Chapter 4 The Storm Water Overflows at Midleton

The stormwater overflows from the Midleton sewerage scheme are discussed in this chapter. The methodology we have used in estimating the *Norovirus* loading from the overflow tanks at Bailick 1 and Bailick 2 is described in the first three sections. The operation of the stormwater tanks is then described. The complete record of overflows is then presented.

In estimating the *Norovirus* loading from the stormwater overflows we have assumed that:

- The *Norovirus* does not settle out in the tanks because it is of colloidal dimension
- The *Norovirus* is not absorbed onto sediment **(key assumption due to lack of experimental data in the scientific literature)**
- The *Norovirus* is neutrally buoyant

We have also assumed that 95% of the *Norovirus* are removed in Midleton WWTP. This assumption is discussed at the end of the chapter as well as in Appendix D.

4.1 Introduction

The sewerage system serving Midleton consists of a network of combined sewers, separated sewers, four pumping stations: Bailick 1 (B1), Bailick 2 (B2), Bailick 3 (B3) and Ballinacurra, a secondary wastewater treatment plant (WTP), and a multi-port diffuser outfall at Rathcoursey Point at the eastern entrance to the North Channel. Their location is shown in Fig. 4.1 against a background enlargement of the top corner of the schematic on the following page (Fig. 4.2). The town of Midleton lies in the top right triangular half of the image. Rathcoursey lies to the west of the image. The Owenacurra River flows from north to south down the centre of the image and turns to the west entering the North Channel to the east of the oyster farm.

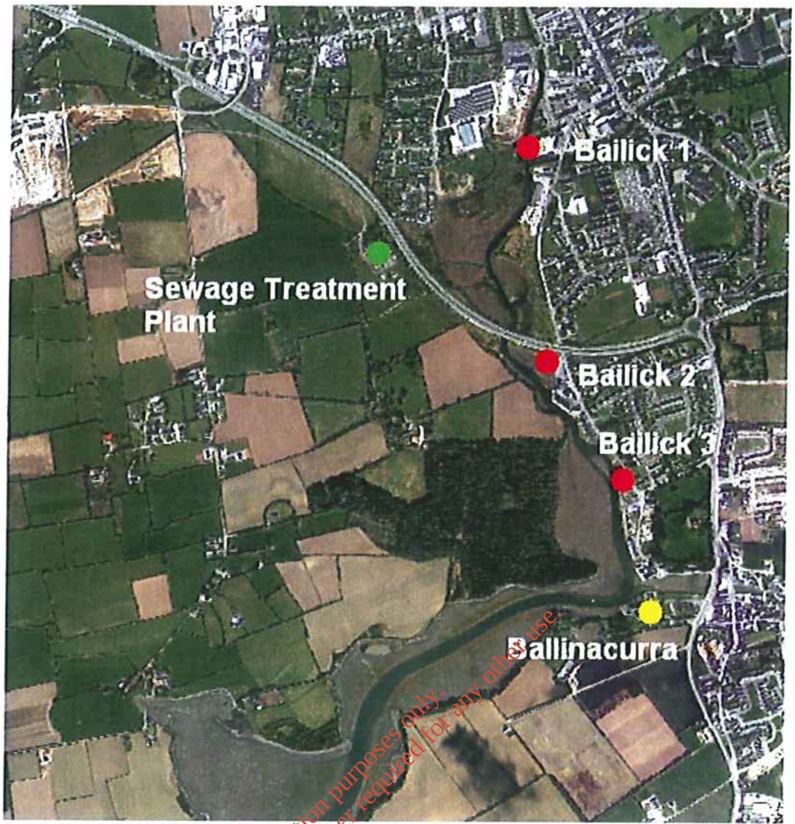


Fig. 4.1 Location of overflow tanks in Midleton

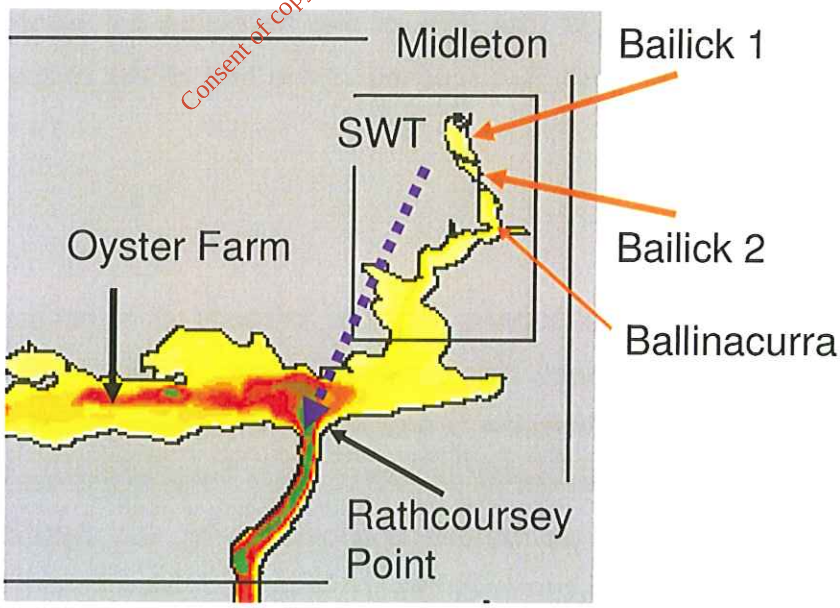


Fig. 4.2 Schematic of the Midleton Sewerage Scheme

As shown in Fig. 4.3 we have schematised the sewers as black arrows feeding into and out of the pumping stations and into the sewage treatment plant. The orange arrows show the storm overflows discharging to the Owenacurra River. The hatched blue arrow indicates the discharge of treated effluent several kilometres to the south east of Midleton at Rathcoursey Point.

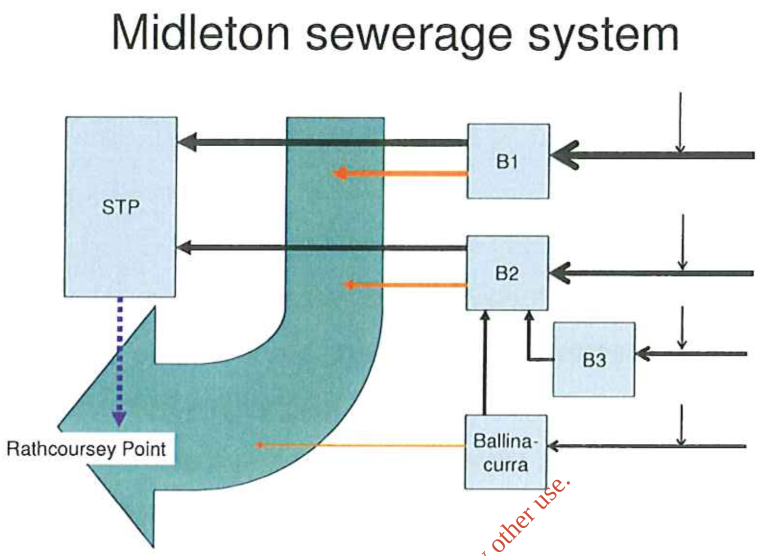


Fig. 4.3 Schematic of Midleton Sewerage Scheme

The treated effluent is pumped westwards to a holding tank close to Rathcoursey Point where it is released in pulses during the first three hours of successive ebb tides, 30 minutes after high water, in the entrance to East Passage. This pulsed release initially takes the effluent out of the North Channel. The discharge is made through a multi-port diffuser located in the deepest point of the entrance to enhance the dilution. The fate of *Norovirus* in this pulsed discharge and its impact on the oyster farm is examined in a later section of this report.

Because our model obeys the principle of superposition we may separate the discharge at Rathcoursey from the storm water discharges to the river that occur when the capacity of the treatment plant is exceeded. These time-varying discharges must be consistent with the assumed constant source of viruses in Midleton as a whole.

During the period we call "summer conditions – T90 of 7 days" there are no storm overflows and the treated viral load is discharged in 3 hour pulses at Rathcoursey.

During the period we call "Winter conditions – T90 of 30 days" there is a substantial discharge of viruses in the storm overflows, especially at Bailick 1, and a corresponding reduction in the flow of viruses to the treatment plant and subsequently to the Rathcoursey outfall.

Consequently, the viral discharges from Rathcoursey, Bailick 1 and 2 are different during our so-called "summer conditions" and "winter conditions".

4.2 The water balances

We were supplied with daily measurements of the volumes of water pumped to the Midleton Wastewater Treatment plant and to the Owenacurra River. An examination of the data showed that discharges from Ballinacurra to the river are rare. Consequently we have simplified the system further by combining the three pumping systems at Bailick 2, Bailick 3 and Ballinacurra into a single pump house which we call Bailick 2 as shown in the diagram below (Fig. 4.4).

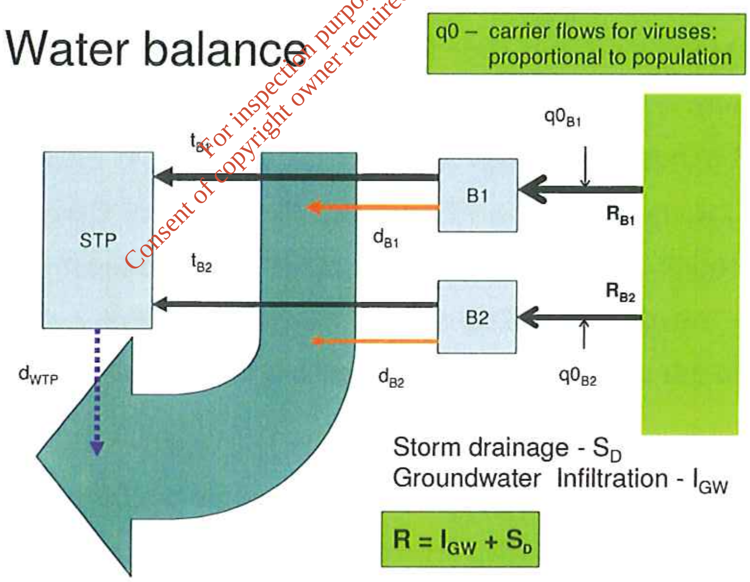


Fig. 4.4 Water Balance

The daily volumes of water that flow in this network are represented as follows:

- d is the discharge to the river with subscripts denoting the three cases: B1 and B2 in the case of the Bailick 1 and 2 pump houses, and WTP (or STP) for the wastewater treatment plant;

- t is the daily volume sent to the sewage treatment plant with the appropriate subscript indicating from which pump house it comes. Subscripts distinguish between the urban catchments serving Bailick 1 and 2.
- R is the sum of the storm drainage S and groundwater infiltration I that each day dilutes the carrier or dry-weather flow q0.

