Glaslough – Castle Leslie
Integrated Constructed Wetland

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Abstract: *The Glaslough pilot Integrated Constructed Wetland (ICW) is part of a unique initiative by the Department of Environment Heritage and Local Government (DEHLG) in treating liquid waste streams in shallow vegetated ponds. It is a co-operative undertaking by Monaghan County Council (MCC), Castle Leslie Estate, DEHLG, and the University of Edinburgh.*
The wetland treats the sewage from the village of Glaslough in North Monaghan and has a design capacity of 1750 Population Equivalent (pe). The current load is approximately 700 pe. No pre-treatment is carried out. The influent is pumped directly to a receiving pond. Thereafter the liquid flows by gravity through 5 number sequential vegetated ponds and the effluent discharges directly to the Mountain Water River. The 'land-take' is leased from the Trustees of the Castle Leslie Estate. Equestrian riding trails are incorporated on the banks of the ponds.
The ICW was constructed during 2006/2007 and became operational on October 2007. Monitoring equipment (flow meters, automatic sampler, lysimeters etc) was installed in each of the ponds. Early results are very encouraging with effluent quality, during the first year of operation, consistently surpassing the quality of the receiving Mountain Water River. The system can robustly cope with large variations in volumetric and Biological Oxygen Demand (BOD) loadings of the influent. There is a significant cost saving in the construction and maintenance of the ICW compared with traditional sewage treatment plants in the county.
The extensive monitoring work being undertaken at Glaslough ICW will help promote the ICW concept and its application to a range of water quality management issues such as leachate (from landfills), sewage sludges, drinking water source protection and flood amelioration (SuDS).

Introduction

Glaslough is a historic village located some 10 km NE of Monaghan town and has developed around the renowned Castle Leslie and the picturesque Glaslough Lake. This paper describes the background, construction and early operation of the Glaslough – Castle Leslie Pilot Integrated Constructed Wetland (ICW), which has been constructed to treat domestic sewage effluent from the village of Glaslough. This project is part of a unique initiative by the Department of Environment Heritage and Local Government (DEHLG) in treating liquid waste streams in shallow vegetated ponds. It is a co-operative undertaking by Monaghan County Council (MCC), Castle Leslie Estate, DEHLG, and the University of Edinburgh.

Background

The sewerage collection system serving the village of Glaslough is combined foul sewer and up to 2001 delivered flows to a small treatment works (dating back to the 1940s) consisting of primary settlement tanks, a single pass biological filter and a humus tank. The effluent from the plant discharged to the nearby Glaslough Stream, a tributary of the Mountain Water River.

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By the 1990s the plant was heavily overloaded and a manifestly poor quality of effluent was being produced, leading to prosecution of MCC by the Eastern Regional Fisheries Board (ERFB).

In 2001 the sewerage system was extended and a temporary package plant, supplied by FM Environmental, was installed with the treated effluent now discharging directly to the Mountain Water River. By early 2003 the FM plant was in turn 'experiencing difficulties' leading to further written complaints from the ERFB.

At this time Consulting Engineers, Nicholas O'Dwyer & Partners (NOD), had prepared a Preliminary Report for the construction of a traditional plant with a design capacity of 350 population equivalent (pe) and a final effluent standard of 20/30 (BOD/SS). The preliminary estimated cost (in October 1989) was IR£205,000. By January 2002 the design capacity had been revised upwards to 650 pe and the cost estimate had risen to €950,000. (Applying construction cost inflation this equates to an estimated 2008 cost of €1,530,000 for a traditional plant of 650 pe capacity).

Integrated Constructed Wetlands (ICWs)

In May 2003 Dr Rory Harrington of the Heritage Service of the DEHLG and Paul Carroll of Waterford County Council gave a presentation in Monaghan on the use of ICWs in the Anne Valley in Waterford. By allowing liquid waste streams (from a variety of sources) to flow sequentially through a number of vegetated ponds, ICWs (through a combination of physical, chemical and biological processes) have the capacity to produce a high quality effluent. In the Anne Valley, during the 1990s a number of on-farm ICWs had been constructed to treat farmyard dirty water. An ICW had also been constructed to treat domestic effluent from the village of Dunhill. Prior to 1990 the water in the Annestown Stream was of very poor quality with little or no fish life. Today the quality of the Annestown Stream is approaching good quality status and sea trout have returned to the stream after an absence of many years.

Nearby in Kimeaden a large ICW covering 10 hectares was successfully treating large quantities of liquid waste from the Kilmeaden food plant.

