Connolly's Red Mills

Integrated Constructed Wetland (ICW) System

Lower Grange, Goresbridge, Co Kilkenny

November 2021

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

Integrated Constructed Wetlands (ICW) System

Client: Connolly's Red Mills

Location: Lower Grange, Goresbridge, Co Kilkenny

Date: 17th November 2021

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1. Introduction

This summary report has been prepared for Connolly's Red Mills in support of an EPA Industrial Emissions Licence (IEL) application in respect of the Integrated Constructed Wetlands (ICW) system at the Connolly's Red Mills facility site, Lower Grange, Goresbridge, Co Kilkenny.

This report provides a summary of the design and construction of the ICW system, the ability and capacity of the system to manage storm water runoff from the facility site, proposals for on-going management and maintenance of the ICW system and proposals for the setting of appropriate trigger values with respect to storm water discharge from the ICW system.

2. Background

2.1. Location of ICW System

As illustrated in *Figure 1* below, the ICW system is located within lands opposite the Connolly's Red Mills facility site at Lower Grange, Goresbridge and to the east of the L2369 public road.

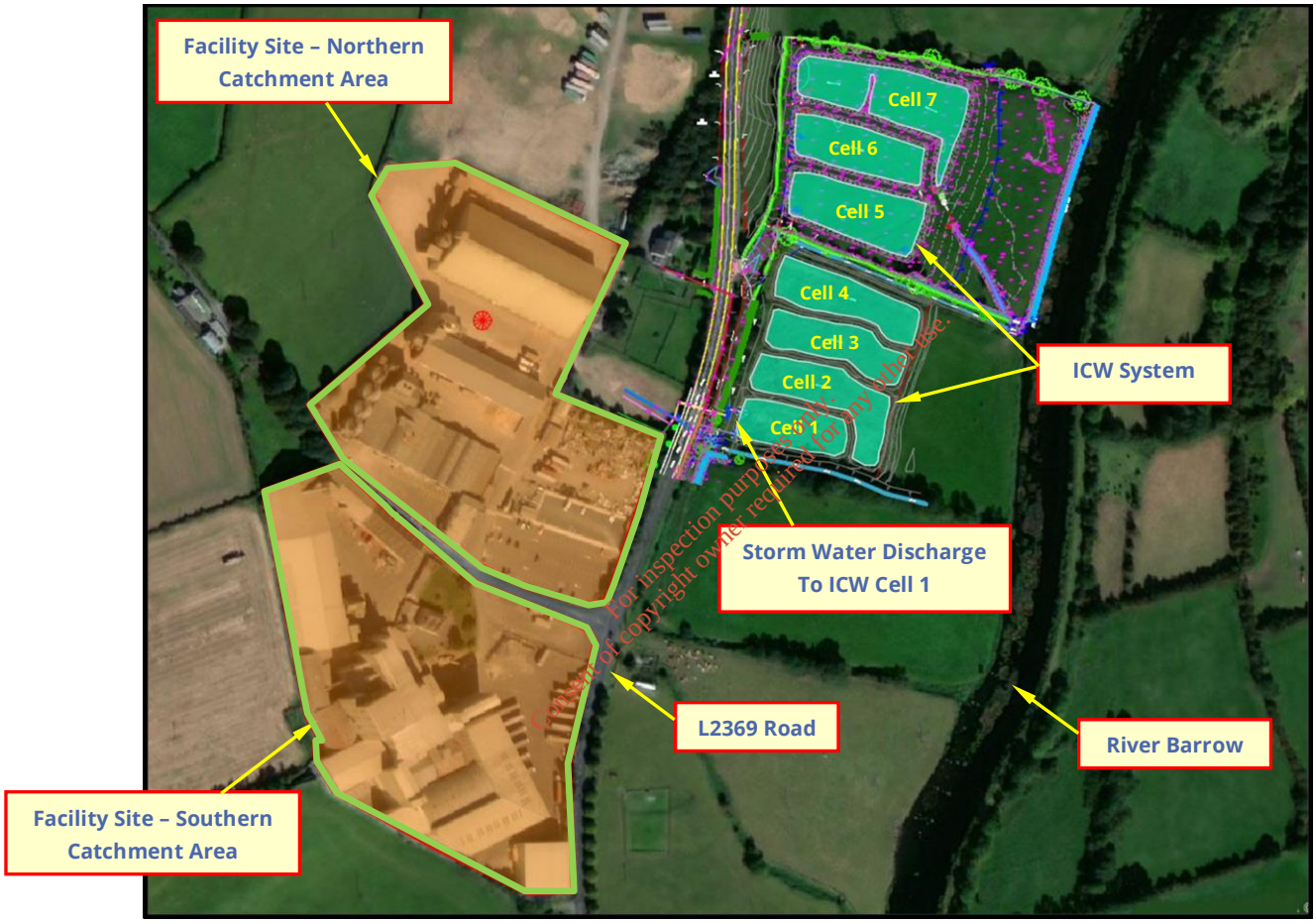


Figure 1 – Location of ICW System

The regional location of the ICW system is illustrated on *Drawing Number IE2383-001-A*, *Appendix A*.

2.2. Requirement for ICW System

The ICW system has been designed and constructed in order to provide an environmentally sustainable means of managing storm water runoff from the overall Connolly's Red Mills facility site prior to discharge to the receiving watercourse.

In particular the ICW system is intended to provide a means of storm water treatment and polishing as may be required and, if required, to provide a means of capturing, isolating and managing any potential future instances or sources of pollution that may inadvertently or accidentally discharge to the storm water drainage system within the Connolly's Red Mills facility site.

2.3. Design & Construction of ICW System

The ICW system has been granted planning permission by Kilkenny County Council under planning reference P.13/196 (for ICW cells 1-4) and planning reference P.19/235 (for ICW cells 5-7).

The assessment, site investigation, design and construction of the ICW system has been undertaken in consideration of the Department of the Environment, Heritage and Local Government Integrated Constructed Wetland Guidance Document, November 2010. In particular, the ICW system has been designed and constructed to achieve a minimum cell basal permeability of 1 x 10^{-8} m/s as required by the above guidance document, and to achieve a minimum storm water runoff retention period of 20 days.

The ICW system has been constructed and vegetated in two phases, with ICW cells 1-4 constructed and vegetated in 2014-2015 and ICW cells 5-7 constructed in 2020-2021 and vegetation expected to be established in cells 5-7 during Quarter 1, 2022. As illustrated in *Figure 1* above, storm water discharge from the overall Connolly's Red Mills facility site discharges to ICW Cell 1. Each of the ICW cells are separate self-contained earth embankment structures interlinked by pipework in order to allow a gravity flow of storm waters throughout the overall ICW system.

The discharge from cell 4 of the ICW system was re-directed to cell 5 of the system in early 2021and the discharge from these cells has not yet been commissioned. For the most part of 2021, no discharge from the final cell of the ICW system (cell 7) has been recorded.

The total cell base area of the ICW system is approximately 1.58 Ha (15,800m^2).