The *Norovirus* are carried into the pump houses by the combined flow q0 plus R. In order to estimate q0 we use a daily water balance to examine the sum of q0 and R, calculated from the daily measurements of d and t. It is not necessary for our model to separate S and I. Only their sum R=S+I is important in determining the possible discharges of *Norovirus.*

The details of the water balances are as follows:

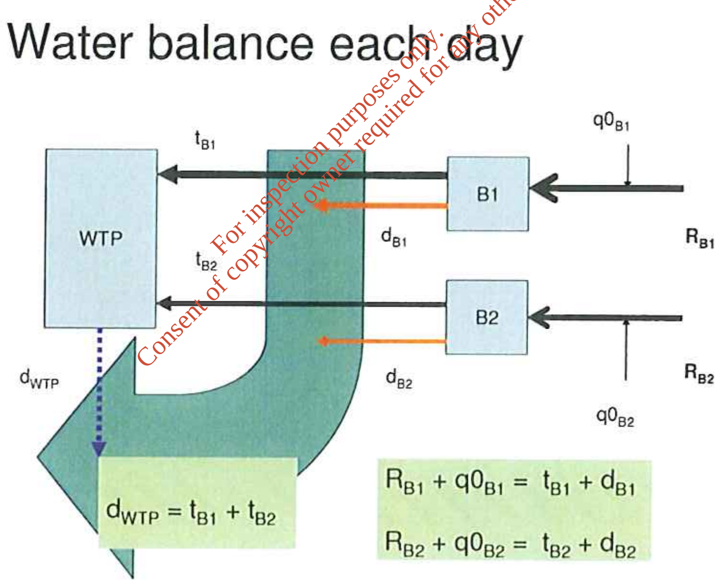


Fig. 4.5 Water Balance equations

The three equations shown in Fig. 4.5 state that water volume is conserved from day to day. We assume that the flows into and out of the pump houses and into and out of the treatment plant must balance at the end of each day.

The two equations on the right state that the volume of water from storm runoff and groundwater infiltration, R, plus the carrier flow from domestic water use, q0, that enter each pumphouse each day must equal the sum of the daily volumes pumped to the treatment plant, t, and to the river d.

The equation to the left says the volume of water discharged from the sewage treatment plant each day is equal to the sum of the two volumes pumped to it each day.

In other words we assume (1) there are no sources or sinks of water within the treatment plant and pumphouses, and (2) no carryover storage from one day to the next. The later assumption is justified by the small residence time of approximately five hours for the tanks at Bailick 1 (see section 4.4)

A time-series plot of d_{B1} (red), d_{B2} (purple) and $d_{WTP} = t_{B1} + t_{B2}$ (dark blue) is shown below.

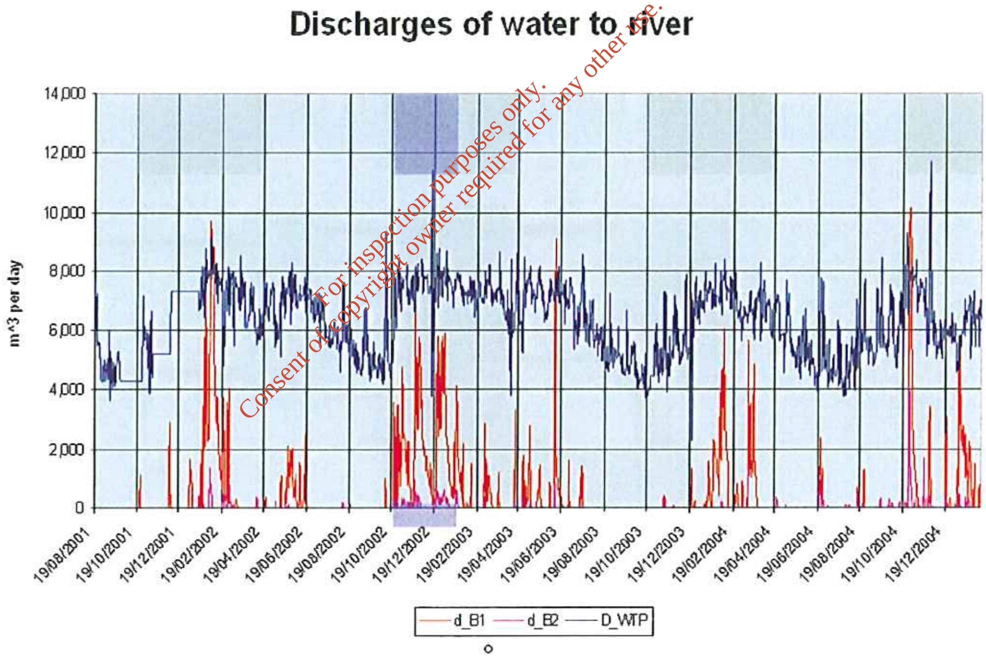


Fig. 4.6 Discharges of water to river

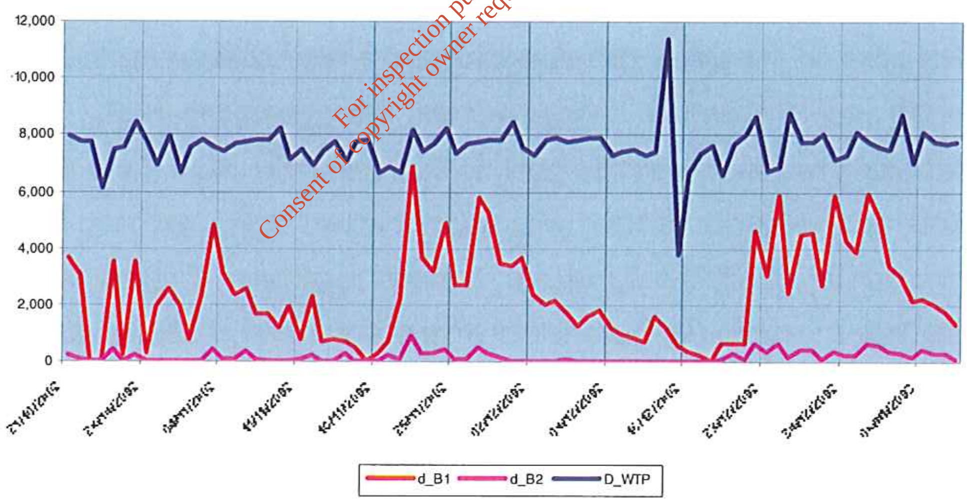
The intermittent discharges to the river from Bailick 1 are roughly six times those from Bailick 2 and occasionally surpass the discharge volume to/from the treatment plant.

The grey hatching shows that storm overflows occur most often in the wintertime. In two of the three summer periods in the figure the daily volumes pumped for treatment show a steady decline. This may be due to falling groundwater levels with a consequent reduction in infiltration to the sewers.

It is also clear that intermittent storm overflows have occurred in the summer months. Conversely, there were brief periods in the winter months when there were no storm overflows. However, the data supports the useful distinction already introduced between "summer conditions – T90 of 7 days – no overflows" and "winter conditions – T90 of 30 days – overflows"

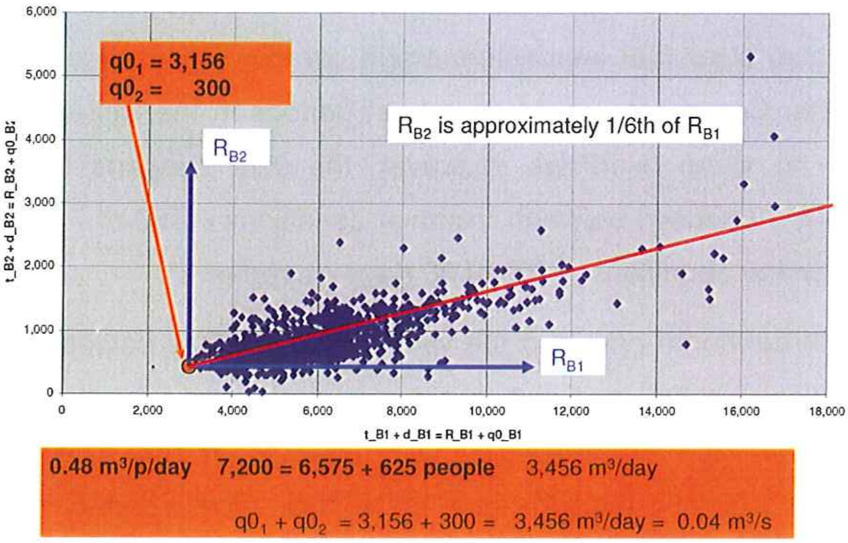
The three-month period in the winter of 2002/03 is hatched in blue above and highlighted in the next plot. It contains prolonged infiltration events and storm overflows. We have chosen the final period of 20 days as a typical period when there is a significant discharge to the river. The complete overflow dataset is analysed in section 4.5.

Discharges to the river from 21 Oct 2002 to 9 Jan 2003



From the time-series of d_{B1}, d_{B2}, t_{B1} and t_{B2} we can calculate $d_{B1}+ t_{B1}$ and $d_{B2}+ t_{B2}$ and plot them against each other in the following figure. We observe that the flow $R_{B1}+q0_{B1}=d_{B1}+t_{B1}$ for Bailick 1 is almost always greater than 3,000 m^3/day.

$t_{B2} + d_{B2}$ versus $t_{B1} + d_{B1}$



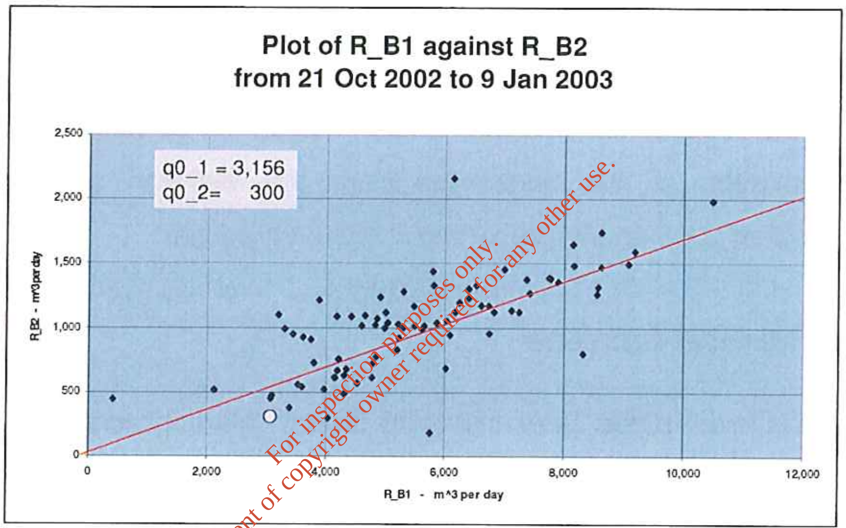
Consequently we take 3,156 m^3/s as the carrier flow, $q0_{B1}$, when infiltration and storm runoff are zero *i.e.* when $R_{B1}=0$. The estimation of the carrier flow for Bailick 2, $q0_{B2}$, is more problematic since the minimum value of $R_{B2}+q0_{B2}=d_{B2}+t_{B2}$ for Bailick 2 is close to zero. We take the carrier flow $q0_{B2}$ to be 300 m^3/s.

The point on the graph corresponding to the two constant carrier flows estimated in this way is shown as a large red dot. We can represent R_{B1} and R_{B2} on this plot using two axes with this point as their common origin. Only one value of R_{B1} plots as a negative number, whereas 16 values of R_{B2} are less than zero in the time series of 1,268 daily values. A rough regression through this origin shows that the ratio of R_{B1} to R_{B2} is 6 to 1 whereas the ratio of $q0_{B1}$ to $q0_{B2}$ is roughly 10 to 1. Adjusting the common origin to bring these ratios closer together increases the number of negative values of R_{B2} which is physically unrealistic. We have not done so, since Bailick 1 is the more important discharge of the two.

