answer
Agricultural Need for Sustainable Willow Effluent Recycling

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ANSWER
(Agricultural Need for Sustainable Willow Effluent Recycling)

Use of Short Rotation Coppice (SRC) willow for the bioremediation of effluents and leachates: **Project Report**

ANSWER

(Agricultural Need for Sustainable Willow Effluent Recycling)
Project Report

July 2014

The ANSWER project was part-financed by the European Union's European Regional Development Fund through the INTERREG IVA Cross-border Programme managed by the Special EU Programmes Body.

The Project ran from November 2010 to December 2014.

There were seven partners:
Agri-Food & Biosciences Institute (AFBI) – Lead Partner
South West College
NI Water
ITSligo
Teagasc
Monaghan County Council
Donegal County Council

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INTRODUCTION

Water utilities in Ireland, Northern Ireland, Great Britain and many parts of Europe face significant challenges. There are numerous small rural Waste Water Treatment Works (WWTWs) dotted around the countryside. Although often they are only handling small volumes from dwellings with less than 500 People Equivalents (PEs) potentially seriously polluting effluent is being discharged throughout the year into neighbouring water ways, with negative impacts on water quality. In the vast majority of cases it is impractical and totally un-economic to upgrade these WWTWs in order to make them fully compliant. Other, cost-effective, environmentally safe and sustainable technologies for managing waste water are needed.

There are also many landfill sites of varying ages producing highly environmentally damaging leachate. On the more modern sites the leachate can be collected and transported to the nearest WWTWs that will take it. On older landfill sites, often already closed and capped there is still danger of leakage of leacahte to surrounding land and water ways. It is extremely expensive to treat leachates in WWTWs and they can have a detrimental effect on the efficiency of the normal biological processes within the works, which can limit the volumes that can be processed.

Many small and medium sized food processors e.g. potato processors, bakeries, apple processors etc. are producing relatively high volumes of low nutrient, but still potentially polluting effluents. Often these are being discharged in ways which could impact water quality. Many farm activities result in large volumes of farm waste water. While this can legally be applied to the land at certain times of the year alternative methods of disposing of it may be welcome.

When irrigated with a number of diverse effluents ranging from municipal, industrial, landfill and agricultural sources, Short Rotation Coppice (SRC) willow has been shown to be highly effective in preventing leaching to groundwater and / or run-off to surface water. ANSWER enabled the application of basic scientific research in order to establish commercial sized, proof-of-concept effluent irrigation schemes to SRC willow.

Re-sprouting willow plant after cutback

One year growth after coppicing

ANSWER

In 2009, in response to a call from INTERREG IVA a project proposal was submitted as part of the Environmental theme. The project was developed on work done as part of the RENEW (Renewable Energy Network for Environmental Welfare) in which the planting of Short Rotation Coppice (SRC) willow and its utilisation for heat production had been encouraged. The new project sought to add value to the growing SRC willow crop, using it for the potential bioremediation of effluents and leachates. There had been some experience in using willow in this way in Sweden with the highest profile scheme being in Enköping, a small town in central Sweden. The nitrogen rich wastewater from dewatering of sludge is irrigated to an adjacent 77 ha willow plantation. The willows are irrigated for about 120 days annually and 'treats' approximately 11 t N and 0.2 t P per year in an irrigation volume of 200,000 m^3. AFBI had conducted research over several years on the possibility of using willow to manage municipal wastewater in Northern Ireland which has a very different climate and growing season from Sweden. Data accumulated demonstrated that the application of even quite potent effluents to actively growing willow did not result in any contamination of groundwater or surface water. It was therefore proposed that this technology for managing wastewater should be subjected to proof of concept testing i.e. in fully commercial sized plantations being irrigated with effluent from currently non-compliant WWTWs.

Hence the ANSWER (Agricultural Need for Sustainable Willow Effluent Recycling) project was formulated. Four local councils / water utilities with responsibility for wastewater and landfill management were involved from the start and agreed to establish relatively large scale (> 10 ha) irrigation, 'Proof of Concept' schemes. It was recognised that while there was a robust scientific data set there were still many unanswered scientific questions about how to optimise the effectiveness of the technology while at the same time determining any secondary impacts. Hence alongside the Proof of Concept schemes there was a proposal to conduct some basic science investigations. Post-graduate students, and a post-doctoral researcher were recruited by science organisations AFBI and Teagasc and by ITSligo. One of the partners in the RENEW project was South West College (SWC) who had developed a significant expertise in using Geographic Information Systems (GIS) to map potential opportunities and so SWC were one of the original partners. INTERREG IVA encouraged the involvement of a Scottish partner. The original proposal therefore included the Scottish Agricultural College as well as an industrial partner who had an issue with the treatment of a high-nutrient wastewater. It had been hoped to involve an industrial partner to develop a sludge injector for the application of biosolids to the soil. The proposal was submitted to the Special EU Programmes Body and following an extensive Economic Appraisal conducted by the accountancy firm BDO the ANSWER consortium was successful in being granted funding for the project. However the industrial partners were not considered eligible to be involved in the project.

The project was titled ANSWER – Agricultural Need for Sustainable Willow Effluent Recycling. The title reflects the involvement of the agriculture industry as this is a land-based technology; the importance of finding alternative approaches to wastewater management which is environmentally safe and sustainable; the evidence that willow is the most suitable plant to be used in Ireland for bioremediation; and that a wide range of wastewater streams could potentially be handled in this way.

Funding

The ANSWER project was part-financed by the European Union's European Regional Development Fund through the INTERREG IVA Cross-border Programme managed by the Special EU Programmes Body (SEUPB). The total original budget was £2.1m allocated over nine partners.

Original partners and objectives

When the project proposal was first submitted the project partners were:

- Agri-Food & Biosciences Institute (AFBI) – Lead Partner
    - Management
    - Supervision of post-graduate students
- Northern Ireland Water
    - Establishment of two proof-of-concept effluent irrigation schemes
- South-West College (Cookstown)
    - Development of GIS mapping of resources and opportunities
- Cookstown District Council
    - Establishment of a landfill site irrigation scheme
- Donegal County Council
    - Establishment of a proof-of-concept effluent irrigation scheme
- Monaghan County Council
    - Establishment of a proof-of-concept effluent irrigation scheme
- Teagasc
    - Investigation of the issues of over-land flow
- ITSligo
    - Investigation of the impact of irrigation on biodiversity
- Scottish partners
    - Establishment of at least one industrial effluent irrigation scheme

Before the commencement of the project the Scottish partners had to withdraw because of match-funding issues. A short time into the project Cookstown District Council also had to withdraw, mainly due to changes in their approach to the management of leachate from their landfill site. The project was given permission to transfer the funding from Cookstown to Donegal County Council who agreed to do similar work on one of their landfill sites. And so the ANSWER project comprised seven partners with AFBI the lead partner.

Original partners at project launch:
(Front row l to r: Alistair McCracken (AFBI), Karen McDowell (NIW)
Ann Marie Duddy (ITSligo) Con McLaughlin (Donegal),
Back row l to r: David Richardson (Cookstown), Declan Ryan
(Teagasc), Aaron Black (SWCO Mark Johnston (Monaghan)

Letter of Offer

Having been successful in our project bid the SEUPB issued a Letter of Offer for the project to commence on 1st November 2010 and to run for four years until the 31st October 2014, extended to 31 December 2014. The funding was allocated to partners in the following way:

• Agri-Food & Biosciences Institute (AFBI) – Lead Partner	
• Management of project	£352,065
• Supervision of post-graduate students	£201,600
• Northern Ireland Water	£419,800
• South-West College (Cookstown)	£176,164
• Cookstown District Council	£132,700
• Donegal County Council	£225,100
• Monaghan County Council	£202,350
• Teagasc	£244,433
• ITSligo	£61,986
TOTAL	£2,016,198

The consortium of science organisations, a water utility, local councils, a college of further education and an institute of technology brought together a diverse group of individuals with a wide spectrum of experiences and skills. As we worked together the team developed into a highly productive and effective group. As each person and organisation sought to meet their own individual objectives there was a great sense of mutual support and encouragement. Alistair McCracken, the lead partner, would want to pay tribute to, and thank sincerely, every member of the ANSWER project team for their commitment to the work, the huge effort that was made by all to deliver, the patience of everyone and their good will and support.

Special EU Programmes Body

The ANSWER partners acknowledge the help and support given by all the staff in SEUPB from the start and throughout the project.

In particular they thank the project officer Mr Ciaran Hanna.

Each of the partners has recorded their own particular reflections on their involvement within the ANSWER project.

Agri-Food & Biosciences Institute




Personnel

Prof. Alistair R. McCracken (ANSWER Project Leader)
Mr. Chris Johnston
Mrs. Linda Walsh (Secretary to the Partners' meetings)
Mrs Mabel Hawthorne (Administrative support)

Objectives

AFBI had three primary objectives.

- Project management
- Supervision of Post-Graduate students
- Input into AFBI research irrigation sites

Project Management

Alistair McCracken had experienced managing a project called RENEW (Renewable Energy Network of Environmental Willow) funded under INTERREG IIIA. However he found that there were much higher levels of bureaucracy and financial controls than previously. This was at times highly frustrating and tedious, trying to meet all the requirements of SEUPB, to provide all the necessary pieces of paper, usually all to a very tight deadline. Many mistakes were made, often there was a need to ask for patience and sometimes Alistair and the team in AFBI were slow to learn. However, as the project progressed things improved. The members of the project would like to pay tribute and thank the Project Officer, Mr Ciaran Hanna in SEUPB who was infinitely patient and very helpful in enabling the project meet its targets. The project met many obstacles and hurdles along the way, some of which had the potential to throw the project completely off-course. Ciaran was always willing to listen, offer suggestions and help us work our way to a satisfactory conclusion. The project partners also acknowledge and thank the other members of the SEUPB team in Belfast and also in Omagh, including Mr. Tony McElholm.

For future projects it would be strongly recommended that a Project Manager is appointed with the sole responsibility of managing the project. The training provided by SEUPB was generally of a very high quality, relevant and necessary. I do remember however sitting through one very long and trying day on EU procurement, which was very hard going indeed. The most useful training were the very practical sessions – How to write a press release! How to make a claim! etc.

One of the highlights of the project was the regular, quarterly, partners' meetings. As the group got to know each other these meeting were always enjoyable, frequently frank and usually very productive. We enjoyed the hospitality of all the partners on more than one occasion but the group agreed that Monaghan County Council provided the best lunch. As lead partner I was both humbled and very appreciative of the huge amount of work and effort that went into making the project happen: the way that Donegal County Council worked tirelessly to overcome all sorts of hurdles to establish a superb irrigation site at Bridgened, or when they took on the extra commitments when Cookstown District Council had to withdraw; how Monaghan County Council were able to develop two irrigation sites one in particular, Knockatallon, was a real challenge, not least to keep out the deer; NIWater struggled for so long to get things going but with great perseverance established an excellent irrigation site in a mature willow plantation in Co. Tyrone; SWC amazed us with highly sophisticated GIS maps and the student at ITSligo fascinated us with reports of worms and arthropods; a member of staff working on the project at Teagasc had to leave because of illness but they were able to recruit a new young scientist to develop the work.

Thanks are due to Linda Walsh for acting as secretary to the group and to Mabel Hawthorne for all her help with paperwork, preparation of claims and administration.

AFBI Technical support

There is large team of scientists and field staff working at AFBI who have had many years experience in the establishment and management of SRC willow plantations and effluent irrigation schemes. Their expertise was called upon on several occasions – to gap up sites following poor establishment, spraying sites for effective weed control, working on lysimeters at Ballinacarrick landfill site etc. This often involved travelling significant distances, working in inclement weather conditions and carried out tasks to a very high standard.

The field staff with scientific support were (l-r) Mr. Chris McCann, Mr. Dominic Marsden, Ms. Anne Fisher, Mr. Alan Huston, Mr. Jonathan Redmond, Mr. Freddie Buckley, Mr. Kyle Clarke Mr Kristopher Richardson, and (Mr. Kenneth Wilkinson).

Supervision of Post-Graduate students

Three students were recruited during the summer 2011 and were registered as research students in The Queen's University Belfast in October 2011.

The students and their projects were:

Mr. Michele Garofolo (QUB supervisor,; Dr. John McGrath)

"Effects on plants, soil and water quality of irrigating short rotation willow coppice with municipal effluent."

Miss Sian Farrar (QUB supervisor,; Dr. John Quinn)

"Use of Short Rotation Coppice Willow for the bioremediation of landfill leachates.

Miss Sabina Doll (QUB supervisor,; Prof. Mike Larkin)

"The fate of pathogens in soil after irrigation of Short Rotation Willow Coppice with municipal wastewater."

Michele is from just outside Rome in Italy so had some adjusting to do to the cool damp Belfast weather. His project concentrated in looking at the interaction between willows and high nutrient municipal effluents. Initially he screened over 120 willow (*Salix* spp.) genotypes from which he was able to select a smaller sub-set to study in detail. A number of the genotypes appeared to be particularly effective in tolerating high concentrations of effluent and it in utilising the available nitrogen. Often the genotypes that were most effective seemed have larger root systems, and produced less above ground biomass. His studies at Culmore, a long-term irrigation filed plot found no evidence of either nitrogen leaching to the groundwater or a significant build up of nutrients in the soil following application of effluent over a prolonged period.

Sian is from the Welsh valleys and is a Welsh speaker. She was particularly interested in the use of SRC willow for the treatment of landfill leachate. This type of leachate is usually very polluting and difficult to treat. In Sian's work she screened a wide range of willow genotypes and selected a number that showed significant bioremediation promise. In one major experiment in the greenhouse she generated artificial rain (in Ireland!) and measured the effectiveness of the willow in reducing both surface run-off and secondary leaching, following irrigation with landfill leachate.

Professor Alistair McCaracken, ANSWER project leader with Sian and Michele in the Plant Pathology greenhouses AFBI Newforge.

