Water Quality Review

Bellanaboy River and Carrowmore Lake & Catchment

(Bellanaboy, County Mayo)

(2004-2015)

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1 Executive Summary

The following report presents the findings of a review of water quality in the Carrowmore Lake catchment associated with the construction of the Bellanaboy Bridge Gas Terminal (BBGT) in County Mayo. The review covers the period 2004 to 2015 which includes the construction and commissioning phases of the BBGT.

The datasets reviewed were as follows:

(i) BBGT's surface water monitoring data (discharge point known as SP1) taken from 2005 to 2014. The parameters included physical, nutrient and some metals.

(ii) Mayo County Council surface water chemistry data for 14 tributaries of Carrowmore Lake including 3 sites on the Bellanaboy River from 2005 to 2014.

(iii) Mayo County Council's biological water quality monitoring results (Small Stream Risk Scores - SSRS) for 2 sites on the Bellanaboy River upstream and downstream of the BBGT discharge from 2006 to 20013.

(iv) EPA's summary chemical and biological monitoring results for Carrowmore Lake (2007-2015) and their [1]Q-value monitoring results for several rivers within the Carrowmore Lake catchment including the Bellanaboy River (2005-2014).

The SP1 sampling point was the single discharge point for all the treated surface water that drained the BBGT development site during construction. It is situated at the south western boundary of the site, 2.4km upstream of Carrowmore Lake.

Within the review period (2004-2015) the data reveals that between mid-2005 and mid-2008 the SP1 discharge frequently contained elevated suspended solids and total aluminium concentrations, as well as associated but much less significant increases in nutrient levels (ortho-P, total-P, ammonia and nitrate). However, data for the Bellanaboy River indicates that the SP1 discharge was having at most a very marginal effect on the receiving water chemistry of the river when both watercourses were sampled at the same time. Perhaps more noteworthy, biological monitoring programmes undertaken by both Mayo County Council and the EPA conclusively showed that the SP1 discharge was having no measureable impact on Ecological Quality in the Bellanaboy River throughout this period or of Carrowmore Lake between 2007 and 2015 (i.e. the period covered by the EPA monitoring).

The SP1 chemistry dataset shows that during the period 2005 to 2008 there were occasions when solids levels were relatively elevated in the discharge. This is believed to have been associated with the construction phase of the BBGT during periods of heavy rainfall drainage and treatment systems were at or close to capacity. This period also coincided with more elevated levels of total-P, total aluminium and to a lesser extent, nitrate, ortho-P and ammonia. This is especially the case for total-P and total aluminium and is believed to have been due to the higher solids levels in t samples due to the construction activity. From 2008, the solids levels showed on average a marked decrease in concentration as did all the other

[1] Q-value is the biotic index that has been used by the EPA and it's predecessors to monitor water quality in Irish rivers and streams for more than 40 years. It is based on collections of aquatic invertebrate indicator species and comprises a 9-point scale: Q5, Q4-5 = High Status; Q4 = Good Status; Q3-4 = Moderate; Q3, Q2-3 (Poor Status, Q1, Q1-2, Q2 = Bad Status

parameters which is believed to be due to the completion of the main earth works of the BBGT.

However, despite frequently elevated levels of solids and associated parameters in the SP1 discharge during the 2005-2008 period, water chemistry data from Mayo County Council taken throughout this period on the Bellanaboy River at a site just upstream and downstream of the confluence of the SP1 stream shows that this discharge had a negligible impact on concentrations of all the same parameters in the Bellanaboy River, a fact that can be clearly explained by the very small flows in the SP1 discharge compared to those in the Bellanaboy River at that point.

Results from the SSRS biological monitoring undertaken by Mayo County Council between 2006 and 2013 on the Bellanaboy indicated that on all occasions, the [2]SSRS scores indicated that the river was 'Probably not at Risk' both upstream and downstream of the SP1 discharge. During the same period EPA Q-value data indicated no change in quality status on the Bellanaboy River downstream of the SP1 discharge between 2004 and 2014 during which time a Q4 rating was assigned i.e. Good Status on each of 4 sampling years. EPA summary monitoring data for Carrowmore Lake, into which the Bellanaboy River discharges, revealed High Oxygen Status, Good Nutrient Status and Moderate Ecological Status for all 3 monitoring periods reported on, namely 2007-2009, 2010-2012 and 2013-2015.

[2] SSRS = Small Stream Risk Score. This is another biotic index developed by the EPA which is designed to examine water quality in headwater streams. It is also based on aquatic macroinvertebrate indicator species

2 Introduction & Brief

The Aquatic Services Unit (UCC) was commissioned by Shell E & P Ireland Limited (SEPIL) to review the surface water monitoring undertaken at the Bellanaboy Bridge Gas Terminal (BBGT) and also to review the surface water monitoring undertaken over the same period by Mayo County Council on the Bellanaboy River and all the other main tributaries of Carrowmore Lake catchment over the period 2005-2014. The BBGT water analysis data relate to the main surface water outlet from the BBGT (SP1) which is located close to the boundary fence of the terminal in the south west portion of the site (see Figure 1 for the location of SP1). The majority of the land area of the BBGT lies within the catchment of a small stream whose headwaters are effectively formed by the SP1 discharge. This stream joins the Bellanaboy River approximately 350m downstream from the BBGT boundary line at a point 700m upstream of Bellanaboy Bridge and 2.5km upstream of Carrowmore Lake. The review also covers biological water quality data collected by Mayo County Council and the EPA within the same catchment during the same period.

The object of the review is to assess the trends in water chemistry and biological monitoring data and the implications for the quality of the downstream receiving waters.

3 Historical Land Use Context of the BBGT site

3.1 Overview

There is a history of intense management of the lands at Bellanaboy, as described in the following extract from the 2003 EIS, Chapter 6, Terrestrial flora and fauna:

> ***"Past Land-Use and Management***
> *The proposed terminal site is on part of the former Peatland Experimental Station, Glenamoy, which was established by the Department of Agriculture in 1955 with the following objectives:*
> - *"to find suitable methods of reclaiming and fertilising blanket bog for agricultural and forestry"; and*
> - *"to develop suitable animal and crop husbandry systems for peatland".*
>
> *It was administered by the Soils Division of An Foras Taluntais from 1959 for many years and was wound down in the late 1970s/early 1980s. During that time, a research programme was developed aimed at determining "the best and cheapest methods of reclaiming western blanket peat" (Glenamoy Review Group Report, 1978). A number of issues were investigated at the research station including: drainage, soil fertility and grassland, arable crops, shelterbelts, horticultural and industrial crops etc. Of these, the most relevant to this study are:*
> - *drainage;*
> - *fertiliser applications; and*
> - *shelterbelt planting.*
>
> ***Drainage***
> *According to the Glenamoy Review Group Report (1978) various types of drain were tried in the study area, which included: open drains – about 1m deep and at different spacings from 2.5m to 30m. These were considered dangerous to livestock and wasteful of land;*
> - *clay pipes or similar "field drains";*
> - *sod drains (a traditional method);*
> - *slotted plastic pipes; and*

- *gravel drains (tunnel drains using "tunnel" plough technology. Non-calcareous gravel was laid onto plastic sheeting as the base of the "tunnel").*

> ***Soil Fertility and Grassland***
> *The Review Group Report (1978) lists two methods including "liming and fertilising the native vegetation" and these are detailed in the Review Group Report. The application of lime alone increased the growth of the Black Bog Rush (Schoenus nigricans) while phosphorus alone or with nitrogen encouraged dominance of the Purple Moor Grass (Molinia caerulea). Both methods were applied to the site during the operation of the experimental station.*
>
> ***Shelterbelts***
> *Approximately one fifth of the experimental station's land area was planted as shelterbelt (from 1956 to 1958). These shelterbelts were mostly 30m wide. The main species was Lodgepole Pine (Pinus contorta), with Sitka Spruce (Picea sitchensis), some Japanese Larch and a little Alder. Heavy applications of fertiliser were necessary to counteract the "checking" effect of chlorosis (yellowing of the leaves).*
>
> ***Horticultural and Industrial Crops***
> *New Zealand Flax (Phormium tenax) was first planted as a shelterbelt species then trials showed that (as in its native New Zealand) its fibres were a realistic commercial alternative to jute. However, with the arrival of polyester fibres, this aspect of the research was not developed further.*
>
> *The blocks of land in which the proposed terminal site will be located are part of an area formerly used for grass productivity trials, which has been subject to drainage and substantial applications of fertiliser. The dominant vegetation types, conifer plantations and shelterbelt species present today reflect past management practices."*

The site subsequently came under the management of Coillte Teo, resulting in extensive conifer plantation, particularly to the east of the site and in the temporary construction facilities to the north and east of the footprint.

The site's hinterland was described in the 2003 EIS as follows:

> ***"Habitats and Land-use Around the Site***
> *Much of the area is under coniferous plantation of varying ages, with a large proportion comprising relatively recent planting. Substantial areas of bog to the west of the site and adjacent to the nearby Bellanaboy River have also been planted with conifers. To the south of the site, and south of the R314, is extensive partially modified blanket bog, with active cut peat faces. Some has been fully reclaimed and is now improved pasture….."*

Apart from extensive clear-felling of conifer plantations in areas to the south of the R314 and to the east of the L1202 by Coillte; and that associated with the construction of the import pipeline, there has been no significant change in overall landuse in the hinterland of the site.

3.2 Construction of the Bellanaboy Bridge Gas Terminal:

Planning permission for the Bellanaboy Bridge Gas Terminal (BBGT) was granted in November 2004, under which SEPIL was conditioned to develop an Environmental Management System (EMS) and an Environmental Monitoring Plan (EMP). The EMS & EMP identified the environmental risks to be managed and monitored throughout the construction phase which included a surface water management and monitoring plan. The surface water management was developed in consultation with Mayo County Council, the North Western Regional

Fisheries Board, The Marine Institute and the EPA during the course of the EIS process and in the development of the BBGT construction site-monitoring regime. The EMS & EMP were approved by the planning authority in advance of the commencement of construction in November 2004.

The planning conditions and the EMS/ EMP also required the establishment of discharge limits for surface water discharge at SP1 which were referred to as Target Limits. The discharge limits were established following consultation with Mayo County Council, the North West Regional Fisheries Board, and the EPA. The limits were established for SP1 in March 2005, and were approved by Mayo County Council

The land on which the BBGT was constructed was blanket peat that had to be removed in order to create a solid platform. Therefore, construction involved the excavation of peat and its transportation to an authorised facility and the construction of a solid platform to the required level. To facilitate the excavation of the peat a surface water drainage system was installed which included the construction of two settlement ponds in the south western section of the site. Subsequently it was identified that additional surface water treatment was required and a temporary water treatment plant was installed at the BBGT to facilitate construction and to ensure discharge limits were adhered to.

The construction of the BBGT involved an earth works phase; the installation of permanent drainage systems and required underground services; construction of buildings; equipment installation; tank farms installation; steel erection; and installation for pipe wracks, mechanical piping installation; electrical and instrument installation. The BBGT was constructed and commenced a testing phase in November 2014 upon activation of the Industrial Emissions Licence.

Throughout the construction phase of the BBGT the results of surface water monitoring were reported to Mayo County Council and where exceedances or elevations were identified the incident was reported and the cause, and actions to be implemented, were identified.

3.3 Designation of Carrowmore Lake

Carrowmore Lake is subject to designation under both the EU Habitats Directive (Council Directive 92/43/EEC) and Birds Directive (Council directive 79/409/EEC).

The lake itself is a large (960ha), shallow lake, with a maximum depth of approximately 2.5m and a generally stony bottom. The lake water is almost neutral in terms of acidity (i.e. pH) and generally rather nutrient-poor (oligotrophic/mesotrophic). The shallow waters support species such as Common Spike-rush (*Eleocharis palustris*), Shoreweed (*Littorella uniflora*), Bulbous Rush (*Juncus bulbosus*) and Perfoliate Pondweed (*Potamogeton perfoliatus*). Soft Rush (*Juncus effusus*) and Yellow Iris (*Iris pseudacorus*) are frequent along the shore, with stands of Common Club-rush (*Scirpus lacustris*) and Common Reed (*Phragmites australis*). The lake has one substantial island, Derreens Island, and several small islands; these are dominated by a grassy sward.