In August 2003 Mark Johnston and the author accompanied Samantha (Sammy) Leslie on a field trip to the Anne Valley, hosted by Dr Harrington. As a landowner/developer the support of Sammy Leslie was essential. She was enthusiastic about the ICW concept from the outset and on her return she contacted the Sunday Times - resulting in an article by Scott Millar, in support of ICWs, being published on 31st August 2003. Sammy subsequently played a vital role in convincing the Trustees of Castle Leslie to approve a land lease and allow the ICW to be constructed within the Estate Walls.

Integrated Constructed Wetland Concept

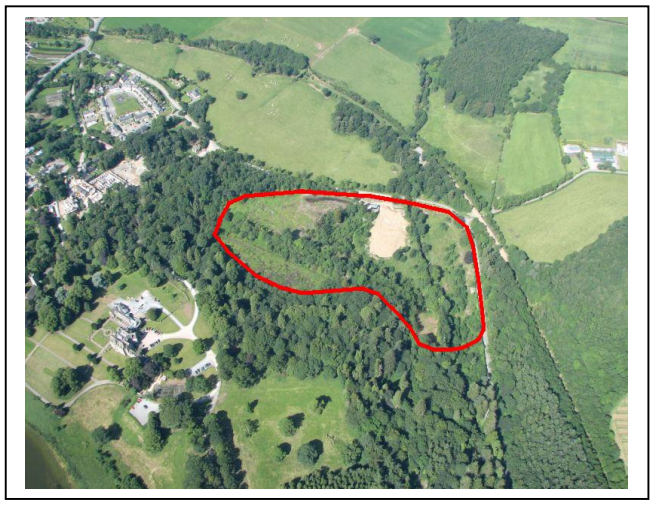
In Ireland over the past 10 years, the National Parks and Wildlife Service of DEHLG has been uniquely developing a more robust and sustainable approach to the use of constructed wetlands. Categorised as surface-flow type wetlands they are similar to natural free surface water wetlands. Their holistic approach termed 'Integrated Constructed Wetland' (ICW) has been successfully applied to deal with a range of effluent types - farmyard runoff, industrial waste and sewage.

The concept is based upon the free surface-flow of water through a series of sequential linked shallow ponds vegetated with a range of emergent plant species. While the footprint of the ponds is relatively larger than that usually used for similar hydraulic loadings in “reed bed” type systems they are generally less costly to build, easier to maintain and consistently deliver better quality water. An ICW has often a long retention time of up to 90-100 days and it can be designed in many instances to have zero surface dischargeIt’s diversity of plant species facilitates microbial and animal diversity and is generally more appealing for recreation and amenity. Due to the slow movement of water through the ponds suspended matter is deposited, and there is adequate time for both aerobic and anaerobic digestion of organic matter. There is good reduction of nitrates and phosphates which are generally greater than 95%. Reduction of fecal indicators is of the order of 99% due to the long retention times and the complex ecology of the aquatic system. ICWs also remove endocrine disrupters such as estrogen and testosterone which are poorly removed with conventional wastewater treatment systems. An ICW effectively creates the important nexus between quality, quantity and amenity in a way that no other traditional Sewerage Treatment Works can.

In rivers phosphates are the controlling pollutant. High levels of phosphate create algal blooms which deplete the oxygen level and kill off fish and invertebrates. The level of Molybdate Reactive Phosphorus set out in the Consultation Paper on Environmental Objectives (Surface Water) Regulations 2008 in river water body is 0.025 mgP/l for High Status and 0.035 mg p/l for Good Status. Therefore effluent from Glaslough ICW with MRP of 0.02mg/l is excellent.

Design, Land Lease and Planning

From 2004 onwards Dr Harrington frequently made the long trip from Waterford to Monaghan. The proposed site, located within the estate walls on the banks of the Mountain Water River and surrounded by woodland, demanded sensitive development in terms of landscape fit, biodiversity, amenity and habitat enhancement.



ICW Site in Castle Leslie

With input from Rory Harrington, Mark Johnston and the author a design and pond layout emerged. The design capacity was 1750 pe. (The current loading is approximately 700 pe). This allowed a 'footprint' map to be drawn up and negotiations to commence on a 99 year lease of the 6.74 hectares (ha) of land required. (The water surface of the constructed ponds measures 3.25 ha.) The lease agreement included the provision of equestrian riding trails on the banks of the wetland ponds. Figure 1 shows the layout of ICW.