Sabina came originally from Latvia but had studied in Belfast. She started her studies in looking at pathogen survival in the soil after irrigation with primary effluent. Her initial studies found that none of the potentially serious human pathogens, *Salmonella* spp., *Campylobacter* spp. or coliforms survived in soil for more than a few hours. Sadly Sabina was taken ill and she had to withdraw from her studies. Everyone associated with the project wishes her good fortune in the future.

The student team working at AFBI, and registered at Queen's University of Belfast were a huge asset to the ongoing work on bioremediation. They worked alongside other students and with other AFBI staff and together made a huge contribution to our understanding of the issues involved in using SRC willow plants to manage high nutrient effluents and leacahtes.

We acknowledge the participation and huge contribution made by the Queen's University of Belfast supervisors who helped and supported the students throughout the process. They were Dr. John McGrath (Michele), Dr. John Quinn (Sian and Prof. Mike Larkin (Sabina).

Monaghan County Council

Personnel

Mr. Oliver Mulligan
Mr Mark Johnston

Objective

To construct a SRC willow effluent irrigation system of around 12 – 15 ha taking municipal effluent from an otherwise non-compliant Waste water Treatment Works

Introduction.

Monaghan County Council became involved in the Agricultural Need for Sustainable Willow Effluent Recycling (ANSWER) project as two of our Sewage Treatment Plants (STWs), Knockatallon & Clontibret, were having difficulty achieving the final effluent quality that is required from each plants Certificate of Authorisation (CoA) (issued by the EPA).

Knockatallon STW consists of two inline settlement tanks and Bord Na Mona puraflo modules on a gravel bed, with effluent discharging to groundwater. The treatment process is based on bio-filtration principles. The bio-fibrous peat media in the system biologically degrades the organic matter in the wastewater prior to discharge. The treatment system, through time, has become less effective and additional treatment is required to meet CoA Standards.

Clontibret STW consists of a flume, grit trap, two primary settlement tanks, rotating Bio-Contactor (RBC) and a final clarifier. This STW is overloaded and the quality of the effluent leaving the plant does not meet the levels required in the CoA for the plant. Therefore, further treatment of the final effluent is required.

Monaghan County Councils main objectives when participating in this project was to prevent the discharge of non-compliant effluent to watercourses, and to utilise the effluent nutrient value by irrigating fields planted with willow. This process reduces the polluting effect of the effluent leaving the STWs. This is achieved by diverting effluent away from feeding into the adjacent watercourses and instead irrigating it onto local lands. The wastewater filtrates into the ground and acts as a fertiliser encouraging willow growth. The willow will be harvested every 3-5 years and the by product utilised (eg. as woodchip) for renewable energy.

Planning, Design and Construction.

In 2011/12 landowners were identified in the vicinity of each STW, who were interested in leasing land to Monaghan County Council for the planting of Short Rotation Coppice (SRC) Willow. Agreements were reached and ten year leases were agreed.

Monaghan Co Co. procured a Swedish consultant to design irrigation networks suitable for each willow location. Each network was sub-divided into zones to ensure irrigation over the lands would be even. Each zone is designed to irrigate at different intervals ensuring no over ground run-off. These networks consist of a series of pipes, valves, and solenoids that would irrigate the land planted with willow.

Planning permission for the Knockatallon site was sought on 19th April 2012 and granted on 13th July 2012. Planning permission for Clontibret was sought on the 1st Match 2012 and granted on 25th April 2012.

Once planning permission was obtained, Monaghan County Council fenced the lands ensuring they were stock and rabbit proofed.

The construction stage of the project consisted of four main phases, Planting, Rising mains, Storage Tanks and Mechanical and Electrical works:

Planting: Planting on both sites began in Summer 2012. This was a very wet summer and ground preparation (spraying, ploughing etc) and planting proved extremely difficult. Due to this poor weather not all land was planted and the land that was planted was not effectively prepared before planting. Therefore some of the willow failed, we believe this was due to the bad weather late planting and poor ground preparation. These areas, and areas not previously planted, were replanted in April and May 2013.

Rising Mains: Rising mains (125mm HDPE pipe) were required to take the flow of effluent from each STW to the willow fields. Knockatallon required 35m of Rising mains under a county road. Clontibret required 380m of rising main under a sports field, agricultural lands and a county road. Each rising main was accompanied by a 50mm electrical duct. These works were carried out in 2013 by directional drilling with some open cut trenching, and took one month to complete.

Storage Tanks: Initially, storage tanks at the STWs were not deemed necessary for this project, as the effluent from the STWs was to be pumped directly to the willow fields. Consideration was given to extreme weather events where land could be saturated for 6-8 days and irrigation would not be possible without surface run-off and possible pollution of nearby watercourses. It was for this reason storage tanks were considered a necessity and included in the scheme.

There is one storage tank at each STWs with a capacity of 204 m^3 providing 6-8 days storage of effluent. This will allow saturated lands to drain before irrigation commences, therefore preventing surface run-off and the risk of pollution.

The tanks were constructed in two phases commencing in October 2013 with completion in December 2013:

Phase 1 - Excavate for and construct a reinforced concrete base.
Phase 2- Erection of prefabricated walls.

Effluent storage tank at Clontibret WWTWs under construction

Irrigations System (Including Mechanical and Electrical works): The Irrigation system consists of a series of meters, pumps, valves, trunk pipe work and lateral pipe work (in fields) that are controlled by a main control panel. The control panel commands the operation of the irrigation system, signalling when to come on, which zones come on, and when to shut off. Rain sensors reduce irrigation when it is not required. These works were carried out over a four month period. The laying of the lateral pipe is restricted until cut back of the willow which is scheduled for spring 2014.

Flow meters determine the volume of effluent being irrigated and the volume being discharged to watercourse. The flow meters monitor the plant operation.

A chamber, approx 3m^3 in volume, captures the treated effluent leaving the STW. This chamber houses two low lift pumps that pump the effluent up into the storage tank. When there is effluent in the storage tank, the control panel will call for a high lift pump to operate and the effluent will be pumped to the willow fields via the rising mains and lateral pipes laid in the willow fields. The irrigation control system is electronically/internet based. This will permit staff to remotely monitor the operation of the plant eg. assessing alarms, trip outs, faults etc, etc..

Fully constructed effluent storage tank at Clontibret WWTWs

Issues that arose during scheme

Monaghan County Council encountered several problems during the course of the scheme at both sites, but more so at Knockatallon.

At Knockatallon the willows initially failed, this was probably due to planting late in the summer of 2012 and in unseasonably wet weather. This failed crop was replaced in spring 2013 and is progressing well. Knockatallon is surrounded by forestry which contains both deer and rabbits which broke into the willows fields at different times and ate the willows. Additional fencing was required to keep these animals out.

In Clontibret the willows have grown particularly well. The main difficulty Monaghan County Council had was getting a landowner adjacent to the plant to lease land for willow growing. The lands that MCC leased required directional drilling of a trunk rising main through a sports field and agricultural lands. This added significant cost to the scheme.

Conclusions

While this project is only in its infancy, there appears to be substantial environmental benefits, not only for the protection of streams and watercourses that may be at risk from pollution by effluent from STWs, but also from the generation of a renewable energy source.

It will take several years to establish the success of the scheme in terms of improvement of water quality within the streams and watercourses adjacent to the STWs. Over ground run-off, pollution of

watercourses adjacent to the willow fields and odours arising from irrigation all have to be monitored over the coming months. This will form part of the overall success story of this project.

The economic viability of the project has yet to be determined. To do this MCC will have to wait a number of years until a crop has been harvested and sold at the going rate, this will give an indication of the return to be made on the willow. The investment in the willow project combined with the return on the sale of the willow product can then be compared against the cost of upgrading a STW to provide effluent that is compliant with the CoA. Only then can a true evaluation of the economic viability of the project be carried out.

Participants at workshop in September 2014 visiting the willows at Clintibret

Donegal County Council

Personnel

Mr. Con McLaughlin
Mrs. Joanne Holmes

Objectives

To construct a 10 -15 ha SRC willow effluent irrigation site
Subsequently, following the loss of another partner, Donegal agreed to construct research lysimeters associated with a landfill site.

Introduction

Donegal County Council initially joined as a collaborator in the funding application process and in late 2010 we learned how the ANSWER Project was one of seven projects which were successful in their bid for Grant Aid under the Interreg IVA Programme, Priority 2, Theme 2: Environment. Donegal were now partners on the ANSWER Project.

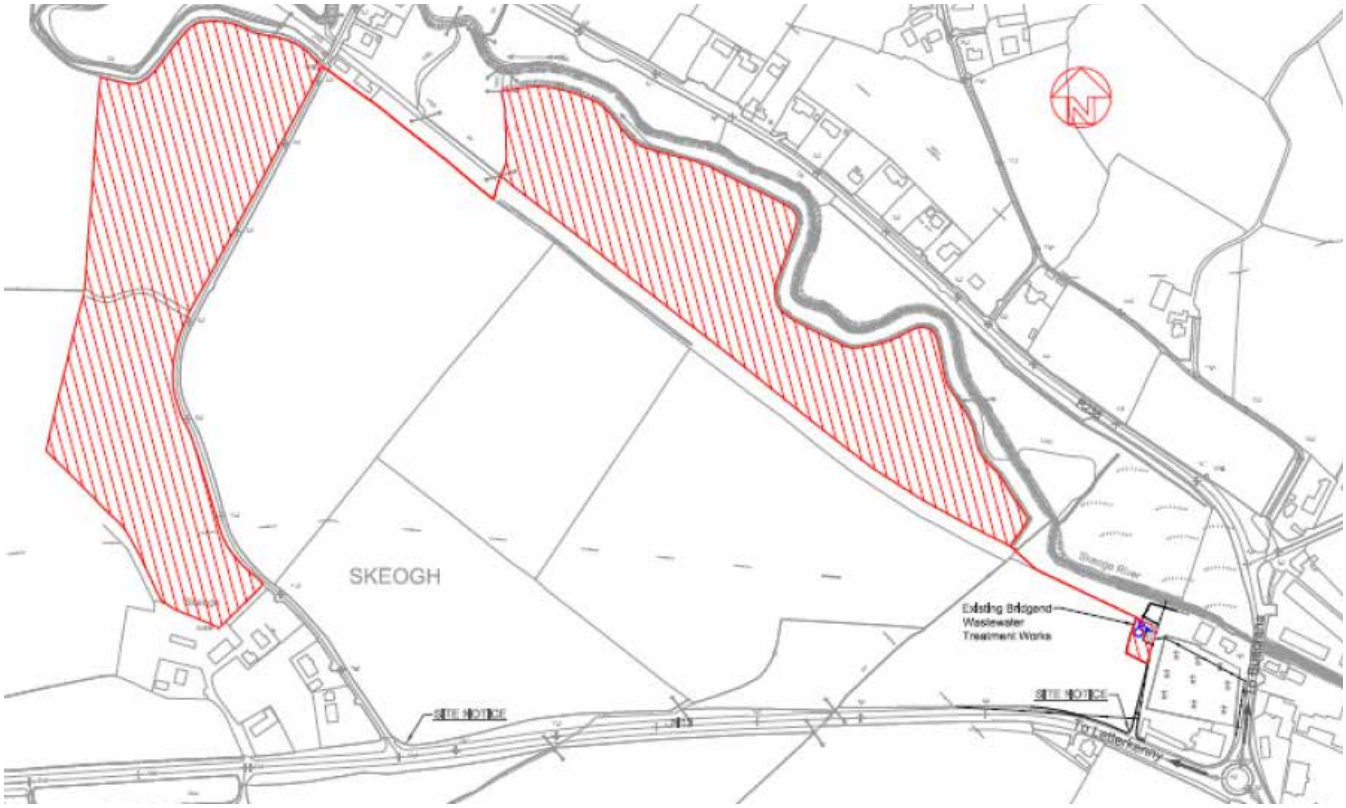
Joanne Holmes, Graduate Engineer with the Council made enquiries about the project in the context of her Masters Degree studies and subsequently got involved part-time in early 2011. Following the Project launch in May 2011, the Council briefed the Environmental Protection Agency (EPA) and the Department of Environment, Community and Local Government on the project.

Site Selection / Donegal Creameries

Whilst the subject site was initially intended to be Ballyliffin Wastewater Treatment Plant, the first milestone was for the Council to firm up on site selection at a locus where we could secure suitable lands for a willow plantation. After meetings with the Irish Farmers Association in Donegal and then Donegal Creameries we were fortunate to secure agreement to lease lands at Bridgend from Donegal Creameries for an initial ten year period. The subject site for this pilot project would now be Bridgend Wastewater Treatment Plant.

It is worth highlighting the significance of the agreement with Donegal Creameries. Due to the long term aspect of the project an early difficulty was getting a suitable landowners agreement. Indeed Donegal Creameries only agreed after corresponding with the Chief Executive and some of the Board members. Early concerns included any restriction for food production or planning consents that may be imposed. With those matters suitably addressed, Donegal Creameries agreed in late December

2011 to lease approximately 34 acres for the purpose of establishing an irrigated willow plantation. In that regard, we wish to record our appreciation for the consideration given in particular by Ian Ireland, Chief Executive at Donegal Creameries PLC.



Lands leased at Bridgetown site. Shaded area is where the willows have been planted

Public Consultation / Planning Process

With land secured, the next focus was the required Public Consultation / Planning Consent. The scheme was advertised from 17th January 2012 inviting submissions / observations up to the 15th March 2012. As part of that process we opened constructive dialogue with a local County Councillor and subsequently with local residents as part of public consultation (Planning) process.

Part of lands was included in a Special Area of Conservation (SAC), as such an 'appropriate assessment' was required for approval by An Bord Plenalla. However the subsequent stage 1 'screening exercise' (part of an appropriate assessment) concluded that there was no significant impacts arising for wildlife.

