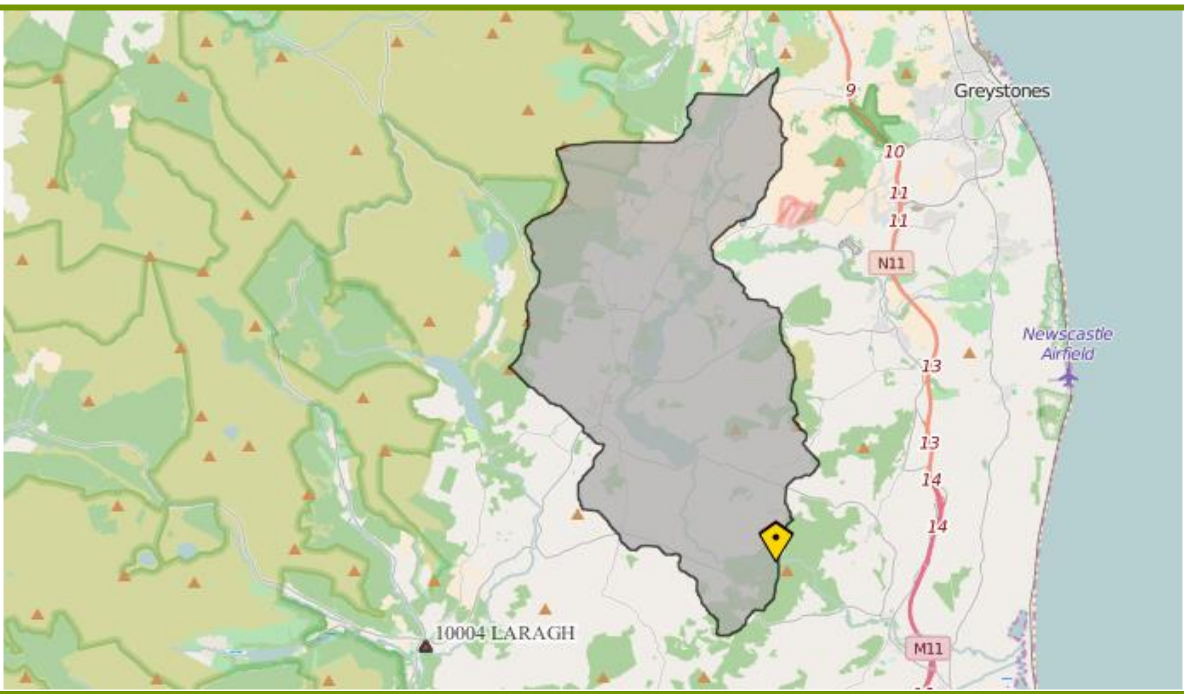
Irish Water

VARTRY WATER SUPPLY PROJECT

RIVER VARTRY HYDROLOGICAL & WATER QUALITY REPORT



September 2016

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VARTRY WATER SUPPLY PROJECT

RIVER VARTRY HYDROLOGICAL & WATER QUALITY REPORT

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B					
C					
D					

CONTENTS

1 INTRODUCTION

This hydrological and water quality report is prepared to support the response to the request for Additional Information from Wicklow County Council (refer correspondence dated 01/06/2016) in relation to the planning application (planning register Reference No. 16/363) for improvements at the existing Vartry Reservoir and Water Treatment Plant site.

This report contains information on the hydrological analysis of the River Vartry and its water quality. Data used in the analysis was obtained from a number of sources namely:

1. Flow Records from the existing plant and reservoir from Dublin City Council
2. Water level and spot flow records at Annagolan and Devil's Glen obtained from the EPA
3. Water Quality Results from the EPA and Dublin City Council
4. Additional flow and water quality results commissioned by Nicholas O'Dwyer on behalf of Irish Water. This data is included in Appendix 2.

The Vartry River is a heavily modified water body. Its upper catchment is dammed by two adjoining reservoirs at Roundwood, with an approximate catchment area of 56 km^2 at this location. The reservoirs store run-off from the catchment and spill excess water when full.

The dams were constructed as part of the Vartry Water Supply Scheme which has served areas of Wicklow and Dublin with drinking water since the scheme was established in the 1860's.

A detailed Hydrological Assessment is contained in Section 2 while Section 3 contains our Water Quality Assessment.

2 HYDROLOGICAL ASSESSMENT

2.1 Vartry River Catchment Characteristics

The Vartry catchment is located entirely within Co. Wicklow with agriculture being the dominant land use. The Vartry River flows into Broad Lough before discharging into the Irish Sea at Wicklow Town (Figure 2-1). The Vartry Catchment is within the Vartry-Avoca Hydrometric Area (HA10) and is known for its beautiful scenery.

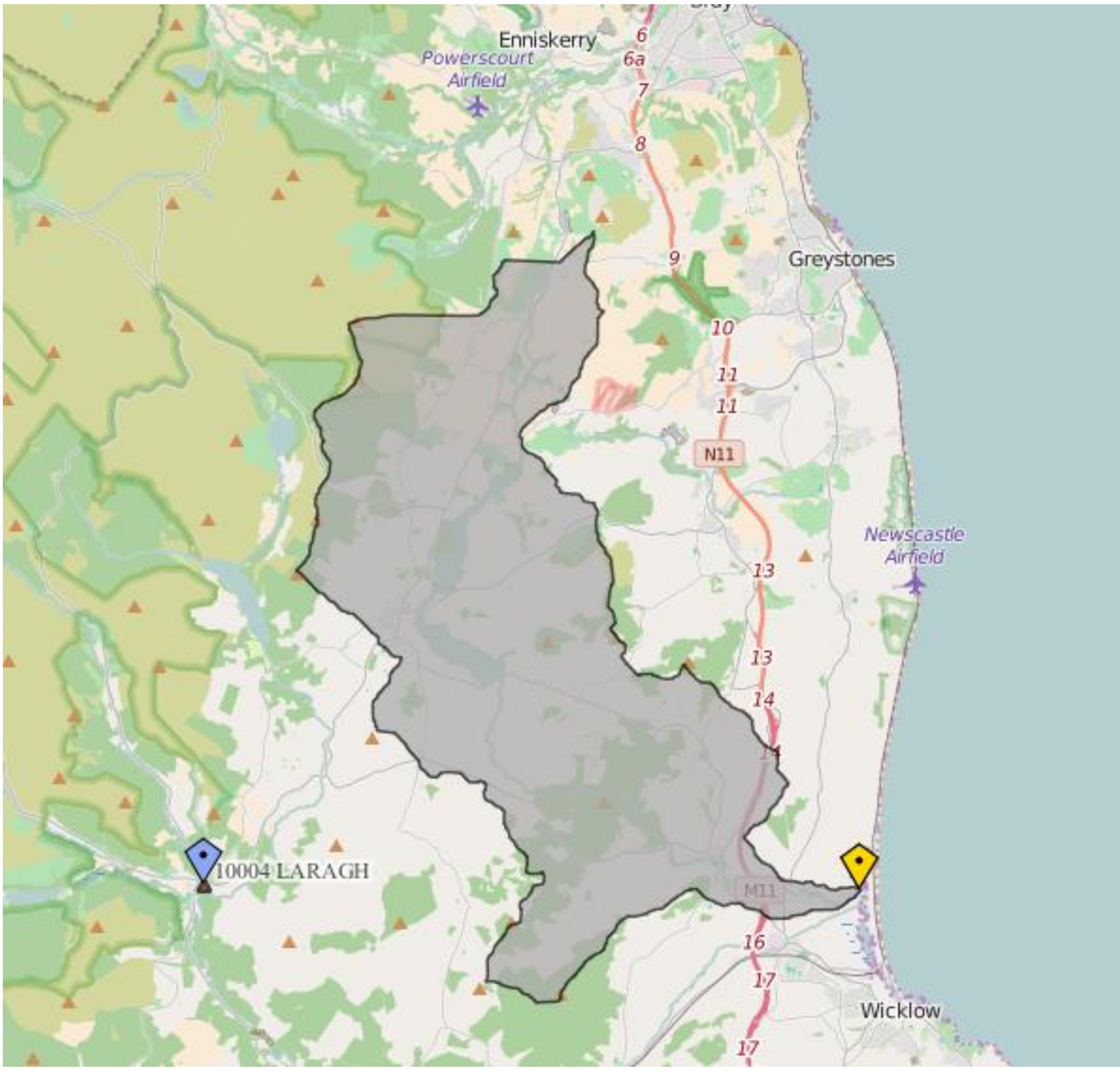

Figure 2-1 Vartry Catchment at its outfall to Broad Lough (A = 104 km^2)

The River Vartry itself is designated for protection under the European Communities (Quality of Salmonid Waters) Regulations 1998 (S.I No 293, 1988). The main hydrological features in the catchment are the lower and upper Vartry Reservoirs built in 1863 and 1923, respectively.

The Vartry Water Treatment Plant at Roundwood is the major user of water in the catchment abstracting circa 80,000-95,000 m^3/day to supply areas in Wicklow and south Dublin.

2.2 Existing Flow Data

There are two locations (Annagolan Bridge - Station No. 10001 and Devil's Glen - Station No. 10020) along the river as shown in Figure 2-2, where historical flow or level records exist. These records are summarised in Table 2-1 below.

There was also a spot measurement taken at Ashford Weir during the 1995 drought. This location is also illustrated in Figure 2-2 and discussed in more detail in Section 2.4.