3.3.1 Carrowmore Lake Complex Special Area of Conservation (SAC Site Code IE 0000476)

The SAC comprises the lake itself and Largan More Bog. This site is of considerable ecological value, primarily for its extensive, intact blanket bog, which has a typical range of habitats, but also as a site for the very rare Marsh Saxifrage. The site supports a number of Greenland

White-fronted Geese, an Annex I bird species. Site specific conservation objective for the Carrowmore Lake Complex SAC is: to maintain or restore the favourable conservation condition of the Annex I habitat(s) and / or the Annex II species for which the SAC has been selected, i.e:

- Habitats (both terrestrial): [7130] Blanket bogs (* if active only) and [7150] Depressions on peat substrates of the *Rhynchosporion*
- *Plant species* (both terrestrial): [1393] *Drepanocladus* (*Hamatocaulis*) *vernicosus and* [1528] *Saxifraga hirculus*

3.3.2 Carrowmore Lake Special Protection Area (SPA Site Code IE 004052)

The SPA was designated for its high ornithological importance because of the nationally important nesting gull colony (Blackheaded and Common Gull) and, in the past, nesting terns (EU Birds Directive Annex I species), though more recently the terns have nested on Inishderry in Broadhaven Bay. The occurrence of overwintering Greenland White-fronted goose on the adjacent bogs of the Carrowmore Lake Complex SAC is of note because this species is listed on Annex I of the EU Birds Directive and uses the lake for roosting and/ or feeding. The site specific conservation objective for the Carrowmore Lake SPA is to maintain or restore the favourable conservation condition of the bird species listed as Special Conservation Interests for this SPA, ie: *Larus canus* [breeding] and *Sterna sandvicensis* [breeding]

4 Nature of the Data Sets

The BBGT data for the SP1 outfall comprise of greater than 600 sampling runs from May 2005 to November 2014. Sampling was undertaken at approximately weekly intervals with most years having greater than 50 sampling events, but with the years 2005, 2006 and 2007 having significantly higher frequencies. A wide range of parameters were routinely tested including: temperature, conductivity, pH, dissolved oxygen, turbidity suspended solids, orthophosphate, total phosphorus, ammonia, nitrate, nitrite and aluminium. Other parameters less frequently analysed included trace metals such as arsenic and zinc; COD and Total Organic Carbon.

Mayo County Council (MCC) collected and analysed samples from 14 tributaries feeding into Carrowmore Lake including among others the Aghoos, the Bellanaboy (3 sites), Glenturk Beg and Glenturk Mor and the Glencullin River along the northern and eastern sides of the lake, as well as several smaller tributaries along the western side (Figure 2). Sampling and monitoring commenced in December 2005 and continued to September 2014 mainly on the northern and eastern tributaries whereas sampling began on the eastern tributaries in the main in May 2007 and also continued to September 2014. On average more than 80 sample runs were undertaken on those tributaries where sampling commenced in December 2005 with 65 or 66 sample runs being undertaken on those tributaries where sampling began in May 2007. MCC sampled at a higher frequency at 3 sites on the Bellanaboy River. The 2 most frequently sampled sites being BEL 1 situated 45m upstream of the confluence of the small stream into which SP1 discharges and BEL 2 located 135m downstream of the confluence. MCC sampled both of these stations in excess of 400 occasions respectively between July 2007 and September 2014. A third site on the Bellanaboy (BEL 3), located at Bellanaboy Bridge (i.e. downstream of the confluence with the Aghoos) was also monitored during approximately the same period (March 2007 to September 2014) but at a lower frequency but in excess of

130 sampling runs. Each watercourse was monitored for all of the same key parameters that were monitored at SP1.

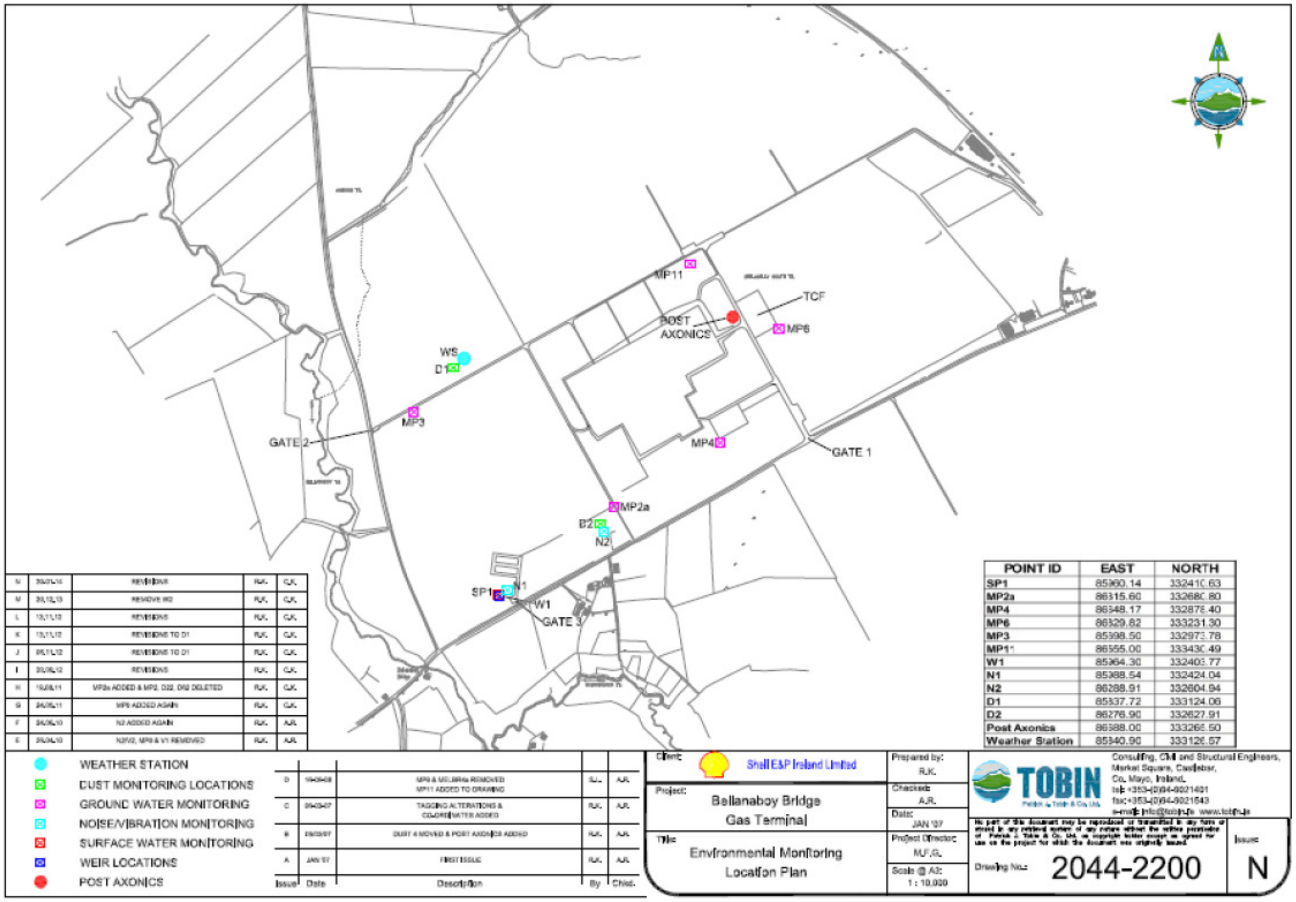

Figure 1: Map showing location of surface water discharge point SP1 in the south west corner of the BBGT site

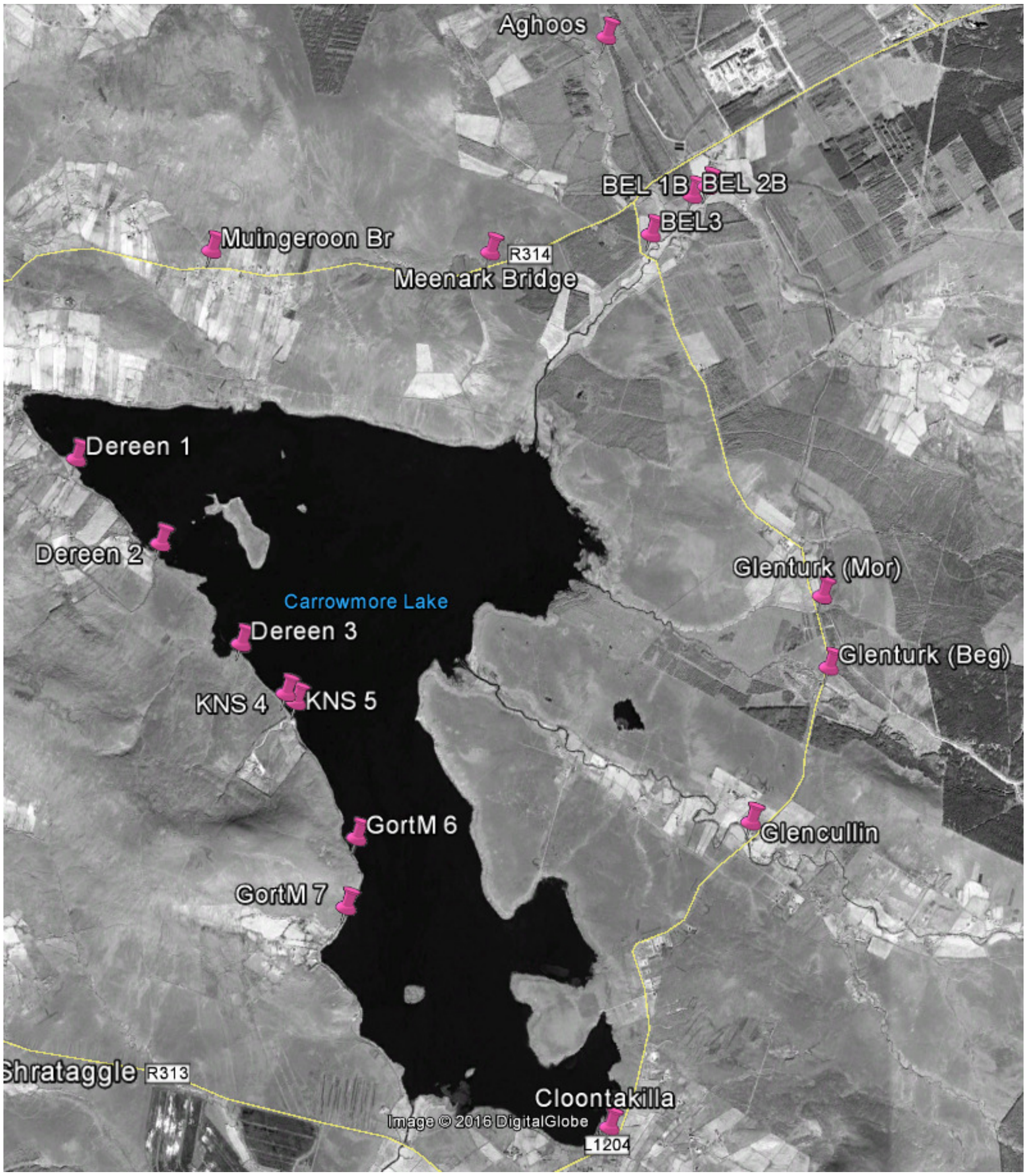

Figure 2: Map showing location of Mayo County Council's monitoring sites on Carrowmore Lake tributaries (2005-20014)

5 Data Analysis

The data was analysed in two ways, namely compiling summary statistics (average, median, max and min) as well as graphing parameters to show trends over the up to 9-year survey period in some cases or combined with other sites to show inter-site relationships. Finally, some parameters e.g. turbidity and Total P, and turbidity and total aluminium were graphed on the same chart to demonstrate the interconnectedness of the concentrations of certain parameters during particular sampling events.