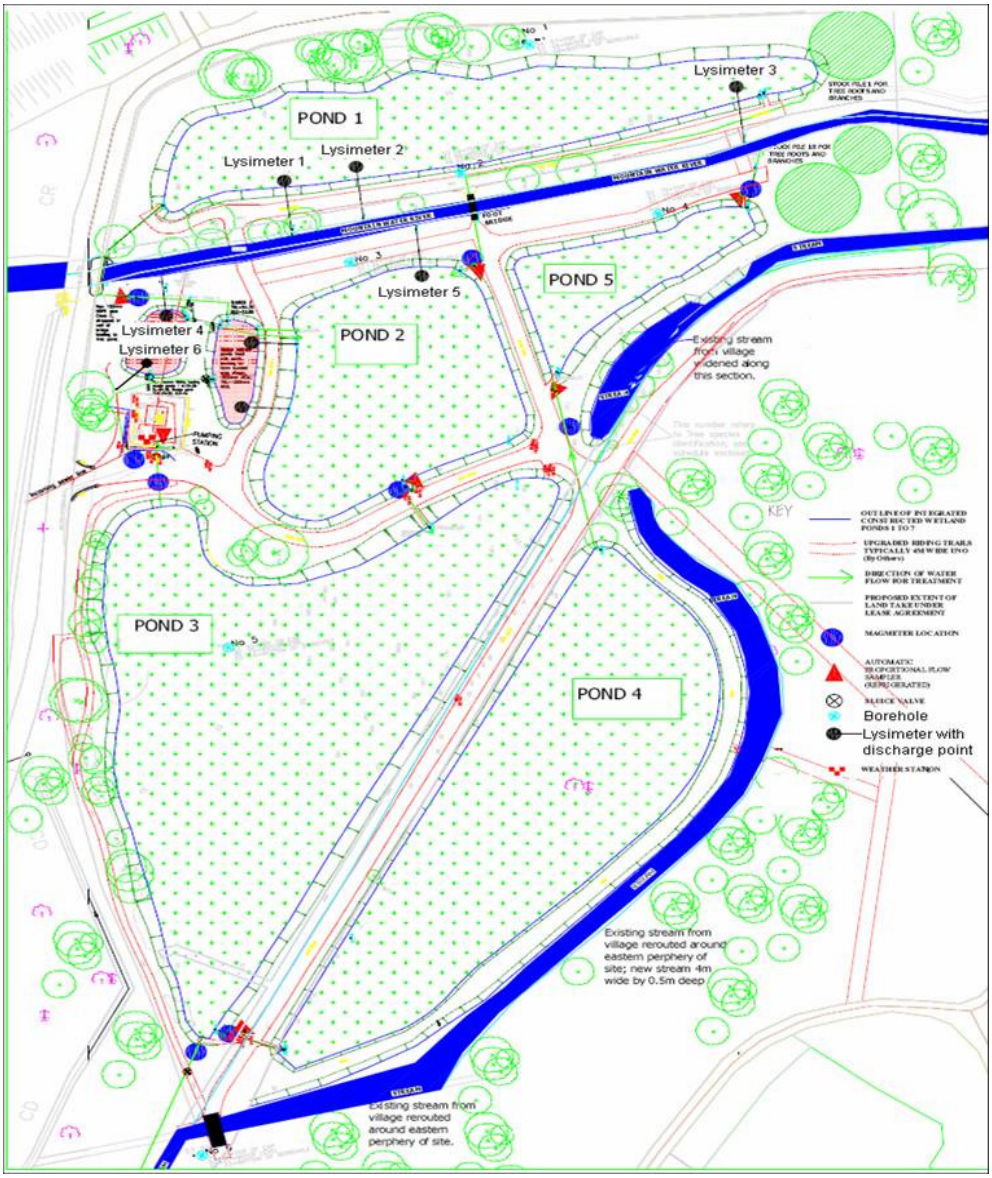


Figure1 - Layout Map of ICW

Site investigation works were carried out by IGSL in September 2005.

GSI Ground Vulnerability Maps, prepared by the Geological Survey of Ireland (GSI), indicate that the site is located in an area of low vulnerability to groundwater contamination.

A Part 8 Planning Application was submitted on 8th July 2005 and Planning Permission was granted on 5th September 2005 (Planning Ref 05/8008)

A land lease agreement was signed with the Trustees in September 2006 at an up-front cost of €233,000 (incl. legal fees) and a nominal annual fee thereafter.

A total of six piezometers were installed (by hydraulic excavator) to allow groundwater around and under the wetland system to be monitored.