A late submission from the Department of Arts, Heritage and the Gaeltacht (National Parks and Wildlife Service) initially contested the conclusions from the screening exercise. After discussions with the local Rangers and correspondence over a particular weekend, they finally agreed with the 'no significant impact' and cleared the way for the Planning Authority to sign off on the scheme. Taking into account submissions / observations received with respect to the development, a 73 page report was presented to the Donegal County Council meeting on 26th March and subsequently passed by the members.

Further civil works at Bridgend included new security fence installed (Dunmore Construction), internal walls / surfacing works (Mast Construction). The construction work at Bridgend has also presented an opportunity for the Council to provide a 'well point' for lowering of the water table and allow for the works to be completely emptied of caked sludge and grit. The restored works has offered a significantly improved operation at Bridgend.

Ballinacarrick Landfill

Donegal County Council proposed Ballinacarrick Landfill as an alternative trial site for bioremediation of leachate following the late withdrawal of Cookstown DC from the project.

Donegal County Council staff together with RPS Consultant Engineers (for DCC) and Lead Partners Dr McCracken and Chris Johnston (AFBI), subsequently developed proposals which would later be agreed with the Environmental Protection Agency (EPA). The proposal focused on utilizing a 2ha area presently available on the cap to develop a series of 12no fully contained lysimeter plots (6m x 12m with approximately 5m gap between each).

The works were priced by an existing Donegal County Council contractor on site at Ballinacarrick and report submitted by RPS Consultant Engineers for the Council, to SEUPB for approval. That Contractor constructed the lysimeter plots by late September 2012. This was too late for willow planting which was deferred then in more suitable weather in the spring. In March 2014, Donegal County Council sought prices for the irrigation system from 8no contractors with closing date on 19th March 2014. DPS (Co Down) were appointed and worked in conjunction with AFBI to complete that work.

Churchtown Landfill

At January 2013 with some funding not committed elsewhere on the ANSWER Project, the Council began developing proposals for bio-remediation of leachate at a closed landfill at Churchtown, Lifford, Co Donegal in conjunction with the EPA, i.e. a scaled up willow plantation for on-site treatment as opposed to tankering off site to a sewerage scheme for treatment. SEUPB approved a reallocation of £170,000 towards that work.

Report prepared by RPS Consultant Engineers for DCC detailing proposals for bio-remediation of leachate at Churchtown closed landfill. Proposal based on combination of imported soils with drainage together with willow plantation to address rainwater and leachate extracted from the site. Approval received in principle from EPA but some detail difficult to resolve in order to make that happen in the 2013 planting season.

The EPA requested that the cap is extended over the entire footprint of the site rather than just the 4Ha area of willow. Also the compacted soil is to act as a barrier. Furthermore additional imported material is required to shape the profile suitably for drainage. The Council subsequently provided the detailed design and got the final approval from the EPA.

The proposal provided for a separate low level 'integrated constructed wetland' for treating leachate collected during the winter months when willows are dormant.

In conjunction with RPS Consultant Engineers, that work was tendered on eTenders in January 2014 for the drainage works and the supply and placement of soils (approx 40,000m^3) at Churchtown. TAL, Co Antrim won that and were appointed to construct the civils element.

In parallel, a separate tender process was run for a willow contractor for which Northern Bio Energy were appointed.

9.0 Recommendation – It is recommended that the development be carried out in accordance with the following conditions:

1. There shall be a minimum separation distance of 10m between any wastewater irrigation pipework, excluding the planting of willow crop, and the boundary of any residential property.

   Reason: In the interests of residential amenity.

2. The Planting and harvesting of the willow crop shall be carried out between the months of May to August only.

   Reason: To protect the qualifying interests and conservation objectives of the Lough Swilly Special Protection Area.

Recommendations included in the Planning Process

Willow Contractor

Following the planning approval, the focus shifted to identifying a suitable willow contractor in time for the current planting season and also to begin a design for the irrigation infrastructure required. A 'request for quotation' for the willows element was subsequently drawn up and issued to five suppliers with a closing date of the 16th April 2012.

On reflection, that process was terminated as the value was anticipated to exceed a €25,000 threshold above which an open tender was required.

The revised tender was done by advertising on the National Procurement e-tenders website together with an advertisement in the Belfast Telegraph newspaper with a new closing date of 27th April 2012. The tender assessment was slightly protracted, however in the final analyses the Council appointed Rural Generation Limited as the Contractor to prepare, source / plant willows. Those works included preparation - spraying (30th May 12), ploughing, rabbit fencing (9th June) and finally planting (w/c 18th June)

Rural Generation Limited subsequently planted approx 26 acres, i.e. two of the three fields in the project at Bridgend (34 acres in total). The third field was too wet to complete and was left for planting again in the spring 2013.

Joanne Holmes at the Bridgend site soon after planting

In April 2013, Donegal County Council requested quotations from four reputable willow contractors for the planting of willows at Bridgend, the third field and headlands at fields 1 and 2 (and provisionally at Lifford Landfill).

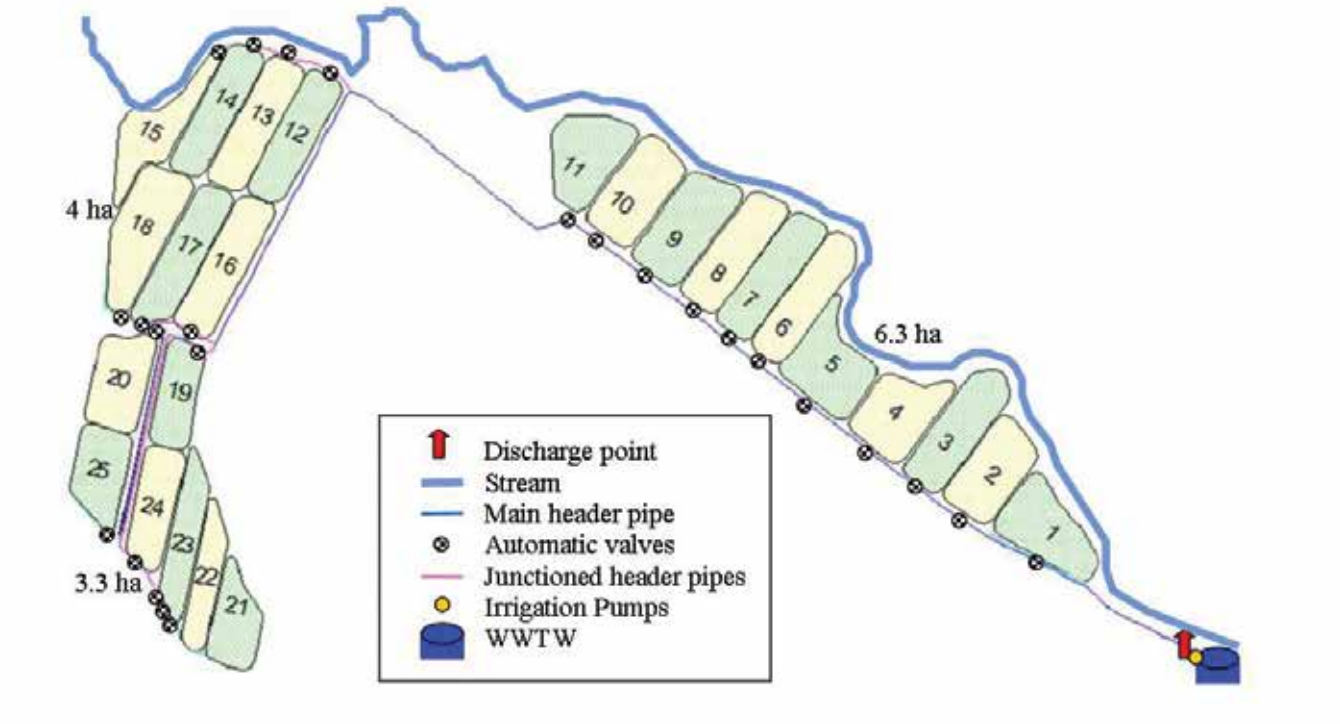
The closing date for the return of quotations was the 29th April 2013, with three companies submitting quotations. Northern Bio Energy Ltd., Co Tyrone were appointed and completed that work.

Cut-back of the plantation was completed in March 2014 followed by final commissioning of the irrigation system.

Soil analyses: Representative soil samples were taken from the lands in question before planting. Those samples were analysed for a range of parameters and shared with the partner science organisations and for comparisons later as the project progresses.

Groundwater Monitoring: The Council sought quotations and subsequently appointed Dullea Well Drilling to develop three five meter deep boreholes for groundwater monitoring before and after irrigation.

Irrigation Infrastructure: Following the withdrawal of RGL from the market, DCC sought quotations for the design and specification of an irrigation system from three companies. This included two of the companies who previously tendered for the willow planting together with Laqua (Sweden) who had previously been introduced to the project by RGL. Following a tender assessment process, Laqua were the preferred option and were subsequently appointed by Donegal County Council.



Layout of Bridgend plantation showing individual irrigation zones

Following design, the Council tendered the following works packages:

M&E works: On the 4th January 2013, Donegal County Council advertised on eTenders and eSourcing NI for the Supply of Mechanical, Electrical, Pumping and Metering Equipment including installation and commissioning. The closing date for the return of quotations the 25th January 2013 with five companies competing. RCC Engineering, (Co. Meath) won that competition and were appointed.

PE Pipe, Fittings & Accessories: On the 11th January 2013, Donegal County Council advertised on eTenders and eSourcing NI for the Supply of irrigation Equipment - PE Pipe, Fittings & Accessories. The closing date for the return of quotations was the 25th January 2013, with ten companies submitting quotations. Egeplast Ireland Ltd., (Co. Waterford) won that competition and were appointed.

Lateral irrigation pipes at Bridgend

Construstion work on high-lift pump at Bridgend WWTW

Irrigation Controller: On the 22nd January 2013, Donegal County Council advertised on eTenders and eSourcing NI for Supply, Install, Supervise, Commission Irrigation Controller Equipment. The closing date for the return of quotations was the 6th February 2013 with three companies submitting quotations. DPS, (Newtownards, Co, Down) won that competition and were appointed.

Storage Tank: On the 26th February 2013, Donegal County Council advertised on eTenders and eSourcing NI for the Supply and Installation of a Holding Tank for Irrigation System. The closing date for the return of quotations was the 12th March 2013 with three companies submitting quotations. Irish Industrial Tanks (Dublin) won that competition and were appointed.

Civil Contractor: With so many aspects now identified and the need for a dedicated team to make it happen, we revised our approach and tendered for a Contractor to deliver the laying of the irrigation system / interface with M&E works.

In February 2013, Donegal County Council requested quotations from four reputable construction companies for the installation of pipework and all associated equipment for the ANSWER project's irrigation system. The closing date for the return of quotations was the 1st March 2013 with two companies submitting quotations.

Mast Construction Ltd won that competition and were appointed.

M&E Design: Hugh Doherty, M&E Supervisor with DCC Water Services provided the technical guidance for the M&E / irrigation controls. We are indebted to Hugh for his expert knowledge in these areas and contribution to the project. We wish Hugh well now as he departs into retirement!

Left: Hugh Doherty,
M & E Supervisor,
DCC Water Services

Right: Patrick Doherty
Waterworks Inspector

Supervision of Construction Works: Patrick Doherty, Waterworks Inspector from the local water services team was reassigned for a period to the Project to provide oversight and liaison with all concerned, including the Health & Safety file. Again we are indebted to Patrick for his dedication to the project and results achieved

Irish Industrial Tanks (Dublin) commenced on site w/c 17th June and constructed the holding tank

IT Sligo

Personnel

Dr. Ann-Marie Duddy
Mr. James Feighan (student)

Objective

To investigate the impact of effluent irrigation on bio-indicator invertebrates in SRC willow.

Introduction

I.T. Sligo became involved with the ANSWER project on foot of a long standing history of the Institute in applied research in the related areas of wastewater treatment and bioremediation. In addition, I.T. Sligo had already successfully collaborated with the Agri-Food and Biosciences Institute (AFBI) and a number of other project partners in an earlier related INTERREG Project known as RENEW (2003 to 2007). The Institute's engagement in the ANSWER project was part of a work package investigating potential environmental impacts associated with the irrigation of SRC willow with various effluents. The focus of I.T. Sligo's research was on ecological impacts in the receiving soil environment.

Dr Ann Marie Duddy, lecturer at I.T. Sligo, joined the ANSWER project in June 2011 and attended the first meeting of the ANSWER group at that time to discuss both project and partner details. The initial meeting was very positive and the enthusiasm of the project partners and particularly the lead scientist Dr Alistair McCracken was very contagious. The importance of responsible accounting and transparency when using public funds was a key theme of the first meeting and every meeting thereafter.

In September, 2011, a post-graduate student, James Feighan, was recruited to investigate the impact of irrigation on key bio-indicator soil invertebrates in established SRC willow plantations. In ecological studies such as this one, it is impossible to investigate potential impacts on all resident soil organisms and therefore one or more bio-indicator organisms are chosen. A bio-indicator can be defined as a species or assemblage of species that is particularly well-matched to the environmental conditions of a specific habitat and is known to react to changes within that habitat. In this instance the specific habitat is an SRC willow plantation and the specific change is the addition of effluent to the soil environment.

The post-graduate student commenced by undertaking an extensive literature review on the characteristics required of a good soil bio-indicator or group of bio-indicators in an SRC willow plantation.

James Feighan at the farm wastewater tank and effluent irrigation controls in AFBI Hillsborough

An important aspect of the literature review was identifying suitable extraction methods for potential bio-indicators. This aspect of the study concluded by selecting three bio-indicators, namely, earthworms, springtails and mites. These were chosen to reflect key roles/functions of soil-dwelling organisms.

