<0.02	<0.02
2,5-Dichlorophenol	ug/l	<0.02	<0.02
2,5-Dimethylphenol :- {2,5-Xylenol}	ug/l	<0.02	<0.02
2,6-Dichlorophenol	ug/l	<0.02	<0.02
2,6-Dimethylphenol :- {2,6-Xylenol}	ug/l	<0.02	<0.02
2-Chlorophenol	ug/l	<0.02	<0.02
2-Ethylphenol	ug/l	<0.02	<0.02
2-Methylphenol :- {o-Cresol}	ug/l	<0.02	<0.02
3,4-Dimethylphenol :- {3,4-Xylenol}	ug/l	<0.02	<0.02
3,5-Dimethylphenol :- {3,5-Xylenol}	ug/l	<0.02	<0.02

Analyte	***Units***	**Q1 Concentration 07/05/2015**	**Q6 Concentration 29/04/2015**
3-Chlorophenol	ug/l	<0.02	<0.02
3-Methylphenol :- {m-Cresol}	ug/l	<0.02	<0.02
4-Chloro-2-methylphenol :- {p-Chloro-o-cresol}	ug/l	<0.02	<0.02
4-Chloro-3,5-dimethylphenol :- {PCMX}	ug/l	<0.02	<0.02
4-Chloro-3-methylphenol :- {p-Chloro-m-cresol}	ug/l	<0.02	<0.02
4-Chlorophenol	ug/l	<0.02	<0.02
4-Methylphenol :- {p-cresol}	ug/l	<0.02	<0.02
Pentachlorophenol	ug/l	<0.02	<0.02
1,2-Dinitrobenzene	ug/l	<1.00	<1.00
1,3-Dinitrobenzene	ug/l	<1.00	<1.00
1,4-Dinitrobenzene	ug/l	<1.00	<1.00
1-Methylnaphthalene	ug/l	<1.00	<1.00
2,3,4,6-Tetrachlorophenol	ug/l	<1.00	<1.00
2,4-Dinitrotoluene	ug/l	<1.00	<1.00
2,6-Dinitrotoluene	ug/l	<1.00	<1.00
2-Chloronaphthalene	ug/l	<1.00	<1.00
2-Methylnaphthalene	ug/l	<1.00	<1.00
2-Nitroaniline	ug/l	<1.00	<1.00
2-Nitrophenol	ug/l	<1.00	<1.00
3 + 4 Nitroaniline	ug/l	<2.00	<2.00
3- + 4-Methylphenol	ug/l	<1.00	<1.00
4-Bromophenyl phenyl ether	ug/l	<1.00	<1.00
4-Chloroaniline :- {4-Chlorobenzamine}	ug/l	<1.00	<1.00
4-Chlorophenyl phenyl ether	ug/l	<1.00	<1.00
Aniline :- {Aminobenzene}	ug/l	<2	<2
Azobenzene	ug/l	<1.00	<1.00
Benzyl Alcohol	ug/l	<5.00	<5.00
Benzyl butyl phthalate	ug/l	<2.00	<2.00
Bis(2-chloroethoxy)methane	ug/l	<1.00	<1.00
Bis(2-chloroethyl)ether	ug/l	<1.00	<1.00
Bis(2-chloroisopropyl) ether	ug/l	<1.00	<1.00
Carbazole	ug/l	<1.00	<1.00
Di-n-ButylPhthalate	ug/l	1.2	<1.00
Di-n-octylphthalate	ug/l	<2.00	<2.00
Dibenzofuran	ug/l	<1.00	<1.00
Diethyl Phthalate	ug/l	<1.00	<1.00
Dimethyl phthalate	ug/l	<1.00	<1.00
Diphenylamine	ug/l	<1.00	<1.00
Hexachlorocyclopentadiene	ug/l	<2.00	<2.00
Isophorone	ug/l	<1.00	<1.00
nNitroso di-n-propylamine	ug/l	<1.00	<1.00
1,1,1,2-Tetrachloroethane	ug/l	<0.1	<0.1
1,1,1-Trichloroethane	ug/l	<0.1	<0.1
1,1,2,2-Tetrachloroethane	ug/l	<0.1	<0.1
1,1,2-Trichloroethane	ug/l	<0.1	<0.1
1,1-Dichloroethane	ug/l	<0.1	<0.1
1,1-Dichloroethylene :- {1,1-Dichloroethene}	ug/l	<0.1	<0.1
1,1-Dichloropropylene :- {1,1-Dichloropropene}	ug/l	<0.1	<0.1
1,2,3-Trichlorobenzene	ug/l	<0.1	<0.1
1,2,3-Trichloropropane	ug/l	<0.5	<0.5

