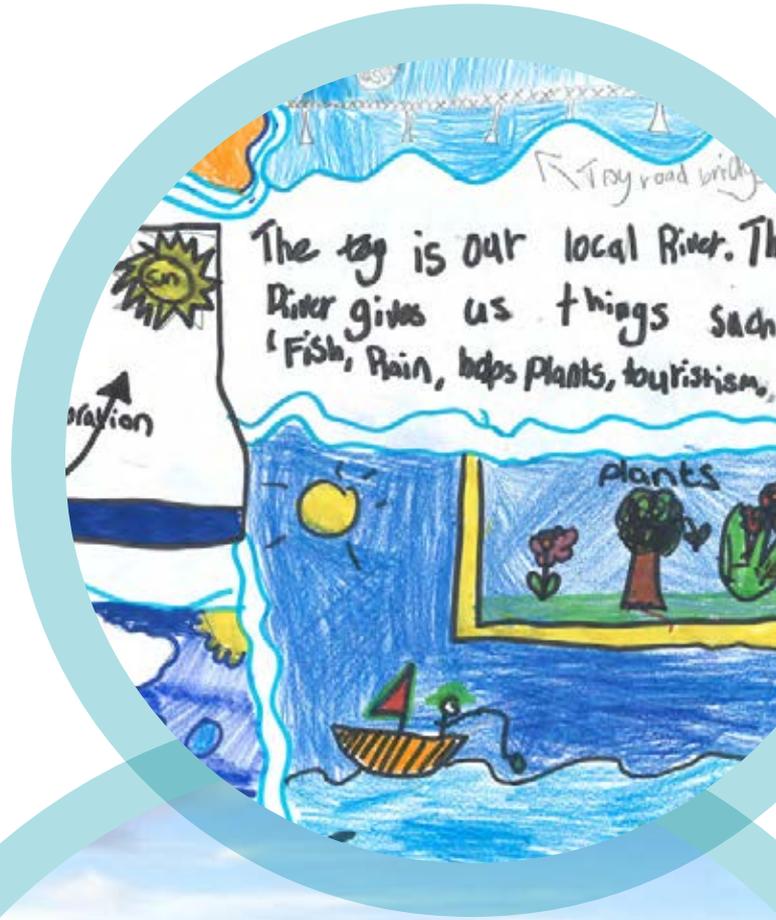


How do we increase public understanding of the benefits provided by SUDS?





Scotland's centre of expertise for waters

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Please reference this report as follows: Duffy, A., Berwick, N., Dello Sterpaio, P., (2015),
How do we increase public understanding of the benefits provided by SUDS? CRW2014/14.
Available online at: crew.ac.uk/publications

Dissemination status: Unrestricted.

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Contents

EXECUTIVE SUMMARY	2
1.0 INTRODUCTION	3
2.0 TAKING A HYDRO NATION AGENDA AND SUDS INTO SCHOOLS AND THE COMMUNITY	4
2.1 The goal	4
2.2 The team	4
2.2.1 <i>Researchers / Water Professionals</i>	4
2.2.2 <i>Abertay University OPEN / STEM Coordinator and Local Authority School Development Officer</i>	5
2.3 The audience	5
3.0 THE WATER AND SUDS LEARNING PACKAGES	6
3.1 Developing the learning package	6
3.2 Delivering the learning package	7
3.2.1 <i>Pre-School (Nursery)</i>	8
3.2.2 <i>Primary School</i>	9
3.2.3 <i>Whitfield Community Group</i>	10
4.0 FEEDBACK AND EVALUATION	11
4.1 Schools	11
4.1.1 <i>School Skills and Development Officer and Teachers</i>	11
4.1.2 <i>School children</i>	12
4.2 Community group	13
5.0 CONCLUSIONS AND RECOMMENDATIONS	14
6.0 REFERENCES	15
7.0 APPENDICES	16
7.1 Appendix 1: Water in the community and our nation – teacher engagement letter	16
7.2 Appendix 2: Lesson plans	20
7.3 Appendix 3: Pupil feedback pre-visit survey	21
7.4 Appendix 4: Pupil feedback post-visit survey	22
7.5 Appendix 5: Competition poster submissions and suds models	23
7.6 Appendix 6: School children certificates following delivery of the learning packages	24