3. Storm Water Management Capacity of ICW System

3.1. General

The analysis and design undertaken in support of the planning application for the ICW system indicates that in order to achieve a sustainable storm water management and polishing regime within the ICW system, then the minimum required retention period within the system is 20 days – i.e. a minimum of 20 days with respect to a unit of storm water runoff discharging to Cell 1 of the ICW system and discharging from Cell 7 of the ICW system to the receiving watercourse.

The ability of the ICW system to achieve a minimum retention period of 20 days is a function of the storm water runoff catchment area discharging to the system and the particular rainfall amount in any 24 hour period.

As illustrated in *Figure 1* above, and following proposed storm water drainage upgrading works, storm water discharge to the ICW system shall be generated from the Connolly's Red Mills facility site northern catchment area and southern catchment area, which for the majority comprise hardstanding roof and external yard areas of approximately 3.4 Ha (34,000m^2) and 3.23 Ha (32,300m^2) respectively. Considering a composite storm water runoff co-efficient of 0.80, the effective storm water runoff total catchment area discharging to the ICW system is:

(34,000 + 32,300) x 0.80 = 53,040m^2 (5.304 Ha).

As a baseline scenario, and in consideration of a daily average rainfall amount of 2.25mm applicable to this particular geographical location, the volume of storm water runoff discharge from the effective total catchment area to the ICW system is approximately:

(53,040 x 2.25/1000) = 119.3m^3.

Under normal operational circumstances, and in consideration that the ICW system operates on a plug-flow reactor basis, an average water depth of 0.35m shall be continually maintained within each ICW cell, thereby equating to a volumetric capacity of approximately 5530m^3 within the overall ICW system.

In consideration of the baseline scenario storm water runoff discharge volume of 119.3m^3, a retention period of approximately 46 days would be achieved within the ICW system, which is in excess of the minimum required retention period of 20 days.

In consideration of a daily rainfall amount of 5mm, the volume of storm water runoff discharge from the effective total catchment area to the ICW system would be approximately 265m^3. In this scenario a retention period of approximately 20 days would be achieved within the ICW system, which as discussed previously is the minimum required retention period required in order to achieve a sustainable storm water management and sustainable polishing regime within the ICW system. Therefore, when daily rainfall amounts at the location of the facility site are forecast, measured or predicted to exceed 5mm, an ICW storm water management system shall be implemented as detailed in *Section 4* below.

As summarised and presented in *Section 3.2* below, the ICW system has the capacity to retain and manage significant volumes of storm water runoff that may be generated from the Connolly's Red Mills facility site.

The storm water management capacity of the ICW system presented above is in specific consideration of the facility site northern and southern catchment areas as illustrated in *Figure 1* above. With respect to future development proposals at this facility site (proposed grain stores, grain dryers, marshalling yard and associated site works – Kilkenny County Council Planning Ref: P.21/573), storm water runoff generated from this future development proposal shall be managed at source via a combination of storm water infiltration systems and limited to existing pre-development greenfield runoff rates via storm water attenuation. Storm water runoff from this future development proposal shall therefore not impact the hydrological, hydraulic or storm water management capacity or regime of the ICW system.

3.2. ICW System Storm Water Retention Capacity

As illustrated in *Figure 2* below, the individual cells within the ICW system are designed in consideration of a normal operational water depth of 0.35m within each cell of the system.

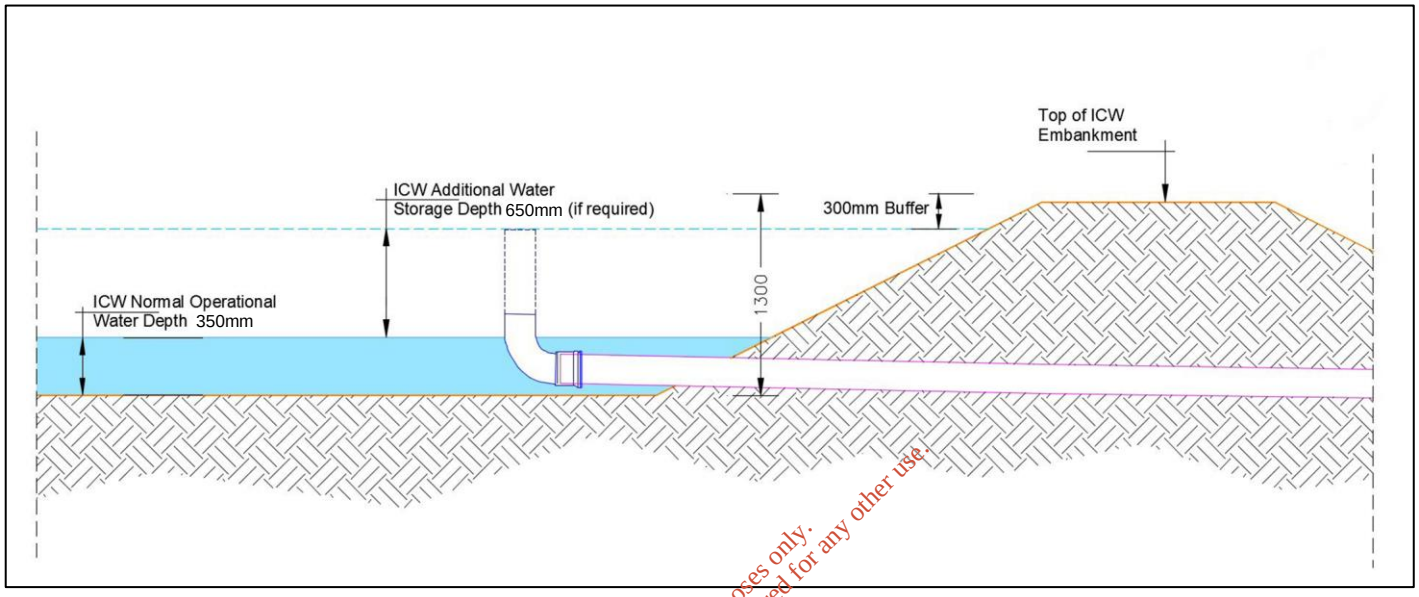


Figure 2

The total surface area of the cells within the ICW system is approximately 15,800m^2. In consideration of the above average operational water depth of 0.35m, the ICW system provides a storage volume of approximately 5530m^3.

Dependant on rainfall amounts the volume of storm water runoff from the catchment area discharging to the ICW system can vary, and in this scenario the additional water storage depth within the wetland system is utilised via adjusting the ICW system pipework system which shall be undertaken as part of the overall on-going management and maintenance of the system as detailed in *Section 4* below.

As illustrated in *Figure 2* above, the additional storage volume that can be provided within the ICW system, if required, is approximately (15,800m^2 x 0.65m) = **10,270m^3**.

In consideration of the occurrence of a 1% AEP (1 in 100 year) 60 minute duration rainfall event, Met Éireann data for this geographical location indicates a rainfall amount of 27.3mm. In this scenario the volume of storm water runoff from the Connolly's Red Mills facility effective catchment area that may discharge to the ICW system would be approximately **1448m^3**.