Prior to analysis, all of the results for datasets that were reported as being below detection limits were taken to be at that detection limit. For example, orthophosphate (ortho-P as mg/l, P) was normally reported as either <0.01 mg/l, P or <0.02 mg/l, P and these were taken to be 0.01 mg/l, P or 0.02mg/l respectively, in order to allow for graphing and the calculation of summary statistics. Inevitably this resulted in somewhat higher average, median and minimum values than occurred in reality. However, this limitation in general isn't considered significant for the purposes of the analysis. In addition, on occasion high outliers were removed from the data set in order to calculate representative average values. However, where this happened, the excluded values were normally listed under 'Maximum' values in the corresponding table or otherwise flagged with an explanatory note.

6 Presentation of the Review's Findings

The findings are presented as follows:

(i) Summary statistics and graphs of the SP1 data and a discussion of the trends in the data

(ii) Summary statistics and graphs of data for BEL 1, BEL 2 and SP1 for dates when all three were sampled and a discussion of the results.

(iii) Summary statistics for the Carrowmore tributaries sampled by MCC and a discussion of trends in the data.

(iv) A summary and discussion of biological water quality data for certain watercourses and for Carrowmore Lake

(v) Overall Conclusions

It is important to note that not all parameters analysed have been reported on. For example, nitrite has not been examined because the detection limits were generally too high for meaningful analysis and also because in a well oxygenated system like the Bellanaboy and the other Carrowmore Lake tributaries nitrite would normally be present at extremely low concentrations. Other parameters such as arsenic and zinc were not measured sufficiently frequently to allow for any detailed analysis. Furthermore, there was no identified risk to surface water discharge associated with these parameters given the nature of construction activities being undertaken at the BBGT.

7 Findings

The summary statistics of water chemistry analysis results of key parameters are at SP1 presented in Table 1A (average), 1B (Median) Table 1C (Maximum) and Table 1D (Minimum) for the period 2005-2014.

The annual average values for each parameters excluding total aluminium fall within the 'Action' and 'Target' limits where these were set in the discharge for SP1. The case of total aluminium will be discussed in more detail later in the review. The average values provide a useful overview, as they clearly point up the broad quantum of concentrations for each parameter. When these are compared with the other summary statistics namely, median, maximum and minimum they give a better overall impression of the underlying range and variation in values. These are briefly discussed here following the sequence in Table 1A-1D.

Conductivity and pH: Average and median data for conductivity indicate that this parameter was generally below both action and target levels most of the time throughout the study period; pH also fell within the action and target ranges set. The full SP1 data set for both parameters are graphed in Figure 3. This shows the few occasions for both parameters when they were outside target and action limits. The most significant of these is pH, which on November 29th 2012 was recorded as 10.9, which is very exceptional for surface waters. This was the only occasion on which pH could be considered out of range. This was as a result of an incident which was reported to Mayo County Council and subsequent actions were implemented to mitigate this issue at the time.

Turbidity and Suspended Solids (TSS): These two parameters are very strongly linked given that turbidity is a measure of light scattering in water caused by suspended particulates and both parameters generally, though not invariably, have a strong correlation in water samples. While turbidity only exceeded action levels (150NTU) twice and never reached target levels (200 NTU), in contrast suspended solids regularly exceeded both levels - in the early years of the monitoring cycle up to July 2008, after which these levels were never exceeded. Both parameters are shown on the graph in Figure 4 to illustrate these trends. The vertical scale has been compressed in order to show more detail, note therefore that a suspended solids spike of 363mg/l on March 26th 2007 is off the top of the graph. This reading is slightly unusual in that the corresponding turbidity reading was much lower (46NTU). The next highest suspended solids value was recorded on March 5th in the same month. These elevated results were generally recorded during periods of challenging site conditions due to heavy rainfall events during which the temporary drainage system was maximised in terms of capacity. The events extended for short periods and the system recovered within a short time period.

Orthophosphate (Ortho-P) and Total Phosphorus (Total-P): Both of these parameters are analysed using the same chemical test. However, while samples for ortho-P analysis are first filtered through 0.45µm membrane filters, those for total-P analysis remain un-filtered and in addition are hot acid-digested prior to analysis. This latter step helps to release any orthophosphate within the particulate component of the sample so that it can be picked up in the test. This explains why the concentration total-P is always higher than ortho-P in a given sample although very occasionally they may be at the same level in the same sample. In general therefore the higher the suspended solids / turbidity the greater the likelihood that total-P will exceed ortho-P in concentration. Data for Table 1A-D show that both the average and median values for ortho-P never reached either the action or target levels set for the

parameter and that only in the Maximum values (Table 1C) is it apparent that either limit was reached or exceeded. Figure 5 shows a graph of the SP1 data set for both parameters. The ortho-P record indicates that the vast majority of results are below the action limit and a small number are between the action level and the target level and just 7 readings are above the target level, the highest at 0.449mg/l, P on December 10th 2012. As mentioned earlier, total-P is always higher than ortho-P and Figures 5 demonstrates that fact, with the overall average concentration ranging from 2 to 5 times as high. However, this latter value is somewhat erroneous and based on the fact that from May 2010 the detection limit for total-P was 5 times higher at 0.05 mg/l, P compared to 0.01 mg/P, for ortho-P. In reality, the average total-P concentration would have been closer to just 2 to 3 times higher than ortho-P on most occasions in more recent years. As Figure 5 shows, most of the above background levels of ortho-P and total-P occurred in the earlier half of the record from 2005 to the end of 2009, thereafter, generally, dropping below 0.075mg/l, P in the case of total-P and much lower in the case of ortho-P with the one exception for both parameters in early December 2012 when both spiked above 0.4mg/l, P The data also indicates that apart from one later exception, both total-P and to a lesser extent ortho-P were generally higher in concentration in the first half of the monitoring period, which seems to have been associated the higher turbidity / suspended solids recorded at that time (Figure 4).

Nitrate: Nitrate is generally not a nutrient which controls eutrophication in freshwater systems, which is why no action or target levels were set for it. Average values generally ranged from 0.5-1mg/l, N (Table 1A), and while most values were below 3-4mg/l, N, there was one unexplained outlier of 12.34 mg/l, N recorded on November 8th 2005 (Table 1C). Figure 6, which shows both turbidity and nitrate on the same graph, demonstrates that the higher nitrate concentrations occurred at the same time generally as higher turbidity concentrations. As nitrate is entirely in soluble form it is not directly enhanced by suspended matter in a watercourse. However, it is likely that whatever activity was increasing the availability of suspended solids / turbidity may also have been increasing the availability of nitrate, an effect which was far more pronounced in the earlier part of the monitoring period.

Ammonia: Average values of ammonia were all well below the action and target levels and indeed most of the maximum concentrations recorded were also below both of these levels. When shown on a graph with turbidity, it can been seen that while the interaction between both parameters is generally weak, at the earlier part of the monitoring period both parameters' tended to be at their highest levels.

Total and Dissolved Aluminium are shown on the graph along with turbidity in Figure 7. This reveals that dissolved aluminium rarely exceeded the target value of 200µg/l, whereas total aluminium regularly exceeded it during the first half of the monitoring period. Notable however is the very close relationship between turbidity and total aluminium which the graph illustrates - this points strongly to a cause-and-effect relationship. Aluminium which is one of the most abundant metals in the earth's crust was clearly being released during analysis from the mineral component in the solids which turbidity represents - something which occurred throughout the monitoring period but which was more obvious during the earlier half when both parameters were at their highest levels.

7.1 Overview of SP1 Trends

The physico-chemical monitoring record for SP1 constitutes a very comprehensive record of the surface water quality of this very small watercourse. Taken as a set, the data points to

higher than average concentrations for several parameters, including in particular, turbidity, suspended solids, total-P and total aluminium in the earlier part of the monitoring between mid-2005 and the end of 2008. The data also points to turbidity as co-varying to a greater or lesser extent with several other parameters including suspended solids, total-P, total aluminium and even nitrate, which reveals a link between increased particulates and increased ground disturbance with variations in these parameters. One of the main drivers of turbidity and suspended solids in all watercourses is flow and if turbidity at SP1 is plotted in a graph against flow over part of the record (Figure 8) it can be seen that peaks in flow often coincided with peaks in turbidity. However, this was only evident in the earlier years of the record, whereas later on, even under conditions of elevated flow, turbidity was low. This indicates that while flow is the proximate driver of the turbidity levels, elevated run-off is not the source of the turbidity and its associated parameters, these were derived from the on-site activities. Note that flow at SP1 is measured in litres per second, indicating that the volumes involved are very small in the context of the wider Bellanaboy and Carrowmore Lake catchments.

Table 1A: AVERAGE - (Summary statistics for SP1 data 2005-2014)

Year	Sample Count	Cond. (µS/cm)	pH	Turbidity (NTU)	TSS (mg/l)	Ortho-P (mg/l, P)	Total-P (mg/l, P)	Nitrate (mg/l, N,)	Ammonia (mg/l, N)	Aluminium (diss) µg/l	Aluminium (total) µg/l
Action Limits		**400**	**<3.5 or >7.5**	**150**	**25**	**0.04**		**5.6**	**0.2**	**100**	**135**
Target Limits		**500**	**<3 or >8**	**200**	**35**	**0.07**		**1.5**	**0.5**	**150**	**200**
2005	70	199	6.7	16.8	10.5	0.036	0.078	0.96	0.028	182	832
2006	158	185	7.0	9.9	7.5	0.018	0.048	0.52	0.020	88	260
2007	114	251	7.3	26.4	24.4	0.030	0.073	1.20	0.040	88	499
2008	55	260	7.3	12.1	8.8	0.016	0.058	0.92	0.019	42	233
2009	53	260	7.1	5.2	3.5	0.012	0.044	0.59	0.016	42	133
2010	51	309	7.2	2.7	3.0	0.011	0.044	0.52	0.013	38	115
2011	51	247	7.2	2.5	2.6	0.012	0.052	0.47	0.018	44	77
2012	46	283	7.4	3.8	2.5	0.032	0.075	0.47	0.017	66	121
2013	53	254	7.4	2.1	2.8	0.011	0.056	0.58	0.016	56	88
2014	42	268	7.2	3.8	2.5	0.011	0.051	0.63	0.015	66	115
All	693	239	7.2	10.7	8.7	0.020	0.058	0.71	0.022	70	243

Table 1B: MEDIAN - (Summary statistics for SP1 data 2005-2014)

Year	Sample Count	Cond. (µS/cm)	pH	Turbidity (NTU)	TSS (mg/l)	Ortho-P (mg/l, P)	Total-P (mg/l, P)	Nitrate (mg/l, N,)	Ammonia (mg/l, N)	Aluminium (diss) µg/l	Aluminium (total) µg/l
Action Limits		**400**	**<3.5 or >7.5**	**150**	**25**	**0.04**		**5.6**	**0.2**	**100**	**135**
Target Limits		**500**	**<3 or >8**	**200**	**35**	**0.07**		**1.5**	**0.5**	**150**	**200**
2005	70	198	6.7	15.2	6.5	0.038	0.070	0.64	0.020	69	748
2006	158	176	7.1	5.5	4.0	0.015	0.043	0.44	0.015	79	190
2007	114	240	7.3	15.3	10.5	0.020	0.054	0.88	0.030	53	294
2008	55	247	7.0	5.2	4.0	0.010	0.036	0.58	0.006	37	153
2009	53	259	7.1	3.2	2.0	0.010	0.034	0.44	0.007	40	126
2010	51	304	7.2	1.7	2.0	0.010	0.050	0.44	0.005	30	67
2011	51	245	7.0	2.0	2.0	0.010	0.050	0.44	0.007	36	63
2012	46	275	7.3	3.0	2.0	0.010	0.050	0.44	0.012	54	113
2013	53	244	7.4	1.8	2.0	0.010	0.050	0.44	0.012	55	78
2014	42	253	7.2	2.6	2.0	0.010	0.050	0.54	0.010	67	119
All	693	238	7.2	3.9	4.0	0.010	0.050	0.44	0.014	52	123

Table 1C: MAXIMUM - (Summary statistics for SP1 data 2005-2014)