Executive summary

Background to research

Recent Scottish Government policy is to develop Scotland as the world's first Hydro Nation which places more emphasis on water as central to our national identity. This agenda is increasing the international profile of Scotland's skills and experience in supporting the good stewardship of water resources. There is a need to increase awareness among the public of the benefits that water provides and how our actions can help protect and improve them. Successful legislative and policy reform have been responsible for sustainable urban drainage systems (SUDS) becoming commonplace in Scotland. There is a deficit of understanding surrounding the multiple benefits which SUDS can offer communities such as pollution control, flood prevention, enhancement of biodiversity and wildlife habitats. Conveying an understanding of benefits to those who live within close proximity to SUDS can help lend acceptance to these innovative green technologies that are replacing traditional forms of drainage.

Objectives of research

Key CREW objectives are to develop a hydro literacy programme that:

- (a) increases public understanding of the benefits water provides and issues involved in its management
- (b) increase science engagement through community outreach/public education
- (c) support Scottish water policy.

This project was a public outreach activity that targeted primary and secondary school children located to the north of Dundee where there are excellent examples of SUDS. The key objective was to raise awareness of the Hydro Nation agenda with a scope that was twofold: explain the urban water cycle; and promote awareness and understanding of the local SUDS and related benefits. To realise these objectives we had to ensure alignment of the science, environmental, engineering and social aspects related to SUDS with the curriculum for excellence and which contributed to general science experiences and outcomes.

Key findings and recommendations

Dissemination of the Hydro Nation Agenda and the benefits of SUDS were delivered to a total of 106 children (ages 3-10) and 14 adults. Based on feedback, the outreach programme to schools was deemed an unquestionable success by the Local Authority, teachers and school children alike. This was due to a strategic approach taken for the development and delivery of a 'water and SUDS' learning package that included a variety of mechanisms and activities to fit the time available and suit the knowledge level of the target audiences. This facilitated engagement, enthusiasm, knowledge retention and empowerment – learning whilst also having fun. Evaluation of feedback, and with hindsight, recommendations for improving future outreach initiatives to school children and local community groups include:

- Timing is crucial to ensure alignment with the curriculum, particularly secondary schools.
- Hands on sessions including experiments and digital technology related to local real world issues combined with local walks were powerful strategies that provided a direct and personal connection that engaged, promoted and embedded learning concepts and new terminology.
- Future roll out of the initiative would be beneficial to integrate the SUDS learning package materials with current lesson plans; specifically delivery of a practical legacy teaching asset that could be up scaled/rolled out across Scotland.
- The Community Group session was put together quickly with limited time. This was beneficial for the Group regarding imminent dialogue with Dundee City Council planners however a more organised session and discussion would have enhanced understanding of current best practice SUDS.

Key words: *Public Outreach, Hydro Nation, STEM, Curriculum for Excellence, Urban Water Cycle, SUDS, active learning.*

1.0 Introduction

SEPA have estimated that the natural capital of Scotland is worth £25 billion a year to the economy (Curran, 2014). Of this, 70% is as a result of the ecosystem services provided by freshwaters.

There is a need to increase awareness of the benefits that water provides and how our actions can help protect and improve them. Concerns over water quality and quantity are increasing around the world and these are exacerbated by climate change and other pressures. Arguably, and having a plentiful supply of water from rainfall, Scotland has not been severely affected by these issues. Consequently there is a perception that public understanding of water and the benefits provided is often low. Scottish Government's policy to develop Scotland as the world's first Hydro Nation places more emphasis on water as central to our national identity. The Hydro Nation agenda is increasing the international profile of Scotland's skills and experience in supporting the good stewardship of water resources, but it is also important to increase understanding of the water resource among the people of Scotland. Key to the success of River Basin Management Plans and the Flood Risk Management Act is increasing the understanding of water and its management. CREW is developing a programme of knowledge exchange activities to help improve public understanding of water and the benefits that water provides (CREW, 2015). The aims of this are to:

- increase the public understanding of the benefits water provides and the issues involved in its management
- increase science engagement through community outreach and public education
- support the aims and objectives of water policy in Scotland.