Tender drawings and documents were prepared (by Mark Johnston) and advertised in the National Press and e-tenders website on 29th September 2005. The tender documents were not comprehensive in that the extent of the riding trails to be provided was still under negotiation with Castle Leslie. Likewise requirements for sampling and monitoring equipment were still being considered. And furthermore, subsequent to tender, an opportunity arose to secure approximately 5,000m^3 of boulder clay material from construction work on the nearby N2 Bypass of Monaghan town. This allowed the area of the initial receiving ponds to be raised and avoided secondary pumping across the Mountain Water River.

The successful tenderer was Eamon Sherry Plant Hire Ltd, a local contractor, who regularly features on MCC's Annual Tender List.

Site Clearance, Construction and Planting

The chosen site, within the estate walls and straddling the Mountain Water River, presented a number of construction difficulties – not least being the felling of trees and removal of tree roots within the affected area. A tree survey was carried out by Land Survey Services (Joe Finlay MSIF) during April 2005. A tree felling licence (No. 4775) was granted to Castle Leslie by the Department of Agriculture on 13th May 2005. The majority of good quality trees along the estate walls and the river were retained.

Tree felling commenced in September 2005 with commercial timber being stockpiled for use or sale by Castle Leslie. A hydraulic wood chipping machine proved of limited success in dealing with tree roots. Roots and wood debris were subsequently stockpiled on site creating a wildlife habitat.

When the lease was signed earthworks commenced in October 2006 and, following a winter break, continued through 2007. The photographs below give a good indication of the construction process.

Pond 1 –April 2007

Pond 1 – May 2007

Pond 5 – May 2007

Installing Lysimeter - May 2007

Planting, using a variety of wetland species, was carried out by Aila Carty, VESI Environmental, Little Island, Cork. Planting commenced in November 2006 and continued through 2007. During dry spells water was pumped from the river to prevent the plants drying out.

Pond 1 – November 2007

Pond 1 – April 2008

Pond 1 – November 2008

Pond 5– November 2008

Ductwork, cabling and sampling and monitoring equipment (as described below) were installed in Summer/Autumn 2007.

The ICW system was commissioned on 26th October 2007. The temporary FM plant was decommissioned and taken off site.

Finishing works (including hardcore surfacing of riding trails) were completed during 2008.

Sampling and Monitoring.

While the ICW concept is essentially a low-tech and low maintenance system of water cleansing the ICW at Glaslough does include a substantial suite of hi-tech sampling and monitoring equipment:

- Computer-linked Siemens Magmeters record all significant flows into, within and out of the wetland system.
- These are linked to automatic samplers, which sample the liquid as it progresses through the system.
- Eight Lysimeters installed before construction of the wetland ponds give an 'upper-limit' indication of infiltration through the subsoil. [Note: Site Investigation work by IGSL in September 2005 indicated a soil coefficient of permeability of 9.07^{-11} metres/second].
- A computer linked weather station is located beside the inlet pump sump.
- Six piezometers allow the groundwater around and under the wetland system to be monitored.

As Constructed Layout (see Figure 1)

As stated above the 'land take' measures some 6.74 ha while the water surface of constructed ponds measures 3.25 ha. The design capacity is 1750 pe. with a current load of approx 700 pe.

No pre-treatment is carried out. The influent is pumped directly to the receiving pond using a mascerator pump. There are two such receiving ponds which can be used alternately to allow for desludging (on an annual basis). Thereafter the liquid flows by gravity through five sequential vegetated ponds and the effluent discharges directly to the Mountain Water River.

Refinements to the original layout included the following:

- The Glaslough Stream, which originally flowed ***through*** the site, was diverted (and substantially widened) around the perimeter of Pond 4, with the excavated material being used to construct the banks of Pond 4. By slowing the flow in the stream and planting with wetland plants an improvement in water quality in the stream (which is otherwise independent of the wetland system) will be achieved.
- A dam was constructed upstream with a valved and metered pipeline installed to link with Pond 3. This allows the wetland system (Ponds 3, 4 & 5) to be kept hydrated in

prolonged dry spells when the volume of influent would evaporate before reaching the outfall.

- A valved and metered pipeline was installed linking Pond 3 back into the inlet pump sump. This allows partially treated liquid to be recirculated through the system. This will be the subject of further study in 2009.
- Two footbridges were constructed – a steel bridge across the Mountain Water River and a smaller wooden bridge across the widened Glaslough Stream linking the banks of Pond 4 with Castle Leslie.