The field study phase began in May 2012 with a month-long pilot study to investigate the abundance of earthworms, springtails and mites in irrigated and non-irrigated plots at two AFBI SRC willow sites located at Culmore, Co. Londonderry and Hillsborough Co. Down. These two sites were chosen, from a number of AFBI sites offered to I.T. Sligo for investigation purposes since they were established plantations and in receipt of two different types of effluent. A number of plots at the Culmore SRC willow plantation were irrigated from May to October with primary treated effluent at a rate of 10m^3/ha/day from the nearby Culmore wastewater treatment plant. SRC willow plots at the Hillsborough plantation were irrigated with various volumes of dairy washings (17, 34 and 44 m^3/ha/day). Control sites existed within the Culmore and Hillsborough plantations. The pilot study allowed the various extraction methods to be tested and refined prior to the commencement of the investigation.

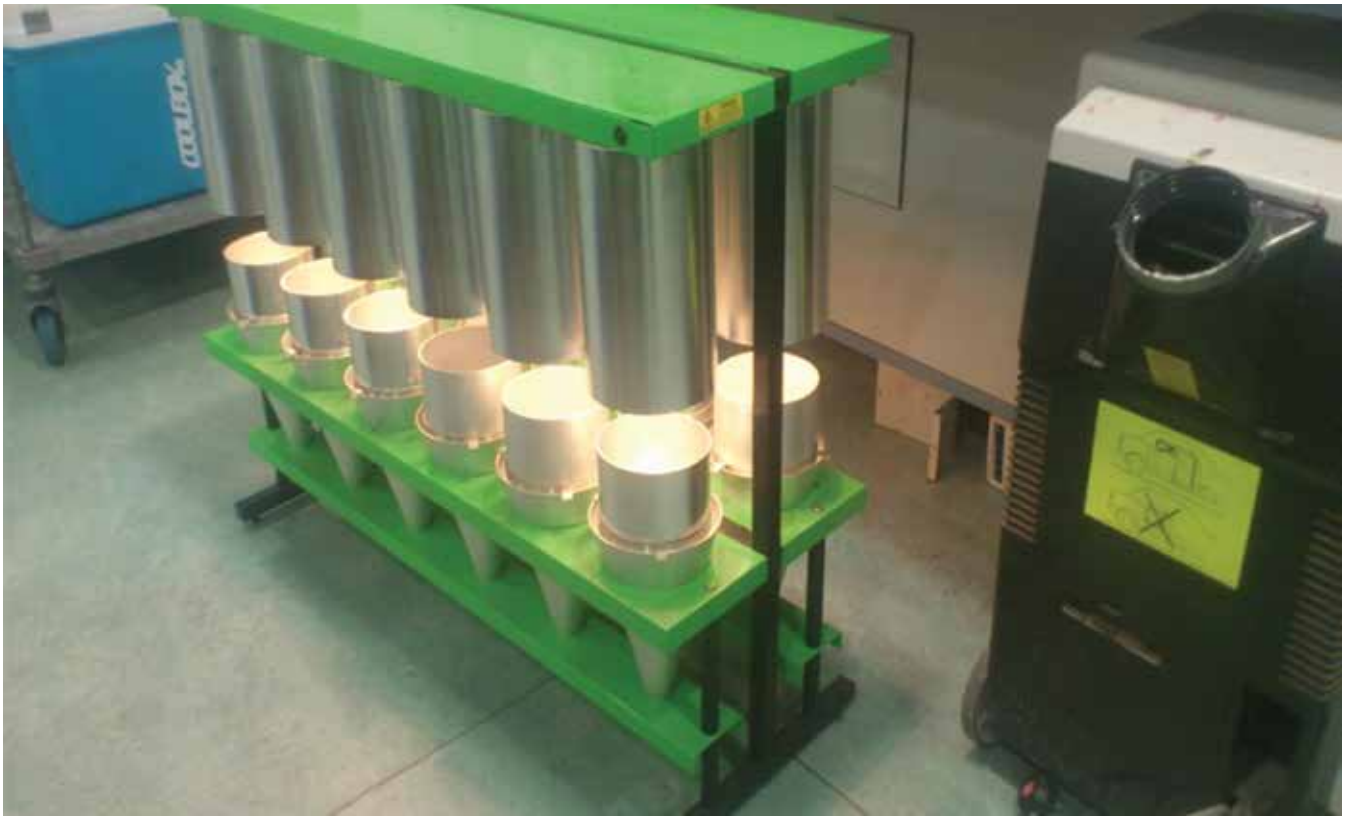
Access to established AFBI SRC willow plantations was a major benefit of project involvement as this avoided a lead-in period for plantation establishment and the study could commence immediately. These facilities were not available at an established stage at I.T. Sligo.

The investigation commenced in June 2012 and monthly samples were taken until August 2013. The field study focussed on a number of key questions during the investigation period (1) whether there was a significant difference in the abundance of earthworms, springtails and mites in SRC willow plots in receipt of primary treated municipal effluent as compared to plots that were not being irrigated and (2) whether there was a significant difference in the abundance of indicator organisms in plots receiving various volumes of dairy washings. Samples were taken during the irrigation period and also outside of this period to establish any variations in bio-indicator abundance. Weather conditions during the irrigation period were significantly different from one another, with 2012 being a particularly wet summer and 2013, an unusually dry one.

James sampling site for earthworms

Extraction of earthworms occurred in situ using an adapted International Standards Organisation (ISO) method (ISO 23611:2006). This method involved using a solution of mustard to expel the earthworms and then hand-sort them from the soil. The extracted earthworms were taken back to the laboratory for identification and enumeration. Earthworms are generally extracted from soil using formalin however, due to the toxic nature of this chemical for soil flora and fauna, formalin was replaced with mustard powder, which is also given as an alternative, less toxic chemical expellant in ISO 23611:2006. The toxicity of the earthworm extraction solution was a very important aspect to the continued good health of the SRC willow plantation. In addition, other students in the ANSWER project were investigating environmental aspects that may have been affected by formalin.

Heat extraction of springtails and mites occurred in the laboratory following the taking of soil cores in the field. Banks of Berlese-Tullgren funnels were used for extraction. These funnels were purchased for the ANSWER project using INTERREG funds. Tullgren funnels are the preferred method for extracting micro-invertebrates such as springtails and mites from soil. These are usually standalone units assembled using a specialised funnel and a heat source. Due to the scale and nature of sampling for micro-invertebrates in Culmore and Hillsborough SRC willow plantations, the assembly of a sufficient number of Tullgren funnels gave rise to a number of health and safety and space issues which forced the use of alternative equipment. Berlese-Tullgren units were purchased because they are compact and have an inbuilt heat and light source. (shown below) Each unit housed 12 separate extraction funnels and used about 25% of the space required for individual Tullgren funnels. The purchase of four of these units allowed for a large scale ecological investigation of micro-invertebrates that could not previously have been undertaken at I.T. Sligo.



Banks of Berlese-Tullgren units used in the ivestigation for extraction of micro-arthropods

During the investigation period, soil characteristics that are known to influence the activity of earthworms, springtails and mites were also monitored including soil pH, temperature and moisture content. pH and temperature measurements were taken in situ while soil moisture content was determined in the laboratory.

The key findings of the investigation into the effects of irrigation on key bio-indicators soil inertebrates within an SRC willow plantation are; (1) earthworms, springtails and mites are not significantly affected by irrigation of the SRC willow plantations with primary municipal effluent at a rate of 10 m^3/ha/day; (2) the response of bio-indicator organisms to the receipt of various volumes of dairy washing effluent

at an SRC willow plantation indicate that there is an uppermost limit of effluent tolerable by some bio-indicators, however, the response is not uniform across all bio-indicators used in the investigation. Earthworms are most sensitive to higher irrigation rates and a significant decrease in abundance was observed at irrigation rates between 18 and 34m^3/ha/day. Earthworms are almost eliminated in plots in receipt of 44m^3/ha/day of dairy washing effluent. The abundance of springtails and mites are not affected across all irrigation rates investigated (18 to 44 m^3/ha/day) for dairy washings. These findings are confirmed by a two year ecological investigation with sampling occurring both in the irrigation period and also pre and post irrigation.

I.T. Sligo has benefitted immensely from its involvement in the ANSWER project. The ANSWER project partners worked very well together. The team were skillfully guided by Dr Alistair McCracken (AFBI) who was very generous with his knowledge and experience and was always accessible for enquiries or advice. This was also true of other project partners. The quarterly meetings were invaluable to keep the group informed of progress on all aspects of the work packages from the planting of willow plantations and installation of irrigation systems to the various aspects of scientific research arising from the project.

Liaison with other scientific researchers, both post-graduate students and their supervisors, was very beneficial as it allowed exchange of scientific information on aspects related to soil ecology e.g. soil characteristics and nutrient levels. These aspects are outside the scope of the I.T. Sligo investigation but are very relevant to the interpretation of results generated in the study and add greatly to the final report.

The involvement of I.T Sligo with the ANSWER project has been a very positive one. The members of the ANSWER team were dedicated, determined and enthusiastic and possessed a great deal of knowledge in many disciplines. It was very rewarding to be part of such a dynamic team. The investigation, with its outcomes hves been introduced to the classroom of a number of programmes taught at I.T. Sligo including Modules on ‘Energy Management’ ‘Soil Quality’ and ‘Environmental Issues’.

TEAGASC



Agriculture and Food Development Authority

Personnel

Dr. John Finnan
Dr. Declan Ryan
Dr. Paul Galbally

Objective

To investigate overland flow and its mitigation.

Background

Teagasc has a long history of involvement in bioenergy and the use of energy crops, research on this subject commenced in the early 1970s in the immediate aftermath of the first energy crisis. Energy crops research represents an important component of the Teagasc research programme in recognition of the fact that Ireland needs to develop means of reducing its overdependence on imported fossil fuels, in addition to reducing its emissions of greenhouse gases (GHG's). Energy crops will play an important role if Ireland is to meet its bioenergy targets as the country has only a small percentage of its land mass covered by forestry (11%). Much of Ireland's poorer land is being used inefficiently for small scale livestock production , and a more efficient national strategy for how Ireland's land resources can best be used is required particularly since most of Ireland's food production is exported whereas most of our energy needs are imported. Thus, the use of land for energy production can play a major role in redressing export/import imbalances.

It is generally accepted that energy crops, in addition to the provision of renewable energy, can also offer environmental and ecosystem services such as the provision of habitats for rare species and a general increase of biodiversity. Generally speaking, the improved services that energy crops can provide will emanate from the perennial nature of energy crops and the low level of inputs needed for their growth. In addition to the provision of renewable energy and ecosystem services, it is increasingly accepted that energy crops are also able to improved local services at low cost such as cleaning of waste and wastewater from urban areas.

Waste water must be treated prior to being released back into the environment in order to remove contaminants that could pose an environmental risk. Water from urban areas is treated to remove nutrients and pathogens before release to rivers and streams. This treatment produces a nutrient-rich sludge (sewage sludge) which can potentially be used as a fertilizer. However, the treatment processes at wastewater plants when taken alone may not offer sufficient protection to vulnerable receiving waters; unfortunately a significant number of smaller rural areas only have very rudimentary treatment of their wastewater with basic screening in place. It is highly undesirable that effluents

coming from smaller treatment plants that cannot treat wastewater to a standard high enough be allowed back into the water cycle. Both sewage sludge and wastewater from such plants can be applied to energy crops whose growth can be enhanced by absorbing the nutrients from these wastes. In this way, the potential for eutrophication of nearby streams and rivers is decreased and the by-products of treatment can be used to increase the yield of renewable energy resources. As such systems are passive there is also little in the way of energy costs once the planting of energy crops near wastewater facilities has been completed.

Overland flow measuring point including weir and datalogger. The volume, as well as the time and duration of overland flow are recorded.

Additionally, control of potential harmful compounds is much simpler if they are concentrated in harvested energy crops, as opposed to being released into the general environment. This concept offers considerable potential benefits to farmers who can fertilize their crops at either a reduced cost, or no cost or even be paid to fertilize their crops by waste companies. This practise also provides an incentive to local authorities and water authorities who can discharge a much 'cleaner' waste discharge to water bodies and also provides benefits to society in general in terms of increased renewable energy resources in tandem with cleaner water bodies.

However, the practise of waste application to energy crops has still to be proven safer than the current means used for handling and treating waste from water treatment plants before it can be recommended as a general practice. For this reason, Teagasc secured funding from the Department of Agriculture Stimulus fund in 2005 to carry out research to study the fate of nutrients and heavy metals from waste by-products applied to energy crops. In these studies, two different wastes, sewage sludge and brewery effluent, were applied to the two current most popular energy crops, short rotation coppice willow and *Miscanthus* X *giganteus*. Losses of nutrients and heavy metals to

groundwater and overland flow were quantified throughout the lifetime of the project.
The project concluded that such losses were small compared to other 'loss' pathways such as crop uptake, and that heavy metals contained in biosolids did not pose a threat to water quality as they tend to remain within receiving soils and also get taken up by energy crops, to some extent.

Calibration of overland flow weirs

It was only possible, however, to conduct this research at one site and it was recognised that further research needed to be conducted at other sites, as well as on other aspects of this overall concept. Also the project identified that phosphorous loss through overland flow would be single largest concern (in terms of nutrient loss) if very large catchment scale plantations using bio-waste fertilizers were set up. Although it was determined that the smallest losses of nutrient and heavy metals occurred via the overland flow loss pathway, it was difficult to accurately measure the precise quantities of overland flow lost from energy crops. This was principally because accurate low-cost proportional flow samplers were not available at that time. Hence, it was concluded that further research was necessary to develop an accurate, low cost proportional overland flow sampler in the first instance. Furthermore, it was recognised that overland flow needed to be quantified on sites with different topographies and soil conditions before it could be concluded that significant loss through the overland flow pathway was unlikely.

