Reanimating land-water interfaces and associated habitats using ‘Integrated Constructed Wetlands’

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VESI Environmental Ltd.
TOWARDS COHERENT LAND, WATER (and air) MANAGEMENT
ECOLOGICAL REANIMATION AND RESTORATION
INTEGRATING SOCIAL, ECONOMIC AND ENVIRONMENTAL NEEDS
CREATIVITY, INNOVATION AND ENTREPRENEURSHIP….What if?
SOME EXAMPLES AND PERFORMANCE
Leonardo Da Vinci

“Take thought, when you are speaking of water, that you first recount your experiences and only afterwards your reflections”
Inspired by ‘lost’ biotypes (habitat types) and ecosystem functional analyses

- Marshes, fens and bogs
- Forest/woodland
- Reanimation (restoration)
- Ecosystem dynamics
- Evolutionary biology

- Understanding human-generated impacts through an ‘ecosystem approach’

Earliest human Arctic occupation

Paleolithic records of humans in the Eurasian Arctic (above 66°N) are scarce, stretching back to 30,000 to 35,000 years ago at most. Pitulko et al. have found evidence of human occupation 45,000 years ago at 72°N, well within the Siberian Arctic. The evidence is in the form of a frozen mammoth carcass bearing many signs of weapon-inflicted injuries, both pre- and postmortem. The remains of a hunted wolf from a widely separate location of similar age indicate that humans may have spread widely across northern Siberia at least 10 millennia earlier than previously thought.

Science 15 Jan 2016:
Vol. 351, Issue 6270, pp. 260-263. DOI: 10.1126/science.aad0554
Shallow, emergent-vegetated wetlands:

impede water flow..........

and support bio-geochemical processes
Uses for wetland vegetation

Textiles from wetland vegetation

Contains phytol and coumarin: repels mosquitoes

Known in Ireland as ‘holy’ grass (*Hierocloe odorata*), in Poland it is known as ‘bison grass’, used in herbal medicine and in the production of distilled beverages (e.g., Żubrówka, Wisent)

St. BRIGID’S CROSS

Sources of food e.g. *Typha* pollen and rhizome starch
Wetland (and woodland) reanimation recognises that:

Water management is fundamentally a land use issue! (e.g. pollution, aquatic habitats)........

Land management is also a water use issue! (e.g. drainage, flooding)

Wetlands (and woodland) combine the two: facilitating each.... and air quality
REANIMATING WETLAND INFRASTRUCTURES ACKNOWLEDGES THE ROLES OF:

- Ecological reanimation and restoration (Biogeochemical science)
- Wetlands & ICWs
- Ecosystem Approach (social science, economics and ecological/environmental science)
- Law and Regulation (National law/regulation and EU Directives)
The need for ‘new’ economies

Optimal

Maximal

Multiple purpose/benefits

Single purpose/limited use
Starting in 1987/8, Annestown stream:

From a canalised dirty, weedy agricultural drain to one that now supports trout and salmon.
Reanimating wetland and riparian infrastructures

Cut & fill approach – using site characteristics and soils

Approx. 12.5 km of stream and tributaries re-profiled with in-stream & parallel interception- channels, and 22 ICWs treating point sources of pollution
ICW Embankments above flood-line

Forest establishment close to flood-line with internal drainage

Lower Annevalley, Co. Waterford
Integrated Constructed Wetland (ICW) concept explicitly integrates

Integrated Constructed Wetland (ICW)

Biodiversity

Water Management

Landscape fit
Integration provides robustness:
Dependable stable function, with positive synergies
Water’s vectored content

Discharge

Intercepted farmyard polluted water
(also sewage, landfill leachate, mine drainage, etc.)
Specific treatment requirements:

Adequate area (Area:Flow)

Hydraulic loading (Weather related flux flow)

ICW

Soil characteristics and depth

Soil permeability

Use of local or on-site soils:

Influent characteristics (ionic strength, ammonium-N)

Toxicity to vegetation: need for recycling?
Cross section of wetland showing key functional zones

<table>
<thead>
<tr>
<th>Stable anaerobic + $O_2$ zones + flow impedance</th>
<th>Water surface with preferential flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detritus zone</td>
<td>Aquatic zone</td>
</tr>
<tr>
<td></td>
<td>Root zone (Rhizosphere)</td>
</tr>
</tbody>
</table>

Emergent vegetation (Large leaf area index (LAI)) **High primary productivity**
Level areas with tall, dense emergent vegetation intercepting water flow ensures good hydraulic impedance.
Little or no effluent flow during dry weather
BASIC ICW HYDRAULIC MODEL

Wetland emergent vegetation
intercepting precipitation
(Typically 20-40%)

