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Barrow uID Study – Three for the Price of One

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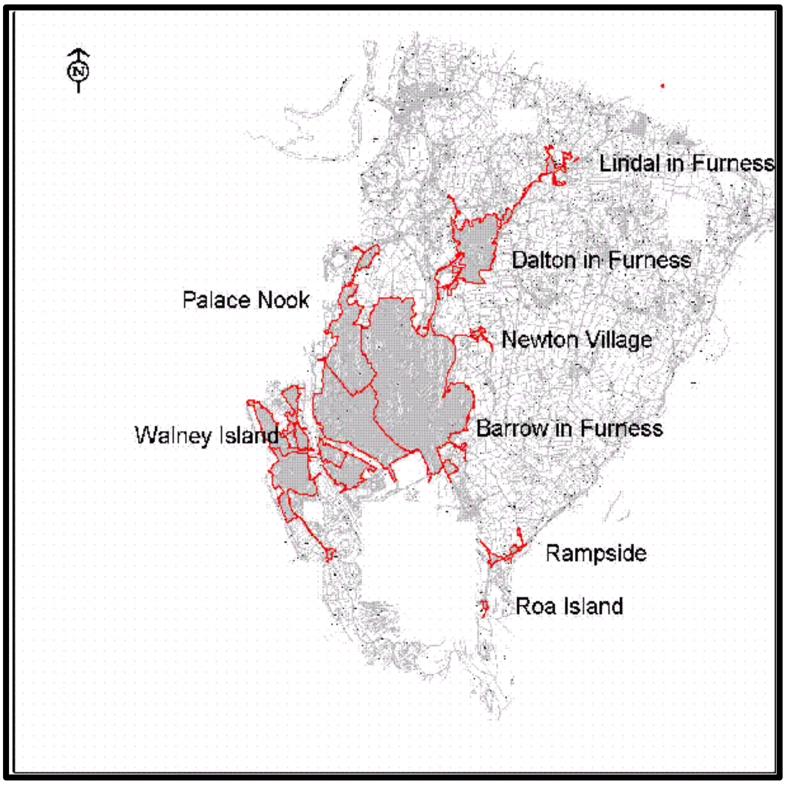
Introduction

This paper covers the work undertaken for the Barrow uID Study. This is part of the United Utilities overall AMP3 uID programme which requires the improvement of 914 uID's by March 2005. The Barrow uID's are programmed for resolution by March 2004.

Brief description of the study area



Barrow Location plan

Barrow-in-Furness lies at the tip of the Furness peninsula in West Cumbria which is bounded by the Irish Sea on its south-west and west sides. Barrow Island was originally separated from the mainland by a narrow channel, which has been infilled by a string of docks. Walney Island lies 150m off shore to the west, separated from the mainland and Barrow Island by Walney Channel.

There are designated bathing waters on the east and north-west coast of the Furness peninsula, and on the West Coast of Walney Island, and designated shellfish waters in Walney Channel.

Combined sewer overflows discharge to the Poaka Beck/Mill Beck system which flows to the sea via Cavendish Dock (SSSI), whilst other overflows spill to Ormsgill Reservoir which has a recreational (non-contact) use.

Total population is calculated as 67,400 based on census data. Overall the population of Barrow is projected to decrease within the next ten years.

Wastewater System

The study area is served by a combined sewer system with post 1960's development drained by separate systems. Before construction of Barrow WwTW in 1996 all mainland flows were discharged without treatment to the south of the peninsula. Now all the network discharges to Barrow WwTW.

The study area also includes the recently constructed AMP2 (commissioned Dec. 2000) Walney and West Barrow Transfer project. Formerly there were a number of crude outfalls, which were picked up by a new transfer sewer, and Formula A flows from Walney Island, Barrow Island and the Graving Dock catchments are now pumped to Barrow WwTW which has been extended to accommodate the additional flows. The CSOs remaining as part of this project (Ferry Pumping station, Biggar Village, Graving Dock and Harbour Yard) do not necessarily comply with bathing/shellfish waters criteria, as the project was designed to purely pass forward Formula A for treatment. Hence they have immediately been deemed as unsatisfactory.

Including the Walney transfer scheme, there are 24 pumping stations within the catchment (pump rates vary from 1l/s to 6.8 cubic metres/sec). There are thirty three consented Intermittent Discharges within the catchment area of which thirty are unsatisfactory. In addition there are two unconsented CSOs.