Successful legislative and policy reform such as the Water Environment Water Services (WEWS) Act (2003) and responsibility for drainage infrastructure (WRc, 2007) have

resulted in sustainable urban drainage systems (SUDS) now commonplace for all new development and many redevelopments in Scotland. There remains however a deficit of understanding surrounding the range of benefits that SUDS can offer communities. The multiple benefits of SUDS are often referred to as ecosystem services (ES) where primary benefits relating to the urban water cycle include: water quality and quantity; recreation and amenity; biodiversity and wildlife habitats and mitigation of climate change impacts. Conveying an understanding of benefits to those who live within close proximity to SUDS can help lend acceptance to green technologies that are replacing traditional forms of drainage.

The CREW project Blue Health (Miller et al, 2012) found that 'SUDS act as a restorative to environments in urban settings owing to their visual amenity, species richness, and recreational potential'. Another recent CREW publication (Duffy et al, 2013) identified that lack of public engagement will become a disabling factor for future implementation of SUDS.

This project was a public outreach activity that targeted primary and secondary school children located to the north of Dundee where there are excellent examples of SUDS. The key objective was to raise awareness of the Hydro Nation agenda and the scope twofold: to explain the urban water cycle; and to promote awareness and understanding of their local SUDS and related benefits. Key to achieving this was to align with the Curriculum for Excellence and contribute to literacy and numeracy skills including general science Experiences and Outcomes (Es&Os). Due to a request from a local Community Group, the project also delivered an outreach activity where the scope was to empower the local community for future negotiations during public consultation. This project provided a unique opportunity for the school children and the local community group to engage with water professionals / researchers.

2.0 Taking a Hydro Nation agenda and SUDS into schools and the community

Dissemination of the Hydro Nation agenda and the challenges related to SUDS and urban water management was achieved in pre-school (nursery), primary school and a community group in the north Dundee catchment (Ardler, Craigowl, Mill O' mains and Whitfield areas) between February and April 2015. This outreach strategy applied Varner's (2013) three phased framework that was originally developed to engage the public in the sciences where participation in outreach activities is low amongst scientists (Figure 1).

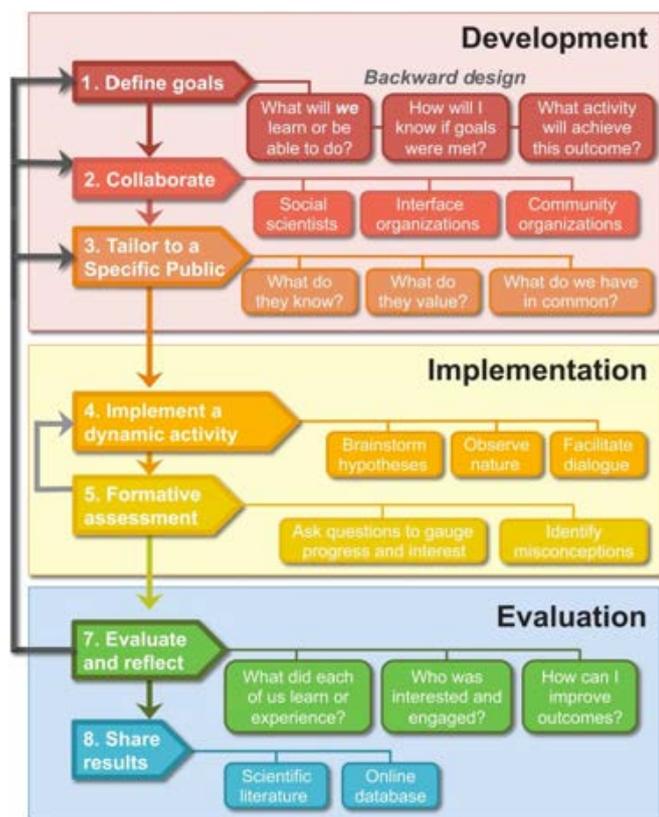


Figure 1 A new framework for effective science communication (Varner, 2013).