Year	Sample Count	Cond. (µS/cm)	pH	Turbidity (NTU)	TSS (mg/l)	Ortho-P (mg/l, P)	Total-P (mg/l, P)	Nitrate (mg/l, N,)	Ammonia (mg/l, N)	Aluminium (diss) µg/l	Aluminium (total) µg/l
Action Limits		400	<3.5 or >7.5	150	25	0.04		5.6	0.2	100	135
Target Limits		500	<3 or >8	200	35	0.07		1.5	0.5	150	200
2005	70	558	7.6	59	79	0.065	0.467	12.43	0.112	2015	3100
2006	158	316	7.7	59	58	0.049	0.232	2.52	0.186	330	1200
2007	114	435	8.2	172	363	0.220	0.424	4.71	0.400	579	2850
2008	55	384	8.1	161	72	0.048	0.245	3.85	0.235	126	1598
2009	53	368	7.9	29	18	0.053	0.200	1.24	0.110	95	428
2010	51	504	8.0	26	14	0.027	0.090	1.14	0.101	115	1370
2011	51	458	8.2	7.4	16	0.052	0.080	1.09	0.146	135	192
2012	46	435	10.9	14	9	0.449	0.490	1.14	0.096	175	314
2013	53	410	7.9	4.3	23	0.057	0.130	1.70	0.116	117	224
2014	42	419	7.8	15	9	0.018	0.080	1.99	0.091	144	198
All	693	558	10.9	172	363	0.449	0.490	12.43	0.400	2015	3100

Table 1D: MINIMUM - (Summary statistics for SP1 data 2005-2014)

Year	Sample Count	Cond. (µS/cm)	pH	Turbidity (NTU)	TSS (mg/l)	Ortho-P (mg/l, P)	Total-P (mg/l, P)	Nitrate (mg/l, N,)	Ammonia (mg/l, N)	Aluminium (diss) µg/l	Aluminium (total) µg/l
Action Limits		400	<3.5 or >7.5	150	25	0.04		5.6	0.2	100	135
Target Limits		500	<3 or >8	200	35	0.07		1.5	0.5	150	200
2005	70	122	5.9	1.3	4.0	0.010	0.032	0.11	0.005	51	57
2006	158	75	5.8	0.7	3.0	0.010	0.010	0.44	0.005	9	7
2007	114	141	6.6	0.8	2.0	0.010	0.010	0.44	0.005	10	13
2008	55	184	6.6	0.4	2.0	0.010	0.010	0.44	0.005	20	20
2009	53	172	6.4	1.3	2.0	0.010	0.010	0.44	0.005	20	20
2010	51	134	6.4	0.8	2.0	0.010	0.015	0.44	0.005	12	20
2011	51	139	6.3	1.1	2.0	0.002	0.050	0.44	0.005	8	23
2012	46	136	6.0	1.2	2.0	0.010	0.030	0.44	0.005	10	29
2013	53	171	6.8	0.6	2.0	0.010	0.050	0.02	0.005	12	17
2014	42	157	6.4	1.0	2.0	0.010	0.011	0.02	0.005	13	13
All	693	75	5.8	0.4	2.0	0.002	0.010	0.02	0.005	8	7