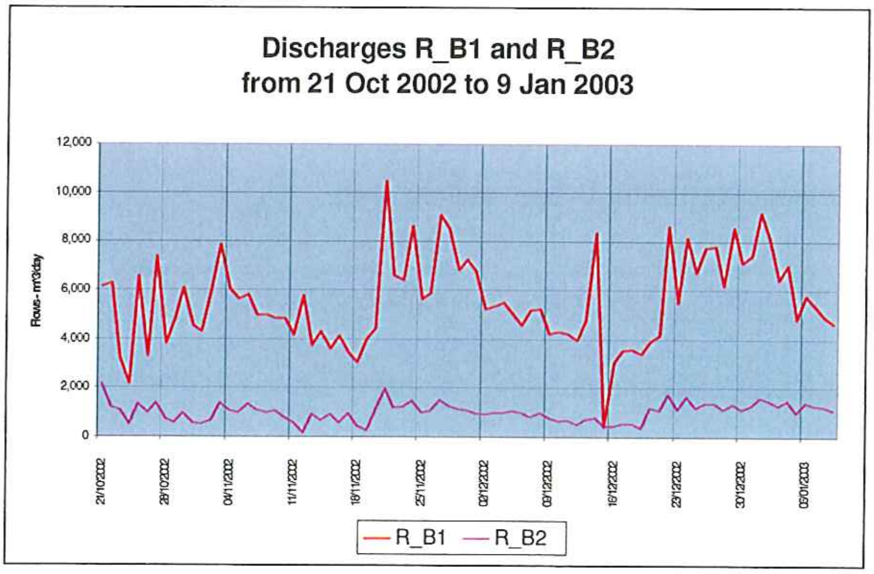
The sum of the carrier flows is 3,456 m^3/day (0.04 m^3/s). Dividing this by the carrier flow of 0.48 m^3/person/day gives a contributing population of 7,200. Dividing the population in proportion to the carrier flows yields 6,575 and 625 as the populations contributing to Bailick 1 and 2, a ratio roughly 10 to 1.

Since the data are daily data we cannot consider variations in flow with a frequency of less than a day. There are many such components in the flows in urban sewerage systems: flash rainstorms lasting a few hours, the hour-day-night variation in domestic water use, the overnight storage in sewers and tanks, and the M2 tide in disused culverts that may still have some hydraulic connection with the sewerage system. In spite of these we believe the values are reasonable and capture the very high, but relatively slow, infiltration of groundwater, and the very fast storm run-off into the combined sewers of Midleton.

The corresponding plots for the special period of interest follow below. In this period there are no negative values of R_{B1} and R_{B2}



The corresponding time-series are illustrated in the following figure:



We have selected the final 20 days in this period, from Dec 20, 2002 to Jan 9, 2003, as a typical period when there is a significant discharge to the river.

In agreement with Pommepuy et al. (2006)[57] we have chosen to examine pulses of *Norovirus* that last for 20 days from all significant sources around the Harbour.

In most cases the pulses carry the same constant concentration of viruses. In the case of

(a) the pulsed discharge at Rathcoursey, and

(b) infiltration and storm overflows at Midleton,

the discharge is not constant. However, as explained in section 1 of this report, equitable statements on the relative impact on the oyster farm of discharges of *Norovirus* require all sources to be treated in exactly the same way. The representation of the discharges from the Midleton overflows is the most complicated case and is presented in the next section.

4.3 The viral balance

The *Norovirus* loose their infectivity slowly. More precisely we may say their numbers decline roughly by a factor 10 in 7 days during summer and 30 days during winter.

Consequently we may assume that numbers of *Norovirus* are conserved on a time scale of one day as they pass through all parts of the sewerage system. In other words they satisfy a number balance in the short term. The later assumption is justified by the small residence time of approximately five hours for the tanks at Bailick 1 (see section 4.4).

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[57] Pommepuy, M. et al. "Fecal contamination in coastal waters: An engineering approach" Book chapter (p331-359) in Oceans and Health: Pathogens in the Marine Environment. Springer 2006. http://www.springerlink.com, http://www.ifremer.fr/docelec

The following diagram (Fig. 4.7) introduces the necessary notation to make the daily number balance. All the assumptions made in relation to the water balance also apply.

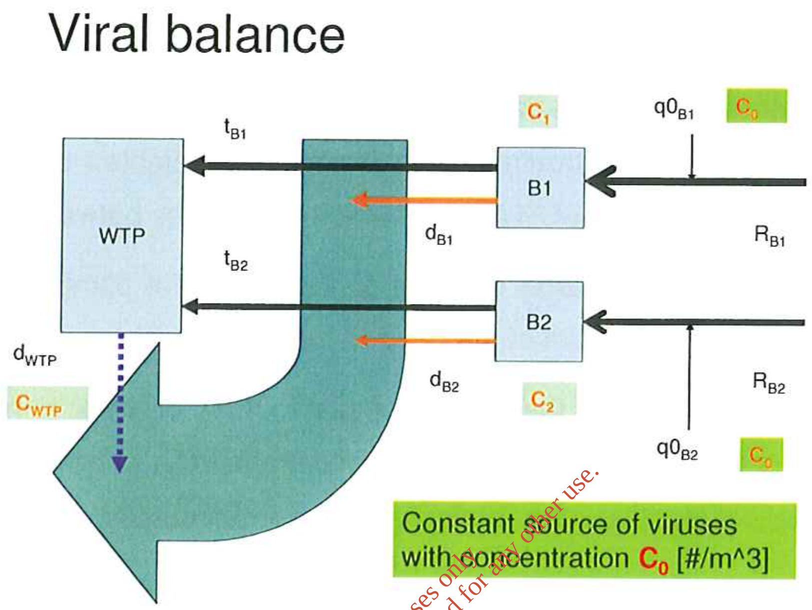


Fig. 4.7 The Viral Balance

The constant source of viruses has a concentration C_0 [#/m^3] which we take to be 50 million particles per cubic metre in the carrier flow of 480 litres per person per day. The total flux of viruses for Midleton is 50,000,000 [#/m^3] times the carrier flow of 3,456 [m^3/day] (i.e. 7,200 times 0.48 m^3/day) equal to 1.728×10^{11} particles per day. The division between Bailick 1 and 2 is shown in the table:

	Bailick 1	Bailick 2	Midleton
m^3/person/day	**0.48**	**0.48**	**0.48**
population	6,575	625	7,200
q0 [m^3/day]	3,156	300	3,456
q0 [m^3/s]	0.03653	0.00347	0.04
C0 [#/m^3]	**5.0000E+07**	**5.0000E+07**	**5.0000E+07**
q0.C0 [#/day]	1.5780E+11	1.5000E+10	1.7280E+11
q0.C0 [#/s]	1.8264E+06	1.7361E+05	2.0000E+06

The fluxes[58] ($q_0.C_0$) for Bailick 1 and 2 are diluted each day by their respective infiltration/storm water flows R giving the tanks in the pumping stations a daily average concentration C_1 [#/m^3] in the case of Bailick 1, and C_2 [#/m^3] in the case of Bailick 2. C_1 and C_2 are always less than C_0.

These concentrations are in turn carried to the treatment plant by the daily volumetric flows t_{B1} and t_{B2} where they are mixed together to give the concentration in the treatment plant as a flow-weighted average concentration C_{IN} equal to $(t_{B1}C_1 + t_{B2}C_2)/(t_{B1}+t_{B2})$ which always lies between C_1 and C_2.

The volumetric discharge of water to the treatment plant and also to the river d_{WTP} is equal to the sum of the flows in the denominator, t_{B1} and t_{B2}.

The effectiveness of the treatment plant (85% or 95% removal rates in this study) reduces the flow-weighted concentration C_{IN} to give the concentration in the final effluent C_{WTP} that is discharged at Rathcoursey.

The operations of dilution and mixing always satisfy a daily balance on the numbers of *Norovirus.*

These ideas may be summarised as follows. In each case the statement of the number balance is boxed in green. The results of the algebra are a concentration and a flow of water. They are boxed for emphasis in the last line of each frame.

Constant viral source for B1:

carrier flow $q0_{B1}$ [m^3/day]

with concentration C_0 [#/m^3]

Viral flow into = Viral flow out of Bailick 1

$$R_{B1}.0 + q0_{B1}.\,C_0 = (t_{B1} + d_{B1}).C_{B1}$$

$$\boxed{C_{B1} = C_0 \,.\, q0_{B1}/(t_{B1} + d_{B1})} \quad \boxed{d_{B1}}$$

dilution $C_{B1} < C_0$

[58] We will see presently that this product giving the number flux of viruses is the fundamental parameter, not the carrier flows on their own.

Constant viral source for B2:

carrier flow $q0_{B2}$ [m^3/day]

with concentration C_0 [#/m^3]

Viral flow into = Viral flow out of Bailick 2

$$R_{B2}.0 + q0_{B2}.C_0 = (t_{B2} + d_{B2}).C_{B2}$$

$$C_{B2} = C_0 . q0_{B2}/(t_{B2} + d_{B2})$$

d_{B2}

dilution $C_{B2} < C_0$

Viral balance on the WTP

Mixing the viral flows to the WTP

$$(t_{B1} + t_{B2}).C_{IN} = (t_{B1}.C_{B1} + t_{B2}.C_{B2})$$

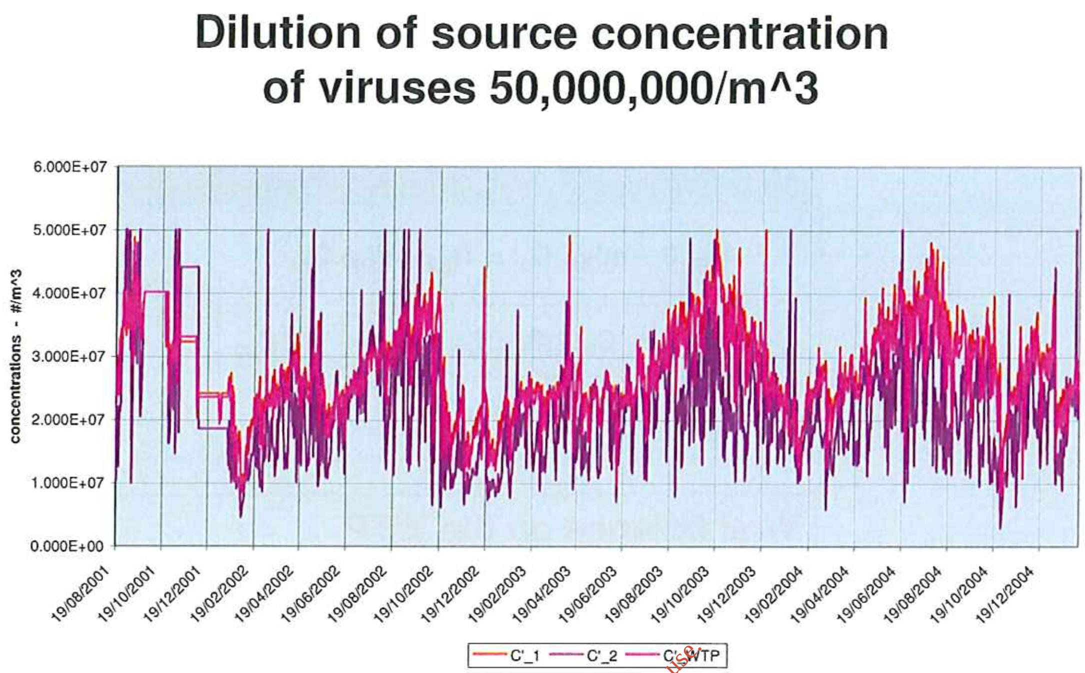
$$C_{IN} = (t_{B1}.C_{B1} + t_{B2}.C_{B2})/(t_{B1} + t_{B2})$$