Purpose of the study

The study reviews the UIDs in the Barrow catchment and considers their performance in terms of impact on the receiving watercourses. This is reviewed against bathing / shellfish water directives, river water quality standards and aesthetic standards. Reported flooding is commented on if adjacent to any UID.

The study was required to address the following:-

- to assess the impact of CSO discharges on the Bathing Waters and Shellfish waters of the Walney Channel.
- to consider water quality needs in Mill Beck/ Poaka Beck from Dalton-in-Furness to Cavendish Dock.
- to assess the aesthetic impact on discharges to Ormsgill Reservoir.

Wastewater Network Modelling

For all the different types of analysis work, a verified hydraulic model was required

Review of Existing Models

There were a number of existing models available in the Barrow WwTW catchment, although there was not a complete model of the whole catchment.

The table below summarises the available models, and the documentation available.

Model Name	Constructed By	Comments
Barrow Central	Halcrow - 1988	No verification Report available or flow survey data.
Lindal	Bechtel - 1997	Verification Report available
Walney / West Barrow	Bechtel - 1997	Draft Model Build and Verification Report available. Wet weather flow survey event data available. Constructed for Walney / West Barrow WWTW project.

Actions/Model Upgrade Required

From the review of the available documentation the following actions were identified:-

Barrow Central – Rebuild model of the existing Barrow WwTW catchment excluding Lindal.

Lindal – The existing model is considered adequate for use in the UPM study.

Walney / West Barrow. – There were a number of issues with the verification, mainly due to the presence of rainfall induced infiltration, and the inability of the modelling packages available in 1997 to represent this adequately. The following actions were therefore identified:-

- For Walney Island and Barrow Island, undergo a re-verification based on the flow survey data carried out in 1997 by Bechtel.
- For the Graving Dock catchment, re-verify the catchment using flow survey data collected by a new flow survey as part of the Barrow Flow Survey exercise.

Flow Survey & Verification

A thirteen week flow survey was carried out. Fifty-five depth and velocity monitors; two depth-only loggers; three pump loggers, seven rain gauges were installed. The model was subsequently verified against this data using conventional techniques. As with all the UU uID projects, strict adherence to the WaPUG Code of Practice guidelines for model verification was required. This had its own problems, as it is extremely difficult to obtain fits within the envelope suggested in the code of practice.

The ground water infiltration elements of the Infoworks software were used to obtain the volume fits, with the use of the Wallingford standard run-off model.

The fits below show the comparisons between the predicted and observed flows for an element of the "Ferry" catchment in Walney Island. The model originally under-predicted the run-off.

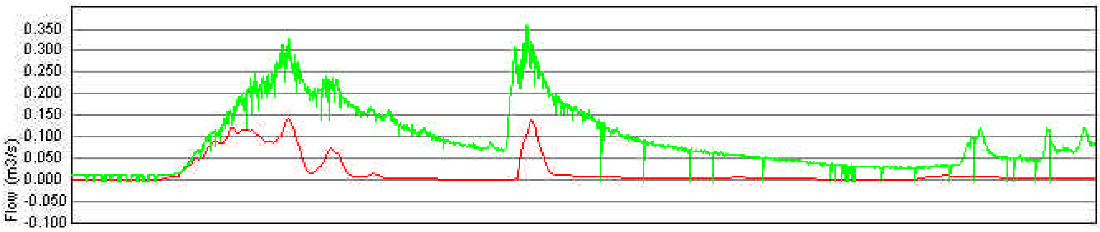


Fig 1. Original verification fit

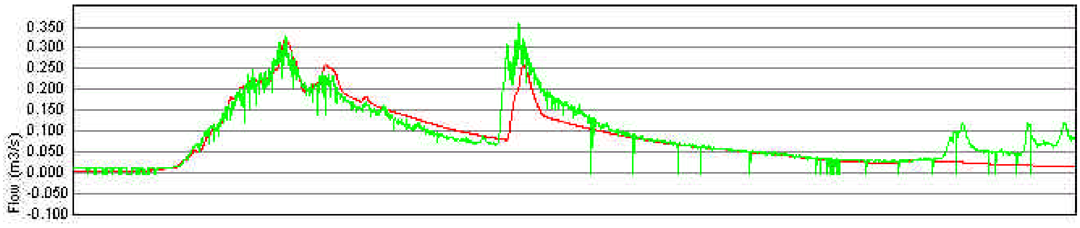


Fig 2. Final fit following inclusion of rainfall induced infiltration

Another feature of United Utilities specification for verification of models for use in Bathing Water analysis is the use of full period data for verification purposes. In this case the full thirteen weeks of data is used for verification purposes as well as verification against individual events. This allows greater confidence on the calibration of the rainfall induced infiltration tool.