Figure 2-2 Flow Gauging Stations on the River Vartry

Table 2-1 Gauging Stations on the River Vartry

Stn. No.	Station Name	Catchment Area, km^2	Easting/ Northing	Record Type	Record Duration
10001	Annagolan	64.40	322200/ 199100	Spot flow measurements - No continuous water level or flow records available.	12no. spot flow measurements (1976-1980)
10020	Devil's Glen	73.70	323740/ 199045	Continuous Water Level Recording	1952-1979 (7726 data points-with some discontinuation)

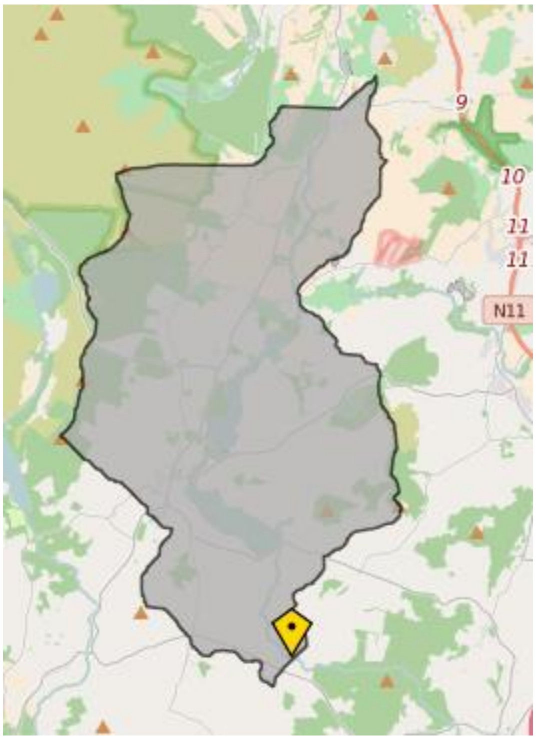

Figure 2-4 Vartry Catchment at Annagolan Bridge (A=64.4km^2)

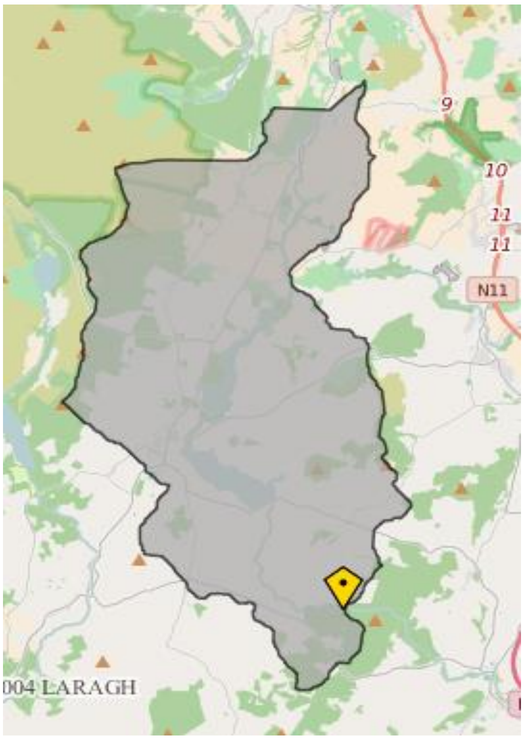

Figure 2-3 Vartry Catchment at Devil's Glen (A = 73.7km2)

2.3 Flow Estimation at Devil's Glen

The EPA previously estimated the Dry Weather Flow (DWF)[a] of the Vartry River at Devil's Glen (Gauge No. 10020) at 0.016 m^3/sec or 1,382 m^3/day[b]. However, the EPA have recently updated their website and the DWF for the Vartry River is not now included. A copy of the previous EPA record is included in Appendix 1.

We have carried out our own assessment of flows in the River Vartry by using flow and level data from Annagolan Bridge and Devil's Glen to generate a flow duration curve and estimate low flows in the river.

The data at Devil's Glen (level data) and Annagolan Bridge (spot flow data) were correlated to generate a flow duration curve at Devil's Glen. The two stations are a short distance apart (less than 10km^2 of catchment area between them, see Figure 2-4 and Figure 2-3 above), and it is considered reasonable to assume that the flows are proportional to the catchment areas. The optimised rating curve has the following form:

$$Q = 2.48(h - 0.1)^{1.47}$$

where Q is the discharge in m^3/sec and h is the water level.

The estimated hydrograph at Devil's Glen is shown in Figure 2-5. The flows generated by the above rating curve were then used to estimate the Flow Duration Curve (FDC) at Devil's Glen. The resulting FDC is shown in Figure 2-6. It should be noted that greater emphasis is given to the low flows than the high flows while estimating the constants at Devil's Glen because the spot flow measurements available at Annagolan Bridge are generally at the low end of the range.

[a] *Dry Weather Flow is a term used to describe low flows and is defined by the EPA as the annual minimum daily mean flow rate with a return period of 50 years (i.e. statistically the flow that occurs at the 98%ile interval)*

[b] *http://www.epa.ie/water/wm/hydronet/*

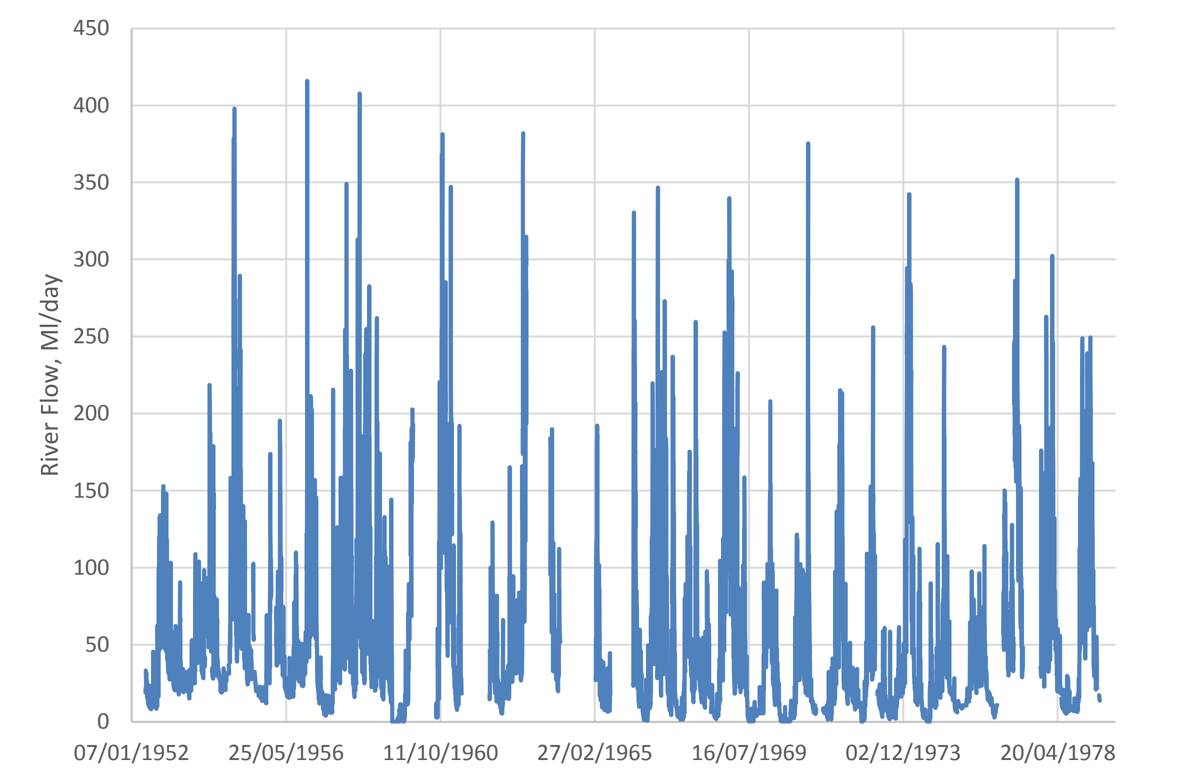

Figure 2-5 Estimated Flows at Devil's Glen

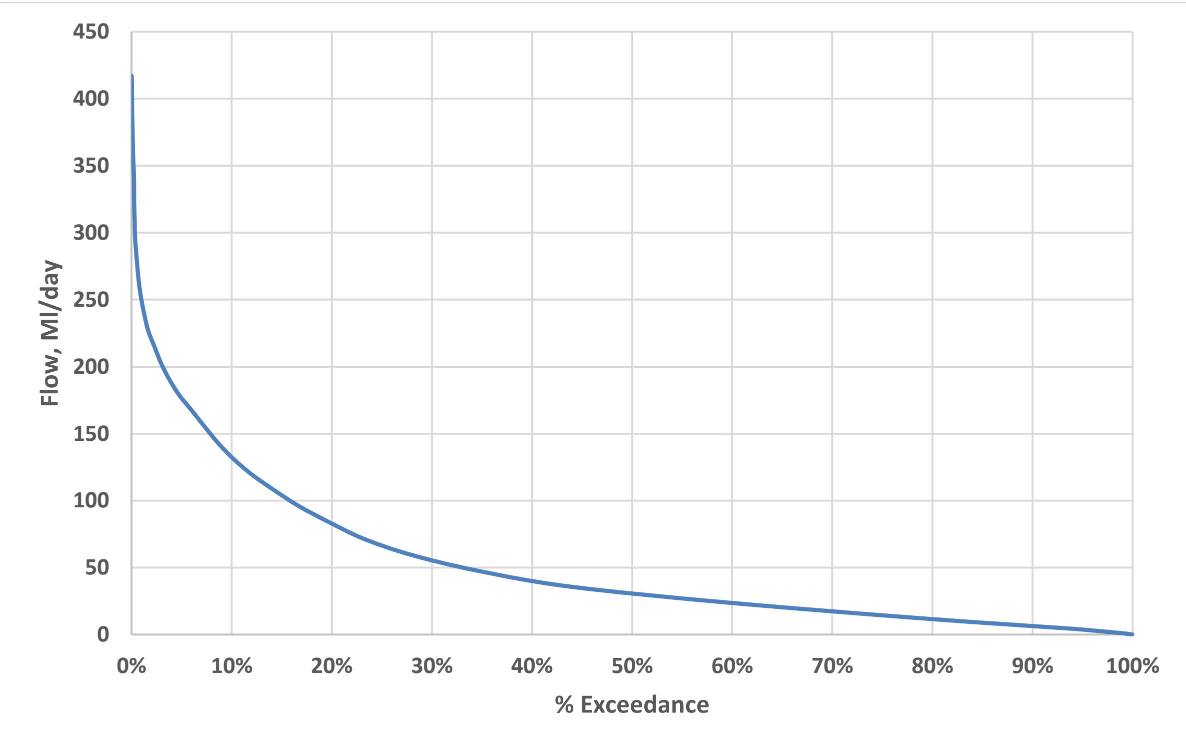

Figure 2-6 FDC at Devil's Glen

From the FDC, the 98%ile (DWF) and the 95%ile flow for the station are calculated as 1.6Ml/day and 3.6 Ml/day, respectively. This DWF estimate is marginally greater than the previous EPA estimated DWF of 1.382Ml/day (1,382 m^3/day).

As outlined earlier, the catchment area at Devil's Glen is 73.7km^2 which includes an area of 56.8km^2 upstream and 16.9km^2 downstream of the lower reservoir. During drought periods, no flows would have been released downstream of the reservoir, therefore it can be calculated that the DWF estimate of 1.6Ml/day (NOD) and 1.38Ml/day (EPA) equates to a yield figure of 96 m^3/km^2/day and 82m^3/km^2/day, respectively (i.e. 1600/16.9 = 96 and 1382/16.9 = 82). These figures are used later to compare with the flow recording at Ashford weir during the 1995 summer drought.

2.3.1 Comparison with Low Flow Estimates in Drought Years

2.3.1.1 The 1976 Flow at Devil's Glen

The EPA[c] regard 1975 and 1976 as exceptionally dry years and accordingly we have used the Devil's Glen hydrograph for those years to analyse the low flow characteristics of the River Vartry.