2.1 The goal

The key goal of this project was to raise awareness of the Hydro Nation agenda to schoolchildren, how SUDS help achieve this in urban areas and at the same foster learning and promote careers in STEM subjects to encourage the next generation of scientists, engineers, architects, planners etc. in the water sector. To achieve these goals the development phase of the framework considered the backward design process where results or goals were first defined (Wiggins and McTighe, 2005, Varner, 2014): what will the children learn, how will we know if they have learned (what is the evidence) and how will we achieve the outcome via a lesson plan and practical experiences.



Figure 2 The Abertay team: Introduction slide for schools.

2.2 The team

With the goal defined – hydro literacy to schools with particular focus on the Hydro Nation agenda and how SUDS can help with achieving this, the next step was to put together the team that linked the school curriculum with our skills/ expertise in up-to-date scientific and engineering research and practice and deliver complicated issues using appropriate language (Fischhoff 2013, Turney et al. 2014). STEM subjects have been highlighted as crucial to the nation's future economic growth and are a core part of the teaching at Abertay with regards the built environment. It is well known that for educational and community engagement/ public outreach activities one person is unlikely to have all of the skills required for successful engagement and learning to be achieved (Daly et al 2015, Varner 2014). In particular, as public outreach to schools required knowledge of the Curriculum for Excellence it was crucial to seek collaboration with Dundee City Council (DCC) Schools Development Officers in order to align with the science, engineering, environmental and social aspects related to the SUDS concept and utilise their knowledge and relationships developed with the local schools identified. The Abertay team included two SUDS researchers from the Urban Water Technology Centre and the Outreach and Public Engagement network (OPEN) and Science, Technology, Engineering and Mathematics (STEM) Coordinator (Figure 2) and a Schools Skills and Development Officer from DCC.

2.2.1 Researchers/Water Professionals

Abertay researchers have more than 15 years practical and academic experience in implementing urban water management policies and practices, particularly SUDS and dissemination via conferences/workshops/seminars/study tours to a range of professionals in the public and private sectors, taught under-graduate/post graduate modules and several Community groups in Dundee and Fife. The specific goal of this public outreach project was not just to educate and inspire school children about their local SUDS but also to attract them to STEM subjects using a variety of formal and informal learning methodologies that enhanced and enriched the school curriculum (Turney et al, 2013).

2.2.2 Abertay University OPEN/STEM Coordinator and Local Authority School Development Officer

Educational development is a core activity at Abertay University which is actively committed to promoting STEM subjects to local schools with specialist staff employed to further develop these links. The DCC School and Skills Development Officer within the Education Department works in collaboration with schools, employers, University of Abertay, University of Dundee and Dundee & Angus College to deliver a skills strategy that enables school children to make connections to life and work beyond school, as well as developing practitioner knowledge to prepare school children for their future employment, through experiential learning and work related exposure. The challenge was to ensure that the three core SUDS concepts of pollution control, flood mitigation and amenity / wildlife benefits were covered in the lesson plans in a way which provided maximum impact on teaching quality and learning.

2.3 The Audience

The City of Dundee has some of the oldest SUDS in Scotland (and the UK) and as such, much of the research undertaken on these SUDS (as reported in Jefferies 2001 and 2004) has informed best practice guidance (CIRIA 2000 and 2008) and national and local policy developments. Two areas were initially chosen to the north of Dundee. The village of Ardler where a regeneration programme disconnected stormwater from the combined sewer in 1996 and the resulting SUDS are now mature (swales, ponds and basins). This area is used as an exemplar case study on both a national and international basis by Abertay University (Figure 3). Mill O' Mains is currently undergoing a four phase community regeneration programme where SUDS are being retrofitted: surface water is disconnected from the existing combined sewer and conveyed to the nearest watercourse (the Dighty Water) via SUDS (permeable paving, filter drains, basins and ponds).