Capital Costs

The total Capital Cost of providing and constructing the Glaslough ICW (including land lease and monitoring equipment) is **€770,000 including VAT.** This is made up as follows:

Item No	**Item Description**	**€ Cost (incl. VAT)**
1.1	Land Lease (incl. legal fees)	**233,000**
2.1	Preliminary Items (site survey, tree survey, aerial photos, site investigation, tree clearance etc)	27,000
2.2	Earthworks, Pipework & Planting (E Sherry & A Carty)	206,000
2.3	Hardcore riding trails	115,000
2.4	2No footbridges	35,000
	Sub-total(2)	**383,000**

	Monitoring	€
3.1	Comm. ducting, manholes etc	48,000
3.2	Broadband connection	4,000
3.3	Lysimeters	3,000
3.4	Siemens Magmeters & Samplers	90,000
3.5	Weather Station	2,000
3.6	Marker posts & signs	3,000
3.7	Piezometers	4,000
	Sub-total (3)	**154,000**
	Total Capital Cost (1 +2+3)	**€770,000**

In addition MCC have entered a contract with Edinburgh University to provide one full time and one part time PhD student to conduct research on the project under the direction of Dr Miklas Scholz at a total cost of some €165,000 over 3 years.

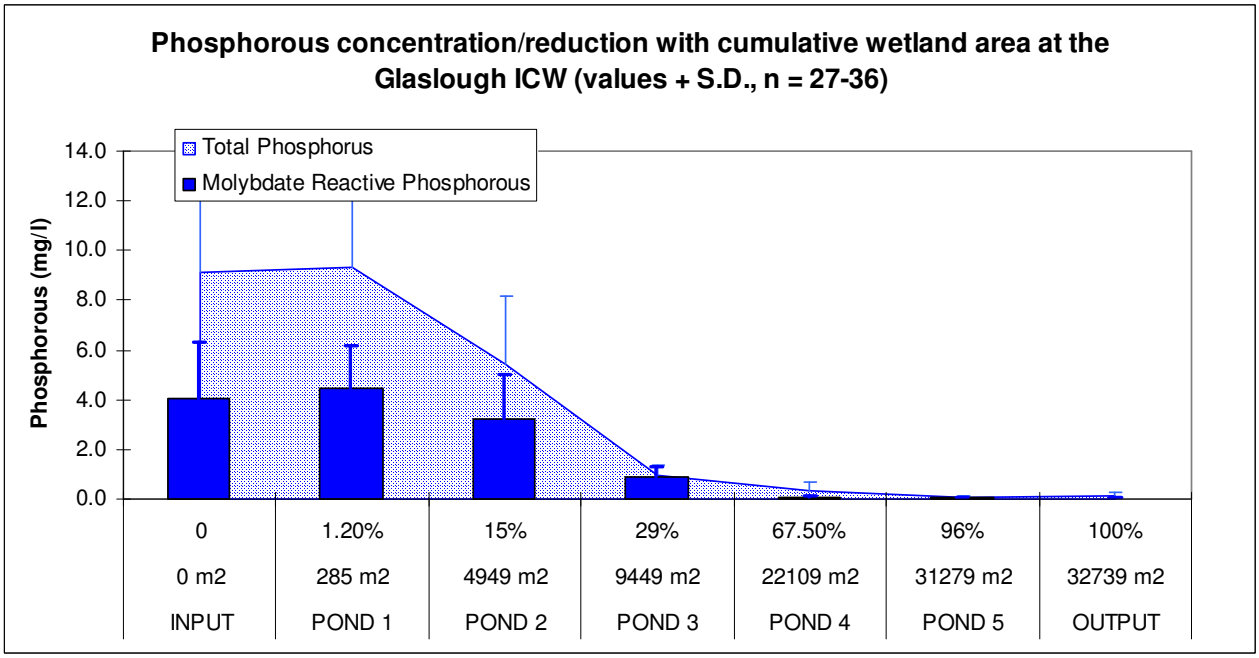
Results

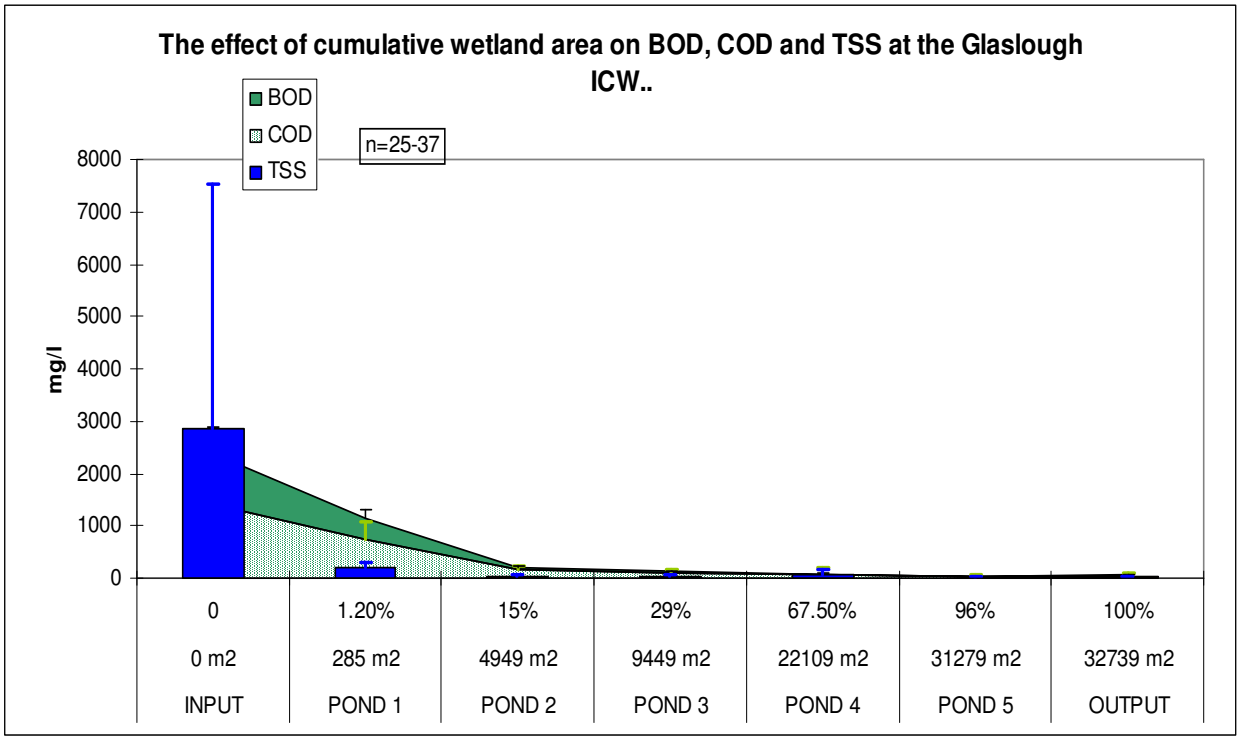
Early results for Glaslough ICW are summarised in Tables 1and 2 and on the attached graphs. These are very encouraging with effluent quality, during the first year of operation, consistently matching the quality of the receiving Mountain Water River. The system can robustly cope with large variations in volumetric and Biological Oxygen Demand (BOD) loadings of the influent.

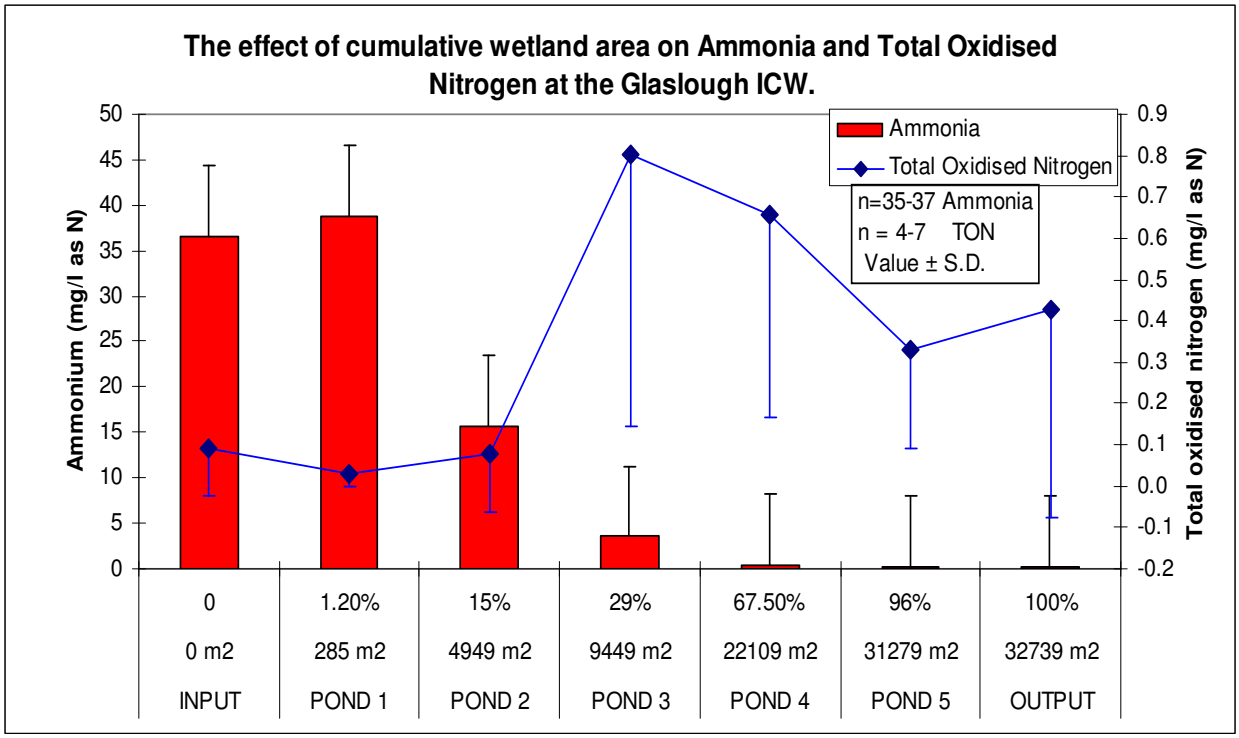
Parameter	*Influent (mg/l)*	*Effluent (mg/l)*	*Removal Efficiency (%)*	*UWWD* (mg/l)*
BOD_5	*997*	*6.4*	*99.4*	*25*
COD	*1444*	*45*	*97*	*125*
TSS	*2952*	*18*	*99.4*	*35*
Total N	*50*	*0.4*	*99.2*	*15*
Total P	*9.23*	*0.14*	*98.5*	*2*
Ammonia	*36.7*	*0.23*	*99.4*	
Nitrates	*5.5*	*0.4*	*93*	
MRP	*4*	*0.02*	*99.5*	