The hydrographs for the 1975 and 1976 flows at Devil's Glen are illustrated in Figure 2-7. The lowest recorded flow is approximately 2.72Ml/day which occurred on the 2nd of July 1976. The drought in that year lasted until mid-September in most parts of the country and particularly in the east and south east which indicates that the minimum flow would have been lower than this figure. However, no measurements were taken at Devil's Glen between August and September of that year. It was subsequently noted by the EPA that minimum flows of the 1976 drought year occurred in the first week of September, just before the drought ended on September 9th.

Data is available for the River Slaney, a nearby catchment, at Rathvilly (Station No. 12013) during this period and is used as a comparator with the River Vartry. The data indicates a flow of 1.7 m^3/sec on 02/07/1976. Flows in the Slaney continued to fall (apart from one rainfall event) until early September where a minimum flow of 0.846m^3/sec was recorded on August 28th as seen in Figure 2-8 and Figure 2-9. This indicates that the flow on 2nd July was approximately two times greater than the minimum flow recorded on August 28th. Using a similar comparator, the minimum flow in the River Vartry during this drought is estimated at 1.36Ml/day (i.e. 2.72/2 = 1.36 Ml/day) which is comparable to that estimated previously by the EPA and also to that determined from the FDC generated in this report.

[c] *"An Assessment of the 1995 Drought, Including a comparison with other known drought years", M. Mc Carthaigh (EPA), 1996*

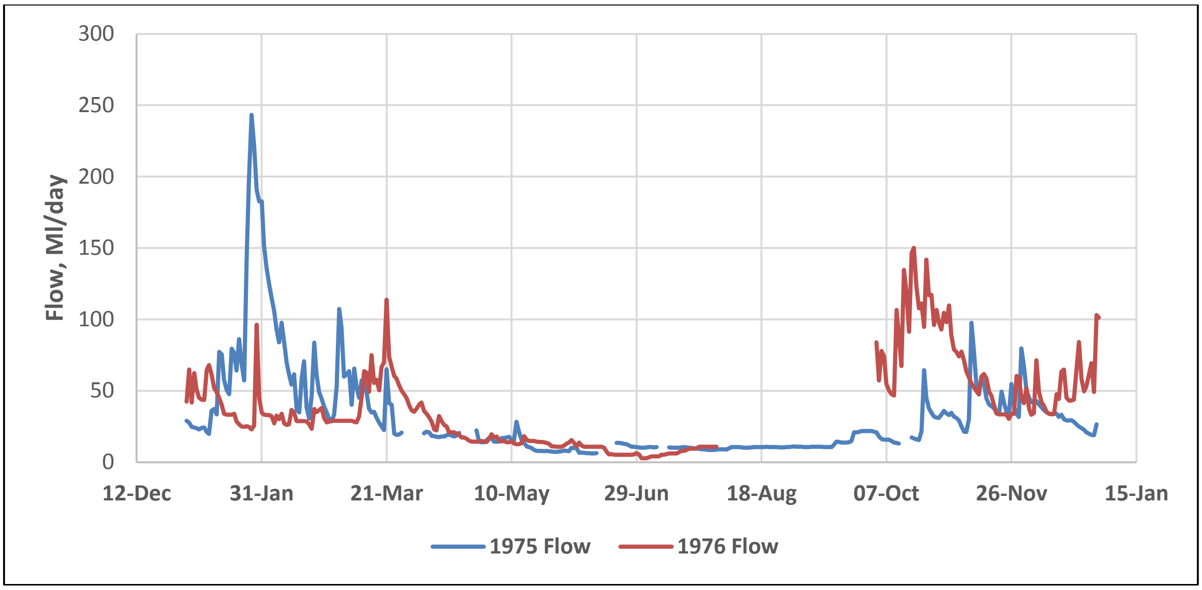

Figure 2-7 The 1975 and 1976 Flow at Devil's Glen

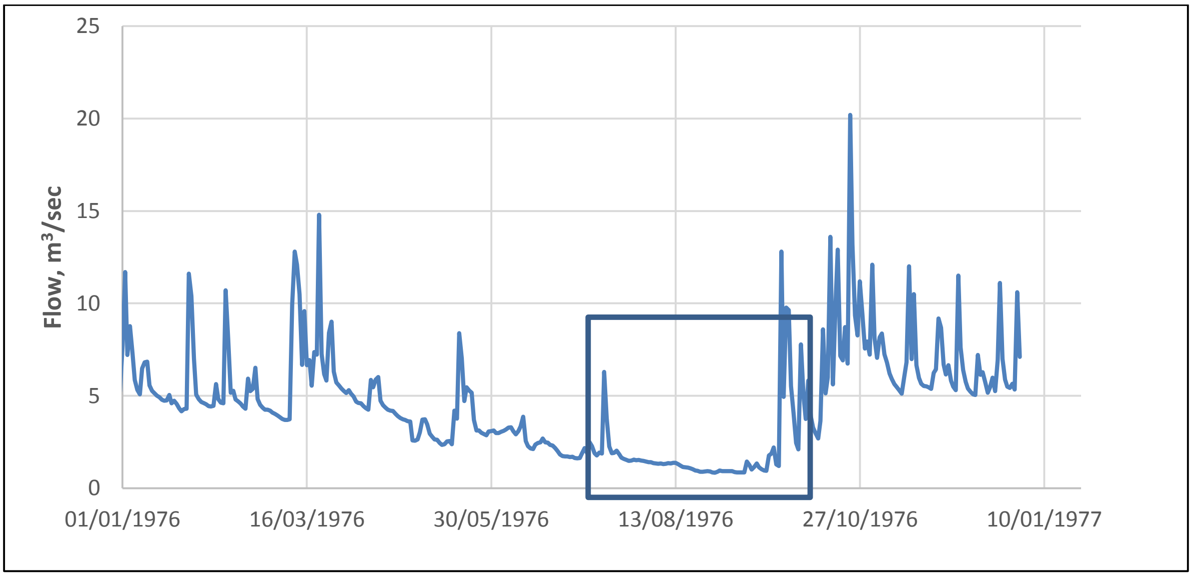

Figure 2-8 The 1976 Hydrograph of Slaney River at Rathvilly

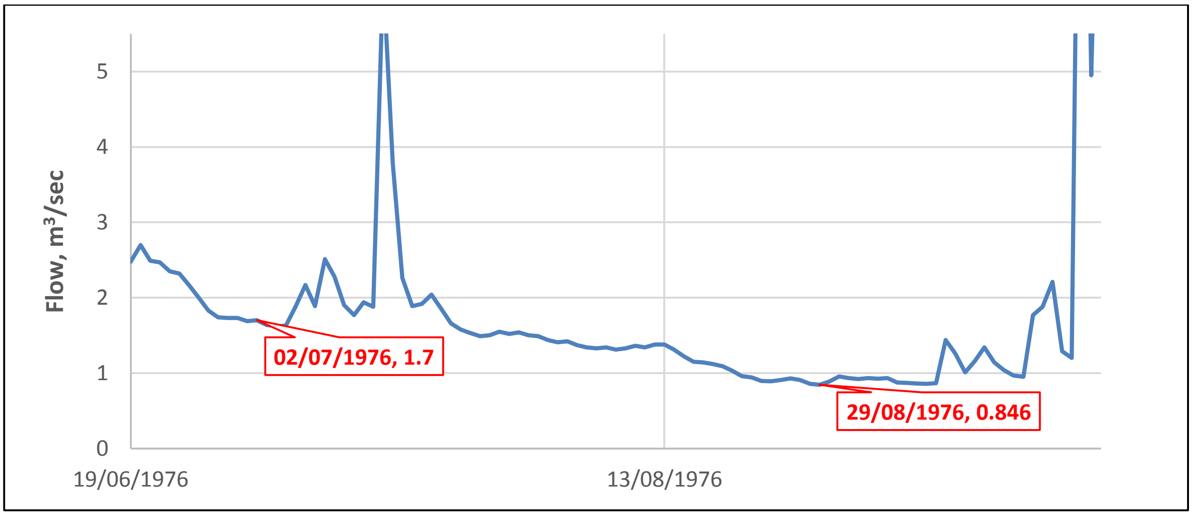

Figure 2-9 July and August 1976 Flows of Slaney River at Rathvilly

2.3.1.2 The 1995 Flow at Ashford Weir

Similarly, 1995 is also considered a very dry year and a low flow of 35l/s (3,000 m^3/day) was recorded by the EPA at Ashford Weir during that summer. The catchment area between Ashford Weir and the Lower Vartry reservoir is approximately 33.4km^2. Therefore, a flow of 3,000 m^3/day equates to a contribution of 90 m^3/km^2/day and is comparable to the contribution per km^2 estimated for Devil's Glen of between 82 to 96m^3/km^2/day for DWF conditions set out previously in Section 2.3.

2.3.2 Conclusion

Based on the calculations above we are satisfied that the FDC generated at Devil's Glen is a reasonable estimation of flows in the River Vartry at that location particularly during low flow conditions.

2.4 Flow Estimation Immediately Downstream of Vartry Impounding Reservoir

There is no gauging station immediately downstream of the dam and so the existing records of flows spilling over the weir and discharges from the works were used to estimate flows immediately downstream of the existing water treatment plant.

A simplified schematic layout of the plant is illustrated in Figure 2-10.