Precipitation

Wind speed, light & temperature
influencing evapo-transpiration
(Typically 120-200% of open pan transpiration)

Decreasing through-flow with increasing area

Cell 1
C.1x10^-10 m/s

Cell 2
C.1x10^-9 m/s

Cell 3
C.1 x10^-8 m/s

No or occasional surface discharge

Freeboard at each cell
delays through-flow,
especially during
heavy rainfall events

Influent
Wetlands with multiple cells (ICW)
Guidelines published December 2010 with contributions from:

Department of Agriculture, Fisheries & Food

Forest Service

Environmental Protection Agency

Central Fisheries Board

Eastern Regional Fisheries Board

Office of Public Works

County and City Managers’ Association

Department of Environment, Heritage & Local Government

National Parks & Wildlife Service

Éamon de Buitléar
ICW for farmyard wastewater - typically C. X2 area of yard and 1% of farm area
Construction of ICW for the treatment of municipal wastewater; Clonaslee, C. Laois
Glaslough Village sewage treatment, Co. Monaghan (Population equivalent = 1700)

A capital cost saving of c.70% and O&M saving of c.90%
Industrial use of ICW systems: Dunhill Enterprise Park

Storm-water & wastewater with separate pathways

Food and light industry factory

Meat processing factory
Tolka Valley Park ICW, Dublin City
Treating Landfill Leachate (A/B) & Mine Drainage (C/D)

A: Dungarvan
B: Dungarvan
C: Galmoy
D: Tara
Ammonia-N reduction from Galmoy Zn/Pb mine cap-drainage 2014/15
Sulphate reduction from Galmoy Zn/Pb mine cap-drainage 2014/15
New Challenges – AMD at Cu/Zn Somincor-Lundin mine, Portugal
SINGLE HOUSE POST-SEPTIC TANK ICW

- ICWs for single/multiple house septic tank
- No ‘discharge’ to adjacent stream
- Integrated into garden/surrounds (e.g. ‘parks’)

Self-evident performance
A role for trees and woodland to deplete surface water

15 year old Cushenstown wood Co. Wexford showing broadleaf forest establishment on internally (limited) drained ground

5 and 4 year old mixed forest/woodland in the Dunnhill/Annestown stream catchment showing integrated tree establishment on internally (limited) drained ground
Evaporation by forest and grassland basins (mm/yr) against annual rainfall

Tree canopy evapo-transpiration and their roots, increase (precipitation-) interception and soil-infiltration: delivering enhanced water balance and much reduced runoff

Hydrological pathways are shown on a forested hill-slope:
Adapted by NA Chappell from the original diagram by Nick Scarle published in Douglas (1977) Humid Landforms. MIT Press
Drainage increases flood risk: Wetlands attenuate
Anne Valley catchment:
Map shows the most significant reanimated wetlands in the Anne Valley catchment, including ICW systems

Catchment area = 2,500ha:

- 16 large (>1ha) integrated constructed wetland (ICW) systems
- C. 12.5 km re-profiled stream corridor
- C. 200ha forest plantation
- C. 20ha extant woodland
Anne Valley: 2 Municipal waste water & 6 of 14 Farmyard point sources each with ICW treatment
Sustained performance over time
# Bio-safety and ICW systems (coliform results (20/01/09)) - Glaslough ICW

<table>
<thead>
<tr>
<th>CELL NUMBER</th>
<th>SAMPLING POINT</th>
<th>ECOLI (Fecal Coliforms) per 100 mls</th>
<th>TOTAL COLIFORMS per 100 mls</th>
<th>ACCUMULATIVE PERCENTAGE OF ICW AREA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sludge pond</td>
<td>INLET</td>
<td>559950</td>
<td>&gt;1209800</td>
<td>1.2</td>
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<tr>
<td>1</td>
<td>INLET</td>
<td>86640</td>
<td>&gt;241960</td>
<td>15</td>
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<tr>
<td>2</td>
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<td>20924</td>
<td>48392</td>
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</tr>
<tr>
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<td>INLET</td>
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<td>1074</td>
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<tr>
<td>4</td>
<td>INLET</td>
<td>&lt;10</td>
<td>63</td>
<td>96</td>
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<tr>
<td>5</td>
<td>OUTLET</td>
<td>&lt;5</td>
<td>49</td>
<td>100</td>
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<tr>
<td>Mountain River Upstream</td>
<td>RIVER</td>
<td>698</td>
<td>2897</td>
<td></td>
</tr>
<tr>
<td>Mountain River Downstream</td>
<td>RIVER</td>
<td>429</td>
<td>2737.5</td>
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</table>