Therefore, when required, the ICW system can provide significant retention capacity to manage and retain various storm water runoff volumes that may be generated from the Connolly's Red Mills facility site and to account for rainfall amounts than will occur directly onto the surface area of the ICW system.

4. ICW System Management & Maintenance Regime

As presented above, under normal operating circumstances the ICW system shall maintain a continual water depth of approximately 350mm within each cell of the system. However, prior to, during or following the occurrence of forecast, measured or predictive daily rainfall amounts in excess of 5mm, the additional available retention capacity of the ICW system will need to be utilised in order to achieve the minimum required retention period of 20 days within the system.

As presented in *Section 3.1* above, in consideration of a 5mm daily rainfall amount, the potential volume of discharge to the ICW system would be of the order of 265m^3, which equates to an inflow to and outflow from the ICW system of approximately 3 l/s.

As illustrated on *Drawing Number IE2383-002-A*, *Appendix A,* in order to assist in the management and maintenance of the ICW system, suitable flow measurement devices shall be installed at the storm water inlet to ICW cell 1 and discharge from ICW cell 7. In addition static water level staff measurement gauges shall be installed at suitable locations within each cell of the ICW system.

In this regard, and as summarised below, the ICW system shall be managed and maintained in consideration of the following scenarios, i.e. Scenario 1 where daily rainfall amounts are less than 5mm and Scenario 2 where daily rainfall amounts are greater than 5mm.

Scenario 1 – Normal Operating Circumstances

1. Daily Observations

   The ICW system shall be visually inspected on a daily basis and a log kept of each daily inspections. Daily inspections shall include observation of inflow to and outflow from each ICW cell, check on water levels within each ICW cell via recording of staff gauge measurements, recording of flow meter measurements of storm water discharge to ICW cell 1 and discharge from ICW cell 7, noting any signs of potential contaminated storm waters and noting any defects in the ICW system such as excessive weed growth, vegetation die-off or ICW embankment or pipework defects. The daily log shall also record the forecast, recorded or predictive rainfall amount in millimetres.

2. Weed Control

Weeds can be used as indicators of ICW system performance and to predict required maintenance requirements. Consideration will be given in the ICW management programme as to the extent of weed control and whether weeds should or should not be allowed to proliferate. It should be noted that weeds are not necessarily detrimental to the overall ICW treatment processes, however weeds are not normally regarded as an important component of the treatment process.

Appearance of weeds can be an indication of poor water level control, with most weeds appearing when pond water levels are low. When required and when conditions permit, weed control shall be undertaken by periodically flooding the ICW cells to a depth greater that the normal operational depth of 350mm to a depth 450-500mm for short periods in the region of 4-5 days.

Chemical based weed killers shall not be used to control weeds in the ICW environment as these can affect non-target aquatic plants, micro-organisms and water quality.

Weed control inspections shall be included as part of the daily observations listed in 1. above.

3. Pest Control

The range of pests which can affect an ICW system include birds, flies, mosquitoes, rats and rabbits, however a well-managed ICW system should not experience any significant pest control issues.

Stagnant areas in an ICW system can promote fly and mosquito breeding zones and these can be controlled by temporarily flooding the particular stagnant area.

Burrowing animals can cause damage to earth embankments, particularly before a vegetation growth is established on the embankments. If burrowing damage becomes a problem then installation of close mesh fencing maybe required, or aggressive hunting, trapping or poisoning in accordance with appropriate guidelines may be necessary.

As part of the daily observations listed in 1. above, an inspection of any defects to the ICW or issues attributed to pest shall be identified and acted upon where required.

Scenario 2 – Daily Rainfall Amount in Excess of 5mm

1. Water Level Control

   Where the flow measurement devices at the storm water inlet to ICW cell 1 or discharge from ICW cell 7 record flows in excess of 3 l/s the following water level control procedures shall be implemented:

   - The interconnecting adjustable pipes between each cell of the ICW system shall be upturned in order to increase the water depth in the ICW system to approximately 450mm-500mm.
   - Water levels in each cell of the ICW system shall be observed and recorded via staff gauge readings following a 24 hour period.
   - Following a 24 hour period the adjustable outlet pipe from the last cell of the ICW system (cell 7) shall be upturned or adjusted as the required so as to ensure the outflow from cell 7 of the ICW system does not exceed 3 l/s.
   - At subsequent 24 hour periods the interconnecting pipes between each cell of the ICW system shall be adjusted as necessary until water levels within the overall ICW system return to normal operational water depths of approximately 350mm within each ICW cell.

In order to operate the Scenario 2 management and maintenance regime as summarised above, Connolly's Red Mills will implement all necessary health and safety requirements and undertake appropriate health and safety risk assessments as deemed necessary.

5. Proposals for the Establishment & Setting of Trigger Values

At present, only storm water runoff generated from an effective catchment area of approximately 10,080m^2 within the Connolly's Red Mills facility site discharges to the ICW system.

Proposed storm water drainage upgrading works will result in a storm waters generated from a total effective catchment area of approximately 53,040m^2 discharging to the ICW system.

At present, the ICW system is significantly oversized in consideration of the current catchment area discharging storm waters to the ICW system. In this regard storm water discharge from the last cell (cell 7) of the ICW system to the receiving watercourse only occurs on a sporadic basis and is directly related to daily rainfall amounts. In effect, due to the significant retention capacity of the ICW system and the evapotranspiration offered by the vegetation within the system at present storm water discharge from the ICW system only occurs during or following significant or high intensity rainfall events.

In this regard, sufficient data is not currently available from which suitable trigger values in relation to storm water discharge from the ICW system can be established or set.

The following is therefore proposed in order to provide sufficient data in order to establish and set suitable trigger values in relation to storm water discharge from the ICW system.

1. Baseline Monitoring

    - Following completion of the proposed storm water drainage upgrading works grab samples shall be obtained from the outflow pipe at the last cell (cell 7) of the ICW system on a monthly basis for a period of 12 months or until such time as a minimum number of 20 No. suitable grab samples are obtained.
    - Each grab sample shall be laboratory analysed for the following parameters:

      Biochemical Oxygen Demand (BOD) mg/l

      Chemical Oxygen Demand (COD) mg/l

      Ammonia (N) mg/l

      Orthophosphate (P) mg/l

      Total Suspended Solids (mg/l)

2. Setting Trigger Values

Following completion of the baseline monitoring as presented above, appropriate trigger values for the above parameters shall be set in accordance with the EPA document *'Guidance on the Setting of Trigger Values for Storm Water Discharges to Off-Site Surface Waters at EPA IPPC And Waste Licensed Facilities'.*

The assessment, rationale and proposals for setting appropriate trigger values and a proposed Response Programme, shall be submitted to the EPA within 2 months of obtaining results of the final baseline monitoring data as presented above.

6. Impact of Discharge from ICW System

As presented above, the ICW system shall be managed and maintained to achieve a minimum retention period of 20 days and on the basis that the maximum discharge from the ICW system shall not exceed 0.003m^3/s (3 l/s).