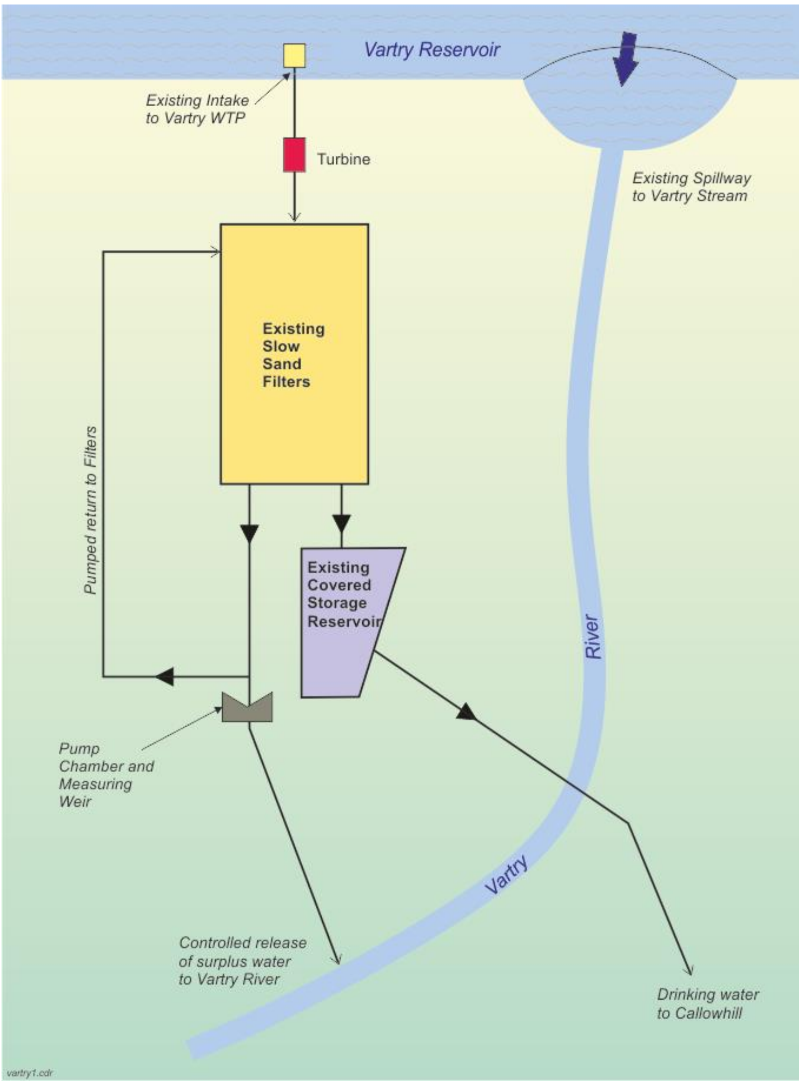

Figure 2-10 Schematic Layout of Vartry Water Treatment Plant

When the reservoir is not spilling the flow immediately downstream of the plant is predominately made up of releases from the plant. This release is made up of water used to drain down and start up filters during the washing cycle and overflows and leakage through the filters. A graph illustrating the release of water from the WTP through the measuring weir (from 1988 to 2016) is illustrated in Figure 2-11 below.

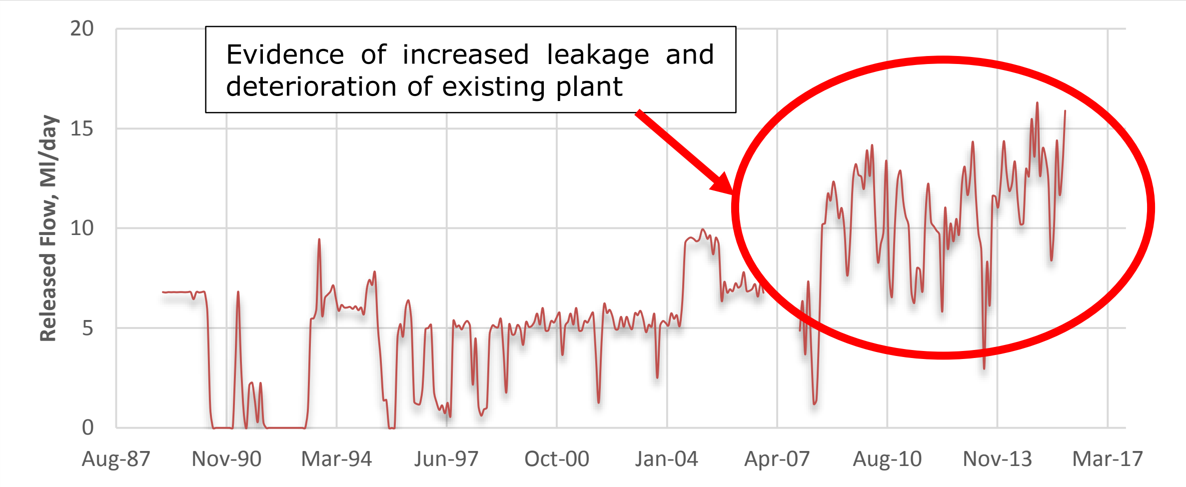

Figure 2-11 Measured Monthly Average Flows from the WTP to the Vartry River from 1988[d] to 2016

There may be other losses through the plant/reservoir from seepage or leaks not recorded in the measuring weir. However, these are considered minor in nature and insignificant during drought conditions as evidenced by the low flow estimates (refer to Section 2.3).

Based on the flow data illustrated above the established normal release from the plant to the River Vartry is between zero and circa 5MLD. The average flow recorded between 1988 and 2007 is 4.6MLD and this is the reported normal practice extending back to the 1920's when the second impounding reservoir was completed. Water has been pumped back to the filters when required, such as the summers of 1990 and 1995 when all water was returned to the filters.

The existing filters are an aging asset with poor structural integrity and have been in decline for some time. The amount of water currently recorded in the leakage channel has increased significantly in recent years to between 10 to 15MLD of which approximately 10-13MLD is attributed to leakage. Clearly this is unsustainable and if left unaddressed leakage will continue to increase as the filters deteriorate further.

The water released from the plant since 2008 has increased due to a number of factors:

- Works carried out between 2006 and 2008 when new filters, pipework and a covered storage reservoir were constructed resulting in increased leakage from the existing filters to the drainage collection channel;
- The continued deterioration of the structural integrity of the existing slow sand filters means that more and more water is leaking into this collection channel. This is illustrated in the upward trend of the graph in recent years and is one of the reasons why the new Treatment Plant is required.
- In recent years' reservoir levels have remained relatively high, as no significant drought has occurred, and recovery of such water by back pumping has not been a major consideration.

The average release for the period 2008 to 2015 (there were no records for 2007) has increased to 10.5MLD. It is worth noting however that even with the increased leakage, considerable flows have been returned to the works, with the corresponding reduction in

[d] *No records from 1868 to 1988*

release water, when deemed necessary. This occurred most noticeably in 2008 and 2013 as illustrated above where reduced flows of approx. 1.2 and 3MLD respectively were released.

In addition to the above releases, water also flows into the River Vartry over the reservoir spillway when the reservoir is full as illustrated in Figure 2-12. These flows have been estimated using the change in storage volumes in Vartry Reservoir and taking account of water supplied to the treatment plant.

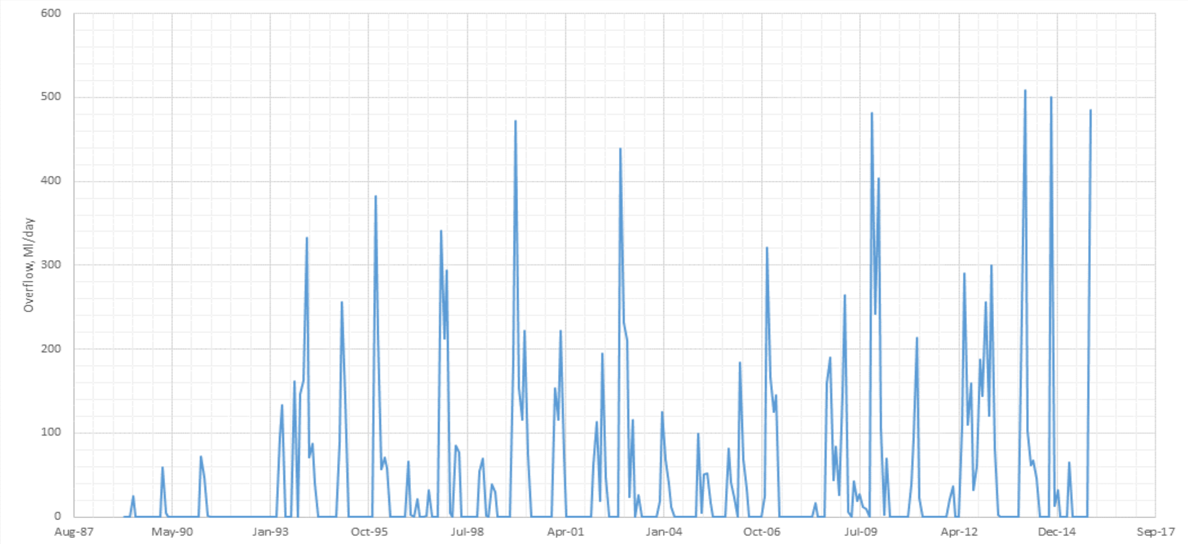

Figure 2-12 Flows from the reservoir to the Vartry River from 1988 to 2016

A flow duration curve (FDC) for the Vartry River immediately downstream of the plant has been generated using the data contained in Figure 2-11 and Figure 2-12.

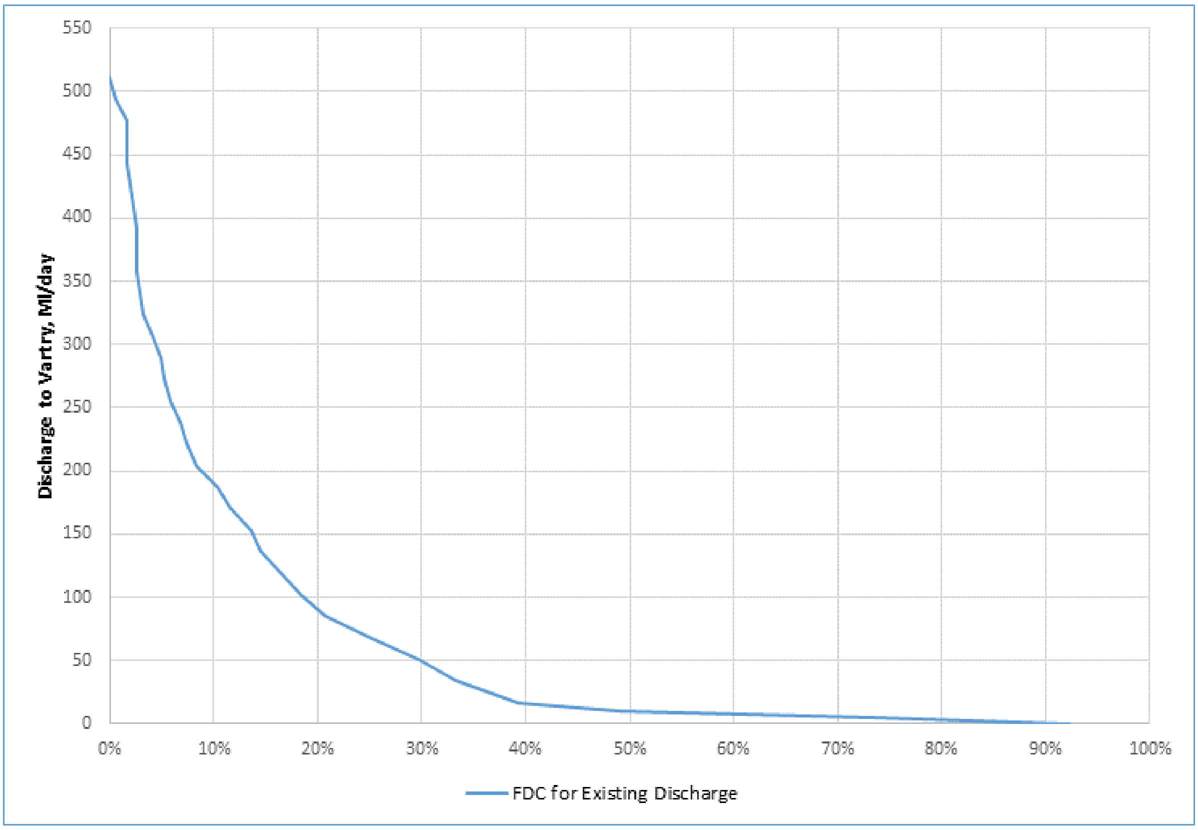

Figure 2-13 Existing Flow Duration Curve immediately downstream of the plant

The above graph illustrates that there are times (approximately 8% of the time) when no flows are released downstream of the water treatment plant. Therefore, the existing 95%ile and DWF are estimated as zero.