<table>
<thead>
<tr>
<th>Lab#</th>
<th>Location</th>
<th>Sample date</th>
<th>COD (mg/L)</th>
<th>Ammonia-N (mg/L)</th>
<th>MRP-P (mg/L)</th>
<th>NO3-N (mg/L)</th>
<th>NO2-N (mg/L)</th>
<th>ToxN (mg/L)</th>
<th>Cl (mg/L)</th>
<th>Total coli (/100ml)</th>
<th>E.coli (/100ml)</th>
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<tbody>
<tr>
<td>20160001</td>
<td>Dunhill ICW stormwater pond u/s of confluence with ww eff</td>
<td>04/01/2016</td>
<td>17</td>
<td>0.09</td>
<td>0.07</td>
<td>4.9</td>
<td>0.113</td>
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<tr>
<td>20160002</td>
<td>Dunhill ICW pond 5 effluent to SW pond</td>
<td>04/01/2016</td>
<td>45</td>
<td>5.8</td>
<td>0.95</td>
<td>&lt;0.1</td>
<td>0.009</td>
<td>&lt;0.1</td>
<td>32.5</td>
<td>2143</td>
<td>10</td>
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<tr>
<td>20160003</td>
<td>Dunhill ICW SW &amp; WW combind dischage to river</td>
<td>04/01/2016</td>
<td>28</td>
<td>2.4</td>
<td>0.42</td>
<td>2.8</td>
<td>0.308</td>
<td>3.1</td>
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<td>20160004</td>
<td>Annestown Stream at footbridge DS ICW</td>
<td>04/01/2016</td>
<td>25</td>
<td>0.24</td>
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<td>Dunhill ICW GW reference pond</td>
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<td>18</td>
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<td>0.04</td>
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<td>Annestown Stream Upstream of ICW outfall</td>
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<td>20160027</td>
<td>Annestown Stream Downstream of ICW outfall @ footbridge</td>
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<td>NT</td>
<td>0.18</td>
<td>0.17</td>
<td>5.6</td>
<td>0.057</td>
<td>5.7</td>
<td>33.9</td>
<td>NT</td>
<td>NT</td>
</tr>
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</table>
Performance improves with increasing wetland area
Bio safety achieved early in the treatment train
Cost of Integrated Constructed Wetland (ICW) systems

Typically 60 – 80% less than conventional WWT (including land cost)

Typically >90% less than conventional WWT
Scientific rigour

Experimental science approach:
• Replicated treatments
• Measurable dynamics of known and emerging contaminants
ICW Concept provides a platform for innovation in natural resource management

**Resources:**
- Biomass
- Bio-char
- Nutrient store
- Hydrocarbon-replacement
- New food crops
- Materials

**Services:**
- Water supply
- Nutrient capture
- Carbon sequestration
- Flood attenuation
- Recreation and amenity
- Biodiversity

*etc..........
Amenity & awareness values of ICWs

Window on river habitats and water quality
Recently enlarged Dunhill village ICW (operational - 12 July 2012)

‘Old’ (1999) ICW

Functional treatment area = 2670m$^2$

Newly extended (July 2012) ICW

Functional treatment area = 9678m$^2$

Total functional treatment area = 12348m$^2$ Flow/PE capacity = c.500)
Reconciling bridge between needs and wants

Societal needs
Clean Air, Water & Soil:
EU: WFD
BWD
UWWD
SD
Etc.
Ramsar (1971)
UN: EP
CBD
Climate change

Sectoral wants
Agriculture
Development:
Urban
Rural
Forestry:
Timber
Biomass
Fishing
Recreation
Nature conservation

Guidance
Awareness
Demonstration
European Commission - Press release

Closing the loop: Commission adopts ambitious new Circular Economy Package to boost competitiveness, create jobs and generate sustainable growth

Brussels, 2 December 2015

Today the Commission adopted an ambitious new Circular Economy Package to stimulate Europe's transition towards a circular economy which will boost global competitiveness, foster sustainable economic growth and generate new jobs.
ICWs sequester carbon, phosphorous and nitrogen
Improved biodiversity
Is change and implementation possible? ...What if? ...what if we do .......... what if we don’t?

What are the roles of leadership, regulation and demonstration.......?

Understanding what makes people respond:

Is there awareness or understanding....? Is there cohesion or differentiation......?
What values are held, is empathy possible...? What are the cultural or social drivers..........?
The ICW concept and its objective to obtain multiple benefits must not be overtaken by formulaic engineered approaches that might compromise its site-specific creative philosophy and scientific depth.

Where formulaic engineered solutions are often applied, opportunities to deliver on multiple benefits (SE&E) are often missed due to a ‘tick-the-box’ approach to design, whereby the ‘little boxes’ are filled-in and the concept lost……..
ACKNOWLEDGEMENTS

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• Paul Carroll and Sue Cook: Waterford Council, Ireland

Thank you for your attention