Treatment efficiency β = 0.85, 0.95

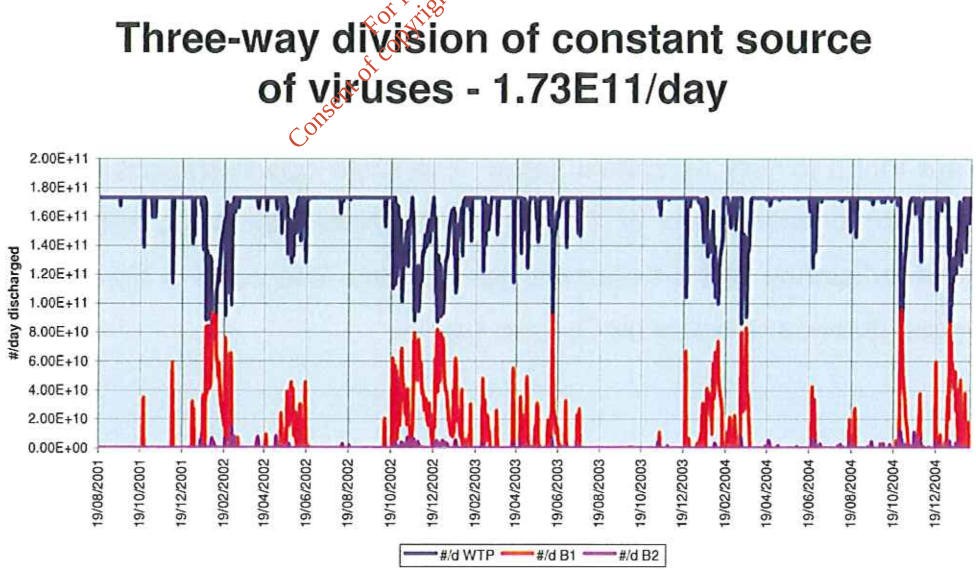
$$C_{WTP} = (1-\beta).C_{IN}$$

$$d_{wtp} = t_{B1} + t_{B2}$$

When the time series are treated in this way the concentrations C_{WTP}, C_{B1} and C_{B2} are found to vary as shown below. The three concentrations are dilutions of the source concentration of 50,000,000 particles per cubic metre. When the removal efficiency of the treatment plant is zero (the case in the figure) C_{WTP} is bounded above and below by C_{B1} and C_{B2}



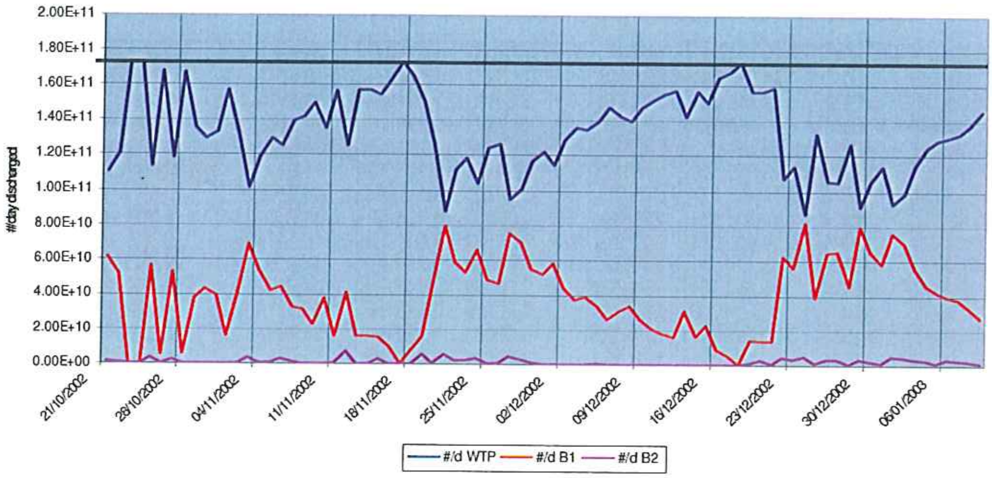
The dilution of the source may also be displayed as a three-way division of the flow of viral particles per day at source. The top line in dark blue is the flux of viruses to the treatment plant.



Expanding the section of special interest shows

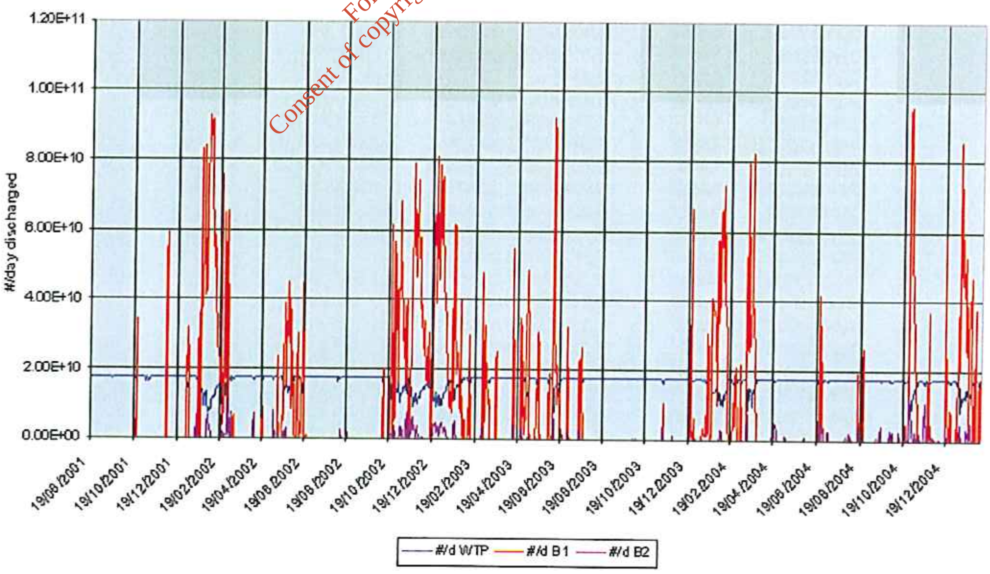
:

Three-way division of constant source 1.73E11/d between 21 Oct 2002 to 9 Jan 2003



As the removal efficiency increases the blue line drops by the appropriate fraction. At 90% removal the horizontal blue line lies at 1.73×10^{10} *i.e.* below the lowest division on the vertical scale, and it is exceeded by the flux into the river from Bailick 1 by a factor of four to five during the largest storm overflows.

Discharges to the river at 90% removal by WTP



We have selected the 20 days, from Dec 20, 2002 to Jan 9, 2003, as a typical period when there is a significant discharge to the river. The corresponding concentrations and discharge rates are the input files for the *Norovirus* transport model of the Harbour. The flows are tabulated in the following series of plots.

	Ballick 1			Ballick 2			Waste water treatment plant		
	m^3/s	#/m^3	#/s	m^3/s	#/m^3	#/s	m^3/s	#/m^3	#/s
	D B1	C B1		D B2	C B2		D WTP	C IN	
CF	0	50,000,000	0	0	50,000,000	0	0.04	50,000,000	2,000,000
20/12/2002	0.0071	22,424,966	159,311	0.00300	9,925,887	29,778	0.089	20,386,028	1,810,912
21/12/2002	0.0073	21,532,080	157,902	0.00050	10,844,419	5,422	0.093	19,749,695	1,836,676
22/12/2002	0.0532	13,415,401	713,252	0.00683	7,347,899	50,211	0.100	12,394,062	1,236,537
23/12/2002	0.0351	18,269,387	640,570	0.00383	10,237,510	39,244	0.078	16,918,430	1,320,186
24/12/2002	0.0671	13,967,816	937,881	0.00708	7,704,160	54,571	0.079	12,743,693	1,007,548
25/12/2002	0.0280	15,956,156	446,108	0.00175	10,195,759	17,843	0.102	15,091,507	1,536,050
26/12/2002	0.0513	14,478,127	743,211	0.00450	8,861,059	39,875	0.090	13,535,200	1,216,915
27/12/2002	0.0520	14,433,895	750,863	0.00442	8,909,480	39,350	0.090	13,504,594	1,209,787
28/12/2002	0.0309	16,902,314	522,915	0.00100	10,501,260	10,501	0.093	15,829,208	1,466,583
29/12/2002	0.0676	13,474,511	910,933	0.00408	9,260,403	37,813	0.083	12,726,399	1,051,254
30/12/2002	0.0490	15,354,377	753,004	0.00258	10,480,715	27,075	0.084	14,542,100	1,219,921
31/12/2002	0.0447	14,910,706	666,322	0.00200	9,555,357	19,111	0.094	13,989,235	1,314,567
01/01/2003	0.0683	12,803,869	874,398	0.00683	7,926,443	54,164	0.089	11,981,916	1,071,438
02/01/2003	0.0580	13,945,596	808,554	0.00608	8,395,836	51,075	0.088	13,020,758	1,140,371
03/01/2003	0.0387	16,493,854	638,793	0.00400	9,353,954	37,416	0.087	15,292,892	1,323,791
04/01/2003	0.0339	15,535,472	526,911	0.00350	8,554,808	29,942	0.100	14,368,274	1,443,147
05/01/2003	0.0248	19,758,590	489,025	0.00167	11,389,522	18,983	0.081	18,360,368	1,491,992
06/01/2003	0.0257	17,655,747	453,164	0.00442	8,612,770	38,040	0.094	16,133,661	1,508,796
07/01/2003	0.0234	18,659,982	436,177	0.00333	9,493,671	31,646	0.089	17,127,717	1,532,177
08/01/2003	0.0195	19,546,637	380,752	0.00292	9,733,939	28,391	0.089	17,899,474	1,590,857
09/01/2003	0.0154	20,236,996	310,722	0.00117	10,769,673	12,565	0.090	18,661,345	1,676,713
average	0.0381	16,655,070	586,703	0.00360	9,431,168	32,048	0.090	15,440,788	1,381,248
max	0.0683	22,424,966	937,881	0.00708	11,389,522	54,571	0.102	20,386,028	1,836,676
min	0.0071	12,803,869	157,902	0.00050	7,347,899	5,422	0.078	11,981,916	1,007,548

	Inputs to WWTP			Rathcoursey discharge from waste water treatment plant at 85% removal		95% removal	
	m^3/s	#/m^3	#/s	#/m^3	#/s	#/m^3	#/s
	D_WTP	C_III		C_WTP		C_WTP	
CF	0.04	50,000,000	2,000,000	7,500,000	300,000	2,500,000	100,000
20/12/2002	0.089	20,386,028	1,810,912	3,057,904	271,637	1,019,301	90,546
21/12/2002	0.093	19,749,695	1,836,676	2,962,454	275,501	987,485	91,834
22/12/2002	0.100	12,394,062	1,236,537	1,859,109	185,481	619,703	61,827
23/12/2002	0.078	16,918,430	1,320,186	2,537,765	198,028	845,922	66,009
24/12/2002	0.079	12,743,693	1,007,548	1,911,554	151,132	637,185	50,377
25/12/2002	0.102	15,091,507	1,536,050	2,263,726	230,407	754,575	76,802
26/12/2002	0.090	13,535,200	1,216,915	2,030,280	182,537	676,760	60,846
27/12/2002	0.090	13,504,594	1,209,787	2,025,689	181,468	675,230	60,489
28/12/2002	0.093	15,829,208	1,466,583	2,374,381	219,988	791,460	73,329
29/12/2002	0.083	12,726,399	1,051,254	1,908,960	157,688	636,320	52,563
30/12/2002	0.084	14,542,100	1,219,921	2,181,315	182,988	727,105	60,996
31/12/2002	0.094	13,989,235	1,314,567	2,098,385	197,185	699,462	65,728
01/01/2003	0.089	11,981,916	1,071,438	1,797,287	160,716	599,096	53,572
02/01/2003	0.088	13,020,758	1,140,371	1,953,114	171,056	651,038	57,019
03/01/2003	0.087	15,292,892	1,323,791	2,293,934	198,569	764,645	66,190
04/01/2003	0.100	14,368,274	1,443,147	2,155,241	216,472	718,414	72,157
05/01/2003	0.081	18,360,368	1,491,992	2,754,055	223,799	918,018	74,600
06/01/2003	0.094	16,133,661	1,508,796	2,420,049	226,319	806,683	75,440
07/01/2003	0.089	17,127,717	1,532,177	2,569,158	229,827	856,386	76,609
08/01/2003	0.089	17,899,474	1,590,857	2,684,921	238,629	894,974	79,543
09/01/2003	0.090	18,661,345	1,676,713	2,799,202	251,507	933,067	83,836
average	0.090	15,440,788	1,381,248	2,316,118	207,187	772,039	69,062
max	0.102	20,386,028	1,836,676	3,057,904	275,501	1,019,301	91,834
min	0.078	11,981,916	1,007,548	1,797,287	151,132	599,096	50,377
Ratio of av. 20-day Ballick flow [618,752#/s] to average Rathcoursey flow [#/s]			0% 0.45		85% 2.99		95% 8.96

The three flows of viruses in the top table sum to 2,000,000 per sec [#/s] on each of the 20 days. The table above shows that as the removal efficiency of the treatment plant increases the relative importance of the Bailick overflows also increases, becoming 3 and 9 times as important as the treated flow, at 85% and 95% removal efficiencies respectively.