2.5 Predicted Low Flows Downstream of the Works

2.5.1 Immediately Downstream of the Works

Following completion of the new water treatment plant water will continue to spill from the reservoir when it is full and releases will continue from the plant as part of the treatment process. It is estimated that the water released from the new plant following treatment will be in the region of 5,000m^3/day. It is not proposed to pump this water back to the plant during drought conditions as happens at present.

A predictive FDC has been generated to demonstrate the projected change in the flow regime of the river following completion of the works as illustrated in Figure 2-14. The low flow range has been magnified to highlight the proposed change.

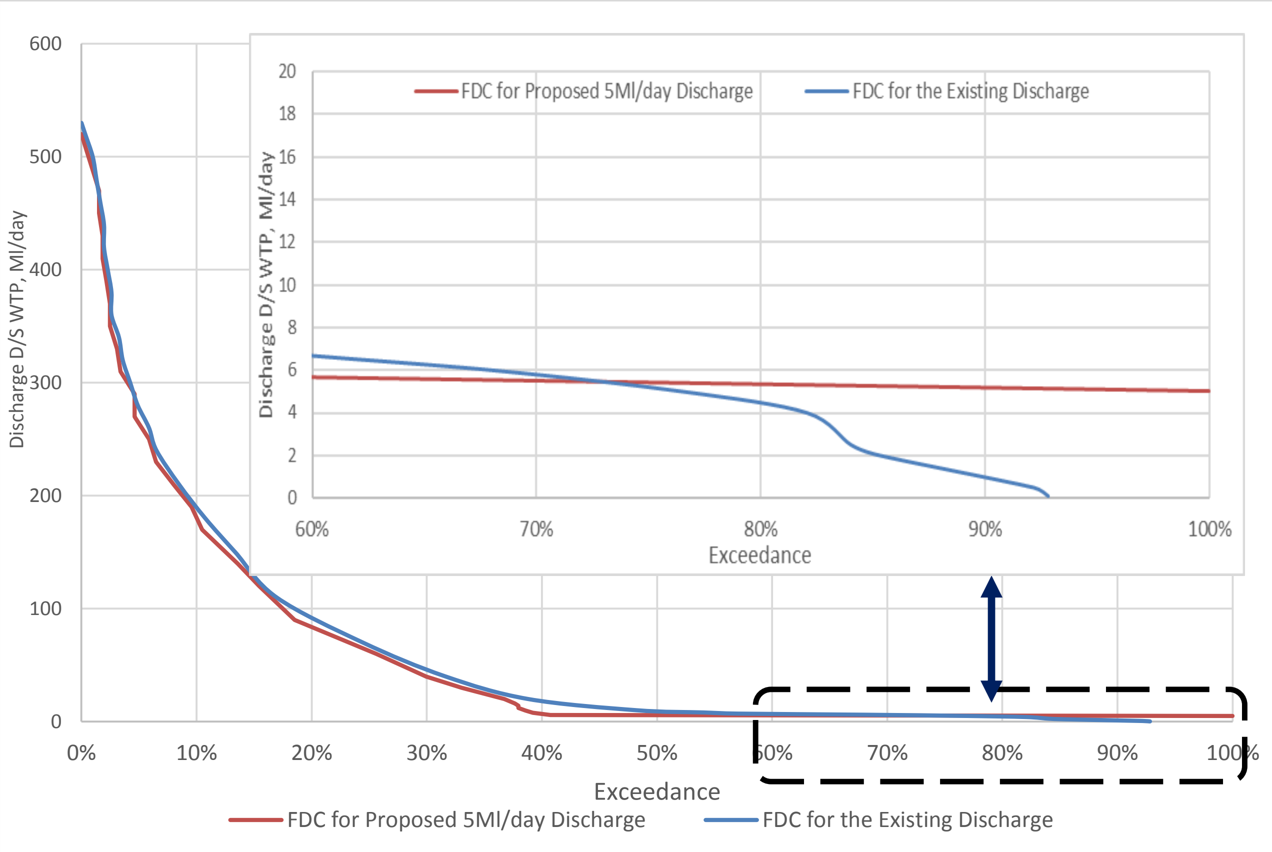

Figure 2-14 – Predicted Flow Duration Curve Immediately downstream of the plant

As illustrated above there will be an increase in downstream flows above the 73%ile interval (i.e. statistically 27% of the time) when it is most needed in the downstream reaches and this will be a significant hydrological benefit to the river.

2.5.2 At Devil's Glen and Ashford Weir

A similar comparison has been carried out at Devils Glen where the existing DWF and 95%ile flows of 1,600 m^3/day and 3,600 m^3/day, respectively are expected to increase significantly to 6,600 m^3/day and 8,600m^3/day respectively. A predictive FDC at Devil's Glen is illustrated in Figure 2-15.

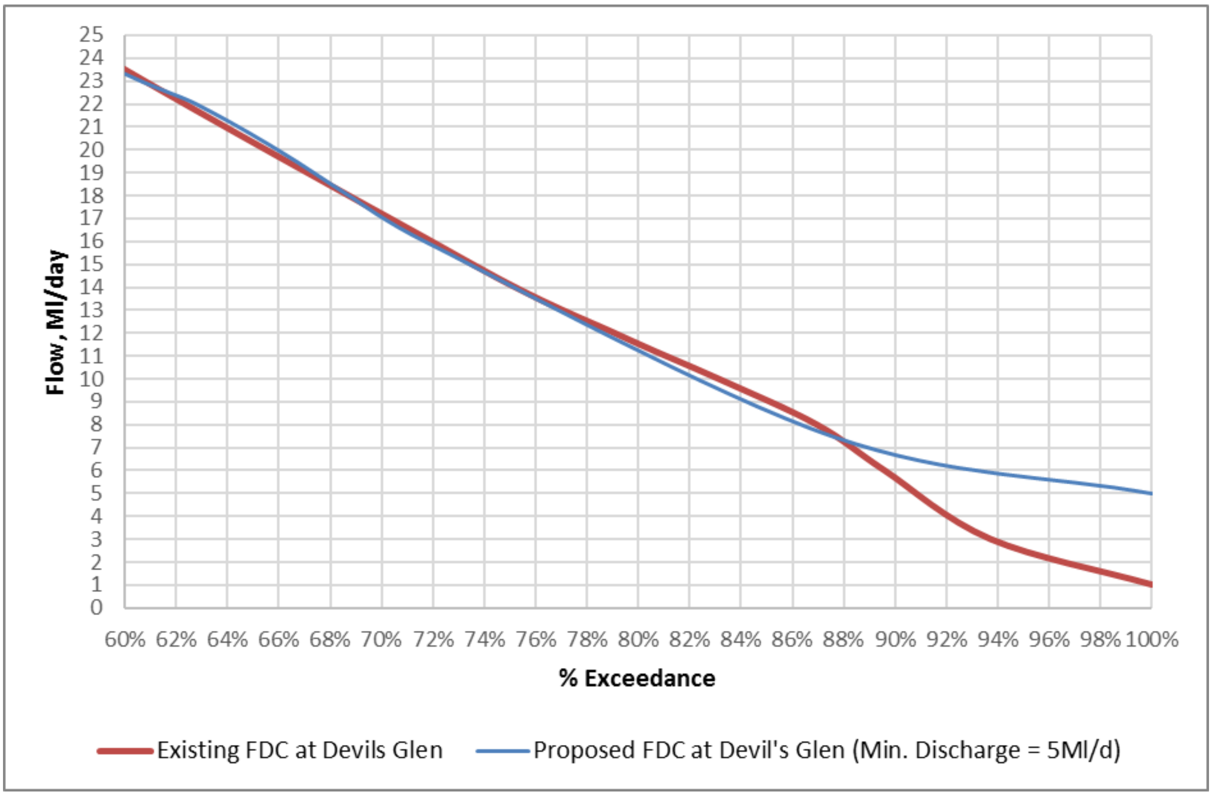

Figure 2-15 Existing and Proposed FDC at Devil's Glen

The DWF estimate at Ashford Weir of 3,000m^3/day would similarly increase to approximately 8,000 m^3/day.

It is clear therefore that the improved flow conditions at low flows will also be significant in the lower reaches of the River Vartry where increased flows of over 100% will arise under drought conditions.

2.6 Summary and Conclusion

The existing 95%ile and dry weather flow estimates immediately downstream of the existing water treatment plant are zero. This situation has arisen during drought conditions as discharges from the works were collected and pumped back to the head of the works and no flow was released downstream.

Under the existing proposals 5,000m^3/day will be released from the works at all times and this will lead to a significant increase on low flows in the river downstream of the works when it is of greatest hydrological benefit.

3 WATER QUALITY ASSESSMENT

3.1 EU Water Framework Directive and Existing Water Quality Status of the River Vartry

The EU Water Framework Directive (2000/60/EC) commits member states to preventing deterioration and achieving at least "good" status in rivers, lakes, estuaries, coastal and groundwater.

The Vartry River system is located within the Eastern River Basin District (ERBD) and the Management Plan for the ERBD was issued in 2010 covering the period 2009 – 2015. Preparation of the second cycle of the River Management Plan for the period 2015 to 2021 is now underway and the ERBD will be merged with the other districts in the Republic of Ireland as one National River Basin District.

In the 2009-2015 Management Plan, the Vartry River System was indicated to have Moderate Status, due to a Moderate status rating in the lower reach of the River, at Ashford. The EPA water quality monitoring stations downstream of the plant are illustrated in Figure 3-1 below and show, for the period 2004 – 2015, the water quality of the River Vartry as "Good Status"[e] at all these monitoring locations, with the exception of Rossana House which was classified as "Moderate" status.