Analyte	***Units***	**Q1 Concentration 07/05/2015**	**Q6 Concentration 29/04/2015**
1,2,3-Trimethylbenzene	ug/l	<0.1	<0.1
1,2,4-Trichlorobenzene	ug/l	<0.1	<0.1
1,2,4-Trimethylbenzene	ug/l	<0.1	<0.1
1,2-Dibromo-3-chloropropane	ug/l	<0.1	<0.1
1,2-Dibromoethane	ug/l	<0.1	<0.1
1,2-Dichlorobenzene	ug/l	<0.1	<0.1
1,2-Dichloroethane	ug/l	<0.1	<0.1
1,2-Dichloropropane	ug/l	<0.1	<0.1
1,2-Dimethylbenzene :- {o-Xylene}	ug/l	<0.1	<0.1
1,3,5-Trichlorobenzene	ug/l	<0.1	<0.1
1,3,5-Trimethylbenzene :- {Mesitylene}	ug/l	<0.1	<0.1
1,3-Dichlorobenzene	ug/l	<0.1	<0.1
1,3-Dichloropropane	ug/l	<0.1	<0.1
1,4-Dichlorobenzene	ug/l	<0.1	<0.1
2,2-Dichloropropane	ug/l	<0.1	<0.1
2-Chlorotoluene :- {1-Chloro-2-methylbenzene}	ug/l	<0.1	<0.1
3-Chlorotoluene :- {1-Chloro-3-methylbenzene}	ug/l	<0.1	<0.1
4-Chlorotoluene :- {1-Chloro-4-methylbenzene}	ug/l	<0.1	<0.1
4-Isopropyltoluene :- {4-methyl-Isopropylbenzene}	ug/l	<0.1	<0.1
Benzene	ug/l	<0.1	<0.1
Bromobenzene	ug/l	<0.1	<0.1
Bromochloromethane	ug/l	<0.1	<0.1
Bromodichloromethane	ug/l	<0.1	<0.1
Bromoform :- {Tribromomethane}	ug/l	<0.1	<0.1
Carbon Disulphide	ug/l	<0.1	<0.1
Carbon tetrachloride :- {Tetrachloromethane}	ug/l	<0.1	<0.1
Chlorobenzene	ug/l	<0.1	<0.1
Chlorodibromomethane	ug/l	<0.1	<0.1
Chloroform :- {Trichloromethane}	ug/l	<0.1	<0.1
Chloromethane :- {Methyl Chloride}	ug/l	<0.5	<0.5
Dibromomethane	ug/l	<0.1	<0.1
Dichloromethane :- {Methylene Dichloride}	ug/l	<0.5	<0.5
Dimethylbenzene : Sum of isomers (1,3- 1,4-) : {m+p xylene}	ug/l	<0.2	<0.2
Ethyl tert-butyl ether :- {ETBE}	ug/l	<0.1	<0.1
Ethylbenzene	ug/l	<0.1	<0.1
Hexachlorobutadiene	ug/l	<0.1	<0.1
Hexachloroethane	ug/l	<0.1	<0.1
Isopropylbenzene	ug/l	<0.1	<0.1
MTBE :- {Methyl tert-butyl ether}	ug/l	<0.1	<0.1
Styrene :- {Vinylbenzene}	ug/l	<0.1	<0.1
Tetrachloroethylene :- {Perchloroethylene}	ug/l	<0.1	<0.1
Toluene :- {Methylbenzene}	ug/l	<0.1	<0.1
Trichloroethylene :- {Trichloroethene}	ug/l	<0.1	<0.1
Trichlorofluoromethane	ug/l	<0.1	<0.1
Vinyl Chloride :- {Chloroethylene}	ug/l	<0.1	<0.1
cis-1,2-Dichloroethylene :- {cis-1,2-Dichloroethene}	ug/l	<0.1	<0.1
cis-1,3-Dichloropropylene :- {cis-1,3-	ug/l	<0.1	<0.1

Analyte	***Units***	**Q1 Concentration 07/05/2015**	**Q6 Concentration 29/04/2015**
Dichloropropene}			
n-ButylBenzene :- {1-Phenylbutane}	ug/l	<0.1	<0.1
n-Propylbenzene :- {1-phenylpropane}	ug/l	<0.1	<0.1
sec-Butylbenzene :- {1-Methylpropylbenzene}	ug/l	<0.1	<0.1
tert-Amyl methyl ether :- {TAME}	ug/l	<0.1	<0.1
tert-Butylbenzene :- {(1,1-Dimethylethyl)benzene}	ug/l	<0.1	<0.1
trans-1,2-Dichloroethylene :- {trans-1,2-Dichloroethene}	ug/l	<0.1	<0.1
trans-1,3-Dichloropropylene :- {trans-1,3-Dichloropropene}	ug/l	<0.5	<0.5