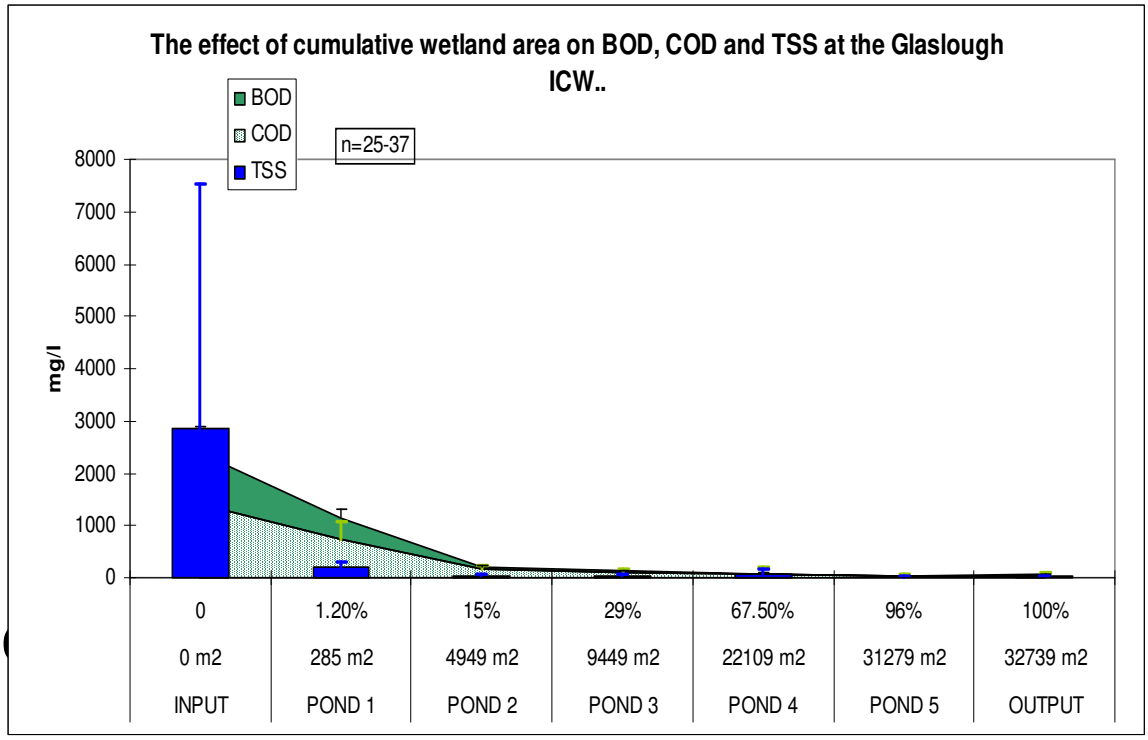
Table 1 - Performance of Glaslough ICW

**UWWD = Urban Waste Water Directive*




The effect of cumulative wetland area on BOD, COD and TSS at the Glaslough ICW..
BOD
COD
TSS
n=25-37
mg/l
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0 m2
INPUT
1.20%
285 m2
POND 1
15%
4949 m2
POND 2
29%
9449 m2
POND 3
67.50%
22109 m2
POND 4
96%
31279 m2
POND 5
100%
32739 m2
OUTPUT