Figure 3-1 EPA Water Quality Map at Monitoring Stations

However, it is now noted from the EPA's *catchments.ie* website, that since the decommissioning of the Wastewater Plant at Ashford in 2010 and the transfer of wastewater from the Ashford collection system to the Wicklow Town plant, the ecological status of the River has improved to "good" status as illustrated in Figure 3-2 below. This was achieved in advance of the target date of 2015 as set out in the Management Plan.

[e] *'Good' Ecological Status, 'Good' physio-chemical status, 'Good' nutrient enrichment status, 'High' chlorophyll status and 'High' macrophyte status resulting in an overall 'Good' water quality status as assessed by the EPA*

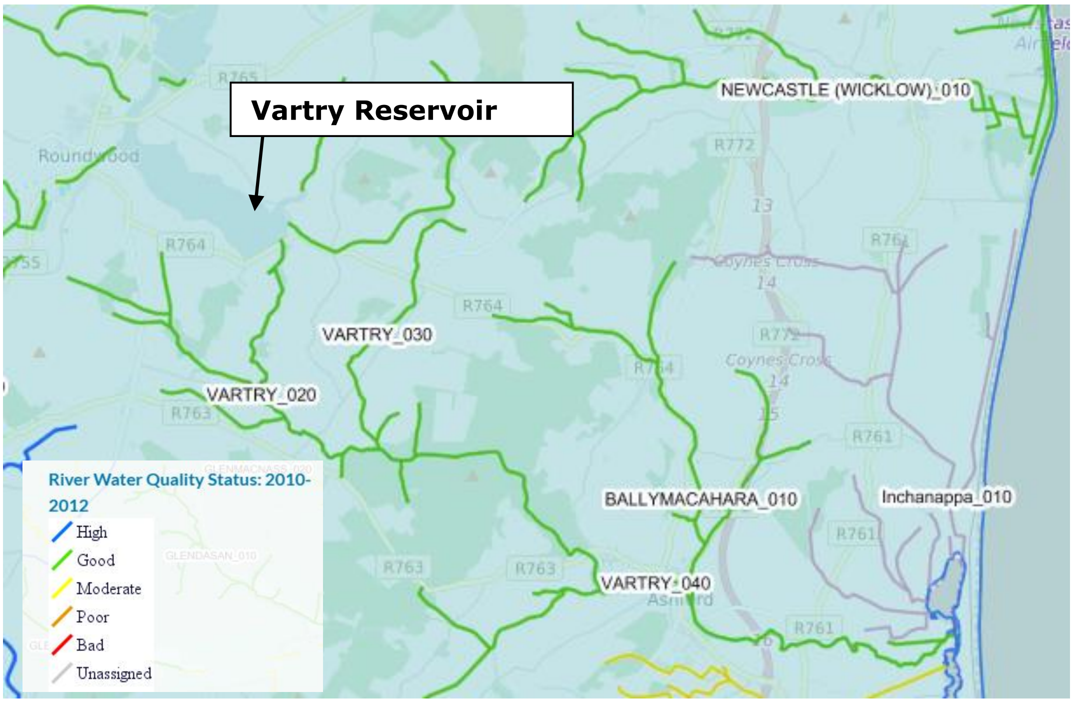

Figure 3-2 Catchments.ie Screenshot of River Vartry

The Upper and Lower Reservoirs at Vartry already has "good" ecological status and are regarded as "Heavily Modified Water Bodies" under the ERBD Management Plan.

Accordingly, since the publication of the ERDB Management Plan in 2008, the status of the entire length of Vartry River downstream of the Reservoirs has improved from "Moderate" to "Good" and henceforth the River Basin Management Plan objective for the Vartry system will be to "Protect" as distinct from "Restore" this status.

3.2 Water Quality Status Downstream of the Water Treatment Plant

The nearest water quality monitoring station downstream of the works is at Annagolan Bridge, approximately 2.7km downstream. (refer to Figure 2-2 previously for location map). The River Vartry at this location has been classified as having good or good/high quality classification since the EPA records began in 1978 as summarised below.

Table 3-1 EPA Biological Monitoring Records for Annagolan Bridge, River Vartry

Site ID: 10V010100	
Year	**Q Value**
1978	5
1982	4-5
1986	5
1990	4-5
1994	4
1997	4
2000	4-5
2003	4
2006	4-5
2009	4
2012	4*
2015	4

Q Value Classifications: 4 – Good; 4 - Good; 4-5 – High; 5 - High*

This period includes times when the quantity of water released through the existing plant was between 0 and 5MLD as outlined previously in Section 2. On this basis, the proposed flow regime of at least 5MLD downstream of the plant will ensure the hydraulic conditions to 'Protect' this status will be maintained.

It will also be necessary however to ensure the quality of discharge from the new plant is such that these standards can be maintained. As there will be times when the only water flowing downstream of the plant will be that which is discharged from the plant, it will be necessary to ensure the quality of this discharge meets the necessary Environmental Quality Standard (EQS).

Water Quality data has been obtained from a number of sources namely:

1. Vartry Reservoir (upstream of the plant) from Dublin City Council for the period January 2016 to July 2016. Weekly and monthly results
2. Annagolan Bridge (nearest monitoring station downstream of the plant) from the EPA for the period 2013 to 2016. Monthly results
3. Monitoring of the background concentrations for key parameters was also commissioned by Irish Water at the locations shown in Figure 3-3 for July and August 2016.

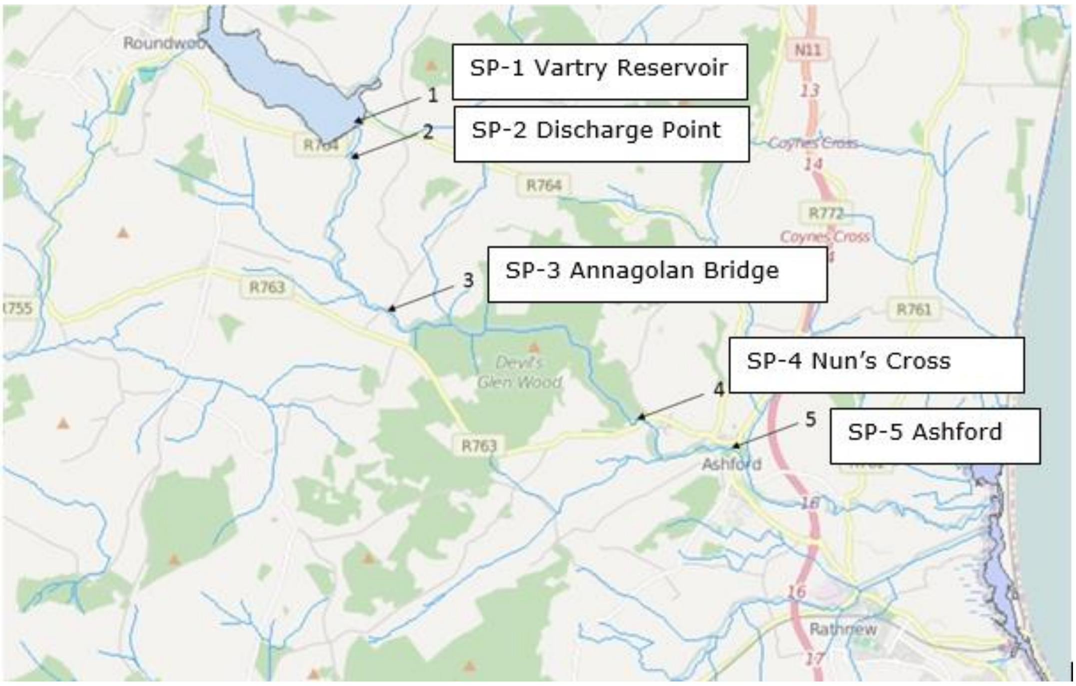

Figure 3-3 NOD's Sampling Locations

A copy or these records is included in Appendix 2 and demonstrate compliance with the existing 'Good' quality status of the river. These records were used to compare the predicted future water quality following the completion of the new water treatment plant.

3.3 Existing Water Quality and Environmental Quality Standards

The River Vartry is designated a Salmonid Water under the European Communities (Quality of Salmonid Waters) Regulations, 1988 which requires certain water quality standards to be maintained. In addition, Schedule 5 of the European Communities Environmental Objectives (Surface Water) Regulations 2009 (S.I. No. 272 of 2009) sets out the standards to be reached for 'good' and 'high' quality standards.

A summary of the existing water quality data as referred to in Section 3.2 upstream (Vartry Reservoir) and downstream (Annagolan Bridge) of the discharge location is included in Table 3-2 below and compared to the aforementioned regulations. The results demonstrate compliance with the existing 'Good' status for the river.

Table 3-2 Background Water Quality Monitoring Stations and EQS

P'meter	Background Concentration								Salmon-id Reg	EQS Rivers Good Status (SI 272 of 2009)	EQS Rivers High Status (SI 272 of 2009)
	Vartry Reservoir (DCC/NOD Samples)				Annagolan Bridge (EPA Values)						
	Min	Max	Avg	95%	Min	Max	Avg	95%			
DO	%Saturation								50%>9 mg/l or ~82%	120%>95%ile >80%	120%>95%ile >80%
	80	109	95	99	81	108	100	106			
pH	6.7	7.9	7.2	7.6	6.1	7.4	6.8	7.2	6.0-9.0	6-9	6-9
Suspended Solids, mg/l	<5	9	<5	<5	1	30	3.74	8.3	<=25	Not Set	Not Set
BOD_5, mg/l	<1				0.3	2.2	0.9	1.4	<=5	<1.5 mean or	<1.2 (mean) or <2.2 (95%ile)
Fluoride, µg/l	<0.05	0.11	0.07	0.10	-	-	-	-	-	500	500
Nitrites as NO_2, mg/l	<0.05				0.001	0.012	0.004	0.009	0.5	-	-
Total Ammonia as N, mg/l	<0.01	0.04	0.02	0.04	0.00	0.06	0.02	0.031	-	<0.065 mean or <0.14 (95%)	<=0.040 (mean) or <=0.090 (95%ile)
Non Ionised Ammonia (NH_3)	-				-				<=0.02	-	-
MRP mg/l	<0.01				0	0.04	0.01	0.011		<0.035 mean or <0.075 (95%)	<=0.025 mean or <=0.045 (95%ile)
Total Residual Chlorine, mg/l	-				-				<=0.005	-	-
Total Zinc, µg/l	1	7	5	7	ND	44	8	31	200	50	50
Dissolved Copper, µg/l	1	3	<3	2.85	ND	6.5	1	4.7	22	5	5

In the following section, we set out our assessment of the treated process water returns to determine if they can comply with the EQS standards set out above.