The ANSWER project offered an opportunity for Teagasc to continue its own research into the important and topical area of waste application to energy crops. In particular, involvement in the ANSWER project offered an opportunity to study overland flow events in greater detail by first

Large scale lysimeteres planted with willow being used to measure overland flow and leaching

developing an accurate overland flow proportional sampler before using it to accurately quantify events at sites with variable topography. It also allowed Teagasc to look more closely at the nutrients and contaminant pathways that were identified as being most problematical in earlier research, focusing research resources where most required. The ANSWER project also allowed researchers from Teagasc to learn new insights from the experience of other participants in the project, including AFBI where work on application of wastewaters to energy crops has also been taking place for several years, allowing for synergies in effective and focused research. There was also the chance to examine overland flow at a large plantation of several hectares on a hilly site in Hillsborough Co. Down, within which a controlled experiment was already taking place and whose scale and conditions met the requirements for the further work that Teagasc had identified. Therefore involvement within the overall ANSWER project framework was very desirable from Teagasc's point of view.

SOUTH WEST COLLEGE (Cookstown Campus)




Personnel

Mr Aaron Black
Mr Paul Cairns
Mr Brian Moss
Miss Kathryn McNair

Objectives

The main objectives for South West College in the ANSWER project were:

1. To use GIS technology to identify potential land resources on which SRC willow may be grown and to match these with effluent production sites in an attempt to reduce overall carbon emissions and environmental impacts; and
2. To openly transfer the results of the research and data generated by developing an online mapping tool for interested parties to use to assess 'land suitability' for SRC willow growth coupled with bioremediation of effluents for the production of renewable fuel for end users with biomass boilers.

Introduction

This report describes the background to South West College's involvement in the ANSWER.

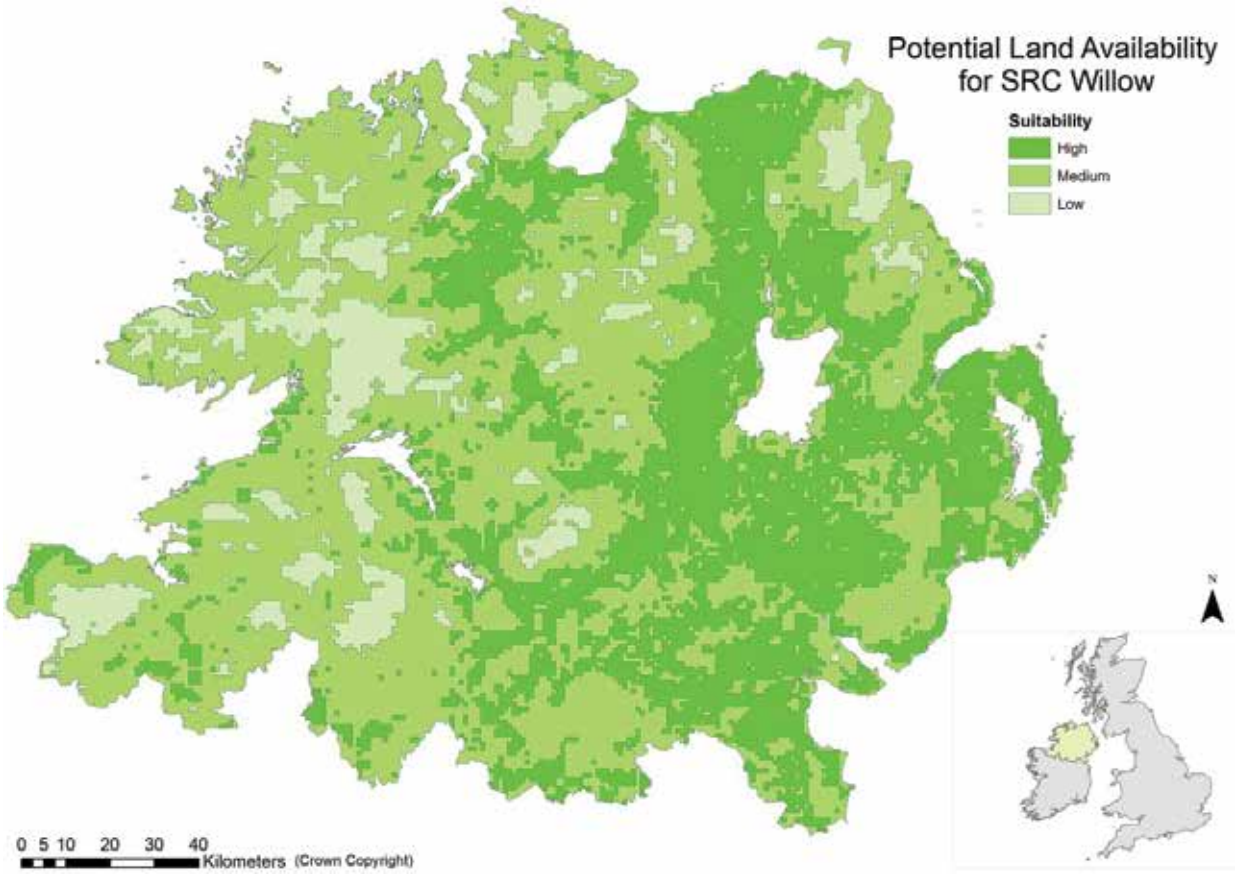
ANSWER project study area

South West College was one of seven partners, with Agri-Food & Biosciences Institute (AFBI) as lead partner and was responsible for using Geographical Information System (GIS) technology to map sources of effluents and match these with suitable sites to grow willow in Northern Ireland and the six bordering counties of, Donegal, Monaghan, Sligo, Leitrim, Cavan and Louth.

Why did South West College get involved in ANSWER?

Being located in a rural environment, South West College has an ethos of embracing renewable energy and sustainability projects. The College has participated in previous European funded renewable energy projects, most notably RENEW (Renewable Energy Networks for Environmental Welfare) and BioEnerGIS (Biomass resources mapping and data collection), and an energy from waste project (NWEEC - North Western Environment and Energy Consortium).

RENEW succeeded in the establishment of numerous SRC Willow plantations across Northern Ireland and the border counties, the installation of biomass boilers, and the development of a willow wood chip supply chain. As a result of this project, the College installed two biomass boilers (150kW and 250kW), both of which continue to be fuelled by locally sourced willow chip established under this programme. BioEnerGIS involved the development of a Geographical Information Systems (GIS) based decision support system aimed at sustainable exploitation of waste biomass energy resources throughout Northern Ireland. NWEEC focussed on farm wastes in relation to the Nitrates Directive, GIS mapping of farm waste resources and the investigation of the potential for Anaerobic Digestion (Biogas) facilities.



GIS generated map showing the suitability fo land in Northern Ireland an border counties for growing willow

ANSWER was an ideal project for South West College to become involved in as it developed knowledge and experience in renewable energy, bioremediation and GIS technologies. This was invaluable in delivering the ANSWER project objectives which included development of a mapping application to show the potential land resources to grow SRC Willow. These data were then matched with suitable sources of effluents in close proximity to identify suitable areas for bioremediation.

Being a combination of academic research, real world application and specialist testing of new technology, the ANSWER project fitted directly into the model developed by South West College for working with industry. ANSWER allowed the College to develop an understanding of this new technology and identify opportunities for it to be taken forward by local companies.
ANSWER was seen as being of strategic importance to the College in the positioning of its services. ANSWER was significant in assisting the College in its journey towards becoming a rural university which is something it has now achieved.

The South West College is always keen to develop strategic working relationships with those around us. As such, the ANSWER project offered us the opportunity to work with the main environmental science organisations in Ireland (AFBI & Teagasc) as well as several local councils (Monaghan & Donegal) and other partner academic institutions (IT Sligo) as well as our local water utility (Northern Ireland Water). The aim of us joining this partnership was to give us a greater understanding of the activities of these organisations and to widen our knowledge of their individual strengths as they are all key organisations in the region.

Mapping a SRC willow plantation

Steps to achieving the objectives of ANSWER

South West College used specialist GIS software to map sources of effluents and match these with potentially suitable sites to grow SRC Willow. Over 100 primary and secondary datasets associated with the region were collected and utilised. These datasets included the most important growing factors for willow – soil conditions (nutrients, soil type and pH), site characteristics (elevation, slope, current land-use, proximity to Waste Water Treatment Works & Bio-remediation potential) and meteorological conditions (rainfall levels, growing days and frost days).

An online mapping resource has been developed using GIS to display the data collected and create a final land suitability classification system (High, Medium and Low suitability). This provides an invaluable and greatly simplified way for landowners and other interested parties to make decisions on land suitability for SRC willow combined with bioremediation of effluents and leachates.

By combining a range of datasets to give a single, three level system, the initial site investigations can be very quickly done thus allowing more on-site checks to be made once the initial selection has been carried out online.

South West College's experiences of ANSWER

The ANSWER project ran from November 2010 to October 2014. Overall, the experiences encountered during this period were very positive and contributed towards the successful outcome of the project and enhancement of the knowledge and skills of the College staff involved.

Positive experiences

1. Vastly improved knowledge of the bioenergy industry and the complexities of commercial bioremediation.
2. More fully developed understanding of the impacts of SRC willow growth when combined with bioremediation and the scientific basis for monitoring the impacts of this activity.
3. Development of mapping resources which can now be made available to industry through our knowledge transfer activities and into the College curriculum, particularly into the Energy, Environment & Sustainability Foundation Degree and the Civil Engineering Foundation Degree courses.
4. Development of knowledge on renewable energy installations and guidance information for industry on the opportunities for low cost bioremediation of effluents.
5. Co-operation and collaboration with the other project partners and third party organisations has enhanced knowledge transfer and opened up opportunities for future project synergism.
6. Well-developed working relationships with partners and stakeholders have provided opportunities for student field visits and access to academic researchers and their work.
7. Opportunities to deliver scientific papers at International Bio-Energy Conferences on the GIS research carried out on the project allowed international exposure for the College and staff involved. These were published and presented in Manchester and Germany and allowed exposure to and progression into the science industry for our staff.
8. Working relationships have been developed with key stakeholders and partners during the sourcing of data and information thus strengthening our position in the bioenergy industry and

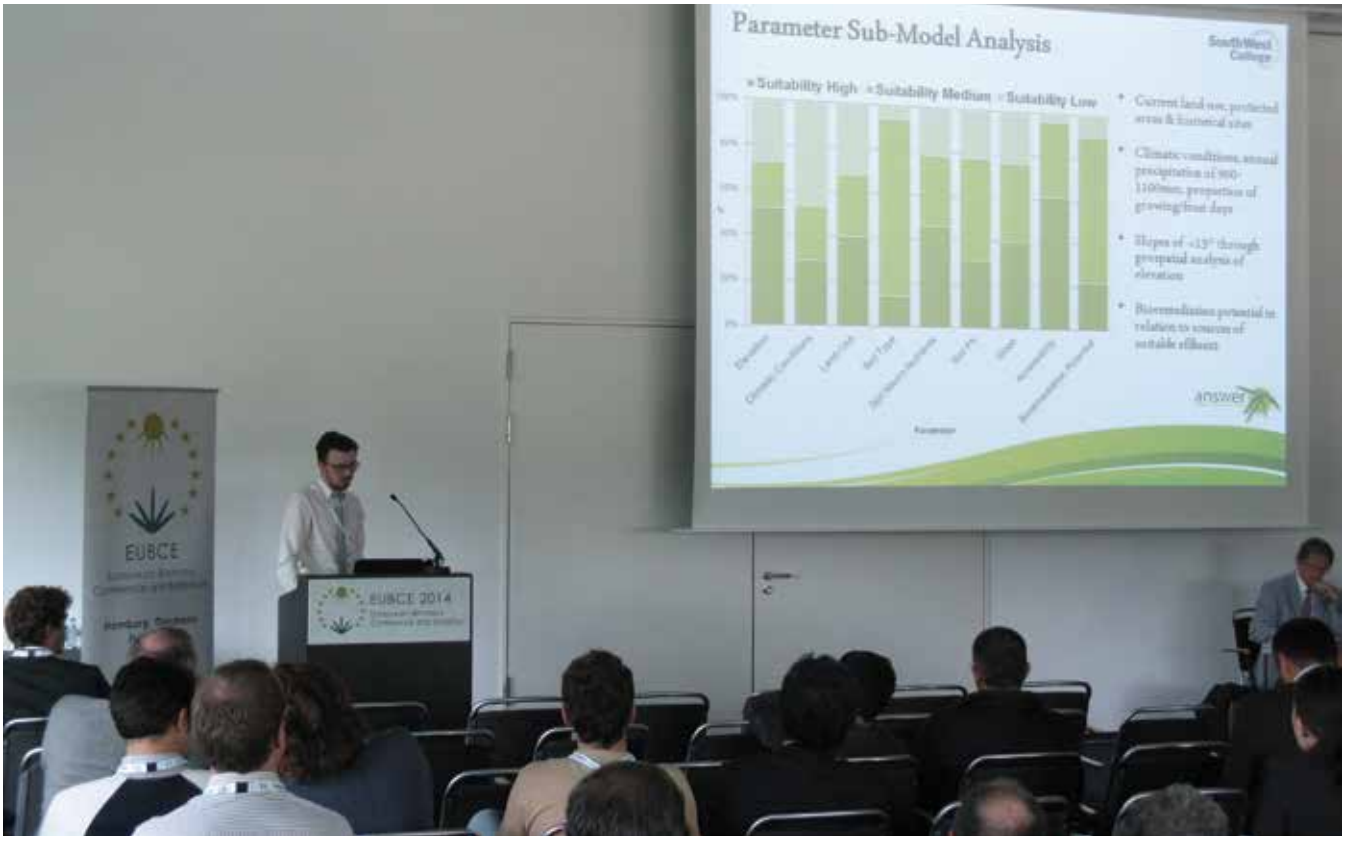
SWC ANSWER staff

the knowledge we have available.

9. ANSWER research publications have been used in the discussions with Queen's University Belfast, University of Ulster and the Department for Employment and Learning to enable the granting of Rural University status to the College.
10. ANSWER work, publications and partnership were key elements in the discussions with the Education and Training Inspectorate (ETI) during the recent whole college inspection. By demonstrating the breadth of work undertaken and the partnership, ETI assessed this aspect of work in the College as being Grade 1 (Outstanding) helping the College to attain a Grade 1 overall putting us in the top 4% of UK colleges.