In order to access the impact of storm water discharge from the ICW system in the receiving watercourse a Mass Balance assessment has been undertaken. The Mass Balance assessment has been undertaken in consideration that the River Barrow is the primary receiving watercourse in respect of storm water discharge from the ICW system and, for the purposes of this assessment, has been undertaken in consideration of the discharge parameters of COD, Ammonia and Ortho-Phosphate.

6.1. Assessment of Flows in the Receiving Watercourse

The 95%ile flow in the River Barrow at the point of discharge from the ICW system was acquired utilising the EPA's online Hydrometrical Data System. The full output report from the EPA Hydrometric Data System is presented in *Appendix B*.

As presented in the output report the 95%ile flow in the River Barrow at the location of the proposed discharge is estimated as 5.758m3/s.

The catchment area of the River Barrow upstream of the discharge location is estimated at approximately 2523.5km2, and predominately comprises agricultural lands with smaller areas of urban development.

6.2. Background Physico-Chemical Quality of Receiving Watercourse

The current status or classification of the receiving watercourse is 'Good' under the Water Framework Directive (WFD). As part of an on-going surface water monitoring program undertaken by Connolly's Red Mills water samples from the River Barrow are obtained and laboratory analysed on a regular basis from a point just upstream of the ICW system site as illustrated on *Drawing Number IE2383-002-A, Appendix A*.

Table 1 below lists results of the laboratory analysis for the parameters of COD (Chemical Oxygen Demand), Ammonia and Ortho-phosphate analysed at this upstream location on the River Barrow at various dates between 2010 and 2021.

(Note:- Laboratory analysis results for the parameter of Orthophosphate are only available for 8 No. sampling periods between 2011 and 2021. COD is only available for 1 No. sampling period in 2021. Where a laboratory analysis result lists < for any parameter, then the upper quartile of that parameter result is utilised).

Date	COD (mg/l O_2)	Ammonia (mg/l N)	Ortho-P (mg/l P)
31-08-2010	11.00	0.01	-
24-02-2011	13.00	0.05	0.03
15-06-2011	17.00	0.01	0.05
25-01-2012	19.00	0.01	0.05
17-05-2012	25.00	0.01	0.05
20-10-2012	19.00	0.06	-
16-06-2016	4.00	0.10	-
12-04-2017	9.00	0.01	-
27-07-2017	17.00	0.13	-
19-12-2018	18.00	0.7	-
29-06-2018	19.00	0.34	-
05-07-2019	15.00	0.06	-
17-05-2021	26.5	0.025	0.02
15-07-2021	-	0.11	0.03
25-08-2021	-	0.03	0.03
22-09-2021	-	0.03	0.03
Average	***16.35***	***0.11***	***0.036***

Table 1 – Physico-Chemical Quality of Receiving Watercourse

6.3. Quality of Storm Water Discharge from ICW System

As presented previously, the ICW system has been designed and constructed in order to provide an environmentally sustainable means of managing storm water runoff from the overall Connolly's Red Mills facility site prior to discharge to the receiving watercourse.

In particular the ICW system is intended to provide a means of storm water treatment and polishing as may be required and, if required, to provide a means of capturing, isolating and managing any potential future instances or sources of pollution that may inadvertently or accidentally discharge to the storm water drainage system within the Connolly's Red Mills facility site.

The ICW system is not intended for nor will be utilised to manage or treat any trade effluents or industrial or domestic wastewaters. Only storm water runoff from hardstanding roof areas and external yard areas will discharge to the ICW system. As illustrated on *Drawing Number IE2383-002-A, Appendix A*, all storm water discharge from the Connolly's Red Mills facility site shall pass through a Class 1 Bypass Separator prior to discharge to the ICW system. Therefore, under normal operating circumstances, no significantly polluted or contaminated storm water runoff is expected to discharge to the ICW system.

As part of the assessment undertaken in support of the original planning application submission for the ICW system, a risk assessment was however undertaken in order to assess the likely storm water treatment and polishing capacity of the ICW system in consideration of the occurrence of a theoretical pollution incident and on the basis of a minimum retention period of 20 days within the ICW system.

This assessment considered the scenario that a pollution incident could occur at any location or combination of locations within the overall Connolly's Red Mills facility site and is therefore applicable for the purposes of this IEL application submission. The assessment was based on the scenario that significantly polluted storm water runoff with characteristics comprising COD – 5410mg/l, Ammonia – 13.5 mg/l (N) and Orthophosphate – 10.2 mg/l (P) would discharge to the ICW system, and the subsequent ability of the ICW system to treat and polish the storm water runoff was estimated by applying a plug-flow reactor model analysis. The output of this assessment indicated that, on a worst case scenario and in consideration of the occurrence of a theoretical pollution incident (as per the characteristics listed above), the treatment and polishing capacity of the ICW system and hence the quality of storm water discharge from the last cell of the ICW system would be as listed below:-

COD – 48.90 mg/l

Ammonia – 1.07 mg/l (N)

Orthophosphate – 0.35 mg/l (P)

For the purpose of this impact assessment, the above 'worst case scenario' parameters are therefore utilised in consideration of the storm water discharge quality from the ICW system.

6.4. Mass Balance Assessment

The Mass Balance is calculated using the following Formula:

$$C_{new} = (C_{back} \times Q_{back} + C_d \times Q_d) / (Q_{back} + Q_d)$$

Where:

C_{new} = resultant concentration in the receiving watercourse (mg/l)

C_{back}= the background concentration of pollutants in the receiving watercourse upstream of the discharge (as per **Table 1** above)

Q_{back}= the 95%ile flow in the receiving watercourse upstream of the discharge (**5.758m^3/s**)

C_d = the worst case scenario concentration of the pollutant in the discharge from the ICW system

Q_d= the discharge flow from the ICW system (**0.003m^3/s**)

Table 1 below summarises the results of the Mass Balance assessment, and lists the background concentration (C_{back}) and resultant concentration (C_{new}) in the receiving watercourse due to the storm water discharge from the ICW system in consideration of the parameters of COD, Ammonia (N) and Orthophosphate (P). For reference *Table 5* also lists the 2009 Surface Water Regulations Good Status Standards for the parameters of Ammonia (N) and Orthophosphate (P).