3.4 Treated Process Water Discharge from the Plant and Quality Standards

3.4.1 Characteristics of Treated Process Water

It is important to distinguish between discharges from water treatment plants and those from other treatment processes such as wastewater treatment plants. The process water at Water Treatment Plants undergoes treatment before being either:

1. Returned to the head of the works or
2. Released as a discharge to the receiving water downstream

The water treatment process itself includes the addition of some chemicals to help remove the impurities in the river water, such as Colour and Total Organic Carbon (TOC) and these chemicals are carefully monitored to ensure their concentrations in final drinking water are below the limit values set by the drinking water regulations.

Similarly, any treated process water is also monitored to ensure it does not have a negative impact on either:

1. the treatment process if returned to the head of the works or
2. the water quality of receiving waters if released to downstream water bodies.

At Vartry, it is proposed to release the treated process water to the Vartry River downstream of the plant. Significant dilution will be available when the reservoir is spilling but there will be limited or no dilution during periods of low flows in the river. On this basis a higher standard of treatment will be required for treated process water than would normally be provided at other water treatment plants.

The proposed works will be constructed using a Design and Build contract and the Contractor will be required to comply with the limits specified for the process water prior to its discharge to the River Vartry. This will require further treatment so that these limits are achieved. One of the options is to use the existing slow sand filters to provide additional treatment prior to releasing the process water to the river. We have assessed this option to demonstrate that the necessary standards can be achieved.

We have used water quality data available from similar plants and accepted removal efficiencies of slow sand filters to determine the likely concentrations of key parameters in the final water. We have then compared these concentrations with the existing raw water (background) levels and the limits set out in the Salmonid and EQS regulations.

Washwater from the new water treatment plant will be treated in the washwater settlement tanks prior to discharge to the Slow Sand Filters for further treatment. We have used wash water discharge data from a recently commissioned water treatment plant for the period between January 2015 and July 2016 as summarised below. The data is from a Coagulation and filtration plant whose source water is of moderate quality (Q3-4). Accordingly, the concentrations are considered conservative. The water treatment plant also uses Aluminium Sulphate (Alum) as the coagulant to help remove impurities in the water and so the predicted aluminium concentrations are also included in the assessment.

Table 3-3 Anticipated upper limit of settled washwater quality

Parameter	Turbidity, NTU	Total Aluminium, mg/l	Total Ammonia, mg/l	Total Phosphorus, mg/l	BOD	COD	Suspended Solids
95% conc from washwater settlement tanks	7.18	0.34	0.13	0.05	2.15	39.86	28

3.4.2 Predicted Process Water Quality Post Slow Sand Filtration

Accepted removal efficiencies of slow sand filters are set out in Table 3-4 below.

Table 3-4 Removal Efficiency of Slow Sand Filters[f]

Water Quality Parameter	Removal Capacity
Turbidity	Reduction to <1.0 NTU when influent <15 NTU
Total Suspended Solids(TSS)	95%
Biochemical Oxygen Demand (BOD_5)	65%
Total Ammonia	80%
Nitrate	95%
MRP	32.5%
Coliforms	1-3 log units
Enteric Viruses	2-4 log units
Giardia Cysts	2-4+ log units
Cryptosporidium Oocysts	>4 log units
Total Organic Carbon	<15-25%
Biodegradable Organic Carbon	<50%
Heavy Metals (Zn, Cu, Cd, Pb) **Fe, Mn** **As**	>95-99% >67% <47%
Total Phosphorus*	80%

**mainly in particulate form which has a high removal efficiency in SSFs*

The above removal rates were applied to the expected concentrations of key process parameters upstream of the slow sand filters and the results are summarised in Table 3-5 below.

Table 3-5 Process Water Concentrations and Removal by SSF

Parameter	Discharge Conc. Post SSF (95%ile)	Background Conc. (95%ile)*	EQS /Salmonid (Good)	EQS/Salmonid (High)
Turbidity, NTU	<1.0 NTU	4.4	N/A	N/A
TSS, mg/l	1.4	<5 (8)	<=25	<=25
BOD_5	0.75	<1, (1.4)	<1.5 (mean) or 2.6 (95%)	<1.2 (mean) or 2.2 (95%)
Total Ammonia, mg/l	0.026	0.04, (0.031)	<0.065(mean) or 0.14 (95%)	<=0.040 (mean) or <=0.090 (95%ile)
***Total Phosphorus, mg/l**	0.01	N/A	N/A	N/A
MRP, mg/l	N/A	<0.01, (0.011)	0.035 mean or 0.075 (95%)	<=0.025 (mean) or <=0.045 (95%ile)
Total Aluminium	0.017	0.038	N/A but 0.2 applied	N/A but 0.2 applied

** Values in brackets are for Annagolan Bridge, other values are Vartry Reservoir*
****Total Phosphorus includes dissolved and particulate forms of Phosphorus. MRP is predominately dissolved phosphorus which is bio available for plant uptake. The anticipate MRP levels in the final water will be significantly less than the total phosphorus levels and therefore there are no anticipated difficulties meeting the required standard*

Polyelectrolytes may also be added to the raw water to aid flocculation and improve the dewaterability of process sludge. None of the polyelectrolytes are classified as priority substance for EQS derivation as they are not considered a risk when kept at prescribed

[f] *Collins, M. R. 1998. "Assessing Slow Sand Filtration and Proven Modifications." In Small Systems Water Treatment Technologies: State of the Art Workshop. NEWWA Joint Regional Operations Conference and Exhibition. Marlborough, Massachusetts.*

concentrations when being added to the water[g]. They are controlled at product specification stage and dose as recommended by the WHO and adopted by the Irish EPA[h]. These controls and the additional bacteriological action available through the slow sand filters will ensure polymers are not a risk in the final treated water.

3.5 Summary and Conclusion

There will be times when little or no dilution is available for treated process water prior to its discharge to the River Vartry. Accordingly, additional treatment from that normally provided at water treatment plants will be provided. While the provision of this treatment will from part of the Design and Build contract for the new works, an assessment of using the existing slow sand filters as an additional treatment stage has demonstrated that the necessary standards are readily achievable. Accordingly, the treated process water will not have a negative impact on the receiving water.

Water quality monitors fitted with appropriate alarms will be installed on the outlet from the washwater settlement tanks and in the outlet chamber to the River Vartry. Alarm levels shall be set to alert operatives if the water quality is approaching the specified limit so appropriate pre-emptive action can occur in a timely fashion. Emergency shut off valves shall also be installed which can be closed automatically in the unlikely event of quality levels being exceeded. This will ensure that the treated process water complies with the necessary standards.

[g] *WRc, 1996. A Review of Polyelectrolytes to Identify Priorities for EQS Development, R&D Technical Report 21, Environment Agency, UK.*
[h] *Parameters of Water Quality: Interpretation and Standards (2001)*

4 REFERENCES

- Collins, M. R. 1998. *Assessing Slow Sand Filtration and Proven Modifications*. In Small Systems Water Treatment Technologies: State of the Art Workshop. NEWWA Joint Regional Operations Conference and Exhibition. Marlborough, Massachusetts.
- www.epa.ie/hydronet -water level and flow records
- US EPA, 2011. Drinking Water Treatment Plant Residuals Management Technical Report, EPA 820-R-11-003, USA.
- www.wicklow.ie - surface water monitoring

APPENDIX 1 – HYDRAULIC INFORMATION AND DATA

Appendix 1a – EPA Estimate of Dry Weather Flow at Devils Glen

epa

Environmental Protection Agency

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Station Information

Station Number	10020	**Station Name**	DEVIL S GLEN	**River/Lake**	VARTRY
Station Status	inactive	**Type of Gauge**	Autographic Recorder	**Owner**	Wicklow County Council
Easting	323740	**Northing**	199045	**RBD name**	Eastern RBD
Records Start	27.05.1952	**Records Cease**	30.06.1979	**Data Available**	Water Level Only

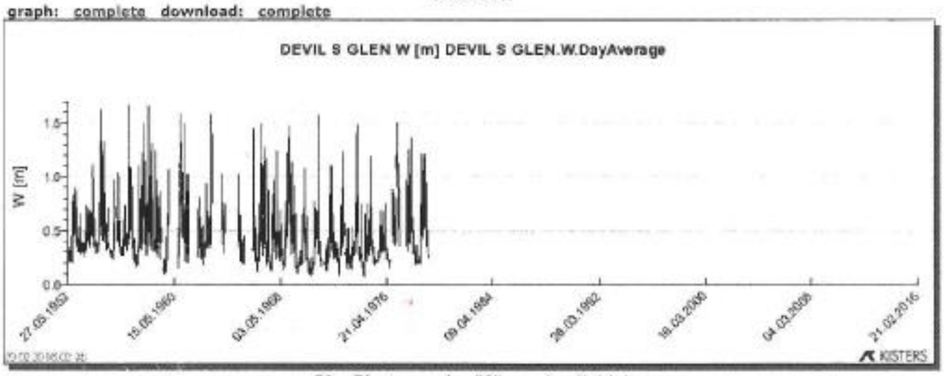
Hydrometric Information

Rating Standard	No Rating	**Catchment Size**	73.7 km^2
Estimated Long Term 95%-Tile	--- m^3/s	**Estimated Long Term Dry Weather Flow**	0.016 m^3/s
Long Average Rainfall (1961-1990)	1152 mm/annum	**Staff Gauge Zero History**	kein Wert vorhanden!

(*) means that the flow is regulated

Water Level

graph: complete **download:** complete



Site Photographs (Where Available)

created at 29.02.2016 01:16

WISKI Web *Public* by KISTERS

DWF = 16 l/sec = 1382 m^3/d.

Vartry washwater current ~ 1700 m^3/d.
proposed ~ 4000 m^3/d.