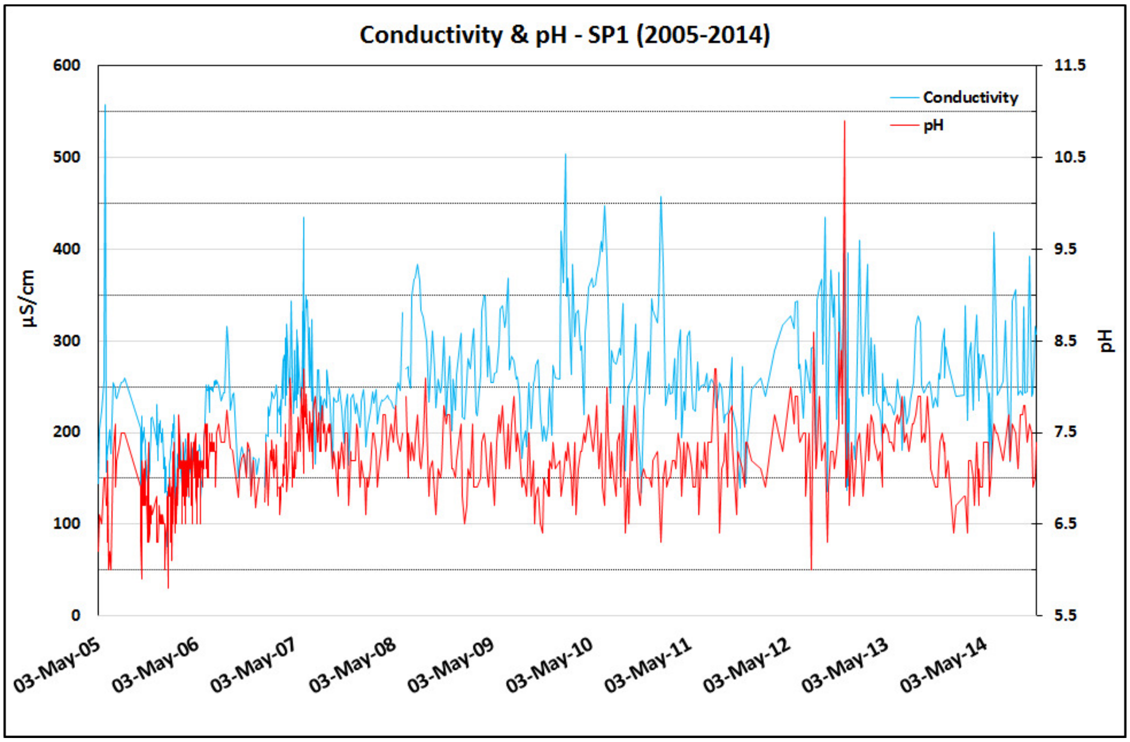

Figure 3

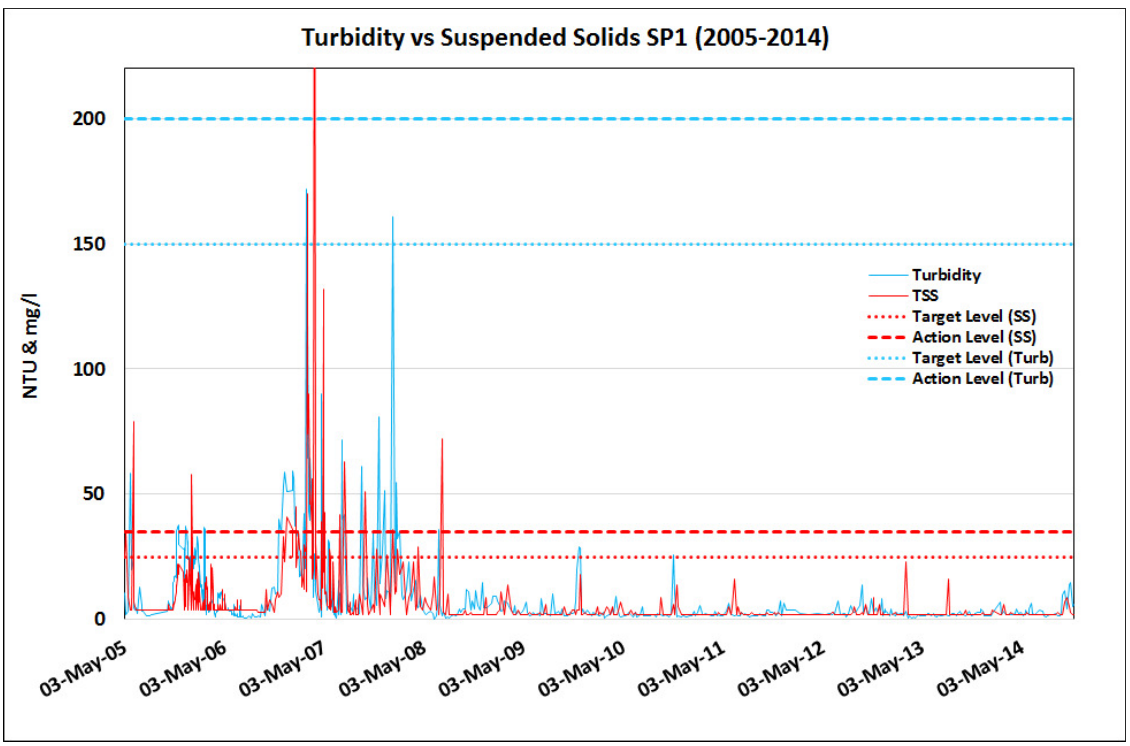

Figure 4

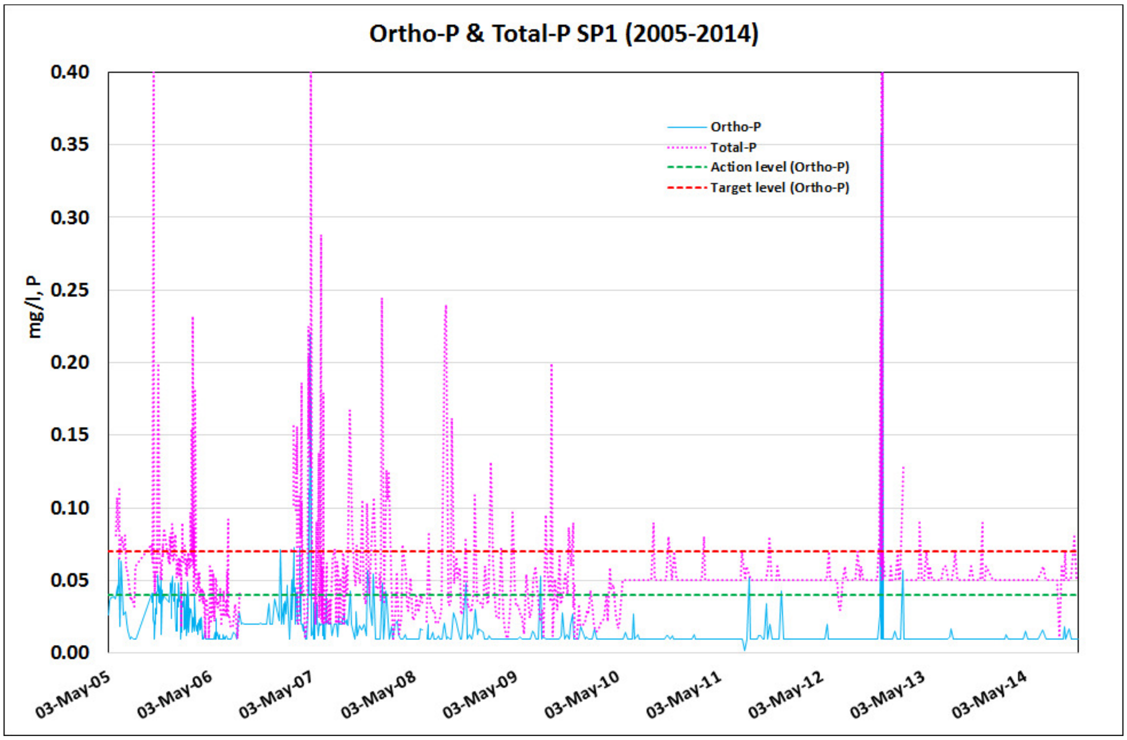

Figure 5

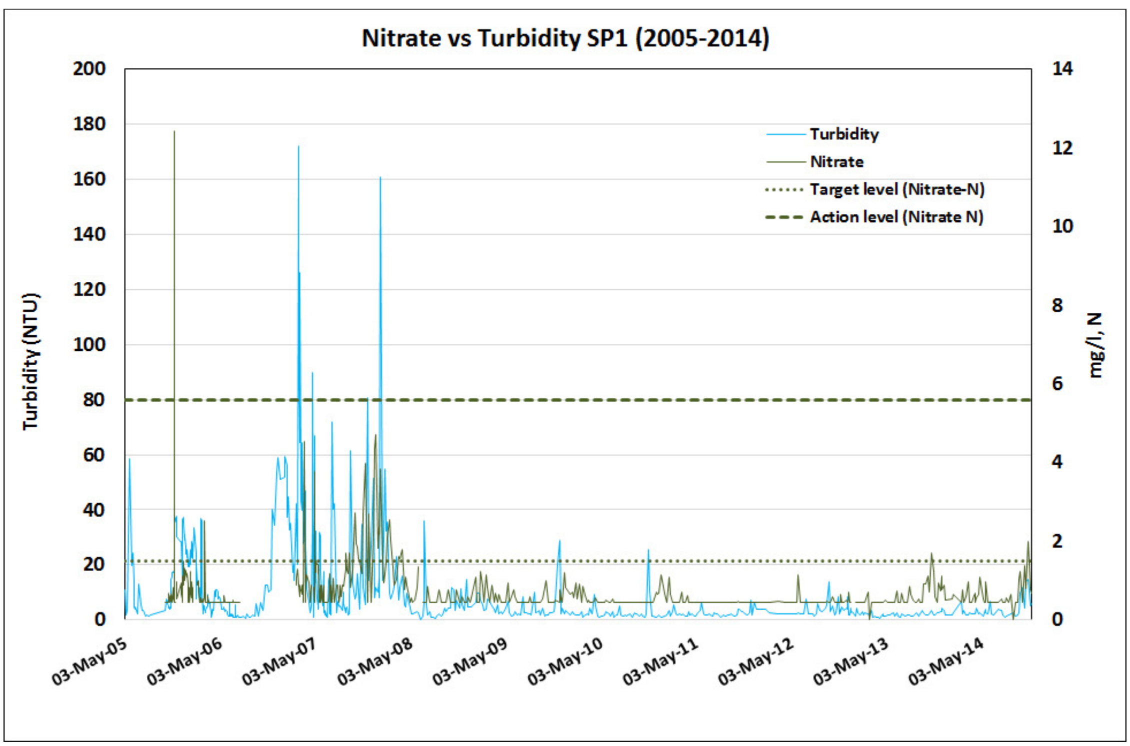

Figure 6

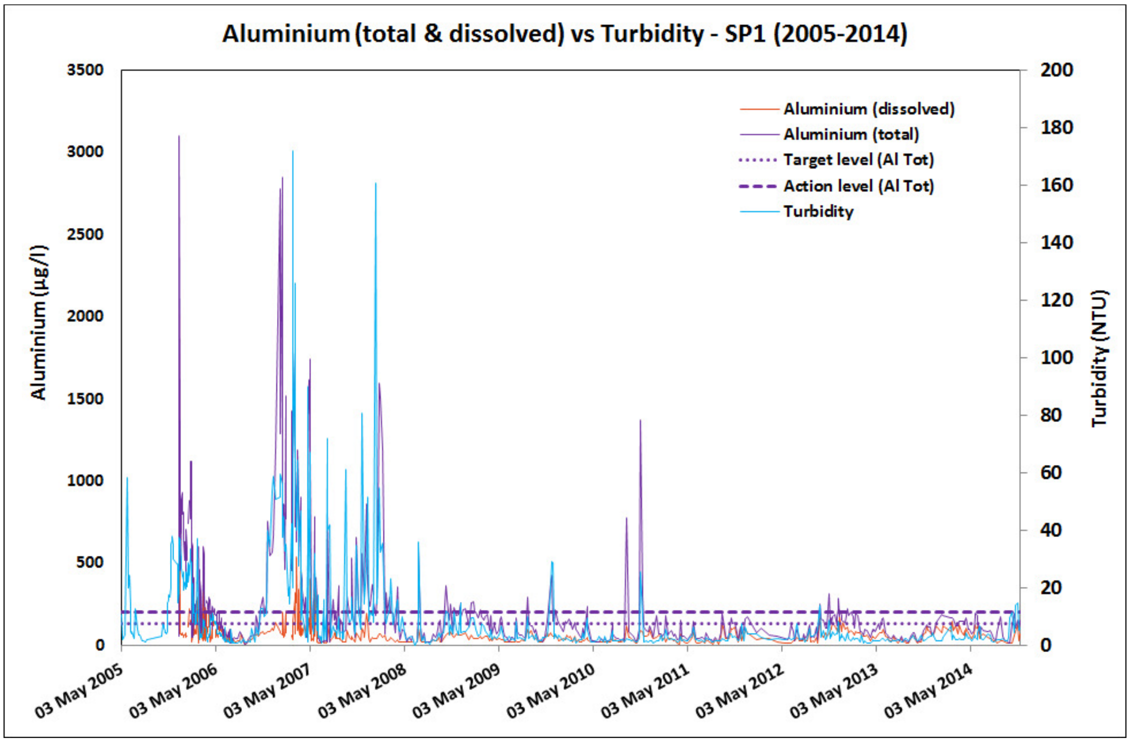

Figure 7

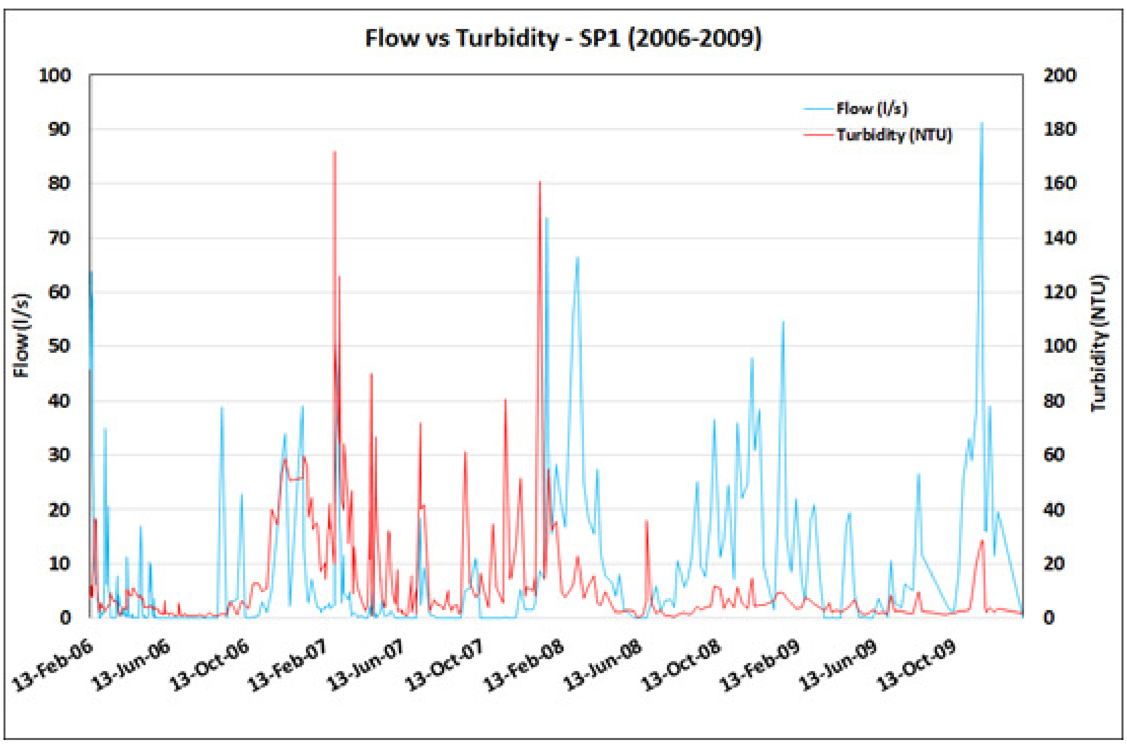

Figure 8

7.2 SP1 Monitoring Results in the Context of Bellanaboy Monitoring Data

From July 2006 to 2016, Mayo County Council (MCC) monitored the water quality on the Bellanaboy River at a site just upstream (BEL1) of SP1 and at a second approximately 135m downstream (BEL2) of the confluence of the SP1 stream. In order to compare these 3 data sets, results for dates when all 3 sites were sampled within the same 24-hour period, were extracted for each of the key parameters and shown as a graph. Clearly, there were many occasions when all 3 sites were not sampled on the same day and so the extracted data-set is smaller than the individual sets. Nevertheless, it is extensive enough to cover earlier and later trends of the SP1 monitoring period and included up to 270 records for most parameters at each site.

The average result for each of the 3 sites is listed in Table 2 below and several parameters have also been graphed to show the trends in the data.

Table 2: Summary statistics for SP1, BEL1 and BEL2 for dates on which all 3 sites were sampled in common

	Sample Count	SP1	BEL 1 (U/S)	BEL 2 (D/S)
Conductivity (µS/cm)	270-271	264	174	189
Turbidity (NTU)	270-271	8.6	3.8	4.2
Solids (mg/l)	270-271	7.2	6.6	6.3
pH	270-271	7.2	7.1	7.1
Ortho-P (mg/l, P)	270-271	0.017	0.025	0.027
Total-P (mg/l, P)	270-271	0.051	0.051	0.059
Nitrate (mg/l, N)	255-566	0.69	0.18	0.21
Ammonia (mg/l, N)	270-271	0.024	0.063	0.076
Aluminium (total) mg/l	270-271	203.7	97.8	108.9

The first graph (Figure 9) shows the trend in conductivity at the 3 sites. Conductivity often shows significant variation with flow and is also easy to measure reproducibly and accurately so for this reason tends to be less prone to unexplained outliers in the data. Furthermore it is a fairly conservative parameter which is less likely to be influenced by biological uptake or transformation, and because it is soluble is unaffected by sedimentation. Figure 9 shows that conductivity at SP1 was generally higher than in the Bellanaboy, often significantly so. Despite this however, the downstream site BEL 2 rarely showed levels much higher than those at the site upstream of the SP1 stream confluence at BEL1. In fact on many occasions the conductivity at BEL 2 was higher than that of SP1, suggesting that conductivity on the Bellanaboy was very little influenced by SP1 results. This is further supported by the data in Figure 10 which shows the turbidity results for the 3 sites. This shows that on many occasions, even though the turbidity levels recorded at SP1 where much higher than in the Bellanaboy, there was little evidence in the BEL 2 data that it was having any perceptible influence on the river. Data for nitrate (Figure 11) also supports this hypothesis showing effectively no response in the BEL 2 data set to much higher nitrate levels from SP1. In the case of the 2 key nutrients orth-P (Figure 12) and total-P (Figure 13) the Bellanaboy data were in most cases (ortho-P) and in many cases (total-P) higher in the Bellanaboy than in SP1 and on those occasions when the reverse was the case the effect on the Bellanaboy downstream at BEL 2 was very minor. Ammonia in the Bellanaboy was generally much higher than in the SP1 (Figure 14) and while total aluminium (Fig 15) was generally at the same concentration or

higher in SP1 compared to the concentrations in the Bellanaboy, the influence on river levels were marginal at the very most.

7.3 Overview of SP1 data in Comparison to the Bellanaboy Data

This analysis has shown that despite having significantly higher concentrations in the case of several parameters, the SP1 discharge generally had extremely little influence on the water chemistry of the Bellanaboy River downstream of the SP1 stream confluence.