Quality Modelling

For the Barrow catchment, a network quality study was required to assess the impact of the spills from the UIDs on Poaka / Mill Beck. In the interests of ensuring continuity with the programme, default network sewer effluent quality values were used as an interim measure. This has since been confirmed by the use of water quality sampling at four locations.

To assess the validity of the default values, a review of existing quality data was carried out. Measured concentrations for the influent at the Barrow WwTW were available. This data was analysed and default dry weather concentrations were produced for dry weather conditions.

As stated above a water quality sampling exercise has since been undertaken. The results of this has been to show that the default values used were generally satisfactory, and in all except one site, the default model over-predicted wet weather quality when compared with the observed sample data. This adds to the belief of the authors that United Utilities have sufficient data from detailed and verified water quality modelling to confidently use a more default approach to water quality modelling.

River Modelling

In order to carry out an analysis of the impact of CSO discharges on Poaka Beck / Mill Beck using the Fundamental Intermittent Standards (FIS) it is necessary to have a river model. In situations where the river impact is seen to be large or the watercourse is very flat it is agreed policy that detailed river modelling is carried out. In this case it was considered that the scope of the water quality problem allowed a more default approach to be taken, and a default river model was built of the watercourses using the UPM tools in Infoworks.

The simple river impact model requires a number of sub-reaches to be identified along Poaka Beck and Mill Beck. These are determined based on the characteristics of channel gradient, width, length, and the location of CSOs entering the river.

The watercourse has been split into two reaches, based on the location of CSO discharges and the potential impact on the watercourse. Reach 1 covers the section of watercourse between Dalton CSO, BRW0074 and just upstream of the Roose Bridge CSO outfall. Reach 2 covers the section of the watercourse from Roose Bridge outfall to its discharge into Cavendish Dock.

Analysis carried out

Aesthetic analysis at Ormsgill Reservoir

There are seven uID's which had been given aesthetic only drivers. In these cases, regardless of the standards required for protecting amenity use, United Utilities policy is to provide 6mm screenings up to the peak flow rate of a 1 in 5 year return period storm. The analysis carried out has therefore been purely hydraulic to evaluate the necessary design parameters of a new chamber.

Of the seven uID's, six share a common outfall with the CSOs discharging to a single overflow pipe. Hence the solution developed has been to screen the common outfall rather than have six individual screen chambers.

Bathing Waters / Shellfish Waters

It has been agreed with the Environment Agency that all analysis against Bathing Water and Shellfish Water Standards shall be undertaken using continuous simulation techniques. A ten year rainfall series has been developed using the StormPac package, based on data for the Sandgate Raingauge in Barrow. This has been used as separate events for analysis against river water quality, and has been concatenated to produce a continuous ten year rainfall series of events from April to September for analysis against Bathing Water Criteria. Effectively concatenation stitches together the individual events into one rainfall file made up of a series of sub-events. Each sub event has its own UCWI value thereby allowing changes in the wetness of the catchment with time.

The models were analysed using continuous simulation of 10 years bathing-season rainfall events to produce the spill volume and frequency results for bathing waters overflows. The performance standard has been assessed as follows:-

- The number of discharges to bathing waters shall not exceed an average of three spills per bathing season.
- Bathing season is 1st May - 30th September inclusive
- Several discharges within a 12 hour period are regarded as a single spill. If discharges extend between 12 and 24 hours they are regarded as two spills and 24-36 hours is regarded as three spills etc.
- Volumes of spill less than 50 m^3 have not been included in the results analysis.