Appendix 1b – Flow Records At Vartry WTP

Appendix 1c - Flow and Level Records at Annagolan Bridge and Devils Glen

APPENDIX 2 – WATER QUALITY DATA

Appendix 2a – Water Quality At Vartry Reservoir

Background Concentrations at Vartry Reservoir

Parameter	Units	Min	Max	95%
Aluminium (Dissolved)	µg/l	9.00	40.00	38.00
Ammonia	mg/l as N	0.010	0.040	0.040
Antimony	µg/l	<0.15	0.26	0.26
Apparent Colour	°Hazen	20.00	62.00	52.60
Arsenic	µg/l	0.36	0.53	0.53
Barium	µg/l	2.00	4.00	3.80
BOD	mg/l	<1.0	<1.0	<1.0
Boron	µg/l	<32	<32	<32
Bromide	mg/l	38.60	41.20	41.16
Cadmium	µg/l	<0.09	0.1	<0.1
Calcium	mg/l	5.00	6.4	6.3
Chloride	mg/l	8	12	12
Chromium	µg/l	0.13	0.23	0.22
Clostridium perfringens	CFU/100ml	10.00	17.00	16.80
COD	mg/l	10.00	16.00	15.40
Conductivity (20°C)	µS/cm	81.00	109.00	98.4
Copper	µg/l	1.00	3.00	2.85
Cryptosporidium	Oocysts/l	<0.10	<0.10	<0.10
Cyanide	µg/l	<0.7	<0.7	<0.7
Dissolved Oxygen	% Sat.	80.00	109.00	99.00
Dissolved Oxygen	mg/l	8.70	10.60	10.10
DOC	mg/l	3.10	5.96	5.28
E. coli	MPN/100ml	1.00	26.00	21.00
Enterococci	CFU/100ml	1.00	3.00	2.50
Fluoride (ISE)	mg/l as F	0.05	0.11	0.10
Giardia	Cysts/l	<0.10	<0.10	<0.10
Iron (Dissolved)	µg/l	<20	183	177
Lead	µg/l	0.16	0.18	0.18
Magnesium	mg/l	2.00	3.00	3.00
Manganese (Dissolved)	µg/l	0.54	1.00	1.00
Mercury	µg/l	<0.2	0.3	<0.2
Nickel	µg/l	0.77	1.00	1.00
Nitrate	mg/l as N	0.63	1.84	1.39
Nitrite	mg/l as N	<0.005	<0.005	<0.005
pH	pH	6.70	7.9	7.6
Phosphorus (Reactive)	mg/l as P	<0.01	<0.01	<0.01
Potassium	mg/l	0.93	1.1	1.1

Parameter	Units	Min	Max	95%
Selenium	µg/l	<0.25	0.5	0.48
Silica	mg/l as SiO2	2.39	5.17	5.08
Sodium	mg/l	5.9	7.6	7.33
Sulphate	mg/l	4.00	7.00	6.80
Total Suspended Solids	mg/l	<5	9.00	<5
Temp.	°C	4.00	16.50	15.70
TOC	mg/l	3.37	5.98	5.61
TON	mg/l as N	0.63	1.84	1.39
Total Alkalinity	mgCaCO3/l	16.00	38.00	20.60
Total Aluminium	µg/l	6	102.00	75
Total Coliforms	MPN/100ml	9.00	1986.00	1246.00
Total Dissolved Solids (180°C)	mg/l	27.00	118.00	99.60
Total Hardness	mgCaCO3/l	24.00	50.00	45.40
Total Iron	µg/l	<20	183.00	177
Total Kjeldahl Nitrogen	mg/l as N	<1.0	<1.0	<1.0
Total Manganese	µg/l	9.00	108.00	90.40
Total Nitrogen	mg/l as N	1.33	1.69	1.65
Total Phosphorus	mg/l as P	0.01	0.02	0.02
Total Solids (180°C)	mg/l	64.00	99.00	96.30
Total Zinc	µg/l	1.00	7.00	6.70
True Colour	°Hazen	16.00	39.00	37.60
Turbidity	NTU	0.46	8.55	4.43

Appendix 2b – Water Quality at Annagolan Bridge

Appendix 2c - Water Quality at 5no. Sampling Stations Commissioned by Irish Water (see attached report)

Sampling Point 1		Date			
Parameter	Units	11/07/16	18/07/16	20/07/16	26/07/16
Nitrate as N	mg/l	0.72	0.71	0.64	0.66
Chloride	mg/l	12	12	11	12
Sulphate	mg/l	6.7	6.6	6.6	6.5
Aluminium	µg/l	6.7	11	8.8	6.4
Cadmium	µg/l	<0.1	<0.1	<0.1	<0.1
Chromium	µg/l	<1.0	<1.0	<1.0	<1.0
Iron	µg/l	35	<20	<20	<20
Mercury	µg/l	0.03	<0.02	<0.02	0.02
Nickel	µg/l	0.8	0.8	0.8	0.8
Lead	µg/l	<0.3	<0.3	<0.3	<0.3
Selenium	µg/l	0.5	0.4	0.3	0.3
Zinc	µg/l	<1.0	1.6	1.1	1.3
Calcium	mg/l	5.4	6.4	6.2	6.1
Copper	mg/l	<0.003	<0.003	<0.003	<0.003
Potassium	mg/l	0.9	1	1.1	1
Magnesium	mg/l	2.5	2.5	2.3	2.6
Sodium	mg/l	6.5	6.3	5.9	6.4
Suspended Solids	mg/l	<5	5	<5	5
pH	pH units	7.4	7.5	7.7	7.6
Conductivity @20oC	µS/cm	97	109	94	96
Total Alkalinity	mg/l CaCO3	31	17	NA	24

Sampling Point 2		Date			
Parameter	**Units**	11/07/16	18/07/16	20/07/16	26/07/16
Nitrate as N	**mg/l**	0.72	0.78	0.75	0.88
Chloride	**mg/l**	12	13	12	12
Sulphate	**mg/l**	6.7	6.6	6.5	6.6
Aluminium	**µg/l**	17	20	19	7.1
Cadmium	**µg/l**	<0.1	<0.1	<0.1	<0.1
Chromium	**µg/l**	<1.0	<1.0	<1.0	<1.0
Iron	**µg/l**	70.00	110	25	56
Mercury	**µg/l**	0.03	<0.02	<0.02	<0.02
Nickel	**µg/l**	0.70	0.8	0.7	0.6
Lead	**µg/l**	<0.3	<0.3	<0.3	<0.3
Selenium	**µg/l**	0.30	0.6	0.5	0.6
Zinc	**µg/l**	<1.0	1.8	1.5	1
Calcium	**mg/l**	7.30	8	7.6	7.7
Copper	**mg/l**	<0.003	<0.003	<0.003	<0.003
Potassium	**mg/l**	1	1.2	1	1
Magnesium	**mg/l**	2.9	2.6	2.6	2.8
Sodium	**mg/l**	7.6	6.2	6.3	6.1
Suspended Solids	**mg/l**	9	<5	<5	<5
pH	**pH units**	7.2	7.5	7.5	7.4
Conductivity @20oC	**µS/cm**	102	121	102	103
Total Alkalinity	**mg/l CaCO3**	35	17	NA	29

Sampling Point 3		Date			
Parameter	**Units**	11/07/16	18/07/16	20/07/16	26/07/16
Nitrate as N	**mg/l**	0.81	0.87	0.99	0.74
Chloride	**mg/l**	12	12	12	12
Sulphate	**mg/l**	7.1	7	6.8	6.7
Aluminium	**µg/l**	17	22	17	9.3
Cadmium	**µg/l**	<0.1	<0.1	<0.1	<0.1
Chromium	**µg/l**	<1.0	<1.0	<1.0	<1.0
Iron	**µg/l**	97	80	55	46
Mercury	**µg/l**	0.03	<0.02	<0.02	<0.02
Nickel	**µg/l**	0.7	0.7	0.7	0.7
Lead	**µg/l**	<0.3	<0.3	<0.3	<0.3
Selenium	**µg/l**	0.3	0.9	0.5	0.2
Zinc	**µg/l**	1.4	1.4	<1.0	1.1
Calcium	**mg/l**	7.1	7.8	7.8	7.9
Copper	**mg/l**	<0.003	<0.003	<0.003	<0.003
Potassium	**mg/l**	0.9	1.1	1	1
Magnesium	**mg/l**	2.8	2.9	2.7	3
Sodium	**mg/l**	7.1	6.4	6.2	6.6
Suspended Solids	**mg/l**	<5	<5	<5	<5
pH	**pH units**	7.4	7.6	7.7	7.6
Conductivity @20oC	**µS/cm**	103	126	107	106
Total Alkalinity	**mg/l CaCO3**	36	14	NA	30

Sampling Point 4		Date			
Parameter	**Units**	11/07/201	18/07/201	20/07/201	26/07/201
Nitrate as N	**mg/l**	1.1	0.88	1	1.1
Chloride	**mg/l**	13	13	13	13
Sulphate	**mg/l**	7.8	6.9	7	7.4
Aluminium	**µg/l**	10	11	11	9
Cadmium	**µg/l**	<0.1	<0.1	<0.1	<0.1
Chromium	**µg/l**	<1.0	<1.0	<1.0	<1.0
Iron	**µg/l**	95	100	69	65
Mercury	**µg/l**	0.03	<0.02	<0.02	<0.02
Nickel	**µg/l**	0.6	0.6	0.6	0.6
Lead	**µg/l**	<0.3	<0.3	<0.3	<0.3
Selenium	**µg/l**	0.5	0.3	0.9	0.4
Zinc	**µg/l**	<1.0	1.2	<1.0	1.1
Calcium	**mg/l**	9	9.5	9.9	9.3
Copper	**mg/l**	<0.003	<0.003	<0.003	<0.003
Potassium	**mg/l**	1.1	1.1	1.1	1.1
Magnesium	**mg/l**	3.4	3.2	3.2	3.3
Sodium	**mg/l**	7.8	6.9	7	6.7
Suspended Solids	**mg/l**	<5	5	<5	<5
pH	**pH units**	7.4	7.7	7.7	7.7
Conductivity	**µS/cm**	118	132	119	117
Total Alkalinity	**mg/l**	40	21	NA	35

Sampling Point 5		Date			
Parameter	**Units**	11/07/201	18/07/201	20/07/201	26/07/201
Nitrate as N	**mg/l**	1.5	1.5	1.7	1.2
Chloride	**mg/l**	14	14	14	14
Sulphate	**mg/l**	8.6	8	8.1	8.2
Aluminium	**µg/l**	8.1	10	9.3	7.1
Cadmium	**µg/l**	<0.1	<0.1	<0.1	<0.1
Chromium	**µg/l**	<1.0	<1.0	<1.0	<1.0
Iron	**µg/l**	54	47	38	<20
Mercury	**µg/l**	0.02	<0.02	<0.02	<0.02
Nickel	**µg/l**	0.5	0.6	0.6	0.5
Lead	**µg/l**	<0.3	<0.3	<0.3	<0.3
Selenium	**µg/l**	0.6	0.8	0.5	<0.2
Zinc	**µg/l**	<1.0	1.3	<1.0	1.2
Calcium	**mg/l**	17.4	16.1	16.7	16.2
Copper	**mg/l**	<0.003	<0.003	<0.003	<0.003
Potassium	**mg/l**	1.1	1.1	1.2	1.2
Magnesium	**mg/l**	4	3.4	3.6	3.8
Sodium	**mg/l**	9.2	7.7	8	7.8
Suspended Solids	**mg/l**	<5	<5	11	<5
pH	**pH units**	6.9	7.9	7.8	7.7
Conductivity	**µS/cm**	225	165	157	158
Total Alkalinity	**mg/l**	70	27	NA	53