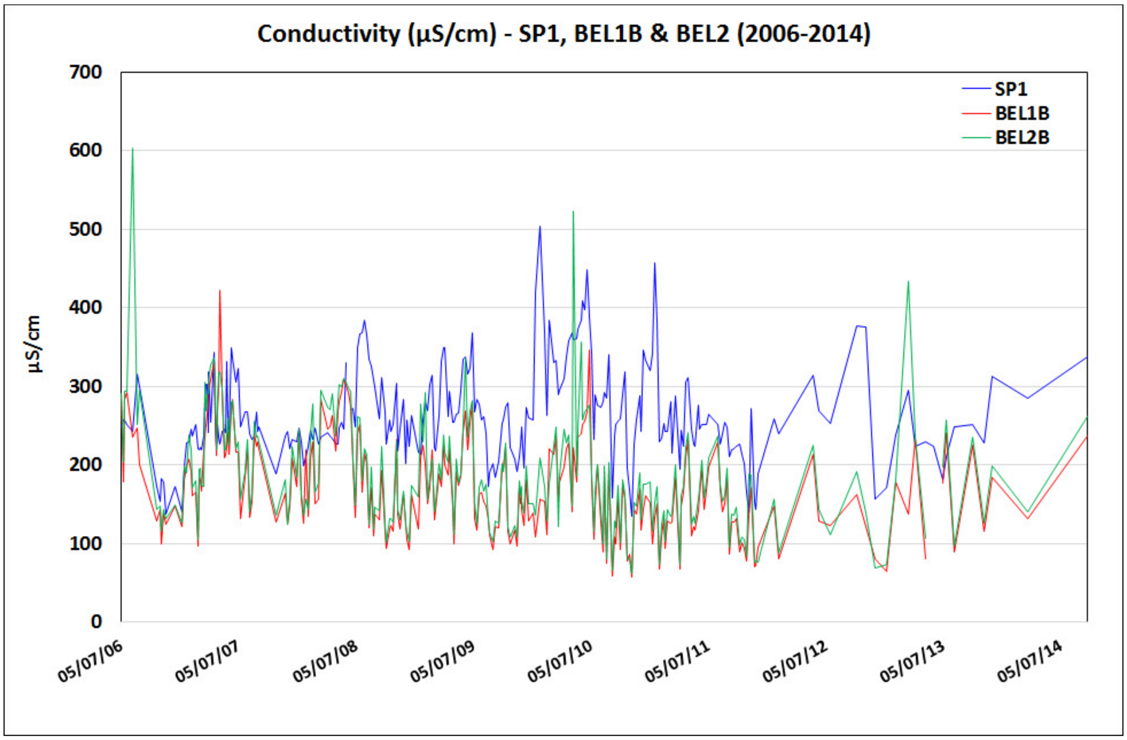

Figure 9

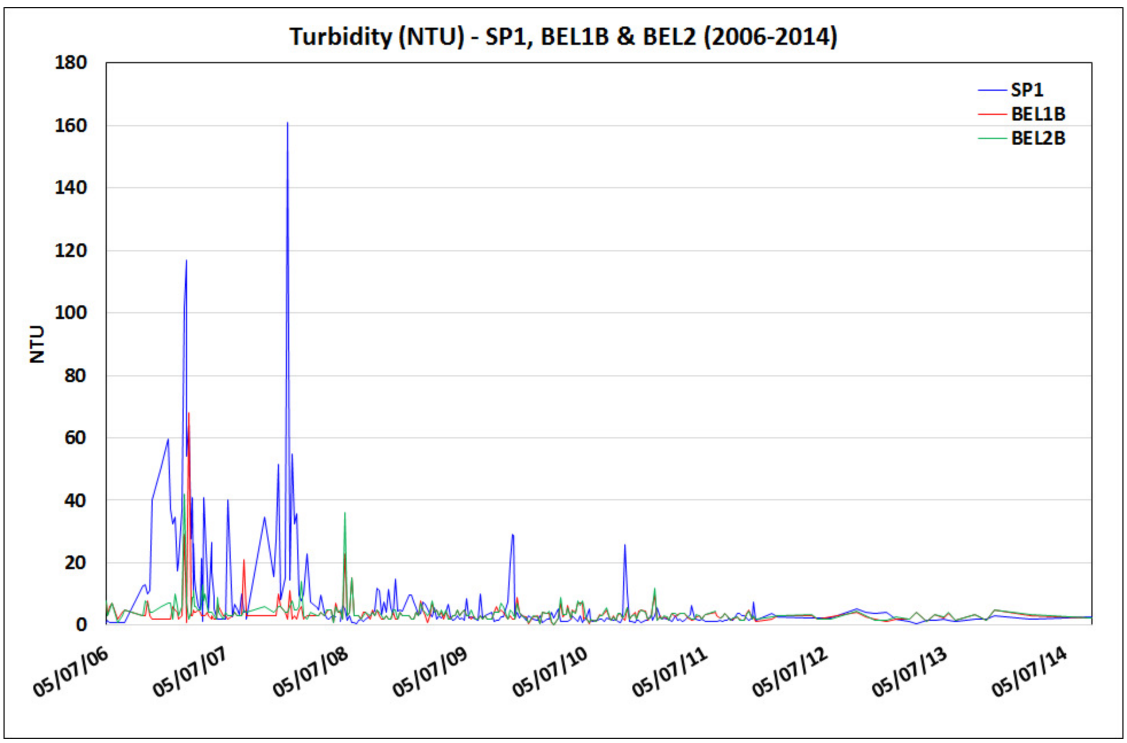

Figure 10

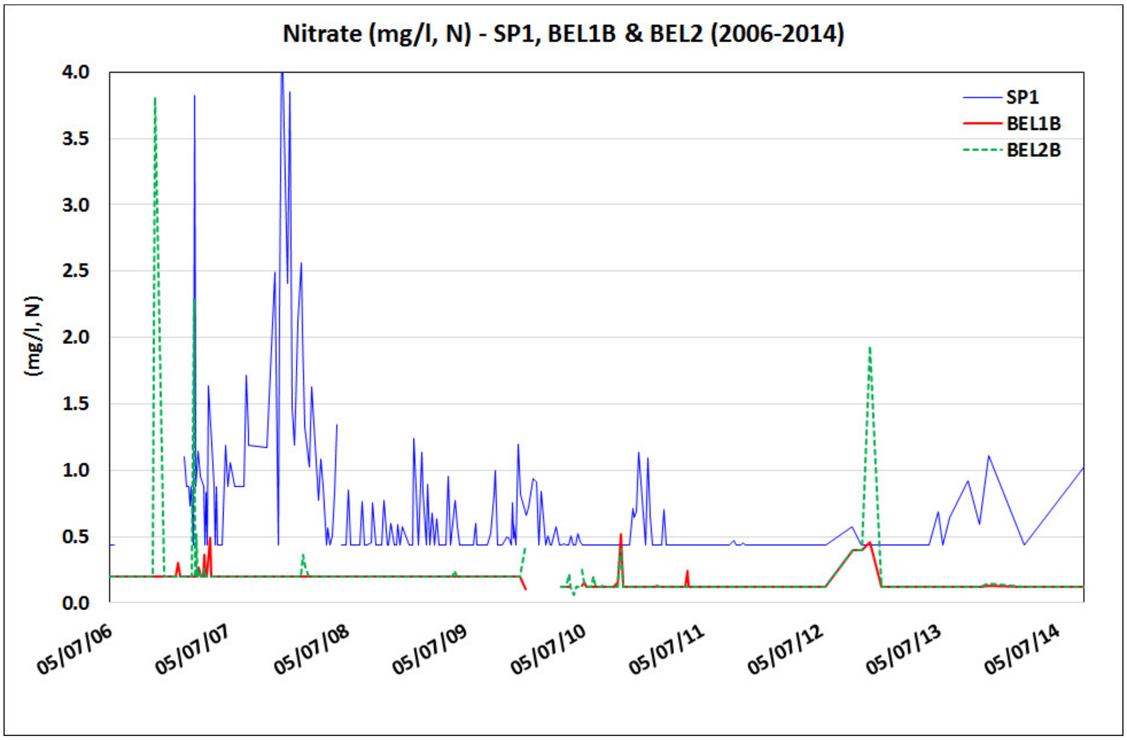

Figure 11

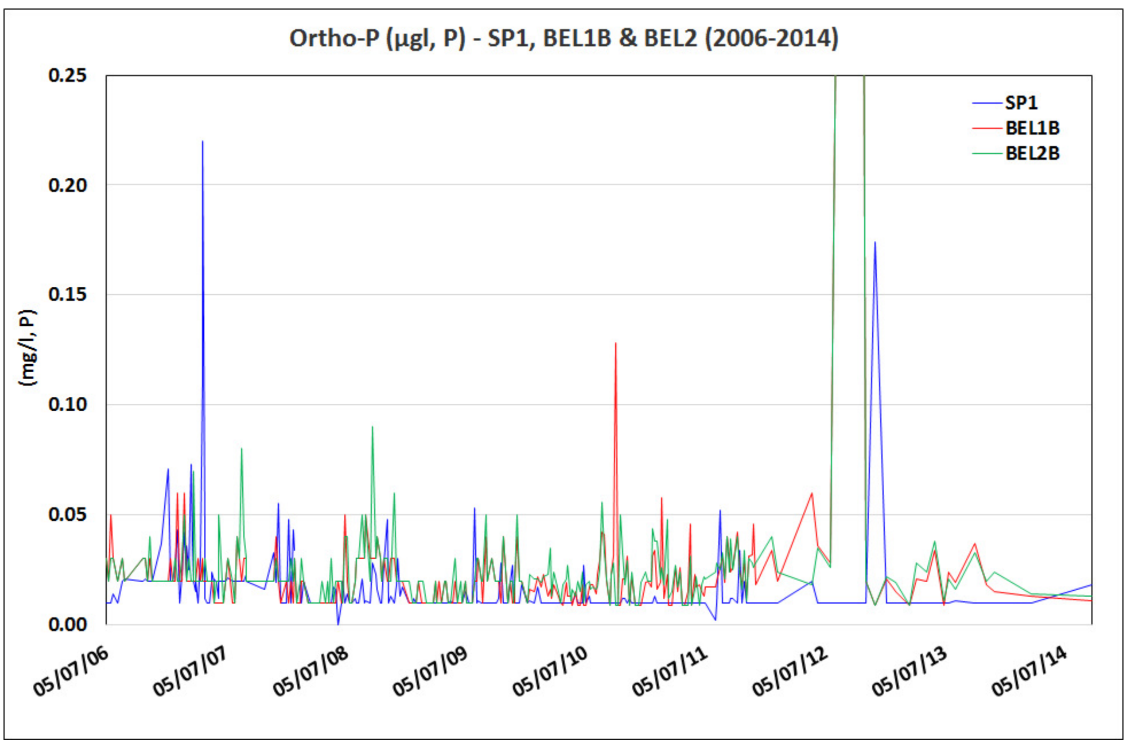

Figure 12

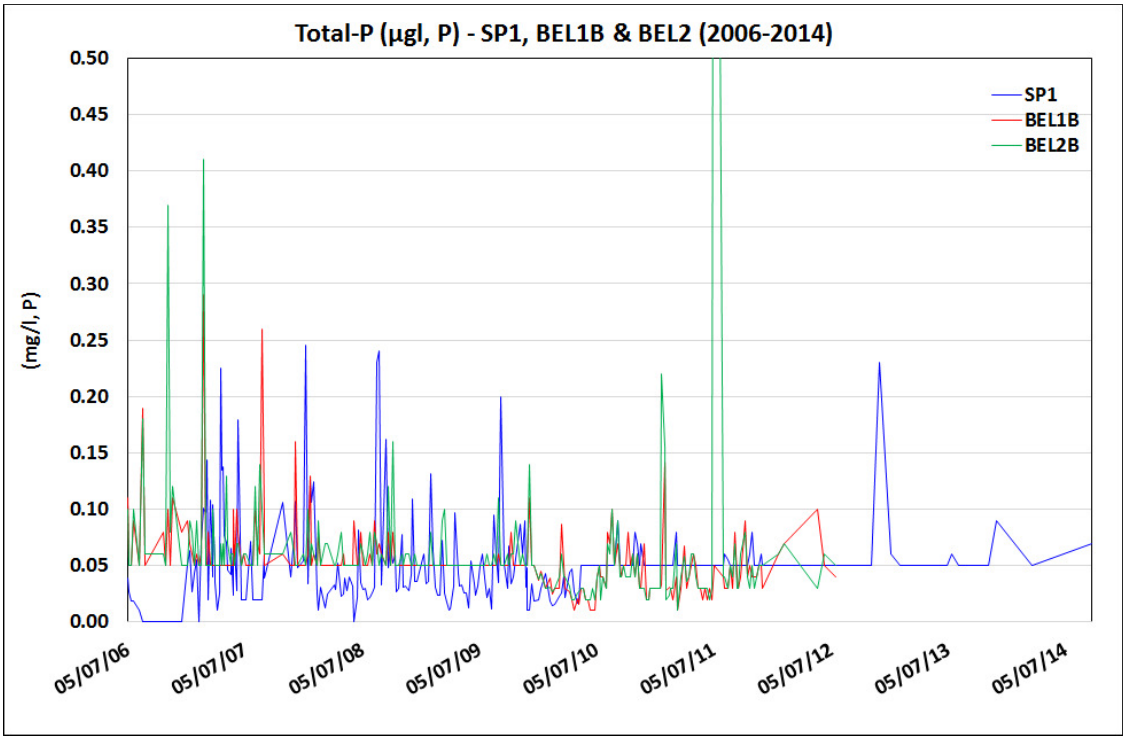

Figure 13

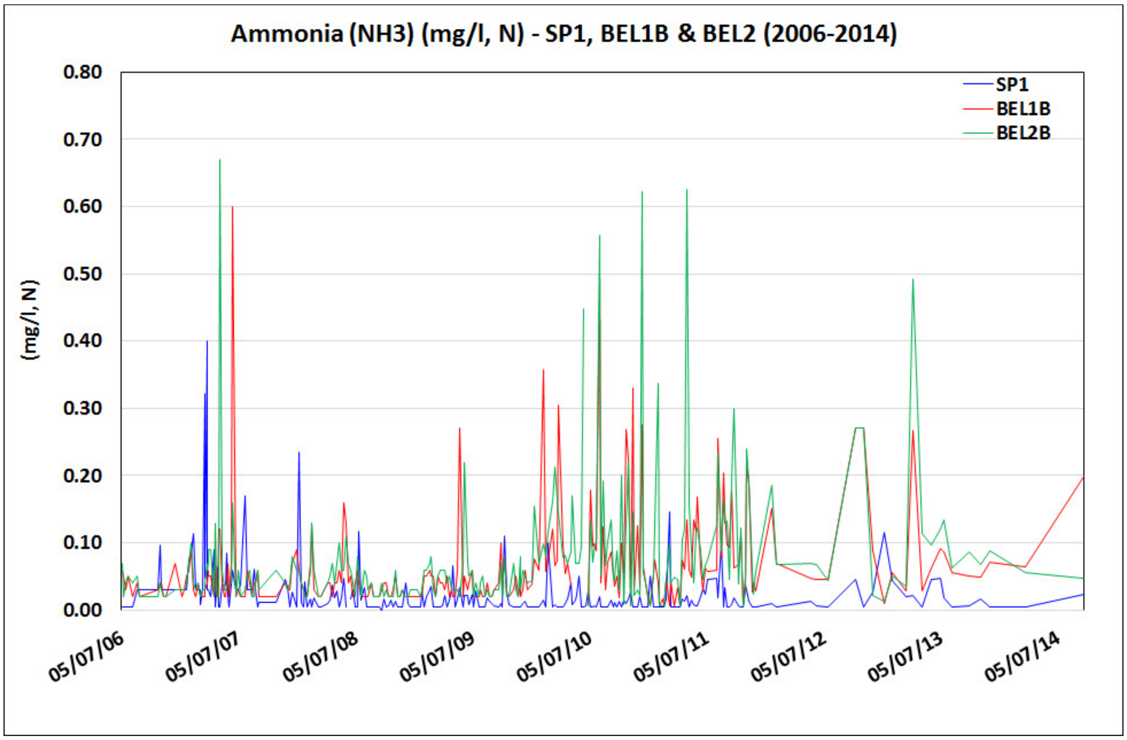

Figure 14

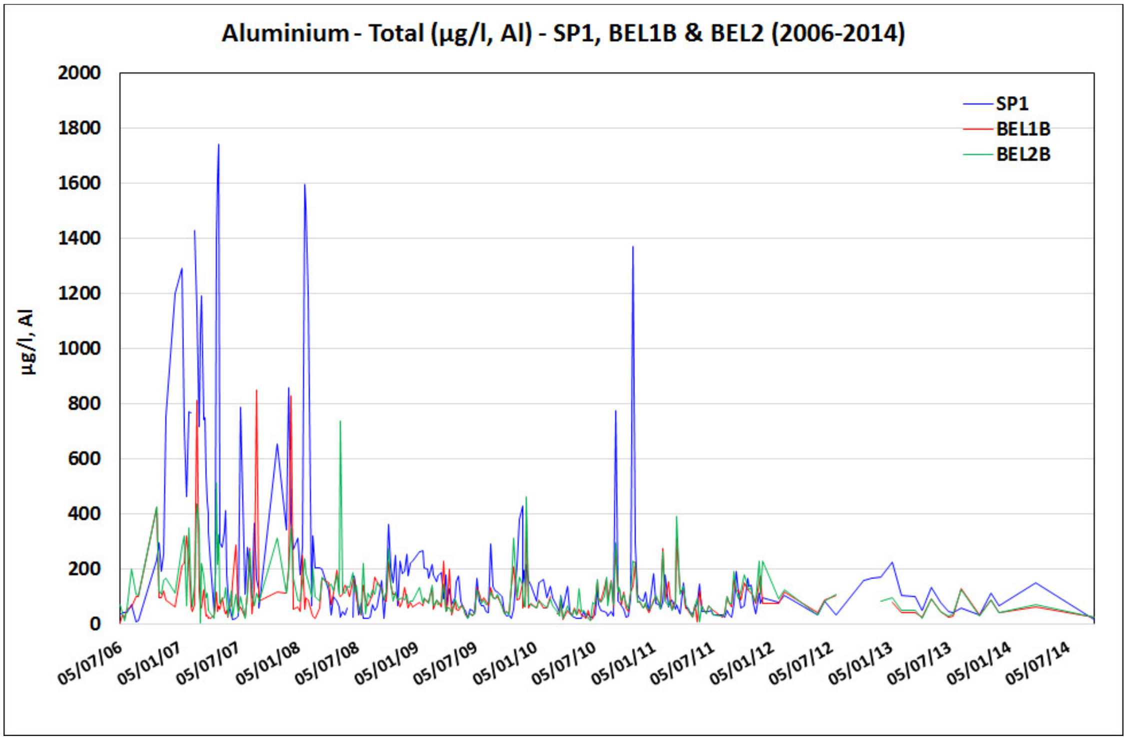

Figure 15

7.4 General Chemistry of all the Carrowmore Lake Tributaries

MCC monitored 15 tributaries of Carrowmore Lake between December 2005 and September 2014 including 3 sites on the Bellanaboy River. These include all of the main tributaries and most of the small ones also (see Figure 2 for a map showing their locations around the lake). These data have been summarised in Table 3A-3D below in order to put the data from the Bellanaboy into a wider perspective, as well as to present the general water chemistry characteristics of the catchment as a whole. The data for SP1 is also included for reference but is not discussed. These data show that while there were no particularly striking differences between the sites in terms of averages of most parameters certain differences are discernible. In terms of conductivity most sites can be described as moderately soft but not very soft and pH in general would be described as circum-neutral with a couple of sites e.g. Gortmore 6 and Gortmore 7 at the lower end of that range. Average turbidity values were all less than 5 (NTU), mainly less than 2 to 3, with the highest values recorded in the 2 most downstream Bellanaboy sites (BEL 2 and BEL 3) and Meenanark Bridge. Somewhat surprisingly, suspended solids didn't follow the same pattern as turbidity with the highest average values (between 7.2 and 7.4mg/l) recorded at Glencullin, Cloonkatilla and the upstream site on the Bellanaboy (BEL 1). The suspended solids averages are however probably an over estimate given that 5mg/l seems to have been chosen in the vast majority of cases as a lower limit of detection. In terms of nutrients both average ortho-P and total-P were fairly low at all sites, i.e. mostly less than 0.020 mg/l, P for ortho-P and less than 0.05mg/l, P for total-P. The highest values for ortho-P (0.021 – 0.029 mg/l, P) were recorded at Cloonkatilla, Aghoos and at the three Bellanaboy sites, while the highest total-P averages (0.053-0.073 mg/l, P) were recorded at Cloonkatilla, Gortmore 7 and at the three Bellanaboy