The *Norovirus* input files for Bailick 1 are plotted in the following set of graphs. The equivalent plots for Rathcoursey before the treatment plant was constructed (i.e. Rathcoursey Period 1, Winter Conditions) are presented as well. We can see from the plots how the concentrations and flow rates from Bailick 1 vary in time while those from Rathcoursey, before treatment was applied, stay constant.

From Fig. 4.11 we can see that the loading from Bailick 1 is never greater than half of the loading of the untreated waste from Rathcoursey.

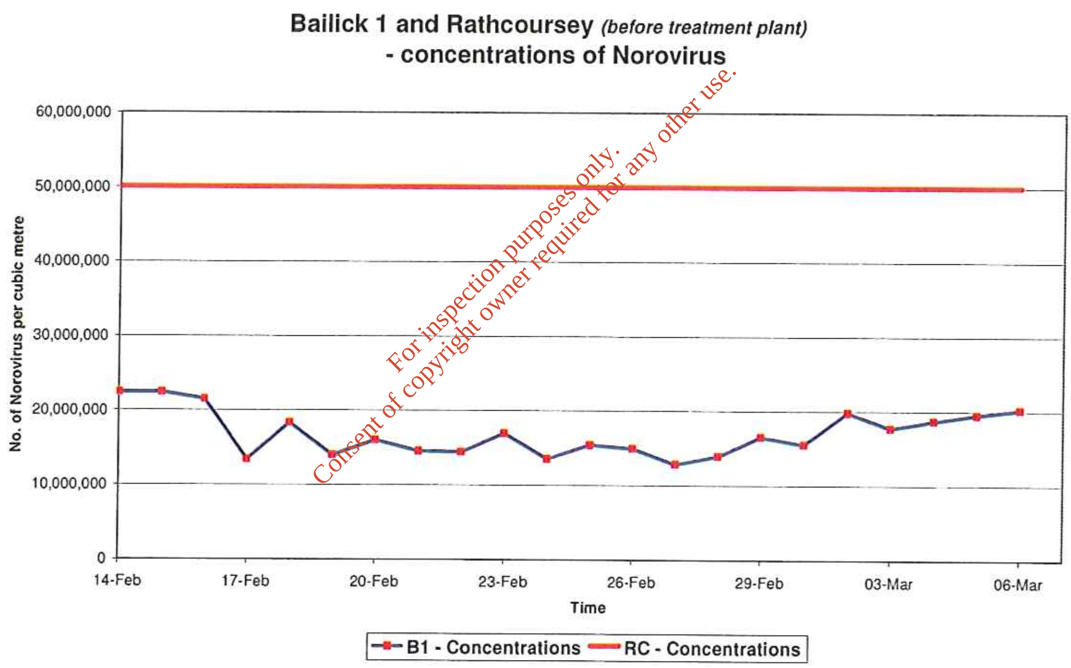


Fig. 4.8 Concentrations of Norovirus from Bailick 1 and Rathcoursey untreated

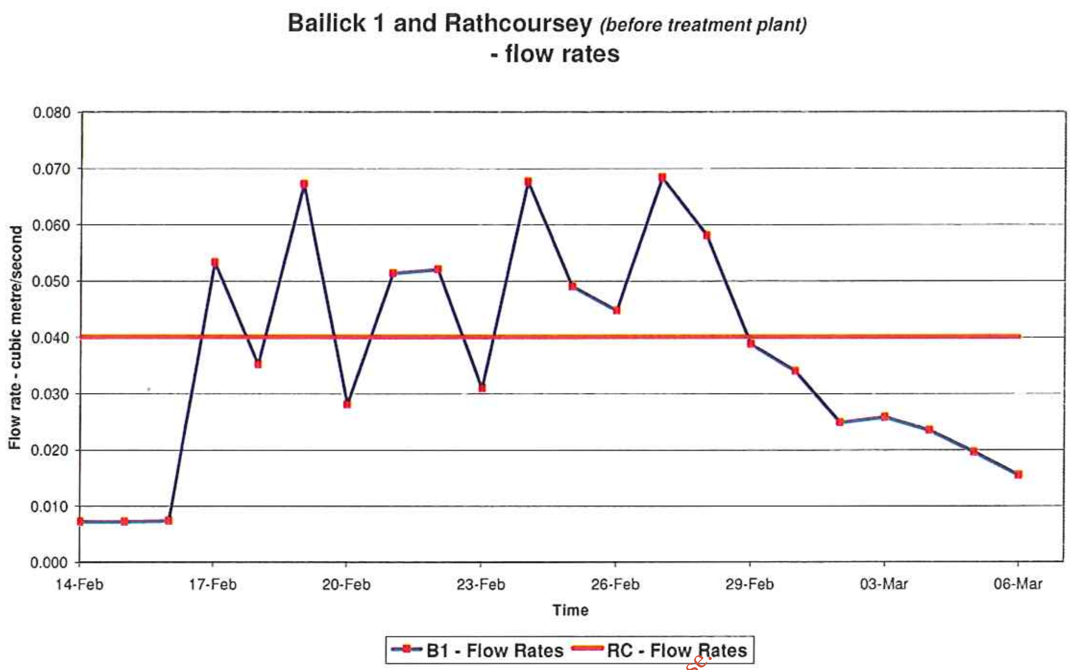


Fig. 4.9 Flow rates from Bailick 1 and Rathcoursey untreated

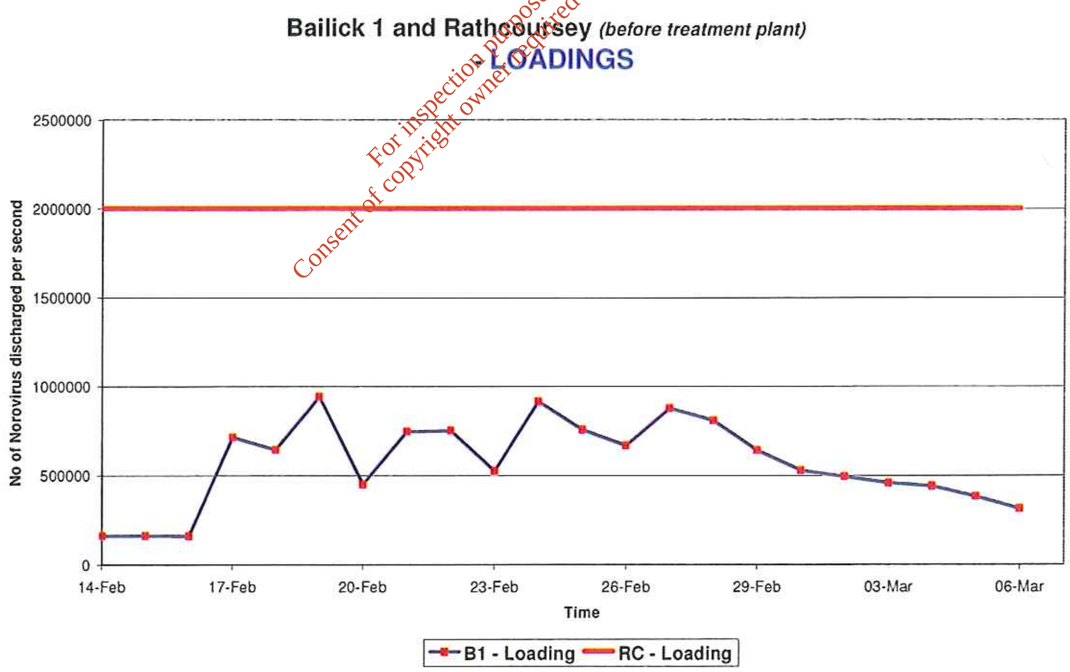


Fig. 4.10 Number of Norovirus released per second – Bailick 1 and Rathcoursey untreated

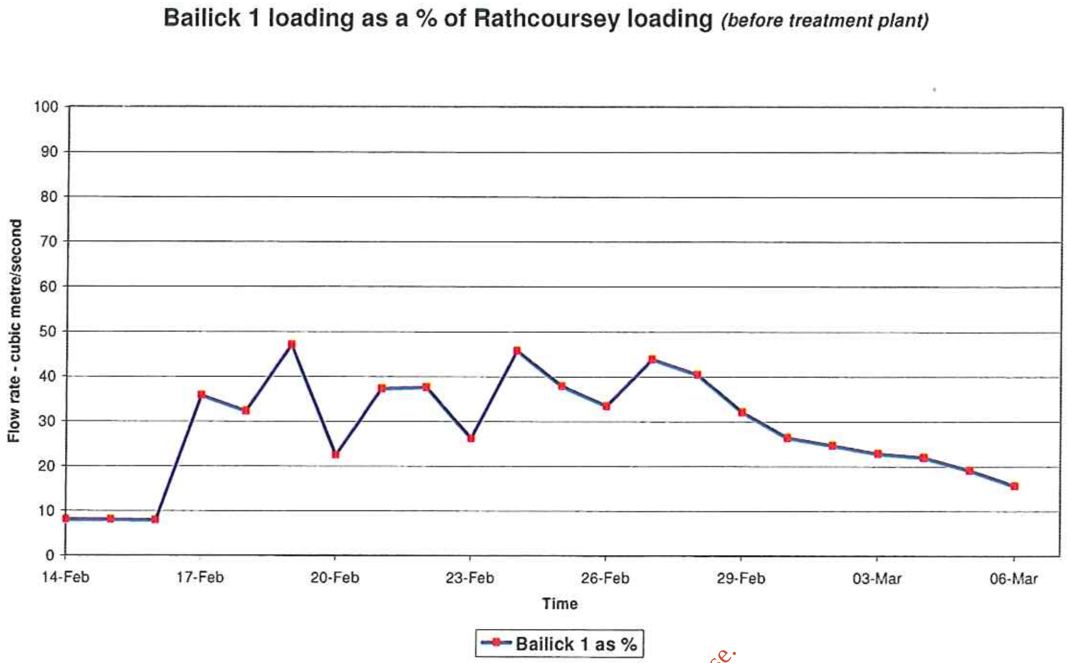
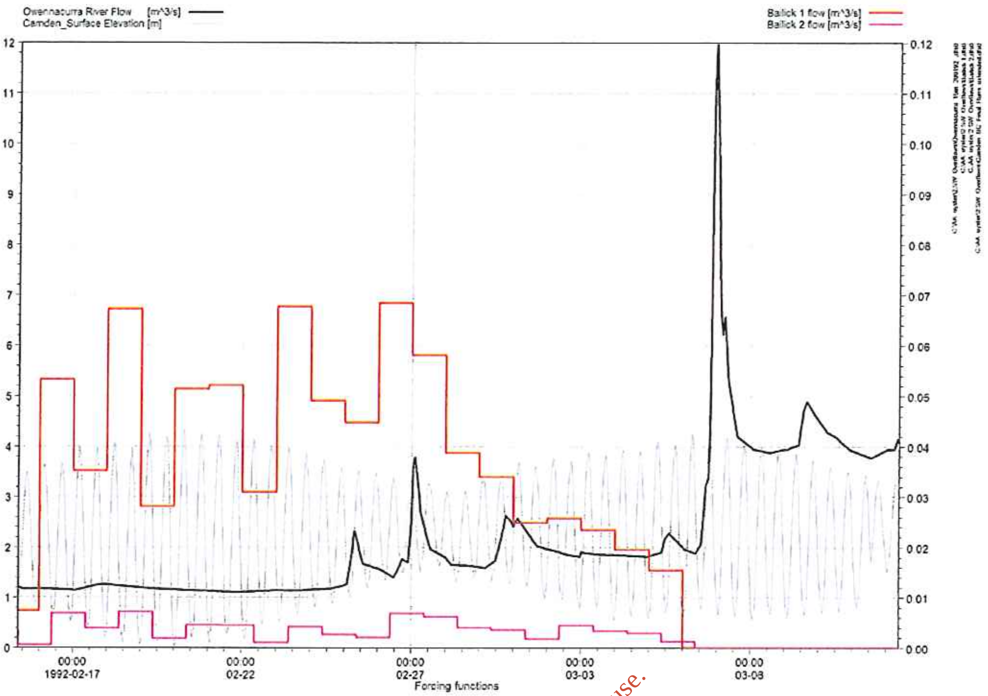