Summary Mass Balance output calculations are presented in *Appendix C.*

Parameter	C_{back} *(mg/l)*	C_{new} *(mg/l)*	*Good Status Standard (mg/l) -2009 Surface Water Regulations*
COD (mg/l)	16.35	16.36	Not Listed
Ammonia (mg/l N)	0.11	0.11	0.140
Orthophosphate (mg/l P)	0.03	0.03	0.075

Table 2 – Mass Balance Results

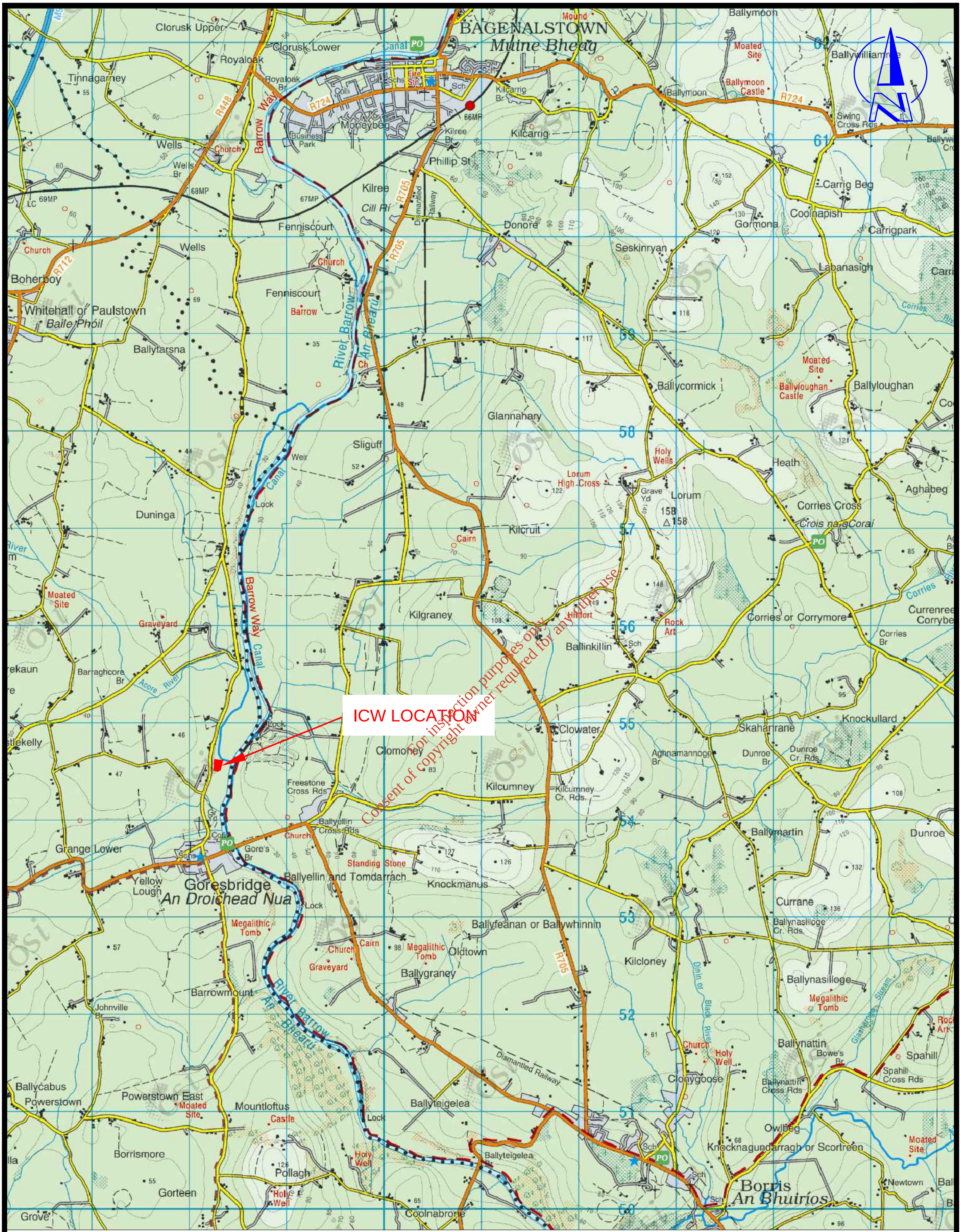
As summarised in *Table 2* above, the impact of storm water discharge from the ICW system to the receiving watercourse (River Barrow) is not predicted to result in an adverse impact to the existing physico-chemical quality of the watercourse.

Appendices

Appendix A.

IE2383-001-A (Regional Location Map)

IE2383-002-A (ICW Layout Plan)



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Project Title:	Connolly's Red Mills - ICW Assessment
Project Address:	Goresbridge, Co. Kilkenny
Client:	Connolly's Red Mills
Drg. Title:	Regional Location Map

Dwg.Scale:	Date:	Dwg.No:	Job No:	Revision:	Dwg.By:
1:50000	11-11-21	IE2383-001	IE2383	A	LM

RIVER BARROW UPSTREAM SAMPLING LOCATION

ICW CELL 7

ICW CELL 6

ICW CELL 5

ICW CELL 4

ICW CELL 3

ICW CELL 2

ICW CELL 1

CELL 6 STAFF GAUGE

CELL 4 STAFF GAUGE

CELL 2 STAFF GAUGE

CELL 1 STAFF GAUGE

CELL 3 STAFF GAUGE

CELL 5 STAFF GAUGE

CELL 7 STAFF GAUGE

EXISTING INTEGRATED CONSTRUCTED WETLAND SYSTEM

EXISTING INTEGRATED CONSTRUCTED WETLAND SYSTEM

LOCATION OF OUTLET FLOW MEASUREMENT

MONITORING CHAMBER

EMERGENCY SHUT OFF VALVE

DISCHARGE TO ICW SYSTEM

CLASS 1 BYPASS SEPARATOR

LOCATION OF INLET FLOW MEASUREMENT

CR

RIVER BARROW

0.27

0.28

27.1

0.73

26.9

0.90

Tree screening

Consent of copyright owner required for any other use. For inspection purposes only.

ICW SITE LAYOUT
SCALE 1:500

LEGEND

rev.	date	amendment	drn	ckd
A	24.11.21	ISSUED FOR IEL APPLICATION	LMc	PMS

Connolly's
RED MILLS

INTEGRATED CONSTRUCTED WETLANDS SYSTEM AT LOWER GRANGE GORESBRIDGE

GENERAL ICW SITE LAYOUT PLAN

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

CARLOW OFFICE:
INNOVATION CENTRE
GREEN ROAD
CARLOW, R93 W248

NEWRY OFFICE:
1 RDC HOUSE
WIN BUSINESS PARK
NEWRY, BT35 6PH

file location:	N:\IE2383\DRAWINGS	scale:	1:500 @ A3
drawing status:	IEL APPLICATION	datum:	MALIN
		drawn:	LMC
drawing no.	rev	checked:	PMS
IE2383-002	A	approved:	PMS
		date:	24.11.2021

Appendix B.