Problems encountered

The delivery of the South West College aspect of the ANSWER activities was both technically complex and time intensive. Inevitably difficulties were encountered over the period of the project. Fortunately, very few problems were on the technical GIS aspect of the work delivery and they primarily revolved around sourcing of data from the wide range of stakeholders involved with the project.



Brian Moss delivering a paper at the 22nd European Biomass Conference and Exhibition in Hamburg, Germany, June 2014

Project management

1. Inevitably, some problems were experienced in acquiring datasets from some organisations for the GIS work due to the large number of datasets needed which delayed progress.
2. Due to the resolution of some datasets, annoymisation was necessary to prevent the identification of individual sites.
3. The varying arrangement of the datasets received resulted in a labour and time intensive process with the requirement to amalgamate the datasets in a consistent and accurate format for use within the analysis.
4. The project may have benefited from an alternative mapping application, with excessive time taken to develop the viewer for various platforms whilst a cross-platform program may have been more beneficial without limiting the functionality and effectiveness of the application.
5. Further integration with the scientific data obtained from the various test sites may have presented a better understanding of the process involved and provided an invaluable resource for relevant stakeholders.
6. The science aspect of the project could have been translated visually using the GIS system.

Future aspirations

The ANSWER project has been important in positioning the College as a provider of scientific research in the areas of GIS, renewable energy and bioremediation. Through participation on this project, the College has been able to access and manage further EU funded programmes including CREST, REPUTE and MOVESMART.

The project and its work have helped put the College on the International stage through the production, publishing and presentation of scientific papers at International conferences; this is something we aim to continue. Without the project, this would not have happened. As a result of this work and that on other EU funded programmes, we have been able to build a reference bank of International publications. These publications have been instrumental in our discussions with the Queen's University, University of Ulster and the Department for Employment and Learning associated with the granting of Rural University status to the College for the creation of a rural university base in Enniskillen which will now be taken forward. This research work assisted in showing that the College was involved in academic work which is being recognised at the highest levels. The granting of Rural University status is of major significance to the College and will enhance its viability and the impact it has in the region for many years to come. It is therefore our future aspiration that this level and quality of work is continued and as such we will be actively looking for a continuation of work with the current partnership and the wider academic and industrial sectors.

As with all project work undertaken in the College, we will be seeking to use the knowledge gained and generated for the benefit of industry through the College's InnoTech Centre. The work of the project has already been used in the assessment of bioenergy opportunities for a number of companies, and as such, this is something we will seek to continue and build upon, thus helping to give a lasting purpose to the work undertaken.

The project has delivered a number of other key outcomes, one of which is the establishment of new willow sites and the installation of infrastructure to facilitate crop irrigation with a range of effluents. This infrastructure will be incorporated into numerous courses in the College for both field visits and case study activities. It will also be used for demonstration purposes to industrial clients. Having the partnership developed and in place allows the College to access resources and information which we otherwise could not. For this reason we aim to continue the partnership and make use of the equipment which has been installed for the benefit of our students and industry.

South West College would be very interested in participating in a post-ANSWER project or other project within the renewable energy sector. This could be in a GIS role or indeed a more scientific nature as the College now has a new state of the art CREST (Centre for Renewable Energy and Sustainable Technologies) facility, capable of providing both R & D and laboratory services.

Northern Ireland Water

Personnel

Ms. Karen McDowell
Mr Paul Davidson

Why did NI Water become involved in the project?

NI Water are the sole provider of water and sewerage services in Northern Ireland and are one of the country's largest employers.

The company faces many challenges including climate change, rising customer expectations, higher discharge standards and rising operating costs. It is widely recognised that there is an need is to find and adopt more environmentally and economically sustainable solutions.

The main attraction of the ANSWER project to us was, that if the process could be demonstrated to be successful on a commercial scale, with outputs and standards acceptable to our Environmental Regulator, it could provide a wastewater treatment process that was both more environmentally and economically sustainable than some of our current solutions.

The only way to prove the process was to trial it in a carefully monitored environment. Being part of the project gave us access to expertise from AFBI, Teagasc and the Sligo Institute of Technology that is not readily available from within NI Water, particularly around the science issues associated with the project and developing the credible evidence that can influence how our Regulators look at the process.

The project also presented an opportunity to work with Donegal and Monaghan County Councils who have similar undertakings and pool our acquired knowledge and findings.

Another attraction was the availability of ring fenced funding for the project. Our own internal capital budgets are under pressure -a large number of projects are competing for a limited "pot" of funding, and as the guaranteed benefits of a Research Development and Innovation (RDI) project such as this are difficult to quantify in monetary terms, a project of this scale may have struggled at the present time to be funded.

What were the successes?

At the time of writing the installation of the irrigation equipment is underway. Looking forward the main success will hopefully be in the proof of the "commercial up-scaling" viability of willows for effluent treatment. An important step for the future uptake of this low carbon waste water treatment technology. It is envisaged that this site will be continue to operate for at least the next 10 Years providing further evidence to the growing knowledge base of the process..

However looking at the main successes achieved to date, these have included:-

The high profile launch of the project at an event in Belfast City hall on Friday 13th May 2011 by the then CEO of NIEA, John McMillen. The support of NIEA throughout the project has been critical, in particular the agreement of an innovative variable discharge consent.

Finding a large scale site with an established willow plantation that was within economic pumping distance of a Waste Water Treatment works.

Working with a local land owner and setting up lease agreements that provided a win-win situation for both parties and provides a model on which any future schemes can be based.

It has provided an opportunity to understand the science behind the process and monitor its impact on the surrounding environment.

Lastly but not least, the Teamwork within the group represented a major success, it had Academics working with non academics, scientists working with engineers, students working with experienced staff, a reflection of the great leadership provided by AFBI.

Treatment Works at Dromore, Co. Tyrone

Willow plntation and adjoining stream at Dromore

What were the frustrations or problems?

There were many!

If we had been in the Olympics, we would have been disqualified for the number of false starts we made.

It took a long and painful process to get to the stage of actually getting a site that was suitable for the project Various challenges presented themselves

At the bid/initiation of the ANSWER project two potential sites were identified:

Magheramason WwTW (PE approx. 600)
Ballyronan WwTW (PE approx. 800)

However, during the ensuing discussions with NIEA, issues were raised over the use of variable discharge consents at these >250PE sites. For the projects to continue NIEA required large volumes of effluent storage for periods during which irrigation could not take place due to climatic and ground conditions. Calculated volumes of storage required were prohibitive and the decision was taken to look for alternative sites.

After consultation with NI Water's Wastewater staff, 8 potential sites < 250 PE were identified. These were

Waringsford WwTW, Tamlaght O'Crilly WwTW, Cladymore WwTW, Glassdrumman (Armagh) WwTW, Dundrod WwTW, The Loup WwTW, Killymuck WwTW and Milltown (Aghorey) WwTW.

A business case for approval of a consultant to prepare the tender documentation was completed, however due to procedural difficulties in getting external consultants appointed, this route was abandoned in preference of developing tender documents in house.

OJEU tender documents, template landowner agreements and variable discharge consents were initiated and an outline business case for this approach was approved internally by NI Water.

A six week sampling regime was initiated for these sites and maps identifying the radius of potential willow sites were produced.

However at this point due to concerns over the time scales available for delivery, this approach was reviewed and an alternative site that already had established willows was proposed; Dromore (Tyrone) WwTW.

The Tender evaluation proved time consuming because of the innovative nature of the bids, it was important to be certain that everyone was on a level playing field.

In conclusion the project has been challenging but extremely worthwhile and looking forward to the next few years of results from it.

POST PROJECT EVALUATION

Action Renewables were asked to carry out an evaluation of the ANSWER project. This was done in August 2014 by Mr. Michael Doran and Ms. Rachel Sankannawar. Their report is appended as it was presented to the Lead Partner on 2nd October 2014.

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1. Executive Summary

Action Renewables was appointed by the Agri-Food & Biosciences Institute (AFBI) to carry out an external evaluation of the ANSWER project (Agricultural Need for Sustainable Willow Effluent Recycling). This report details the findings of the evaluation and highlights the benefits from the project and lessons learned over the course of the project. The lead partner and project manager of the ANSWER Project is AFBI. There are six other partners; South West College (SWC), Northern Ireland Water (NI Water), Institute of Technology Sligo (ITS), Teagasc, Monaghan County Council (MCC), Donegal County Council (DCC).

The evaluation team has found this project to be very successful, demonstrating the real potential of sustainable willow effluent recycling backed up by robust science, technology and four active pilot sites.

- The project was well managed and coped well with the inevitable delays and changes.
- One of the original project partners, Cookstown District Council, withdrew at an early stage. Donegal County Council were able to take on their aspect of the project.
- The project delivered four effluent irrigation sites, one in Donegal, two in Monaghan, and one in Tyrone.
- The project succeeded in establishing research lysimeters at a landfill site at Ballinacarrick and made a significant contribution to the landfill leachate project at the Chruchtown site.
- Successful development of an online mapping tool using GIS technology to map suitable sites for wastewater treatment using SRC willow.
- The project included input from four students, three of whom used the project to produce doctoral theses and the fourth, a Masters dissertation.
- The project achieved its primary aim to provide scientific evidence on the effectiveness and sustainability of using fast growing energy crops for the treatment of organic effluent and sludges.
- The project was very effective in providing environmental solutions for improving water quality, reducing discharge to waterways, reducing total Nitrogen and Solid Reactive Phosphorus.
- The project demonstrated that SRC willow can be used as a cost effective and sustainable method for the irrigation of effluent and landfill leachate.
- An effort should be made to collate the scientific output from the project, as soon as the doctoral theses are complete.
- If future funding could be secured the monitoring work should be continued to provide a more robust scientific case for the use of SRC willow as a bio-filter over a more prolonged period of time.
- There is a need for ongoing basic science research, particularly on the response of SRC willow to landfill leachate

2. Brief

2.1 Action Renewables has been commissioned by the Lead Partner, AFBI, in the ANSWER project to carry out a post project evaluation report. The evaluation process brings accountability to the project, highlighting areas of success and areas which needed greater

progress. These recommendations can be used to improve elements of the project legacy and provide advice for any similar projects going forward. The knowledge gained from the evaluation process will add value to the ANSWER project and will contribute to more successful future planning of similar projects, taking consideration of all project participants and project results.

2.2 The objective of the project was to establish sites (experimental, demonstration and pilot) irrigated with effluents or leachates from a range of sources, using Short Rotation Coppice Willow and built on many years of research by AFBI / DARD Science Service. ANSWER is about developing low carbon and environmentally sustainable solutions for dealing with organic waste, while simultaneously creating renewable bioenergy. In the closing stages of the project, AFBI requires a post project evaluation which will:

- Assess the effectiveness of the project against the original project objectives.
- Highlight the benefits to each partner of being part of the project.
- Identify lessons learned, mistakes to be avoided and any helpful factors.

3. Methodology

3.1 The strategic focus and expected outcomes of the ANSWER project are set out in the project application document, which the partners are contracted into. A large number of actions were proposed in order to achieve the expected outcomes. These actions were organised in a work plan with seven partners. Each partner had designated deliverables and responsibilities as set out below:

Project Partner	Assigned Deliverables
Agri-Food & Biosciences Institute (AFBI), Lead Partner	Project Management Supervision of post-graduate students
Northern Ireland Water (NI Water)	Establishment of two proof-of-concept effluent irrigation schemes
South-West College (SWC)	Development of GIS mapping of resources and opportunities
Monaghan County Council (MCC)	Establishment of a proof-of-concept effluent irrigation scheme
Teagasc	Establishment of a proof-of-concept effluent irrigation scheme
Institute of Technology Sligo (ITS)	Investigation of the impact of irrigation on biodiversity
Donegal County Council (DCC)	Establishment of a proof-of-concept effluent irrigation scheme Establishment of a landfill site irrigation scheme*

*This deliverable was originally the responsibility of Cookstown District Council, however they had to withdraw from the project. The project received permission to transfer funding and the work plan to Donegal County Council.

3.2 In carrying out the final evaluation of the ANSWER project , a methodological approach was used, the steps are described below:

3.2.1 **Understand:** Action Renewables reviewed the objectives of the project and established a general overview of the progress made in the project. As part of this stage, the application and any resulting documentation were reviewed.

3.2.2 **Plan:** The evaluation team then prepared for how the evaluation would be carried out. The project application, work plan and partner deliverables were reviewed and interviews were set up with each project partner.

3.2.3 **Interview:** For the final evaluation, it was necessary for Action Renewables to discuss the project with the project participants. Participants in each partner organisation, including staff and students, were interviewed on the telephone for approximately 30 minutes to assess the outputs achieved against the intended overall and specific objectives. An hour long, in person interview, with the lead partner, was also conducted at the offices of Action Renewables.

3.2.4 **Analyse:** Following the interview sessions, Action Renewables reviewed the findings in combination with the review of the initial documentation. An assessment of the Best Practice Guidelines and leaflets produced was carried out at this stage. A desk top review was carried out to compare the conclusions of the project with other related literature. An analysis was undertaken to determine the effectiveness of the project, both in terms of the delivery against the original objectives, and the contribution that the project could make in delivering environmental solutions in Northern Ireland and beyond.

3.2.5 **Report**: Provide a final evaluation report of the ANSWER project to the lead partner.

4. ANSWER: The Project

4.1 ANSWER is a cross-border project examining the potential of using Short Rotation Coppice (SRC) willow for the bioremediation of effluents and leachates. The ANSWER (Agricultural Need for Sustainable Willow Effluent Recycling) was part-financed by the European Union's European Regional Development Fund through the INTERREG IVA Cross-border Programme managed by the Special EU Programmes Body with AFBI as the Lead Partner. There are seven other partners and a total funding of £2.1m. This is an innovative project forged on strong links between scientists, local authorities, water utilities and educational establishments. ANSWER is about bringing low carbon and environmentally sustainable solutions for dealing with organic waste, while simultaneously creating bioenergy.