The results of the analysis are indicated below:-

CSO ref.	CSO Location	Total no. spills in 10 BS > $50m^3$	31^{st} spill Volume	Operational issues y/n
BRW0001	Biggar Village	0	0	y
BRW0097	Palace Nook PS	66	1509	n
BRW0099	Ferry PS (Walney Island)	480	15585	n
BRW0100	Graving Dock PS (West Barrow)	329	8937	n
BRW0101	Harbour Yard PS (West Barrow)	193	2106	n
NW17470166	WwTw Storm tanks	255	25633	n
NW17470166A	WwTW Inlet CSO	425	14899	n

All the CSOs fail the bathing water criteria with the exception of the Biggar Village EO, which the analysis carried out to date shows no spill.

The 31^{st} spill in the table shows the spill volume at non-compliance of the 3 spills per bathing season criteria. This is an approximation of the likely storage volumes required to achieve compliance. In practice the storage at individual sites should be slightly less to meet the 3 spills criteria as some spills currently extend over more than one 12 hour period, and smaller amounts of storage will reduce the number of multiple failures.

The large spill volumes and frequency from BRW0099, Ferry are due to the large amounts of run-off from permeable surfaces which had been observed at the time of flow survey. A check has been carried out by running the model without the permeable surfaces. On this basis the 31^{st} spill volume was 331 cubic metres. There was therefore an identified need to carry out further analysis of the infiltration in this catchment.

Solutions to upstream UIDs will have a knock on impact on the required storage volumes at the WWTW inlet and storm tanks. Certain assumptions have been made in the modelling which may have an impact on the volumes calculated. The most significant are as follows:-

Average summer infiltration figures have been used in the analysis carried out. Base flows used are higher than the normal definition of base flows, namely DWF after seven dry days following seven days of less than 1mm of rainfall. This is considered more appropriate as the conventional baseflow calculation gives the lowest possible infiltration figures, the use of which would lead to under prediction of spills and hence the construction of a failing solution.

Storm tanks have been modelled as on-line tanks for ease of analysis for Needs Stage. This means that the FTFT rate is maintained continuously when the storm tanks are full. In reality there will be some reduction in FTFT to a level when the storm return pumps cut in. Storm tank spills will therefore be under-estimated in this report, although it is not considered to be a major under-prediction. Solution modelling will include RTC controlled emptying of storm tanks.

River Water Quality - Mill Beck

Analysis has been undertaken against both 99 percentile RE standards and FIS standards. This has entailed running all the 1200 events generated in the StormPac Rainfall Series through the hydraulic and quality models in Infoworks. All analysis has been carried out using the UPM Tools in Infoworks.

Although there are a large number of CSOs discharging to Poaka Beck and Mill Beck, most of these share a common outfall at Roose Bridge. There are therefore only three significant discharge points to the watercourse, being the Dalton CSO, BRW0074, the Frederick Street CSO, BRW0044 and the remainder discharging to the Roose Bridge outfall.

Analysis has been carried out on the two reaches of Mill Beck. Reach 1 has an impact from just the Dalton CSO. Analysis of Reach 2 includes all the Roose Bridge CSOs discharging to the Roose Bridge Outfall, together with the Frederick Street CSO, BRW0044. The analysis has also been carried out with the Dalton CSO included, with some sensitivity against 99%ile standards without the Dalton CSO.

For the analysis on Reach 2, results are included for some sensitivity runs against FIS standards. This has been done on two parameters, in-river mixed DO and BOD decay rates. Two values of DO have been used, being a random pick against the EA river boundary condition, and a fixed 7.0mg/l DO. A value of 0.3 has been used for the BOD decay rate with sensitivity analysis using a figure of 0.5. As there is little risk of failure of FIS standards in Reach 1, no sensitivity analysis has been carried out. All analysis in Reach 1 has therefore been based on DO in boundary condition and a BOD decay rate of 0.3.

Analysis against 99 percentile RE standards has been carried out by mixing one hour of CSO discharges with a random pick of one hour river flow and loads picked from EA provided boundary conditions.

Analysis against FIS standards has been carried out against 1 hour monthly and annual standards, and 6 hour monthly and annual standards.