Fig. 4.11 Loadings from Bailick 1 as a percentage of the Loadings from Rathcoursey untreated

Because simultaneous time-series are not available for all processes of interest, the storm overflows in the previous tables must be shifted in time to match the selected tide and wind data. This process is shown below where the Bailick 1 and 2 overflow rates in the table [m^3/s] are shown on the right hand axis and located on the 1992 time axis to match the correctly timed Owenacurra River flow [m^3/s] and the Camden Surface Elevation [m] shown on the left hand axis. The time interval on the horizontal axis is half a day[59].

[59] The flows are assumed constant throughout each day which of course is not true. The Bailick 2 flow series has been accidentally shifted by half a day and is of no consequence in the examination of relative contributions to the contamination of the oyster farm.



4.4 Operation of Bailick 1 and Bailick 2

The following description (in italics) of the operation of the stormwater overflow tanks at Bailick 1 and 2 was provided by Cork County Council via personal communication.

4.4.1 Design Philosophy

"The tanks at Bailick 1 and 2 were designed to take the larger of two volumes, either:

(a) Three times the dry weather flow [60] *(for two hours) for the catchment draining to them.* [The dry weather flow is 0.1m3/sec for Bailick 1 and 0.04 m3/sec for Bailick 2. These are different to the carrier flows used in this study]

(b) the volume generated by "first flush" after a storm event.

The first flush volume for both tanks is greater than the 3DWF volume. The tank at Bailick 1 provides storage for 1,741m^3. The tank at Bailick 2 stores 337m^3.

[60] 3 Dry Weather Flow: 0.1m3/sec in this study for Bailick 1 and 0.04m3/sec for Bailick 2

If the capacity of the tank is not exceeded during heavy rainfall the volume in the tank drains back into the foul network and on to the WWTP for treatment. If the volume of the tank is exceeded the excess volume flows into a pump-sump where it is pumped out to the river. The material which flows into the pump-sump will have been diluted in the overflow tanks and solid materials will have settled out. As well as this the overflow pumps in the pump-sump have a fine screen attached to them which ensures no solid matter is discharged to the estuary. This system was designed to ensure that all discharges from Bailick 1 and 2 meet secondary treatment effluent standard and comply with the Urban Wastewater Directive (BOD 25 mg/l and SS 35mg/l).

The material that settles out on the main tanks during the holding period is pumped back into the system when the tanks are cleaned out. The settling process prevents the bulk of the solid material collected in the tanks reaching the overflow pump sump.

The overflow tanks are equipped with a tipping bucket cleaning system. When the tanks are dry or holding very little volume (usually summer time) the buckets are filled with water which tip over into the tanks when full. This water is used to clean out the tanks of any remaining debris. This water/debris is then pumped back into the system and on to the WWTP.

There are no tipping buckets in the pump-sump and some debris will, inevitably, collect here. In this instance a local tanker is used to suck any debris out of the sump whereby it is taken to a landfill site when the sump is dry and any debris is sucked out and taken to landfill"

4.4.2 Bailick 1 Overflow tanks

A schematic of the overflow tanks is presented in Fig. 4.12. This diagram is based on the 'as built' drawings of the tanks which were provided by Cork County Council. The authors also undertook a visual inspection of the inside of the tanks.

We can see from the figure that there are 6 sections to the tanks:

1. Storm holding cell 1
2. Storm holding cell 2
3. Storm holding cell 3
4. Overflow channel
5. Pumping Chamber (with 3 separate pumps)
6. Overflow Chamber

When the capacity of the pumps sending waste to the treatment plant are exceeded the excess volume enters the first storm holding cell through a 1.1m diameter pipe. As the volume of sewage increases the level in the cell will rise. When the level reaches a depth of 3.57m (3.15m O.D. Poolbeg) it spills over a side weir into the second storm holding cell (indicated by red arrow on the diagram). The volume contained in the first holding cell when it starts to spill into the second cell is approximately[61] 675m^3.

As the volume of diluted sewage in the second cell increases the level in the tank will rise. When it reaches a depth of 2.6m (1.8m OD) it will spill into the third cell. The volume contained in the second holding cell when it starts to spill into the third cell is approximately[62] 439m^3.

[61] There is a gentle slope on the bottom of the tank to facilitate the cleaning action of the tipping buckets. The lower level at the bottom of the slope has been used in this volume calculation.

[62] There is a gentle slope on the bottom of the tank to facilitate the cleaning action of the tipping buckets. The lower level at the bottom of the slope has been used in this volume calculation.

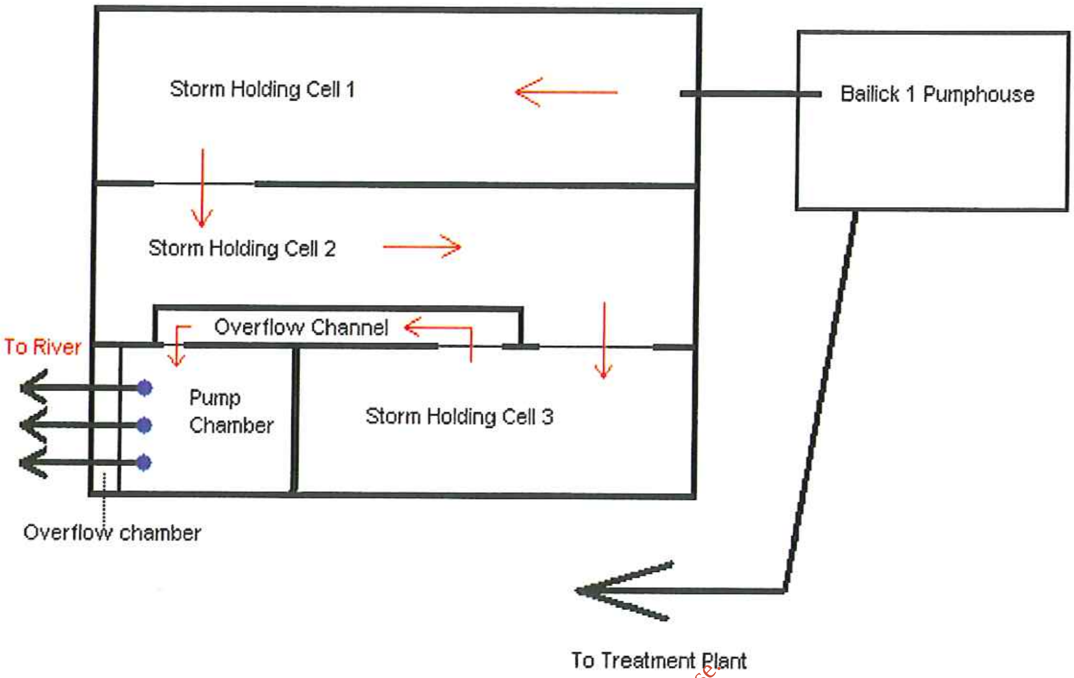


Fig. 4.12 Schematic of Bailick 1 overflow tanks – Plan View

As the volume increases in the third cell the level will rise. The level will rise until it reaches the level of the left hand side of the overflow channel (3.27m OD). When this occurs diluted sewage will be conveyed into the pumping chamber.

When diluted sewage enters the overflow channel the level in all three tanks will be equal as the level of both side weirs is less than the level of the overflow channel.

The overflow channel extends from the end wall of the storm cells to the end of wall of the pumping chamber and is above the level of the weir between tank 2 and 3. For clarity it is not presented like this in the schematic diagram.

If the tanks rise further to 3.34mOD the overflow channel will be submerged.

Given the volume of the three tanks it is possible to estimate the residence time of Bailick 1 based on the dry weather inflow of 0.1m^3/sec. From the calculation highlighted in the spreadsheet printed below we can see that the residence time is approximately 5 hours. This calculation ignores the sloping bottom of the tanks as well as the storage offered in the pumping chamber.

2	**Ballick 1**										
3											
4	Storm tank 1			Storm tank 2			Storm tank 3				
5											
6	Length	27	m	Length	27	m	Length	16.65	m		
7	Width	7	m	Width	7	m	Width	6	m		
8											
9	Height	3.7	m	Height	3.7	m	Height	3.7	m	3.7	m
10										**Sum**	
11	Total Volume =	699.3	m^3	Total Volume =	699.3	m^3	Total Volume =	369.63	m^3	1768.23	
12											
13	Dry weather flow =	0.1	m^3/sec	Dry weather flow =	0.1	m^3/sec	Dry weather flow =	0.1	m^3/sec		
14											
15	Time to fill tank =	6993	seconds	Time to fill tank =	6993	seconds	Time to fill tank =	3696.3	seconds		
16											
17		116.6	minutes		116.6	minutes		61.6	minutes		
18		1.9	hours		1.9	hours		1.0	hours	**Sum**	
19										4.91	hours
20											
21											

Fig. 4.13 Calculation of the residence time.

A schematic of the pumping chamber is shown on the following page in Fig. 4.14.