4.2 The overall objectives of the project are:

1. To support strategic co-operation for a more prosperous and sustainable region: all of the project activities will be carried out by a collaboration of organisations from the two jurisdictions with potential for sustainable economic development.
2. To address infrastructural gaps, particularly in the areas of waste management, water quality and renewable energy.
3. To create synergies leading to a more diverse economy: Issues of waste disposal are similar in each of the regions. By combining efforts and resources new technologies will be developed and potential for new business opportunities formed.

5. Results

5.1 Review of Deliverables

Partner	Deliverables	Assessment of Deliverables
AFBI	1. Project Management 2. Three studentships 3. Training events/ seminars 4. Best practice guidelines 5. Production of leaflets	Over the course of the project AFBI was dedicated to the success of the project and meeting the set objectives. The deliverables of the project were largely achieved, yet there were some that could not be met. One of the students involved in the project fell ill and thus only two PHDs will be delivered. Cookstown County Council also dropped out of the project, however the project manager succeeded in receiving permission to transfer funding and part of the work plan to Donegal County Council. Here AFBI overcame the problem and created a practical solution to deliver the project work plan effectively. AFBI is the lead partner in the ANSWER project and was tasked with overall project management. This was a very successful aspect of AFBI's deliverables, with highly positive feedback from all project partners. AFBI has been complimented with efficient communication, organisation and project management skills. AFBI was heavily involved in dissemination of the project progress and results, through presentations at conferences and seminars, in Northern Ireland, Ireland, England, Greece, Canada, USA and Belgium. This was a very large project with difficult tasks such as land acquisition, producing pilot schemes and applying experimental science. The project experienced some difficulties and did not tick every box, but nevertheless it demonstrated the real potential of the science and technology, producing four irrigation schemes with effluent from operational waste water treatment works. This proved the potential for schemes to be launched commercially. Many participants have noted the need for a subsequent project to take the results and achievements further and to gain further buy in to the project. A risk exists where if problems arise on the pilot sites, there will not be adequate upskilled staff to address the issue.

Partner	Deliverables	Assessment of Deliverables
NI Water	1. Establish pilot effluent recycling (Magheramason WWTW) 2. Demonstration of effluent recycling (Ballyronan WWTW)	At the initial bid stage, two sites (Magheramason and Ballyronan) were identified as suitable for the establishment of a pilot effluent recycling scheme. However due to issues over the use of variable discharge consents and the need for storage at the two sites, NI Water had to look for new sites. The search for a new site was protracted and time intensive. This caused concerns over time scales and agreed delivery periods - a decision was thus made to use an alternative site in Dromore (Tyrone) that already had established willows. As a result of this situation, this partner significantly underspent on the budget assigned to them. Although the full deliverables were not met, the site that was established allowed the partners to take steps forward in terms of understanding the effects of waste water, backed up by strong scientific evidence, resulting in a positive outcome and the future commercial up-scaling viability of willows for effluent. On the other hand, a clearer focus at the beginning of the project, with more active interaction with stakeholders, could have sped up the process to allow the establishment of two sites and a larger spend of the allocated budget. Nevertheless, the lead partner made every effort to, and succeeded in, reallocating the remaining finance to other partners to further the project's effectiveness and success.
SWC	1. Mapping resources and demands (GIS)	SWC was tasked with using specialist GIS software to map sources of effluents and match these with potentially suitable sites to grow SRC willow. SWC also added the production of an online mapping resource to their deliverables which has been developed using GIS, to display the data collected and to create a final land suitability classification system. This tool has added legacy to the project, and can be used by interested parties from now on. The project has vastly improved the available knowledge in this area and has produced a strong piece of work which can be used confidently to advise and inform stakeholders and interested parties. An area where this work plan could have been improved is through consciously targeting and presenting to industry and professionals. This could have been used to promote and further disseminate information on this aspect of the project. This part of the work plan could have also been developed on a larger scale, to include a website and PR initiatives for maximum promotion of the results and the online tool.

Partner	Deliverables	Assessment of Deliverables
MCC	1. Establish pilot effluent recycling (Magheraloon, Co. Monaghan)	MCC became involved in the ANSWER project and initially intended on establishing a pilot scheme at Magheraloon. However, MCC were having difficulty in achieving the final effluent quality required for the sewage treatment plants at Knockatallon and Clontibret and thus these became the test sites for the project. The main objectives here were to prevent the discharge of noncompliant effluent going into watercourses, and to utilise the effluent nutrient leaving STWs. This aspect of the project will need more time for full understanding of the benefits to be realised. In the same way, the economic viability of the work can only be assessed after the willow crop has been harvested and sold at the market rate. Delays such as saturated grounds in winter and the need for storage onsite, are some of the lessons learned that can be passed on to future projects. Important achievements can be recognised in the land acquisition, the new infrastructure and most of all, the environmental benefit of using the effluent and not discharging it into waterways.
Teagasc	1. Establishment of a proof-of-concept effluent irrigation scheme	Teagasc was tasked with studying the effect of nutrients and heavy metals from waste by-products applied to energy crops. For this partner the focus of the worked changed a little to the study of the factors affecting overland flow, it impact and possible mitigation actions. Scientific documentation and papers were produced. The results were scientifically accurate and useful in proving the project valuable. An area for improvement could be to have experiments over longer periods of time with a wider geographical spread – this was limited in the project remit but there is potential for this research to be furthered and expanded upon. A problem encountered with this part of the work plan is that a member of staff was sick for a long period of time and this slowed down the work over a period of 12 to 14 months, this however was unavoidable.

Partner	Deliverables	Assessment of Deliverables
ITS	Investigation of the impact of irrigation on biodiversity One studentship	ITS was responsible for investigating the potential environmental impacts associated with the irrigation of SRC willow with various effluents, in particular, the ecological impacts in the receiving soil environment. A post-graduate student was also recruited to investigate the impact of irrigation on key bio-indicator soil invertebrates in established SRC willow plantations. The deliverables in this part of the work plan did not have any significant changes, only that the team had previously been working on established plantations, which had different land cropping history and the previous cropping history had to be included. The objectives here were realised in achieving three new plantations and one existing plantation, in receipt of different kinds of effluent. The monitoring produced impressive scientific research, to prove this a sustainable treatment for waste water. Looking back over the project, feedback showed that assessment of biodiversity in surrounding plantations and more personnel involvement could have been an added benefit, to make the science even more robust.
DCC	Pilot effluent recycling (Ballyliffin, Co. Donegal) Feasibility of landfill effluent recycling (Ballinacarrick Landfill and Churchtown Landfill)	DCC was tasked with constructing a 10-15 ha SRC willow effluent irrigation site. This partner also agreed to contract research lysimeters associated with a landfill site at Ballinacarrick after Cookstown District Council dropped out of the project. There were no changes in deliverables, other than using a site in Bridgend, rather than the proposed site at Ballyliffin. With the reallocation of extra funding, DCC was also able to develop a proposal and gain a contribution from the ANSWER project, for bio-remediation of leachate at a closed landfill site at Churchtown. Credit must be given here for the efforts made to reallocate funds to aid the development of this project. This partner has been praised for the efficient management of this part of the work plan, gaining buy-in from local land owners, liaising with the environment agency, and bringing on Donegal Creameries as a stakeholder. Public procurement, land acquisition and working with the planning process was carried out professionally and in good time. There was good collaboration throughout the project, however the level of work that was carried out meant that extra staff were required for the running of the project. The confines of the system and nature of recruitment in the project meant there was no flexibility for DCC to get extra help.

5.2 Project Management

Admin support from the project leader	Admin support from SEUPB	Meeting frequency
AFBI was the lead partner for the ANSWER project. Prof. Alistair McCracken was the project leader and was largely responsible for putting the project together and running the project, ensuring delivery from all partners, management of administration and finance, and liaising with SEUPB. During the course of this evaluation, the project participants were asked to provide their views on the project management. The evaluation team received a considerable amount of positive feedback about the project management. Prof McCracken and his team at AFBI were commended on their enthusiasm and efficiency in running the project. Prof. McCracken dealt with SEUPB and managed the instructions and information for the partners. He was positive and proactive in managing finance and administration, which allowed good progress of the project. The management of delays such as, partners leaving the project, underspends by partners and delays with land acquisition, were all managed in a way that overcame the problem and allowed the project to progress to meet its objectives and become a successful demonstration of wastewater treatment. Many partners and staff that worked with Prof. McCracken, during the course of the project, noted how hard he worked and the extra time and dedication that he put into the project. It is recommended here that an extra member of staff to take over administration responsibilities (e.g. making claims) would have lessened the pressure on Prof. McCracken.	Over the course of the project Prof. McCracken was the main point of contact between SEUPB and the ANSWER project. A relationship developed between the lead partner and Mr. Ciaran Hanna from SEUPB to work together. Mr. Hanna has been acknowledged and thanked for being patient and helpful during the project. Moreover SEUPB staff have been complimented for their helpfulness. During this evaluation, partners were asked to comment on the support from SEUPB. Many participants commented that the level of bureaucracy made the running of the project more time consuming on the administration end. For example, quarterly forecasts needed to be within 5% and this was very difficult for partner budgets, considering that many were working with contractors on sites. Moreover SEUPB requires a high level of paperwork with respect to claims and the tendering process. This is an aspect that could be improved to make the finance and administration a smoother, less arduous process. The ANSWER project is very scientific and technical. SEUPB have been critiqued as being less tuned in to the science and the valuable outputs that have resulted, which has been frustrating for the partners.	All partners in the ANSWER project met quarterly. Aside from this, regular remote meetings such as one to one physical meetings at sites and partner organisations were carried out. Many one to one phone calls (here Prof. McCracken was further praised for quick responses and support), and extensive email trails all prove excellent communication and support from the project manager.

6. Review of Technical Aspects of the Project

6.1 *"The primary aim of the project is to provide scientific evidence on the effectiveness and sustainability of using fast growing energy crops, in particular, Short Rotation Coppice, (SRC) willow for the treatment of organic effluent and sludges."*

The project objectives are then described in more detail in a series of deliverables, which includes the establishment of pilot sites, demonstrating irrigation systems and disseminating information. This has been assessed in section 5 IV of this report.

In carrying out the final evaluation of the technical aspects of the project, we have reviewed what was originally proposed, the actions that have taken place during the project, and the material that has been disseminated. We have also reviewed the minutes of the project meetings, the presentations that have been made by the project partners, the work of the students, and the content of the Final Report. We have also interviewed all of the project partners and have then analysed the scientific output, in relation to what was proposed.

6.2 Overview of Scientific aspects of the project

The review of the scientific aspects of the project included an assessment of the following presentations and publications:

National and International Conference Presentations:

Duddy, A.M. (2014). ANSWER (Agricultural Need for Sustainable Willow Effluent Recyling): The benefits of being a partner in an EU funded project to investigate the ecological effects of using SRC willow for bioremediation. Horizon 2020 Conference: 13th March, IT Sligo

Farrar S, McCracken A, Quinn J. (2012) Use of short rotation coppice (SRC) willow for the bioremediation of landfill leachate. 9th International phytotechnology society conference: 2012 Sept 11-14 Hasselt University Hasselt Belgium 296 p

Farrar S, McCracken A, Quinn J. (2013). Effects of varied N concentration on a variety of willow genotypes. 10th International phytotechnologies conference: 2013 Oct 1-4 S.U.NY Syracuse NY USA 90 p (Oral presentation).

Farrar S, McCracken A, Quinn J. (2014) Use of short rotation coppice (SRC) willow for the bioremediation of landfill leachate. 1st AFBI postgraduate symposium, AFBI Headquarter Belfast, UK, 4 June 2014 p 3. (Oral Presentation)

Farrar S, McCracken A, Quinn J. (2014) Understanding contaminant fate of landfill leachate bioremediation using SRC willow. 11th International phytotechnologies conference: 2012 30 Sept - 4 Oct University of Crete Heraklion. (Poster)

Feighan, J. and Duddy, A.M. (2013). The effects of wastewater irrigation on the abundance of bio-indicators in established SRC willow plantations'. Environ Conference 2013, 30th Jan. - 1st Feb. NUI, Galway

Feighan, J. and Duddy, A.M. (2013) The effects of wastewater irrigation on the abundance of earthworms, sprigtails and mites in established SRC willow plantations' STEM Conference 2013, I.T. Sligo.

Feighan, J. and Duddy, A.M. (2014). The effects of wastewater irrigation on the abundance of bio-indicators in Culmore and Hillsborough SRC willow plantations. Environ Conference 2014: 26-28th Feb. Trinity College Dublin

Johnston C, Alistair R. McCracken, Rodrigo Olave (2014. Impact of biomass renewable energy on AFBI research station. Short Rotation Woody Crops Working Group Meeting, Seattle, USA, July 2014 (Oral presentation).

Garofolo, Michele, McCracken, Alistair, McGrath, John (2013). Screening of Salix Spp. (Willow) Genotypes for the Bioremediation of Municipal Effluent, Bioremediation Conference, Rome Italy , September 2103. (Poster).