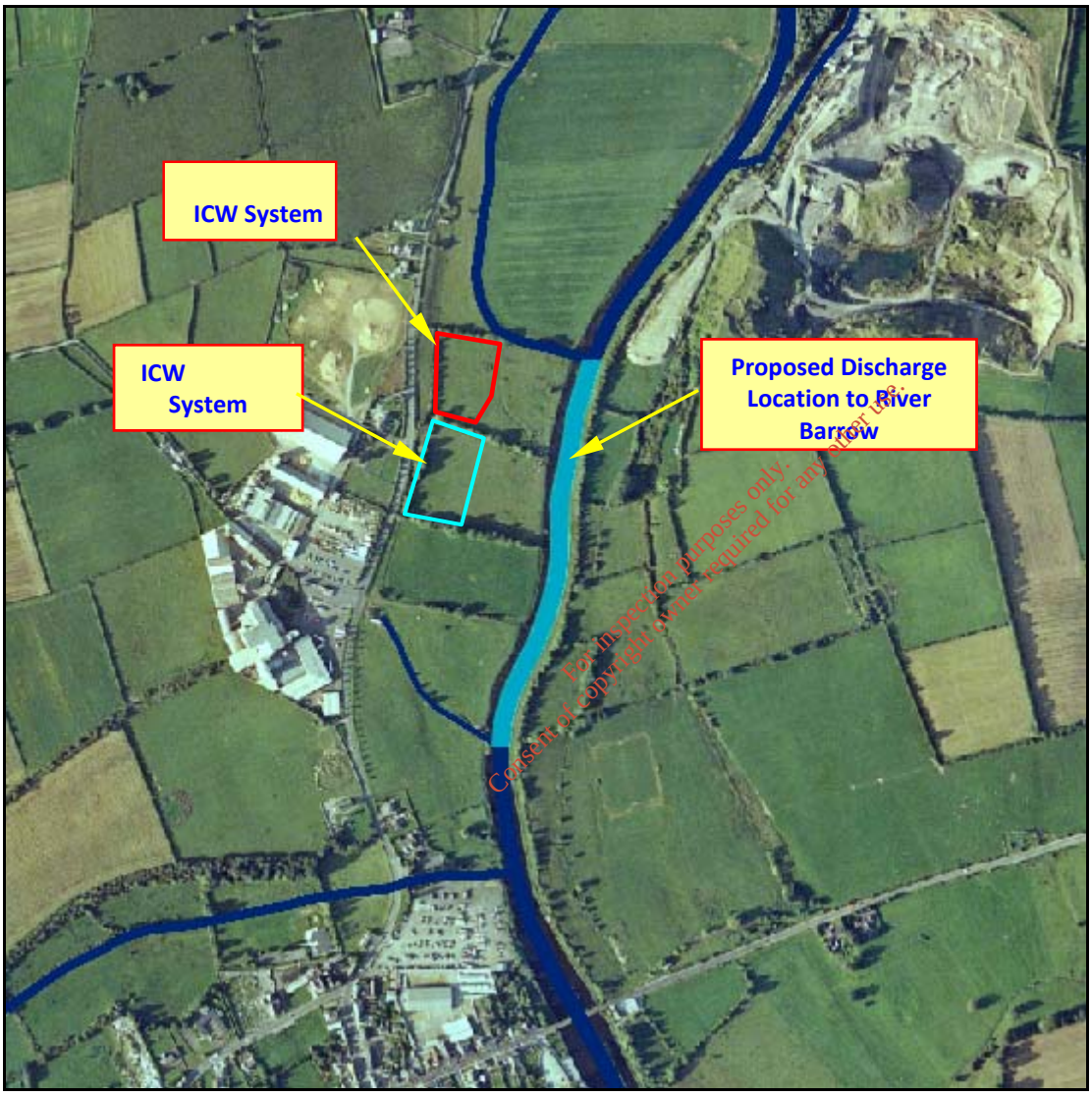
River Barrow 95%ile Flow

Environmental Protection Agency

Estimation of Flow Duration Curve for Ungauged Catchment

River Name	Barrow(14_217)
XY Location	268421,154416 (ING)

River Segment Map



Disclaimer
The source hydrometric data used to estimate the flow duration curve ordinates for ungauged catchments was obtained from (1) water level data and (2) the rating curve(s) generated for each hydrometric station. The Environmental Protection Agency and the Office of Public Works used these data, respectively, to calculate daily mean flows. The daily mean flows were then used by the Environmental Protection Agency to prepare flow duration curves for each station. Neither body accepts any liability for the subsequent handling of the data.

Environmental Protection Agency

Disclaimer

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The user should familiarise himself/herself with the catchment being studied and confirm that the ungauged site is in a natural catchment where flows conditions are suitable for the use of the model.

It is strongly recommended that the user examine the catchment descriptors contained in the report produced and confirm that the percentages of the various constituent elements are comparable to a natural catchment.

If the flow in a catchment is not entirely natural, the estimation of flows using the model in these catchments could be affected due to:

- existence of local conduit karst within the catchment;
- the selected location itself is on local conduit karst;
- regulation of the river flow on the river channel (e.g. power station, sluice gates etc)
- impacts of abstractions upstream of the selected location or the impact of the discharge associated with the abstraction into the same/different catchment;
- estimates of flow being sought at locations effected by storage effects at, or near, lake outfalls;
- lack of similar catchments with observed flows, ie where catchment descriptors lie outside the range of available gauging station catchments (e.g. the catchment area is under 5 km^2);
- any other special circumstances that may affect river flows.

Expert judgement will be required to ensure that the estimate of flow is not unduly affected by any of these influences.

Please note that the model does not provide estimates of flood peaks and, specifically, should not be used for that purpose.

The EPA has also prepared estimates of DWF and long term 95 percentile flows which are also presented on the EPA web site. These data are presented at http://www.epa.ie/whatwedo/monitoring/water/hydrometrics/data/

The data produced by the model for specific stations should be compared to the data contained in this file of DWF and long term 95percentile flows.

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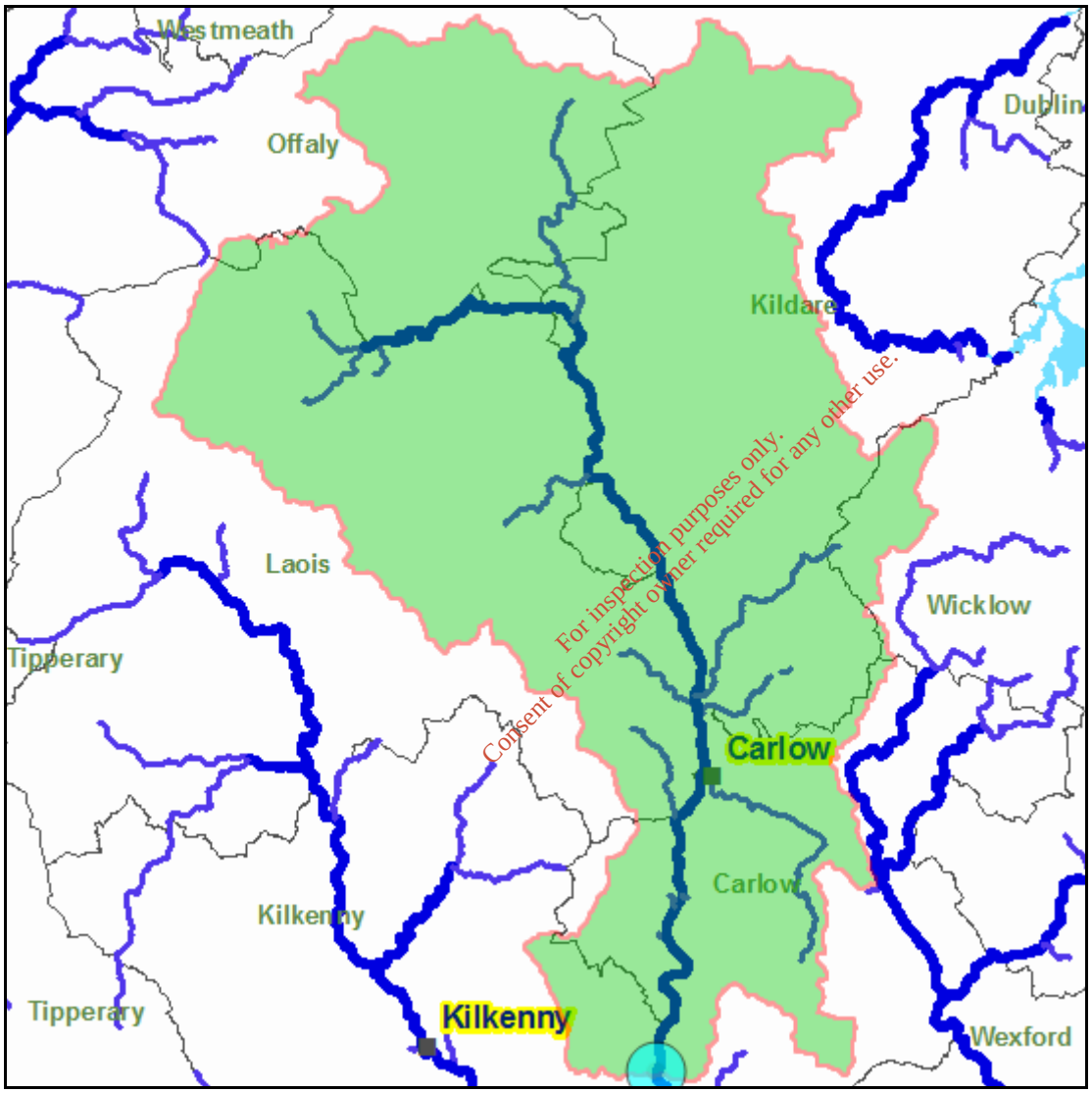
Environmental Protection Agency