Summary table of 10 year spill analysis

CSO ref.	Ann. no. of spills	Annual duration of spills (Hrs)	Annual Spill Volume	% of Total load	Ops issue y/n?
BRW0074	29.4	34	16076	14	n
BRW0044	3.5	4	10696	4	y
Roose Outfall	112	492	78585	82	
BRW0031	42.6	35	3934	2	n
BRW0032	19.6	11	877	0	y
BRW0033	0.0	0	0	0	n
BRW0035	41.2	33	2799	1	n

CSO ref.	Ann. no. of spills	Annual duration of spills (Hrs)	Annual Spill Volume	% of Total load	Ops issue y/n?
BRW0036	79.6	146	8113	9	n
BRW0037	3.1	2	171	0	n
BRW0038	0.0	0	0	0	n
BRW0039	3.1	2	127	0	n
BRW0040	1.2	1	174	0	n
BRW0041	110.1	492	41358	53	n
BRW0042	41.4	33	903	0	y
BRW0034	73.3	115	20072	17	y
BRW0008	0	0	0	0	n
BRW0082	0	0	0	0	n
BRW0084	0	0	0	0	n
SD21699202	1.9	1	57	0	n
SD20716407	0	0	0	0	n

From the analysis carried out in Reach 1, it was shown that the Dalton CSO, BRW0074 has little impact on the watercourse. The watercourse is generally steep in this reach and therefore re-aeration occurs quickly. The analysis against the 99 percentile RE3 standards shows an average failure in wet weather of approx. 23 hours per annum. Even when an allowance is made for dry weather failures, there will not be a failure against the 87.6 hours per annum target for compliance. There are hardly any failures for either ammonia or un-ionised ammonia. There are virtually no failures against the FIS standards, and all FIS standards are met.

From the analysis of the spill results it can clearly be seen that the majority of the impact on Reach 2 comes from 5 CSOs, BRW0041, BRW0034. BRW0074, BRW0044 and BRW0036. Of these, BRW0041 discharges approximately 50% of the total CSO load to the watercourse. In terms of spill duration, there are three CSOs, BRW0041, BRW0036 and BRW0034 that have annual spill durations in excess of 88 hours and will have a major contribution to failures of the 99 percentile RE standard. From the spill duration analysis it is unlikely that any other CSOs will impact on non-compliance with that standard.

From the analysis against the 99 percentile RE3 standards, it was shown that the watercourse fails this standard, showing approximately 140 hours failure in wet weather per annum. As discussed above this is almost certainly due to the impact of three CSOs discharging to the Roose Bridge Outfall. The sensitivity analysis carried out by removing the Dalton CSO showed that the Dalton CSO had little additional impact on the failures against this standard, and any impact from Dalton was masked by the other CSOs. Hence it is considered that the Dalton CSO does not impact on any water quality standards in the catchment.

For the analysis against FIS standards, some sensitivity analysis was carried out, mainly due to the non-failure of the watercourse using the parameters considered to be appropriate to this watercourse. The sensitivity was carried out by varying the mixed river DO and also varying the BOD decay rate in the simplified river model.

The table below summarises the impact on FIS compliance of changing the parameters.

Standard	Boundary DO 0.3 BOD Decay	Boundary DO 0.5 BOD Decay	7mg/l DO 0.3 BOD Decay	7mg/l DO 0.5 BOD Decay
1hour analysis				
1mth DO	PASS	FAIL	PASS	FAIL
1mth un-amm	PASS	PASS	PASS	PASS
1 yr DO	PASS	FAIL	FAIL	FAIL
1yr un-amm	PASS	FAIL	PASS	FAIL
6 hour analysis				
1mth DO	PASS	PASS	PASS	PASS
1mth un-amm	PASS	PASS	PASS	PASS
1 yr DO	PASS	PASS	PASS	PASS
1yr un-amm	PASS	PASS	PASS	PASS

It can be seen that the most sensitive parameter is the BOD decay rate, with quite small changes causing a large difference in failure rates.

The watercourse therefore fails the 99 percentile RE standard in reach 2 and also marginally fails the FIS standards, depending on the parameters used in the default river modelling.

Solution Development

Development of outline solutions is currently on-going, based on 99 percentile and FIS standards in river, and both Bathing Water and Shellfish Standards. Some analysis is being carried out on the impact of a standard based on "agglomeration" rather than individual CSO spill. In addition, the WwTW capacity is being increased to allow more throughflow and reduce considerably the storage requirements at the WwTW inlet and stormtanks.

Conclusion

The study covers every aspect of the UU methodologies for assessing the impact of Intermittent Discharges on the receiving waters, and has served to confirm the discharges that are having an impact, and conversely provide proof of the lack of impact from others.

Throughout the study, the Infoworks software package has been used, with the new ground infiltration and UPM tools.