The effect of cumulative wetland area on Ammonia and Total Oxidised Nitrogen at the Glaslough ICW.
Ammonia
Total Oxidised Nitrogen
n=35-37 Ammonia
n = 4-7 TON
Value ± S.D.
Ammonium (mg/l as N)
Total oxidised nitrogen (mg/l as N)
50
45
40
35
30
25
20
15
10
5
0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
0
0 m2
INPUT
1.20%
285 m2
POND 1
15%
4949 m2
POND 2
29%
9449 m2
POND 3
67.50%
22109 m2
POND 4
96%
31279 m2
POND 5
100%
32739 m2
OUTPUT



	Glaslough		Mountain River		
Parameter	*Influent (mg/l)*	*Effluent (mg/l)*	*Upstream (mg/l)*	*Downstream (mg/l)*	*UWWD* (mg/l)*
BOD_5	*997*	*6.4*	*2.35*	*2.39*	*25*
COD	*1444*	*45*	*29.74*	*29.33*	*125*
TSS	*2952*	*18*	*0.51*	*0.61*	*35*
Total N	*50*	*0.4*	*3.47*	*2.73*	*15*
Total P	*9.23*	***0.**14*	*0.15*	*0.15*	*2*
Ammonia	*36.7*	*0.23*	*0.36*	*0.37*	
Nitrates	*5.5*	*0.4*	*0.91*	*0.88*	
MRP	*4*	*0.02*	*0.1*	*0.08*	

Table 2 - Quality of Receiving Water

UWWD = Urban Waste Water Directive

Comparison of recently constructed Emyvale and Glaslough Treatment Plants

In 2007 / 2008 two wastewater treatment plants were constructed in North Monaghan. The plant at Emyvale is an upgrading of the existing plant using a conventional treatment system. The Glaslough plant uses the ICW system. As the Emyvale Plant is only fully operational since November 2008 a comparison of the performance with Glaslough Plant is not meaningful at this stage

Cost Comparison
The estimated cost of a traditional treatment facility of 650pe capacity for Glaslough was **€1,530,000** at 2008 prices. Including the monitoring equipment costs (for additional research and development) and the cost of additional amenities including surfacing the horse riding trails etc, the **ICW provides approximately 3 times the pe capacity at half the price.**

The cost of upgrading the Emyvale Plant with a design of comparable capacity (pe of approximately 2000) was **€1,400,000**.

ICW Biodiversity and Amenity

The shallow emergent vegetation (and stable food supply) of the wetlands provides an ideal habitat for the microbes to go about their work. The microbial world is itself a fascinating, vital and little understood realm.

The long residence time (which is of the order of 80 days in Glaslough - indeed in dry spells there is no surface discharge at all) allows ample time for the necessary aerobic and anaerobic processes to occur and insulates the wetland system from the effects of shock loadings which would overwhelm a traditional plant.

The large footprint area required is sometimes quoted as a downside of ICWs. But in Glaslough the amenity value of the affected area has been greatly enhanced and complements the tourism-based activities of Castle Leslie and the equestrian centre. The detritus in the beds of the ponds provides a storehouse of carbon, phosphorous and other nutrients.

Horses using Riding Trail around the Ponds of ICW

The extensive monitoring work being undertaken at Glaslough ICW will help promote the ICW concept and its application to a range of water-quality management issues such as:

- leachate (from landfills).
- sewage & drinking water sludges.
- drinking water source protection.
- flood amelioration (SUDS).

Acknowledgments

I wish to thank the following for their support in this Castle Leslie ICW project:-

- Monaghan County Council (for supporting the project)
- Sammy Leslie (Castle Leslie)
- Miklas Scholz (University of Edinburgh)
- Eamon Sherry (Contractor)
- Aila Carty, (VESI Environmental)
- Paul Carroll and Sue Cook (Waterford County Council)

Footnote:
SEPA (The Scottish Environmental Protection Agency) recently published the Constructed Farm Wetlands Design Manual (prepared by Aila Carty). This can be accessed on the SEPA website:
http://www.sepa.org.uk/land/land_publications.aspx