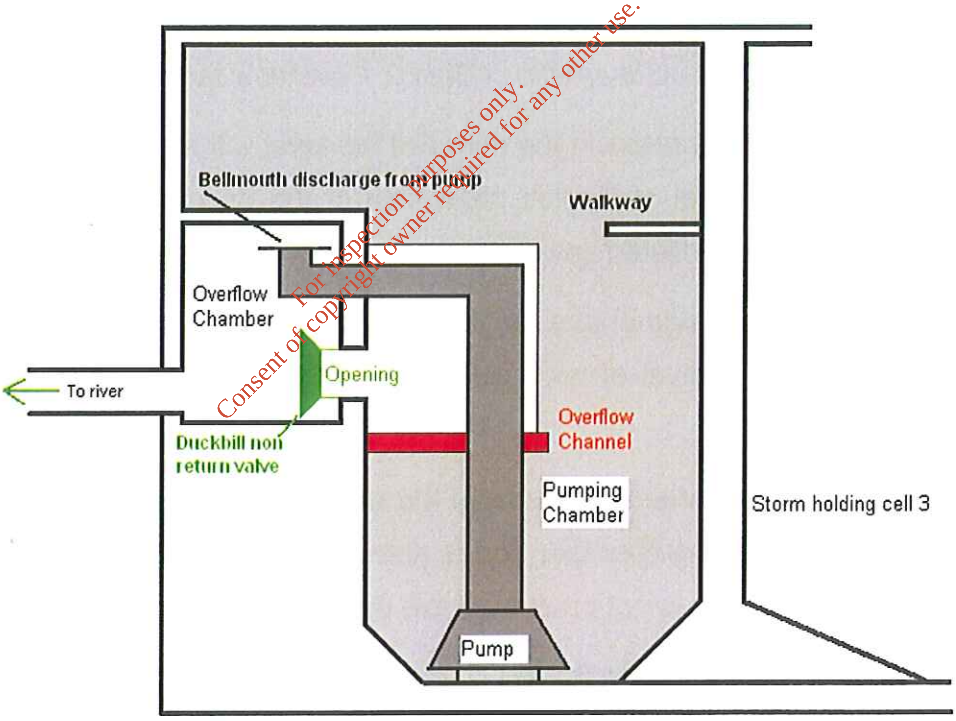


Fig. 4.14 Schematic of the pumping chamber – side elevation view. The pumps have fine screens attached to their underside which are not indicated on the diagram.

The red shading in the diagram is the endpoint of the overflow channel. Diluted sewage falls from here into the pumping chamber. There are three pumps (dark grey shading) in the chamber which pump the diluted sewage into the overflow chamber. There are fine screens (5mm) attached to the underside of the pump shafts which inhibit solid matter from being discharged to the overflow chamber. The diluted and screened sewage flows under gravity from the overflow chamber into the Owenacurra estuary.

There are 4 gravity overflow openings which connect the pumping chamber with the overflow chamber. They act as a fail safe mechanism in the event of each one of the pumps failing[63]. There is a duckbill non-return valve on the other side of the opening to prevent backward flow from the overflow chamber (and estuary) into the pumping chamber.

Each of the three pumps have a design flow rate of 550l/s which is equivalent to 0.55m3/sec. This value is 14 times greater than the carrier flow used in this study (0.04m3/s). The combined capacity of the three pumps is 1.65m3/sec which is 42 times greater than the carrier flow and 17 times greater than the dry weather flow. Consequently the frequent stormwater overflows to the estuary are most probably due to faults in the sewer system feeding the pumphouse.

When the level in the pumping chamber reaches a certain height the first pump will start up and discharge diluted and screened sewage to the estuary. The next time the height is reached the second pump will be used instead and likewise the third pump will be used when the height is reached again. This is to ensure that all three pumps are used equally. This system also ensures that if a pump fails one of the other pumps can be used instead.

4.4.3 Site Visit

The authors of this report visited the overflow tanks at Bailick 1 on the 27th of August 2007. A number of photographs were taken during the visit and are presented in the following set of figures. To aid the reader in interpreting the images a plan schematic of Bailick 1 is presented with the location of where each photograph was taken as well as the direction in which the camera was pointing (Fig. 4.15).

[63] Personal communication with the design engineers

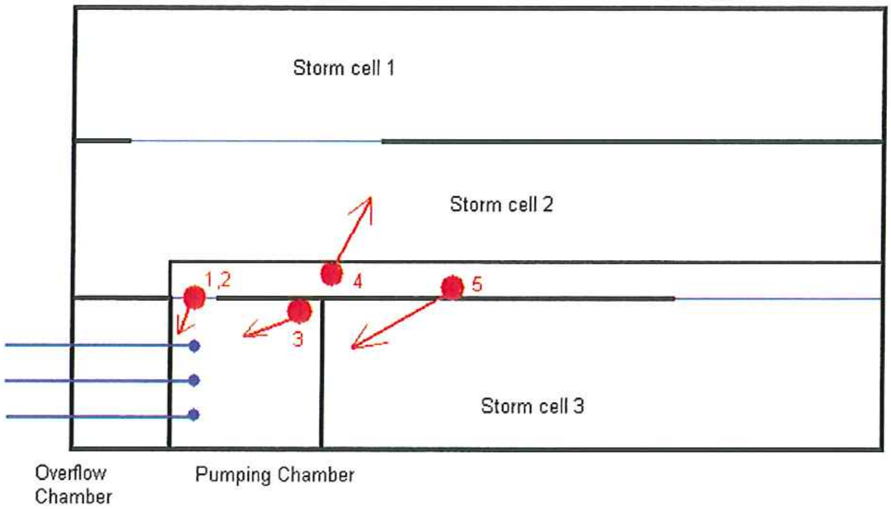


Fig. 4.15 Location of photographs

Fig. 4.16 Photo 1 – Pumping chamber showing the four gravity openings - A,B,C & D

We can see from Fig. 4.16 a thin coat of sewage particles stuck to the walls in the pumping chamber. We can also see a constant line across the wall indicating the level reached at some time prior to the site visit. This level is greater than the level of the openings to the overflow chamber.

There are three conclusions to be reached from this:

- on at least one previous occasion the diluted sewage discharged from the pumping chamber through the openings;
- the recorded overflows from the pumps, on at least one occasion, underestimated the total discharges from Bailick 1;
- some of the discharges to the river, on at least one occasion, did not pass through the fine screens attached to the underside of the pump.

We have been unable to find evidence of why this happened. The most likely explanation is of a failure in the supply of electricity to the pumps (i.e. a failure of both the ESB power source and back up generator). We have been assured that there is no record of a power failure in the supply to the Bailick 1 pumps. An alternative explanation is a failure of the non-return valves or their operation. A third possible reason may be due to the switching off or failure of the pumps in Bailick 1 pumphouse which pump to the treatment plant.

A combination of these three events may also have occurred.

We can also see from Fig. 4.16 that toilet paper is stuck to the access ladder in a few places indicating that not all of the solid matter present in sewage has settled to the bottom before entering the pumping chamber.

A close up view of the openings is presented in Fig. 4.17. We can see from the figure than the wall is stained underneath the opening. We have interpreted this as a sign that water from the Owenacurra estuary is leaking into the pumping chamber through the overflow chamber and the non-return valves.

We can see from Fig. 4.18 that the thin coat of sewage particles is also present on the surface of the pump shafts. We can also see from the photograph that there are different degrees of encrustation of sewage particles on the pump shafts.

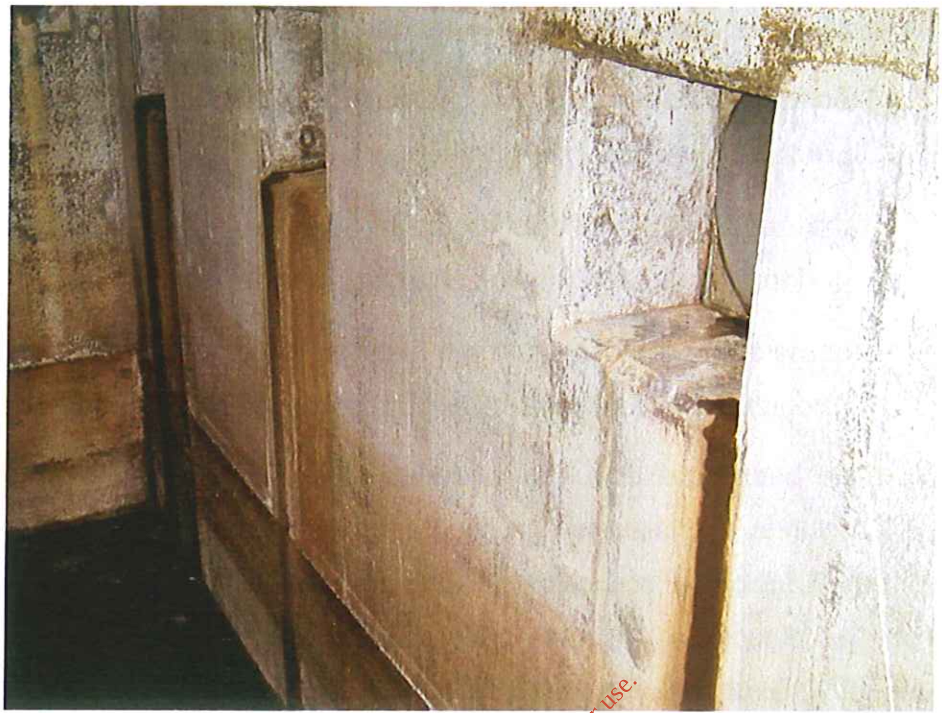


Fig. 4.17 Photo 2 – Openings

Fig. 4.18 Photo 3 – Pumping Chamber

We can see from Fig. 4.19 and Fig. 4.20 that the thin coat of sewage particles is also present on all the walls of the tanks. The different levels of encrustation which were observed on the pumps are repeated on the tank walls.

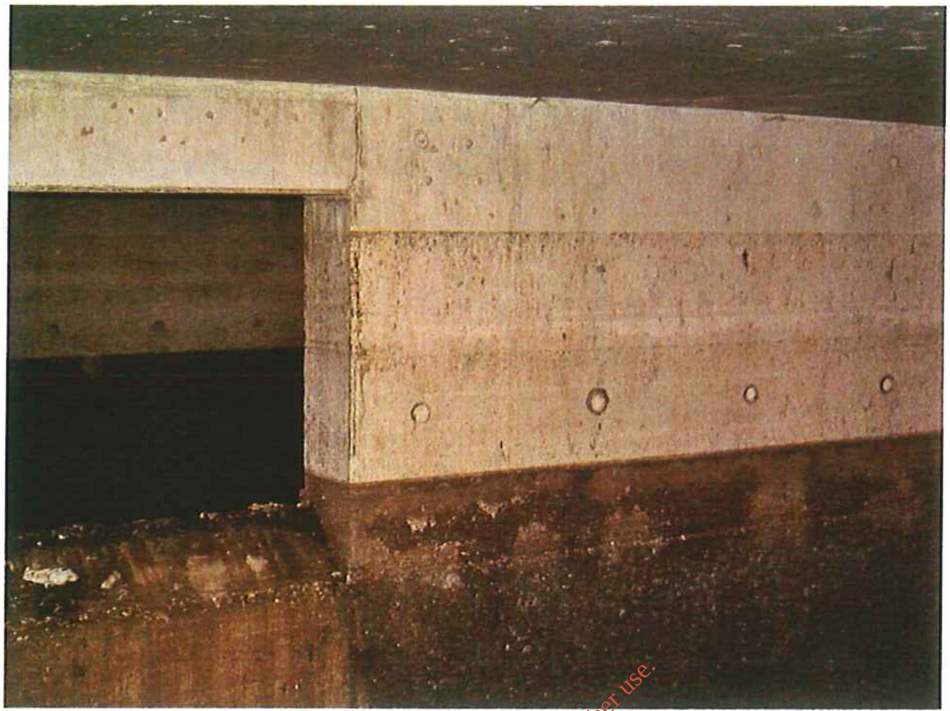


Fig. 4.19 Photo 4 - Side weir and wall from cell 1 into cell 2

Fig. 4.20 Photo 5 – Large tipping buckets in Cell 3

4.5 Analysis of entire overflow dataset

The entire pumped overflows dataset[64] was provided by Cork County Council. The volume pumped to the estuary from Bailick 1 is plotted in Fig. 4.21. The volume pumped to the estuary from Bailick 2 (with the same y-axis scale) is plotted in Fig. 4.22.