sites. Average nitrate was similar, with most sites at about 0.2mg/l, N and Clookatilla higher at 0.37 mg/l, N. Average ammonia concentrations were generally less than 0.050mg/l, N with higher values (0.060-0.079 mg/l, N) at Dereen 1 & 2 and the three Bellanaboy sites.

In terms of Water Framework status, under the Surface Water Objectives, sites vary in their level of compliance depending on which parameter is in question. Based on dissolved oxygen most sites pass (marked green in Table 3A), with just two failing to meet the objective (marked yellow in Table 3A). In terms of ortho-P all sites are high status (blue in Table 3 A) bar two which are Good (green in Table 3A). Based on ammonia, seven sites are High status (blue), seven Good status (green) and three less than good (yellow)

Table 3A - AVERAGE - Mayo County Council Data for Carrowmore Lake Tributaries (2005-2014) with WFD Surface Water Objectives for certain parameters

Tributary	**Count (max)**	**Cond. (µS/cm)**	**pH**	**DO % sat.**	**Turbidity (NTU)**	**TSS (mg/l)**	**Ortho-P (mg/l, P)**	**Total P (mg/l, P)**	**Nitrate (mg/l, N)**	**Ammonia (NH3-N) (mg/l, N)**	**Total Alumin. (µg/l, Al)**
				95%ile>80% sat 95%ile <120% sat			High Status (≤0.025 (mean) or ≤0.045 (95%ile) Good status ≤0.035 (mean) or ≤0.075 (95%ile)			High Status (≤0.04 (mean) or ≤0.09 (95%ile) Good status ≤0.065 (mean) or ≤0.14 (95%ile)	
Glenturk Mor	66	162	6.9	99	3.3	5.9	0.015	0.045	0.17	0.055	129
Glenturk Beg	84	113	6.5	97	2.0	6.6	0.013	0.040	0.18	0.042	177
Glencullin	84	153	7.4	100	2.8	7.2	0.013	0.042	0.19	0.036	112
Cloontakilla	84	185	7.3	95	3.1	7.3	0.021	0.057	0.37	0.043	182
Gortmore 6	65	114	5.1	93	1.1	5.4	0.011	0.034	0.17	0.039	282
Gortmore 7	23	153	5.2	93	1.3	5.8	0.011	0.053	0.20	0.022	226
KNS5	66	129	6.6	98	2.4	5.8	0.013	0.040	0.21	0.035	246
KNS4	65	117	6.3	96	1.4	5.3	0.011	0.033	0.18	0.040	165
Derreens 3	66	169	7.1	93	1.2	5.2	0.015	0.038	0.19	0.034	74
Derreens 2	66	174	7.3	95	1.3	5.0	0.011	0.037	0.18	0.079	86
Derreens 1	66	152	7.1	97	0.9	5.1	0.011	0.038	0.18	0.070	102
Muingeroon	66	177	7.0	96	3.9	5.2	0.019	0.043	0.18	0.048	80
Meenanark Bridge	84	173	6.8	97	4.7	5.8	0.016	0.037	0.17	0.042	65
Aghoos	81	162	6.8	96	3.7	6.2	0.020	0.049	0.23	0.046	97
Bellanaboy (BEL1)	423	173	7.1	91	3.7	7.4	0.029	0.061	0.18	0.062	102
Bellanaboy (BEL2)	424	184	7.1	91	4.3	6.8	0.029	0.070	0.20	0.072	115
Bellanaboy Br. (BEL3)	135	194	7.1	91	4.5	6.0	0.025	0.073	0.21	0.060	114
SP1	693	238	7.2	-	10.7	8.7	0.020	0.058	0.71	0.022	243

Table 3B - MEDIAN - Mayo County Council Data for Carrowmore Lake Tributaries (2005-2014)