Estimation of Flow Duration Curve for Ungauged Catchment

River Name	Barrow(14_217)
XY Location	268421,154416 (ING)

Nested Catchment Map

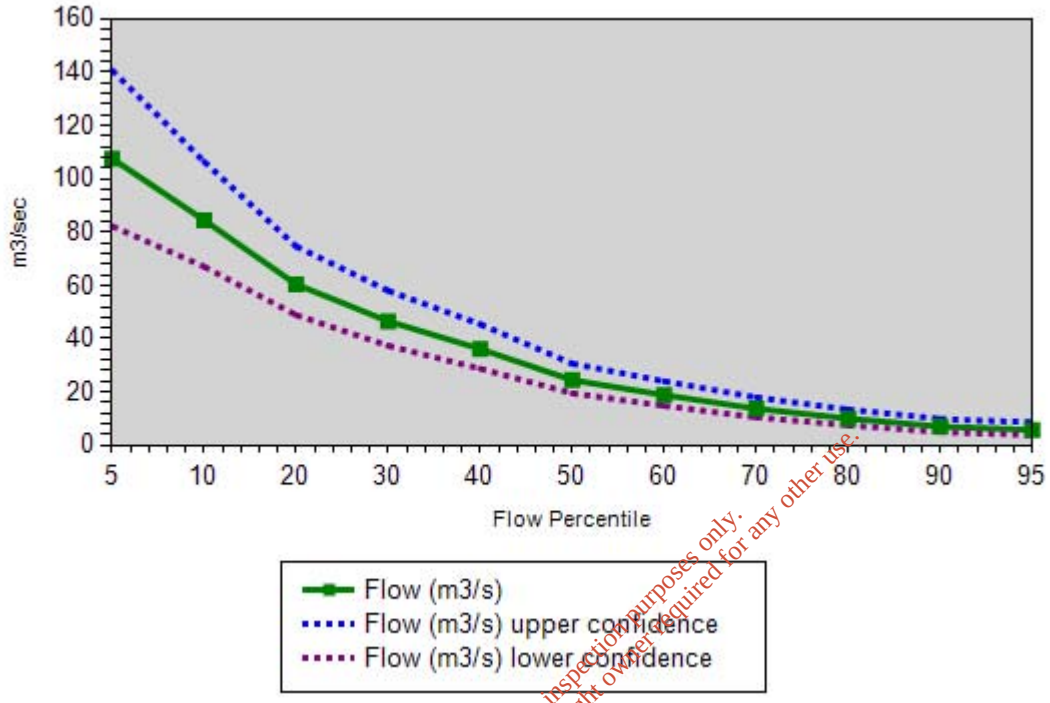


Disclaimer
The source hydrometric data used to estimate the flow duration curve ordinates for ungauged catchments was obtained from (1) water level data and (2) the rating curve(s) generated for each hydrometric station. The Environmental Protection Agency and the Office of Public Works used these data, respectively, to calculate daily mean flows. The daily mean flows were then used by the Environmental Protection Agency to prepare flow duration curves for each station. Neither body accepts any liability for the subsequent handling of the data.

Environmental Protection Agency

Estimation of Flow Duration Curve for Ungauged Catchment

Flow Duration Curve (Flow in m3/sec)



%ile	flow(m3/sec)	upper 95% confidence limit m3/sec	lower 95% confidence limit m3/sec
5	107.555	140.682	82.228
10	84.444	106.4	67.019
20	60.375	74.623	48.847
30	46.54	57.989	37.352
40	36.145	45.434	28.755
50	24.47	30.661	19.529
60	18.872	24.024	14.825
70	13.754	17.977	10.523
80	10.076	13.451	7.547
90	7.037	9.936	4.984
95	5.758	8.636	3.838

Environmental Protection Agency

Estimation of Flow Duration Curve for Ungauged Catchment

Catchment Descriptors		
General		
Descriptor	**Unit**	**Value**
Area	sq km	2523.5
Average Annual Rainfall (61-90)	mm/yr	862
Stream Length	km	1848.9
Drainage Density	Channel length (km)/catchment area (sqkm)	0.7
Slope	Percent Slope	2.8
FARL	Index (range 0:1)	1

Soil	
Code	**% of Catchment**
Poorly Drained	23.5
Well Drained	47.6
Alluvmin	5.6
Peat	22.2
Water	0
Made	1.2

Disclaimer
The source hydrometric data used to estimate the flow duration curve ordinates for ungauged catchments was obtained from (1) water level data and (2) the rating curve(s) generated for each hydrometric station. The Environmental Protection Agency and the Office of Public Works used these data, respectively, to calculate daily mean flows. The daily mean flows were then used by the Environmental Protection Agency to prepare flow duration curves for each station. Neither body accepts any liability for the subsequent handling of the data.