Garofolo, Michele, McCracken, Alistair, McGrath, John. (2014). Effects on plants, soil and water quality of irrigating short rotation willow coppice with municipal effluent. International Poplar Symposium, Vancouver, Canada; July 2014. (Poster)

McCracken A. R.Larry Smart, Chris Johnston, Linda Walsh (2014). Evaluation of thirty-nine diverse *Salix* spp. (willow) genotypes in a maritime climate. Short Rotation Woody Crops Working Group Meeting, Seattle, USA, July 2014 (Poster)

McCracken A. R., Agricultural Need for Sustainable Willow Effluent Recycling. (2014), International Poplar Symposium, Vancouver, Canada; July 2014. (Poster)

McCracken A. R. and Chris Johnston, Agricultural Need for Sustainable Willow Effluent Recycling (2014). Water Conference, August 2014, Brighton. (Oral Presentation)

Moss, B.P. Black, A.M, Cairns, P.F. & McCracken, A.R. (2014) The assessment of land availability for Short Rotation Coppice (SRC) Willow in Northern Ireland & Republic of Ireland Border Region through the application of Geographic Information Systems (GIS) In: *Conference Proceedings of the 22nd Annual Biomass Conference & Exhibition, Hamburg, Germany 23-26th June 2014*

Moss, B.P. Black, A.M, Cairns, P.F. & McCracken, A.R. (2014) Mapping opportunities for biomass production using a criterion based selection system through Geographical Information Systems (GIS): A case study of Northern Ireland & Republic of Ireland border region. *Poster presented at the International Bioenergy Conference, Manchester, UK, 11-13th March 2014*

6.2 Publications

Feighan, J. and Duddy, A.M. (2014). The effects of wastewater irrigation on the abundance of bio-indicators in established SRC willow plantations. M.Sc. thesis. IT Sligo

Feighan, J. and Duddy, A.M. (2014). The effects of irrigation with primary treated municipal wastewater on the abundance of earthworms, springtails and mites in an established SRC willow plantation. Journal of Applied Soil Ecology

Feighan, J. and Duddy, A.M. (2014). The effects of irrigation with dairy farmyard effluent on the abundance of earthworms, springtails and mites in an established SRC willow plantation. Journal of Applied Soil Ecology

6.3 Findings

This project is an unusual mixture of commercial deliverables, supported by a sound science based research capability. The technical aspects of the project, including the research element, the design and installation of the irrigation systems, and the monitoring of the systems performance, were well managed. The project promoters seemed to have the confidence of their partners in the Local Authorities, in the EPA, in Northern Ireland Water and in the NIEA. Much of the work was innovative from a legislative point of view. The project team's ability to overcome the normal inertia in the regulatory environment, which relies on the precautionary principle, was testament to their sound science based approach. It was evident that the project team's approach, in providing robust scientific evidence, was significant in persuading NIEA and EPA to make decisions that might normally have considered "outside their comfort zone". It is likely that AFBI's reputation as a science based organisation was influential in persuading the regulatory authorities to engage with the project.

6.4 Recommendations

There is a considerable amount of acquired knowledge embedded in the project partner's outputs. This includes technical papers, poster presentations, oral presentations from seminars and conferences, and in the Doctoral and Masters papers produced by the students, who were an integral part of the scientific delivery of the project. (Some of the student's dissertations were not complete at the time of this evaluation). We recommend that this scientific output should be collated and incorporated within a scientific report before the end of the project.

The application of effluent and leachate is a process which four government departments have a vested interest. In Northern Ireland it would be beneficial to have a working group with representatives from the DOE, DARD, DETI and DRD to ensure that the opportunities which have been highlighted in this project are not missed.

6.5 Conclusion

The scientific aspect of the project was well managed. There has been considerable dissemination of the findings through presentations at international conferences and seminars. We consider that the project has fulfilled its primary aim to "provide scientific evidence on the effectiveness and sustainability of using fast growing energy crops, in particular, Short Rotation Coppice, (SRC) willow for the treatment of organic effluent and sludges".

It is important to collate the scientific output of the project before the momentum that was generated during the project, dissipates.

7. Relevance of the Project to Providing Environmental Solutions

7.1 Overview of the environmental solutions provided within the project

There is a considerable amount of data, relating to the application of elements of this project, in providing environmental solutions, including:

- Improving water quality
- Reducing discharge to waterways
- The treatment of leachate run-off
- The ability to reduce Total Nitrogen in both drainage water and run-off
- The ability to reduce Solid Reactive Phosphorous in both drainage water and run-off
- Providing risk assessment of overland flows
- Certain willow genotypes appear to be particularly effective in taking up Nitrogen from effluents
- SRC willow can offer a cost-effective and sustainable approach to landfill leachate management
- Assessing the impact of irrigation on soil invertebrates.
- Managing nutrient loading.

7.2 The scientific aspect of the project was directed by the staff from AFBI, under the supervision of Alistair McCracken, but involved a considerable amount of work from all of the partners, particularly SWC and Sligo IT.

The dissemination of the findings was done through attendance at conferences and workshops, on an international platform that included presentations in Belgium, Greece, England, Ireland, Northern Ireland, Canada and the USA

The environmental aspects of the project incorporated the work of four post graduate students. Their focus was as follows:

Mr. Michele Garofolo, *"Effects on plants, soil and water quality of irrigating short rotation willow coppice with municipal effluent."* His project concentrated in looking at the interaction between willows and high nutrient municipal effluents. Initially he screened over 120 willow (*Salix* spp.) genotypes from which he was able to select a smaller sub-set to study in detail. A number of the genotypes appeared to be particularly effective in tolerating high concentrations of effluent and it in utilising the available nitrogen. Often the genotypes that were most effective seemed have larger root systems, and produced less above ground biomass. His studies at Culmore, a long-term irrigation filed plot, found no evidence of either nitrogen leaching to the groundwater or a significant build-up of nutrients in the soil following application of effluent over a prolonged period.

Miss Sian Farrar, *"Use of Short Rotation Coppice Willow for the bioremediation of landfill leachates."* She was particularly interested in the use of SRC willow for the treatment of landfill leachate. This type of leachate is usually very polluting and difficult to treat. In her work she screened a wide range of willow genotypes and selected a number that showed significant bioremediation promise.

Miss Sabina Doll, *"The fate of pathogens in soil after irrigation of Short Rotation Willow Coppice with municipal wastewater."* She started her studies in looking at pathogen survival in the soil after irrigation with primary effluent. Her initial studies found that none of the potentially serious human pathogens, *Salmonella* spp., *Campylobacter* spp. or coliforms survived in soil for more than a few hours.

Mr James Feighan, *"To investigate the impact of effluent irrigation on soil biodiversity in SRC willow effluent irrigated plantations."* He was recruited to investigate the impact of irrigation on key bio-indicator soil invertebrates in established SRC willow plantations. In ecological studies such as this one, it is impossible to investigate potential impacts on all resident soil organisms and therefore one or more bio-indicator organisms are chosen. A bio-indicator can be defined as a species or assemblage of species that is particularly well-matched to the environmental conditions of a specific habitat and is known to react to changes within that habitat. In this instance the specific habitat is an SRC willow plantation and the specific change is the addition of effluent to the soil environment.

Recommendations

The project demonstrated that Short Rotation Willow, SRC, can be used, sustainably, as a biofilter, for the irrigation of effluent and leachate, under controlled conditions. This was a three year project, time limited by the window of funding. It would be preferable to extend the monitoring work, if future funding could be secured, either as an extension to this contract, or as a part of a new project. The results, to date, have been encouraging, but it would be valuable to continue monitoring, as the systems and data loggers are already in place and the irrigation systems are up and running. It is important that further scientific research and analysis is carried out on an ongoing basis on the Landfill Leachate sites.

As was mentioned in the recommendations in section 6, we advise that an effort should be made, before the completion of the project, to collate the scientific output. This is also relevant to the environmental solutions which the project has provided.

8. Conclusion

8.1 The project was very effective in providing environmental solutions for:

- Improving water quality
- Reducing discharge to waterways
- The treatment of leachate run-off
- Reducing Total Nitrogen in both drainage water and run-off
- Reducing Solid Reactive Phosphorous, in both drainage water and run-off
- Providing a cost-effective and sustainable approach to landfill leachate management
- Managing nutrient loading.

8.2 Desk Top Review to Compare the Conclusions of the Project, with Other Related Literature

8.3 We have reviewed the following literature, as a comparison with the aims, objectives and conclusions of this project.

Aronsson, P., Perttu, K., 1994. Willow vegetation filters for municipal wastewaters and sludges. Proceedings from a study tour, conference and workshop in Sweden, 5-10 June 1994. Report 50, pp. 1-230. Department of Ecology and Environmental Research, Section of Short Rotation Forestry, Swedish University of Agricultural Sciences, Uppsala, Sweden. ISSN 0282-6267. ISBN 91-576-4916-2.

Carlander, A., Stenström, T.A., Albihn, A., Hasselgren, K., 2002. Hygienic aspects of wastewater-irrigated *Salix* plantations – Investigations at three fullscale facilities. Report 2002-1, VA-FORSK, Swedish Water and Wastewater Works Association, Stockholm, Sweden. In Swedish, English summary.

Dimitriou, I., 2005. Performance and Sustainability of Short Rotation Energy Crops Trwated with Municipal and Industrial Residues, Uppsala Sweden. ISSN 1652-6880. ISBN 91-576-7043-9

Hasselgren, K., 1999a. Irrigation of short-rotation energy forestry with secondary wastewater effluent. Report 1999-5, VA-FORSK, Swedish Water and Wastewater Association. In Swedish, English summary.

Hasselgren, K., 2003. Use and Treatment of municipal waste products in willow biomass plantations. Results from field experiments with wastewater, sewage sludge, and landfill leachate. Lund University, Department of Water Resources Engineering. Report 3242.

Holtze, A. and Backlund, A., 2002a. Collection, storage and application of urine from the Møn Museumsgård. Ecological Urban Renewal and Wastewater Treatment. National Danish Agency of Environmental Protection, Copenhagen, Denmark.

Pettygrove, G.S., Asano T., 1984. Irrigation with reclaimed municipal wastewater. - A guidance manual. Report No. 84-1 wr, California State Resources Control Board, Sacramento, CA, USA.

Rosenqvist, H., Aronsson, P., Hasselgren, K., Perttu, K., 1997. Economics of using municipal wastewater irrigation of willow coppice crops. Biomass and Bioenergy 12(1): 1-8.

Sopper, W.E., Kardos, L.T., 1973. Recycling treated wastewater and sludge through forest and cropland. Pennsylvania State University Press, University Park, PA, USA.ISBN 0-271-01159-9.

Wittgren, H.B., Hasselgren, K., 1992. Natural systems for wastewater treatment and resource management in temperate climate. Report 1992-15, VA-FORSK, Swedish Water and Wastewater Association. ISSN 1102-5638, ISBN 91-88392-28-7. In Swedish, English summary.

8.2 We have also reviewed the work carried out within the following projects.

BioReGen, "Biomass, Remediation reGeneration: Re-using brownfield sites for renewable energy crops". Life III Environment Programme, 2006.

"Short-rotation Willow Biomass Plantations Irrigated and Fertilised with Wastewaters". Sustainable Urban Renewal and Wastewater Treatment No. 37 2003.

RENEW "Renewable Energy Network for Environmental Welfare" INTERREG IIIA project. 2006.

8.3 Conclusions

The ANSWER project has delivered a number of operational sites handling the irrigation of wastewater and landfill leachate in a sustainable way. The sites are distributed in both Northern Ireland and in the Republic of Ireland. The results are encouraging, indicating that irrigating SRC, with effluent and landfill leachate is a viable and cost effective method of bioremediation.

In comparison to the other projects and literature considered, the ANSWER project:

- Builds on the work already carried out, particularly in Northern Ireland, England and Sweden.
- Has established 4 operational sites.
- Proven the sustainability of the systems, at least for the duration of the project.
- Established that this method of bioremediation is cost effective.
- Proven that this method of bioremediation is a commercially viable option, in Ireland.
- Has disseminated the project results widely, throughout the duration of the project.
- Should endeavour to ensure that the scientific results are captured, collated and incorporated within a report which is available after the completion of the project.

9 About the Author

9.1 About Action Renewables

Action Renewables is a private company, limited by guarantee and with charitable status. We operate under an independent Board of Directors, and we currently have a team of 17 staff operating from Belfast throughout Northern Ireland, Ireland, GB, Europe and beyond.

We are widely recognised as the foremost authority on renewable energy in Northern Ireland. Our charitable objectives are to work to create the conditions necessary to facilitate the increased penetration of renewable energy in Northern Ireland in order to provide a sustainable solution to our future energy needs, to bring enhanced fuel security, safeguard future energy costs and help combat the impending threat of climate change. Much of this is achieved through European funded projects, which bring valuable experience and knowledge into Northern Ireland, and export ours to Europe.

9.2 Expertise

Having been work package leaders in seven EU INTERREG projects over the past six years, and more recently having written and subsequently acted as Lead Partner for two Atlantic Area INTERREG projects, Action Renewables has gained extensive experience in how they operate, how to manage a partnership, how to get results and more importantly how to evaluate the success of a project and ultimately learn lessons from mistakes.

Action Renewables wrote two project proposals for Atlantic Area, in 2011 and again in 2013. Both projects were accepted and we are the lead partner in both. The first one 'BATTERIE', is a strategic project which started in 2012 and runs for three years. With 12 partners representing all of the regions in Atlantic Area and a budget of €3.4m it is an ambitious undertaking with important strategic deliverables. Experience gained has helped considerably to lead the second Atlantic Area project 'REPUTE', which runs from January 2014 to June 2015 and has a budget of €1.7m.

While these two projects have provided us with experience of how to deliver results, such experience was developed while being work package leaders in seven other EU INTERREG projects. Taking just two as examples, RASLRES was about developing biomass supply chains in rural areas of the Northern Periphery of Europe. On completion of that project, after three years, the Lead Partner was awarded another project called Biopad, which is on-going and building on the success of the earlier one.

Action Renewables thus understands the importance of EU INTERREG projects in promoting and supporting collaboration and the transfer of expertise and knowledge in Europe.

Notes

European Union
European Regional
Development Fund
Investing in your future

The ANSWER project was part-financed by the European Union's European Regional Development Fund through the INTERREG IVA Cross-border Programme managed by the Special EU Programmes Body.

PROJECT PARTNERS

afbi Agri-Food and Biosciences Institute

northern ireland water

SouthWest College

eagasc Agriculture and Food Development Authority

IT Sligo