Tributary	Sample Count (max)	Conductivity (µS/cm)	pH	DO % sat.	Turbidity (NTU)	Suspended Solids (mg/l)	Ortho-P (mg/l, P)	Total P (mg/l, P)	Nitrate (mg/l, N)	Ammonia (NH3-N) (mg/l, N)	Total Aluminium (µg/l, Al)
Glenturk Mor	66	152	7.1	100	2.7	5.0	0.010	0.050	0.20	0.029	135
Glenturk Beg	84	106	6.7	97	1.6	5.0	0.010	0.050	0.20	0.020	157
Glencullin	84	132	7.5	99	1.6	5.0	0.010	0.050	0.20	0.020	53
Cloontakilla	84	175	7.3	95	2.0	5.0	0.015	0.050	0.22	0.029	104
Gortmore 6	65	110	4.9	93	1.0	5.0	0.010	0.050	0.20	0.020	288
Gortmore 7	23	145	4.8	93	1.0	5.0	0.010	0.050	0.20	0.020	219
KNS5	66	123	6.6	98	1.3	5.0	0.010	0.050	0.20	0.022	213
KNS4	65	110	6.4	97	1.0	5.0	0.010	0.050	0.20	0.020	153
Derreens 3	66	166	7.2	94	1.0	5.0	0.010	0.050	0.20	0.020	61
Derreens 2	66	166	7.4	96	1.0	5.0	0.010	0.050	0.20	0.020	72
Derreens 1	66	146	7.1	98	1.0	5.0	0.010	0.050	0.20	0.027	91
Muingeroon	66	180	7.2	97	3.5	5.0	0.016	0.050	0.20	0.020	69
Meenanark Bridge	84	156	7.0	98	3.0	5.0	0.010	0.050	0.20	0.023	47
Aghoos	81	153	6.9	95	3.0	5.0	0.019	0.050	0.20	0.025	81
Bellanaboy (BEL1)	423	164	7.1	92	3.0	5.0	0.020	0.050	0.20	0.040	80
Bellanaboy (BEL2)	424	174	7.1	91	3.4	5.0	0.020	0.050	0.20	0.040	89
Bellanaboy Br. (BEL3)	135	182	7.1	91	4.0	5.0	0.020	0.050	0.20	0.030	81
SP1	693	238	7.2	-	3.9	4.0	0.010	0.050	0.44	0.014	123

Table 3C - MAXIMUM - Mayo County Council Data for Carrowmore Lake Tributaries (2005-2014)

Tributary	Sample Count (max)	Conductivity (µS/cm)	pH	DO % sat.	Turbidity (NTU)	Suspended Solids (mg/l)	Ortho-P (mg/l, P)	Total P (mg/l, P)	Nitrate (mg/l, N)	Ammonia (NH3-N) (mg/l, N)	Total Aluminium (µg/l, Al)
Glenturk Mor	66	260	8.1	113	11.0	29	0.053	0.330	0.60	0.691	276
Glenturk Beg	84	270	8.0	112	16.9	68	0.116	0.134	1.32	0.408	770
Glencullin	84	337	8.4	113	45.0	113	0.107	0.310	1.93	0.406	1700
Cloontakilla	84	345	8.3	104	31.0	80	0.134	0.310	5.60	0.309	2300
Gortmore 6	65	280	8.0	105	7.0	19	0.029	0.140	0.60	0.292	437
Gortmore 7	23	309	7.9	116	3.0	21	0.030	0.120	0.23	0.040	578
KNS5	66	275	7.5	117	27.0	***24**	0.038	0.110	****1.78**	0.433	756
KNS4	65	202	7.8	111	9.0	15	0.033	0.070	0.70	0.376	667
Derreens 3	66	329	8.1	118	4.0	11	0.320	0.340	0.74	0.270	184
Derreens 2	66	297	8.0	120	6.0	9	0.030	0.110	0.70	1.851	**ǂǂ254**
Derreens 1	66	337	7.8	119	5.5	10	0.026	0.250	0.70	1.590	228
Muingeroon	66	293	7.9	114	18.9	12	**ǂ0.111**	0.090	0.60	0.793	220
Meenanark Bridge	84	391	8.3	108	22.0	53	0.165	0.110	0.60	0.280	460
Aghoos	81	295	7.7	112	10.0	59	0.123	0.170	1.17	0.293	820
Bellanaboy (BEL1)	423	433	8.3	109	68.0	88	**§1.200**	0.400	0.62	0.910	848
Bellanaboy (BEL2)	424	604	8.6	110	42.0	91	1.200	1.400	3.81	0.850	736
Bellanaboy Br. (BEL3)	135	433	8.4	110	34	31	0.380	1.200	2.28	1.940	1091
SP1	693	558	10.9	-	172	363	0.449	0.490	12.43	0.400	3100

* This had been 275 mg/l but was removed to prevent a biased mean, it is also considered an outlier; ** This had been 35.98mg/l, N but was removed to avoid biasing the mean and is considered an outlier, ǂ Total-P was not measured on this sample. ǂǂ This had been 3302 µg/l, but was removed to prevent a biased mean and is considered an outlier. § This is also believed to be an outlier as the total P result for the same sample was much lower

Table 3D - MINIMUM - Mayo County Council Data for Carrowmore Lake Tributaries (2005-2014)

Tributary	Sample Count (max)	Conductivity (µS/cm)	pH	DO % sat.	Turbidity (NTU)	Suspended Solids (mg/l)	Ortho-P (mg/l, P)	Total P (mg/l, P)	Nitrate (mg/l, N)	Ammonia (NH3-N) (mg/l, N)	Total Aluminium (µg/l, Al)
Glenturk Mor	66	79	4.7	81	0.61	4.0	0.009	0.010	0.01	0.008	26
Glenturk Beg	84	63	4.0	78	0.11	1.0	0.009	0.010	0.10	0.005	28
Glencullin	84	53	5.7	82	0.39	2.0	0.009	0.010	0.01	0.005	2
Cloontakilla	84	77	5.7	84	0.69	2.0	0.009	0.010	0.10	0.007	13
Gortmore 6	65	70	4.4	71	0.11	1.0	0.009	0.010	0.12	0.007	5
Gortmore 7	23	97	4.4	71	1.00	5.0	0.010	0.050	0.20	0.020	45
KNS5	66	76	5.0	77	0.38	2.0	0.009	0.010	0.12	0.007	2
KNS4	65	68	4.6	75	0.11	1.0	0.009	0.010	0.12	0.007	2
Derreens 3	66	55	5.6	45	0.15	1.0	0.009	0.010	0.12	0.007	2
Derreens 2	66	66	6.1	75	0.30	2.0	0.009	0.010	0.12	0.007	13
Derreens 1	66	68	6.1	75	0.17	1.0	0.009	0.010	0.12	0.007	5
Muingeroon	66	16	5.6	76	0.11	1.0	0.009	0.010	0.12	0.007	17
Meenanark Bridge	84	51	4.7	73	0.11	1.0	0.009	0.010	0.10	0.007	5
Aghoos	81	64	5.0	73	0.11	4.0	0.009	0.010	0.02	0.005	5
Bellanaboy (BEL1)	423	56	5.7	69	0.11	2.0	0.009	0.010	0.10	0.007	2
Bellanaboy (BEL2)	424	61	5.0	68	0.11	2.0	0.009	0.010	0.06	0.007	2
Bellanaboy Br. (BEL3)	135	64	5.5	69	0.65	5.0	0.009	0.010	0.12	0.013	2
SP1	693	75	5.8	-	0.40	2.0	0.002	0.010	0.02	0.005	7

7.5 Biological Water Quality Monitoring on Carrowmore Lake & Tributaries

7.5.1 River Quality

Within the area of the review, the EPA monitored several rivers on a regular basis including on 4 occasions between 2005 and 2014. Table 4 lists these results which show that apart from one occasion in 2005 all sites returned a Q-4 i.e. Good Status. In addition, Mayo County Council have undertaken a Small Stream Risk Score (SSRS) survey on the Bellanaboy at the two water chemistry monitoring stations i.e. BEL 1 upstream of the SP1 stream discharge and BEL 2 downstream, each year from 2006 to 2010 (twice in 2006) and again in 2013 when they were assisted by IFI. Their findings show that on every sampling occasion a 'Probably not at Risk' score has been recorded at both sites. These findings confirm that in terms of biological water quality the SP1 discharge has had no adverse impact on the Bellanboy River.

Table 4: EPA Water Quality monitoring results for some Carrowmore Lake Tributaries

River Name	Bellanaboy	Glenturk	Glencullin	Munhin
Site Code	RS33B070200	RS339071000	RS33G030100	RS33M030200
River Site	Br u/s Carrowmore Lake	Br u/s Carrowmore Lake	Br u/s Carrowmore Lake	Br u/s Owenmore River
2005	Q4	Q4	Q4	Q3-4
2008	Q4	-	Q4	Q4
2011	Q4	-	Q4	Q4
2014	Q4	-	Q4	Q4

7.5.2 Lake Quality Status

Table 5 Lists the ecological and physico-chemical survey outcomes from the EPA monitoring of Carrowmore Lake over three periods since commencement of monitoring in 2007 (2007-2009, 2010-2012 and 2013-2015). These data show that Carrowmore Lake has remained at Moderate Ecological Status and Good Nutrient Status throughout this period. In the first period (2007-2009) there were 3 Biological Quality Elements (BQE) that failed to reach Good Status, while in the remaining 2 monitoring periods 2 BEQ's failed to reach Good Status. It is worth noting that total-P remained at Good Status and ammonia at High Status in all 3 monitoring periods.

Table 5

Status Years	**2007-2009**	**2010-2012**	**2013-2015**
Macrophyte Status	Good	Good	Moderate
Phytobenthos Status	High	Good	High
Other aquatic flora	Good	Good	Moderate
Chlorophyll Status	Moderate	Moderate	Good
Phytoplankton Composition Status	Moderate	Good	Good
Phytoplankton Status	Moderate	Moderate	Good
Fish Status	Good	High	Good
Overall Status for *BQE	Moderate	Moderate	Moderate
Ammonia Status	High	High	High
Total-P Status	Good	Good	Good
Oxygenation Status	High	High	High
Acidification Status	High	High	High
Thermal Conditions	High	High	High
Nutrient Conditions Status	Good	Good	Good
General Conditions	Good	Good	Good
Specific Pollutants	Pass	Pass	Pass
Supporting Chemistry Status	Good	Good	Good
**GPC Status	Good	Good	Good
Ecological Status	Moderate	Moderate	Moderate

*BEQ = Biological Quality Elements; **GPC = General Physico Chemical

8 Overall Summary and Conclusions

The water chemistry data available for undertaking this review is considered very comprehensive, covering an extended timescale and a wide range of sites and parameters. The data for the surface water discharge point from the BBGT site SP1, displayed two relatively distinct phases in terms of its water quality results. An earlier phase approximately between May 2005 and August 2008 when several parameters including, turbidity, suspended solids, nitrate and total aluminium and to a lesser extent ortho-P and total-P were elevated above background levels; and a later phase from the autumn of 2008 until the end of the data series in November 2014, when the levels of these parameters dropped back to baseline levels.

The discharge volumes from SP1 were small (measured in litres per second) and when the entered the Bellanaboy river between May County Councils monitoring sites i.e. BEL 1 upstream and BEL 2 downstream, it was clear from the data that the SP1 discharge was having a minimal effect on the receiving water chemistry.

An examination of the MCC database for the wider Carrowmore Lake catchment tributaries (2005-2014) indicated that, for most sites and most relevant parameters, Water Framework Directive surface water objectives were being achieved. The data also suggested that in respect of ortho-P and ammonia concentrations, the Bellanaboy River had marginally higher average concentrations of these parameters than all of the other sites in the case of ortho-P and all bar one of the sites in the case of ammonia. It is important to note however that there is no evidence in the dataset that this is due to the SP1 discharge.

Biological data collected by the EPA in the Bellanaboy, Glenturk and Munhin Rivers between 2005 and 2014 indicate that water quality on the vast majority of occasions was at Good Status in these channels, one of which (at Bellanaboy Bridge) is downstream of SP1.

The EPA, in monitoring water quality in Lough Carrowmore between 2007 and 2015, has classified the lake throughout this period as at Moderate Ecological Status and with Good Nutrient Status and good Supporting Chemistry Status throughout. This suggests that the lake has not undergone any significant changes in quality during the period which overlaps to a considerable extent with the development phase of the BBGT project.

To conclude, this review indicates that for the period from 2005 to 2014, there have been no changes in chemical or biological quality within the Carrowmore Lake catchment.. The quality is within normal and natural variation, the system appears to be relatively stable in terms of its water quality, which is generally good.