Subsoil Permeability		
Code	**Explanation**	**% of Catchment**
H	High	16.5
M	Moderate	46.8
L	Low	20.5
ML	Moderate/Low	0
NA	No Subsoil/Bare Rock	16.2

Aquifer		
Code	**Explanation**	**% of Catchment**
LG_RG	LG:Locally important sand-gravel aquifer RG: Regionally important sand-gravel aquifer	14.5
LL	Locally important aquifer which is moderately productive only in local zones	35.5
LM_RF	LM: Locally important aquifer which is generally moderately productive RF: Regionally important fissured bedrock aquifer	6.7
PU_PL	PU: Poor aquifer which is generally unproductive PL: Poor aquifer which is generally unproductive except for local zones	17.2
RKC_RK	Regionally important karstified aquifer dominated by conduit flow	0
RKD_LK	Regionally important karstified aquifer dominated by diffuse flow	25.5

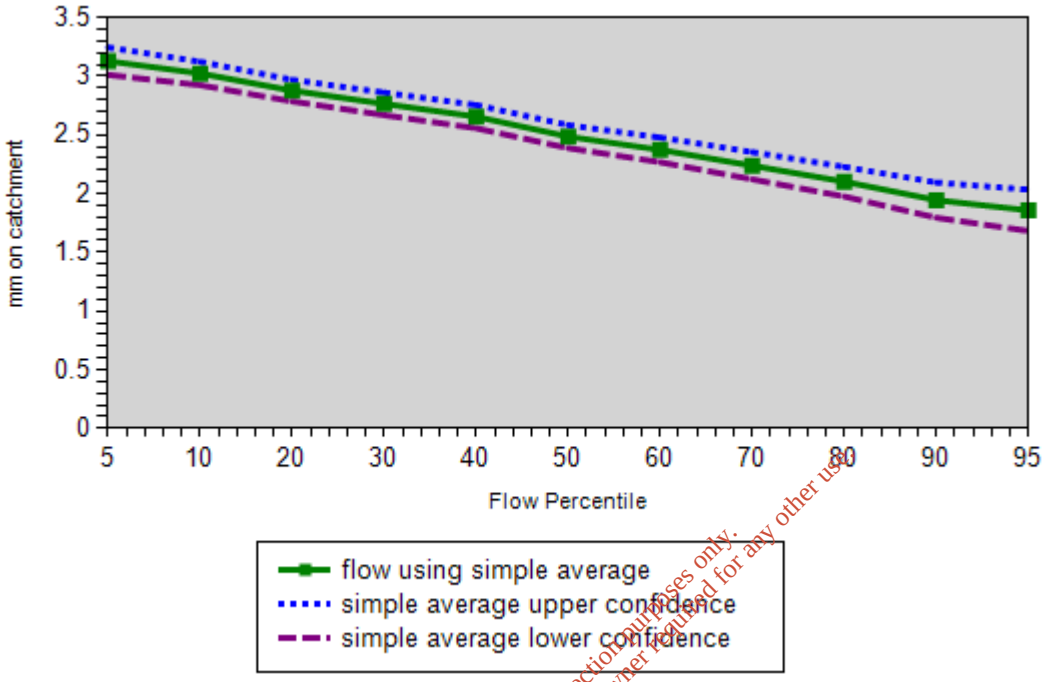
Stations in Pooling group			
%ile Flow	**Station 1**	**Station 2**	**Station 3**
5	07012	15006	07009
10	07012	15006	07009
20	07012	15006	07009
30	07012	15006	07009
40	07012	15006	07009
50	07003	14019	07009
60	07003	14019	07009
70	07003	14019	07009
80	07003	14019	07009

90	07003	14019	07009
95	07003	14019	07009

Environmental Protection Agency

Estimation of Flow Duration Curve for Ungauged Catchment

Flow Duration Curve (mm on catchment)



Log Flow (mm on catchment)			
%ile	mm	upper 95% confidence limit	lower 95% confidence limit
5	3.129	3.246	3.012
10	3.024	3.124	2.924
20	2.878	2.97	2.786
30	2.765	2.861	2.669
40	2.656	2.755	2.557
50	2.486	2.584	2.388
60	2.373	2.478	2.268
70	2.238	2.354	2.122
80	2.102	2.228	1.976
90	1.945	2.095	1.795
95	1.858	2.034	1.682

Appendix C.

Mass Balance Assessment – Summary Calculations

IE2838 - Connolly's Red Mills - COD Mass Balance Assessment

Q_{95} = 5.758 m3/s

Cback = 16.35

ICW Discharge Concentration = 48.9 **mg/l**

Q_{95} = 95-percentile flow in m^3/s

Discharge from ICW = **259.2** **m^3/day** (0.003m3/s)
= 259200 **l/day**
= 12.675 **Kg/day**

Mass Balance - Resutling COD Concentration in the Receiving Watercourse

$$C_{new} = \frac{c_{back}q_{back} + c_d q_d}{q_{back} + q_d}$$

c_{back} = 16.35 c_d = 48.9

q_{back} = 497491200 q_d = 259200

C_{new} = 16.36695 mg/l **Resultant Concentration in Receiving Watercourse**

where,

C_{new} = Resutling COD Concentration in the Watercourse (mg/l)

c_{back} = Background COD Concentration in Receiving Watercourse

c_d = COD Concentration in the ICW storm water discharge

q_{back} = 95 percentile flow in receiving watercourse

q_d = discharge fow from ICW system

IE2838 - Connolly's Red Mills - Ammonia Mass Balance Assessment

Q_{95}	=	5.758	m3/s		Q_{95} = 95-percentile flow in m^3/s
				ICW Discharge Concentration =	
Cback	=	0.11		1.07	mg/l

Discharge from ICW	=	259.2	m^3/day	(0.003m3/s)
	=	259200	l/day	
	=	0.277	Kg/day	

Mass Balance - Resutling Ammonia Concentration in the Receiving Watercourse

$$C_{new} = \frac{c_{back}q_{back} + c_dq_d}{q_{back} + q_d}$$

c_{back} =	0.11	c_d =	1.07
q_{back} =	497491200	q_d =	259200

C_{new} = 0.11050 mg/l **Resultant Concentration in Receiving Watercourse**

where,

C_{new} = Resutling Ammonia Concentration in the Watercourse (mg/l N)

c_{back} = Background Ammonia Concentration in Receiving Watercourse

c_d = Ammonia Concentration in the ICW storm water discharge

q_{back} = 95 percentile flow in receiving watercourse

q_d = discharge fow from ICW system

IE2838 - Connolly's Red Mills - Orthophosphate Mass Balance Assessment

Q_{95}	=	5.758	m3/s		Q_{95} = 95-percentile flow in m^3/s
				ICW Discharge Concentration =	
Cback	=	0.03		0.35 mg/l	

Discharge from ICW	=	259.2	m^3/day	(0.003m3/s)
	=	259200	l/day	
	=	0.091	Kg/day	

Mass Balance - Resutling Orthophosphate Concentration in the Receiving Watercourse

$$C_{new} = \frac{c_{back}q_{back} + c_d q_d}{q_{back} + q_d}$$

c_{back} =	0.03	c_d =	0.35
q_{back} =	497491200	q_d =	259200

C_{new} = **0.03017** mg/l **Resultant Concentration in Receiving Watercourse**

where,

C_{new} = Resutling Orthophosphate Concentration in the Watercourse (mg/l N)

c_{back} = Background Orthophosphate Concentration in Receiving Watercourse

c_d = Orthophosphate Concentration in the ICW storm water discharge

q_{back} = 95 percentile flow in receiving watercourse

q_d = discharge fow from ICW system