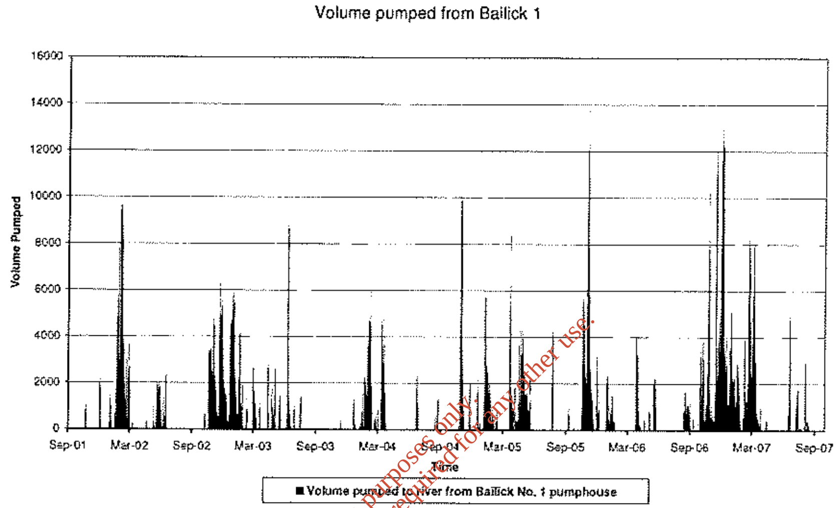


Fig. 4.21 Volume pumped from Bailick 1

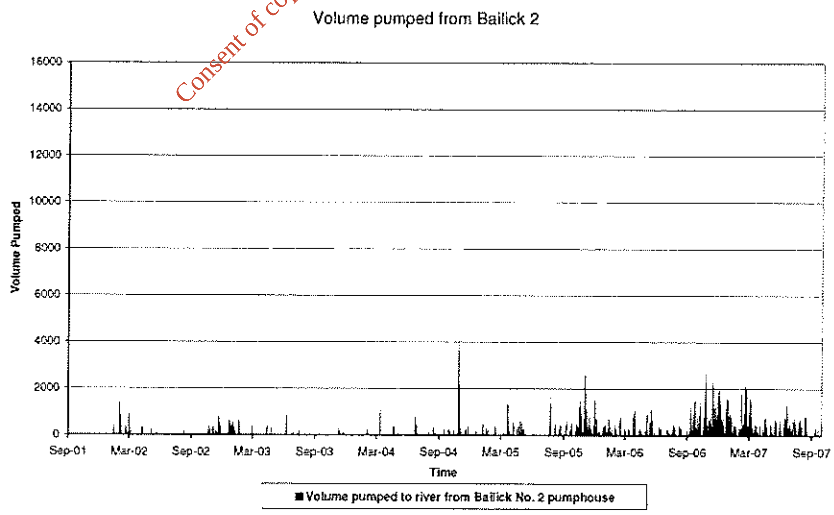


Fig. 4.22 Volume pumped from Bailick 2

64 from August 2001 to September 2007

The number of hours for which the 3 individual pumps in Bailick 1 were run is plotted in Fig. 4.23. We can see from the graph that up until April 2002 only the first pump was discharging diluted and screened sewage to the estuary. From this point onwards all three pumps are working equally.

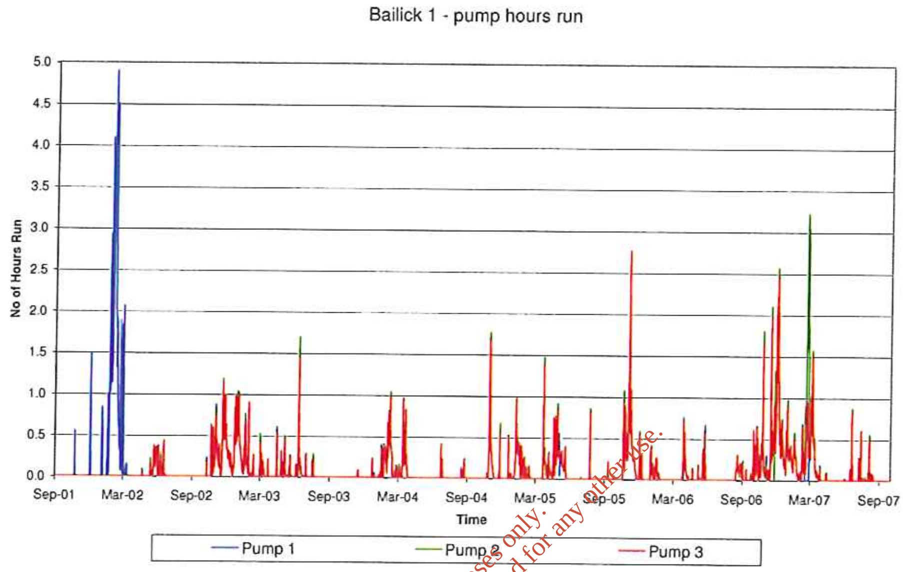


Fig. 4.23 Bailick 1 – pump hours run

Fig. 4.24 presents a summation of the dataset based on the first and second halves of the water calendar. The water calendar begins on the 1st of October and runs until the 30th of September the following year. The year is numbered with the year of the final day, the 30th of September.

In Fig. 4.24 the first six months of the water year have been labelled as Winter[65] while the second six months are called Summer[66]. The total volume pumped to the estuary[67] in these six month periods is presented in the figure. We can see from the plot that the 2006/2007 winter (i.e. winter 2007 water year) is by far the worst period for overflows to the estuary. The total volume pumped is double that

---

[65] i.e. Winter 2002/2003 = {October 2002 + November 2002 + December 2002 + January 2003 + February 2003 + March 2003}

[66] i.e. Summer 2002 = {April 2002 + May 2002 + June 2002 + July 2002 + August 2002 + September 2002}

[67] i.e. from Bailick 1, Bailick 2 and Ballinacurra

for Winter 2003 which is the period used in this study. We can also see from the plot that Summer 2005 and Winter 2004 are similar in terms of the total volume pumped.

The maximum value in each six months period is presented in Fig. 4.25.

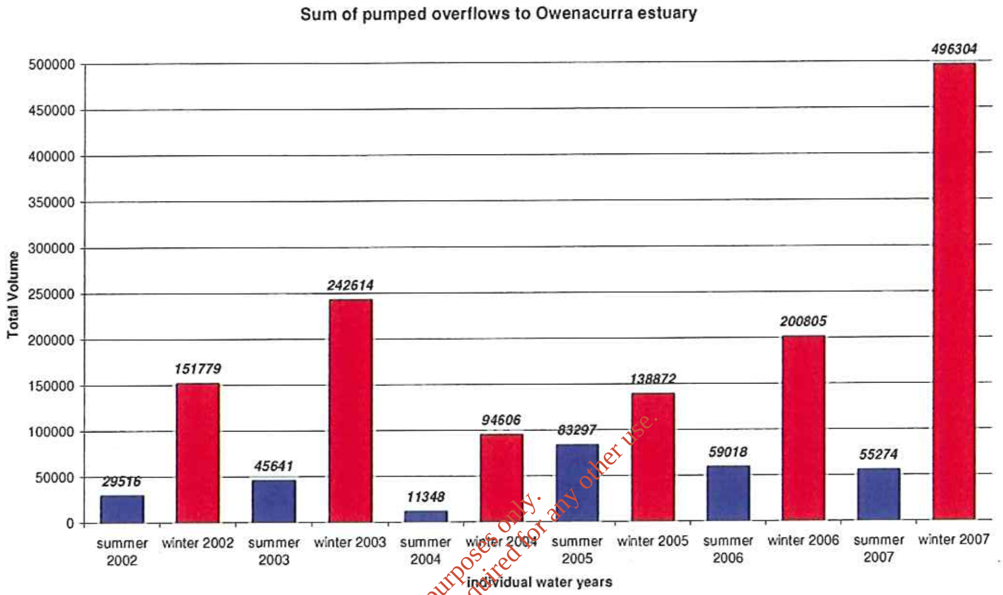


Fig. 4.24 Summation of pumped overflows to river

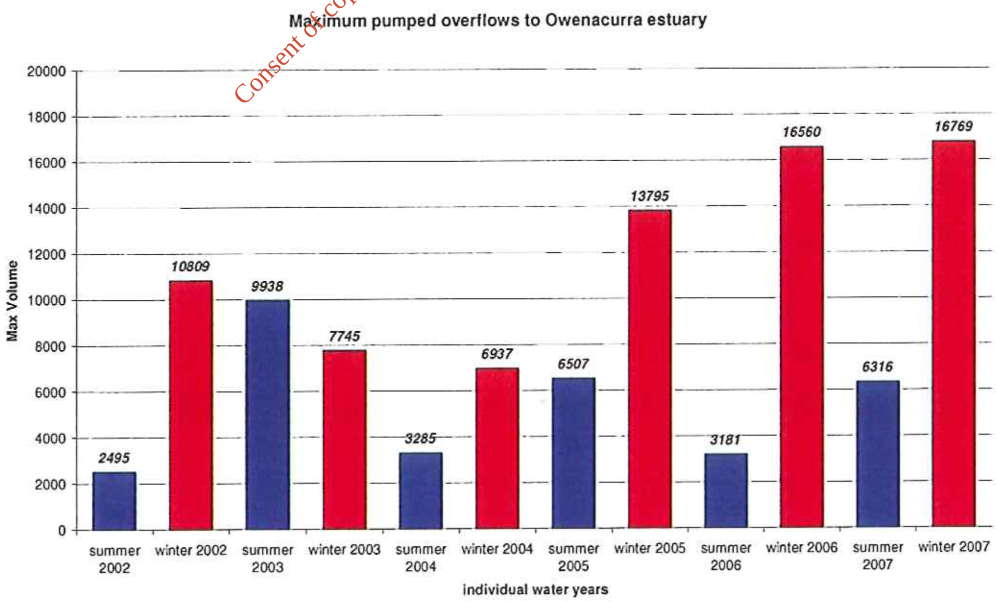


Fig. 4.25 Maximum pumped overflows to estuary

The reference storm overflows used in this report occurred in December 2002 and January 2003. The data from the current year (winter 2006/2007) show that there has been a further disimprovement in the Midleton sewerage system: more frequent, longer lasting, and intense overflows to the river. Consequently, our model results for storm overflows at Bailick 1 and Bailick 2 underestimate for the current year - 2007. On the other hand, when more viruses are discharged to the river, there is a matching reduction in the number of viruses entering the treatment plant during the reference 20-day pulse of *Norovirus*. At the same time, the treatment plant is operating above its maximum design loading, and the range of uncertainty in the removal of model viruses is increased. In the absence of (a) a calibrated model of the treatment plant, and (b) any measurements of viral particles, we are content to use the range from 95% to 85%, for the removal or inactivation of *Norovirus*. We have used the same range of uncertainty for the much larger Carrigrennan WWTP even though no UV treatment is present there. We do not imply that the removal efficiencies are the same in both cases.

4.6 Revision of RP model to model the overflows

The Roches Point (RP) model was extended to resolve the effect of the overflows from Bailick 1 and Bailick 2. The revised set of nested grids is shown in the figure below. It contains an additional 6m grid to resolve the Owenacurra estuary and the road bridge that cuts across it between Bailick 1 and 2. The 6m grid at Belvelly was removed to ensure there was no increase in the very demanding computation time. The extent of the 18m grid was reduced.