Six schools (two Secondary and four Primary) in both these areas were invited for delivery of a water and SUDS learning package that included: classroom lessons including animated graphics, talks and discussions; interactive activities such as a learning game developed by Abertay during an EU funded project called Water Town (<http://watertown.abertay.ac.uk/>) and a laboratory experiment using equipment provided by Abertay; and local show and tell walks to the Ardler and Mill O' Mains SUDS.

Four Primary Schools responded to the invitation. The Secondary schools did not respond and one of the Primary schools did not appreciate the limited timescale of the offer and requested that the team deliver the session during the Summer term. A contingency plan existed in that if any of the schools were unable to participate or did not respond to the invitation then the scope would be broadened to schools in neighbouring areas that also had good examples of multiple SUDS schemes.

Before there was a need to fall back on the contingency plan the team was contacted by a Nursery School (in the Mill O' Mains catchment area, following delivery of the learning package to the local primary school) and a nearby Community Group in Whitfield, also to the north of Dundee, where a DCC Communities Officer had heard of this initiative via the Schools Skills and Development Office during a meeting. Sessions were

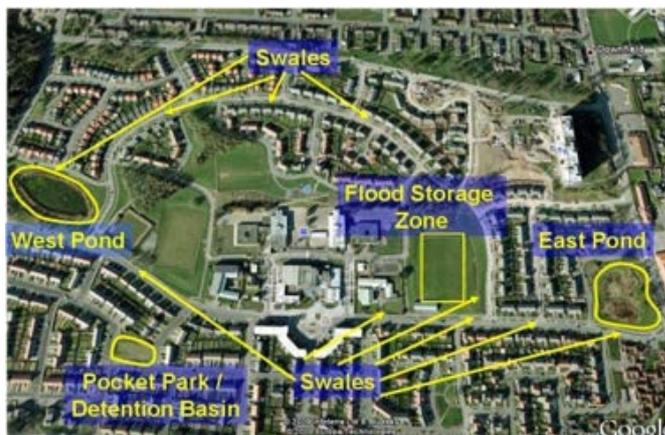


Figure 3 Ardler village regeneration: location of SUDS.

booked with both within the project timescale. Whitfield is a planned five phase regeneration project that aspires to build a new community within the existing community where land has been cleared including development of up to 1,000 new residential properties. The drainage infrastructure to support the first phase of this project includes SUDS with a regional pond, permeable paving, swales and a basin already in situ. The Community Officer requested a workshop type event combined with a study tour of local SUDS to increase understanding of the operational features of the systems and awareness of best practice designs in other areas of Dundee

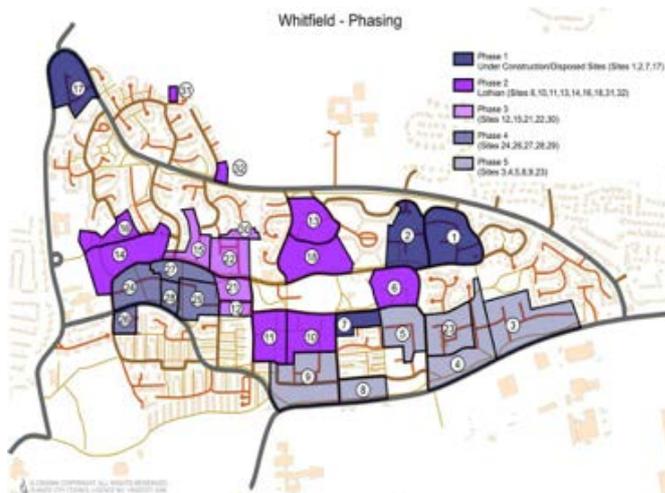


Figure 4 Whitfield existing SUDS(left) and Regeneration Phasing Plan (right).

as it was felt that the existing Whitfield SUDS were 'non-inspirational'. This would assist with empowering the local community for future negotiations during public consultation for the next phases of development.

Consequently delivery of the Hydro Nation and SUDS learning package in the northern area of Dundee has been achieved for 120 children and adults with ages ranging from 3-68 years (Figure 5)

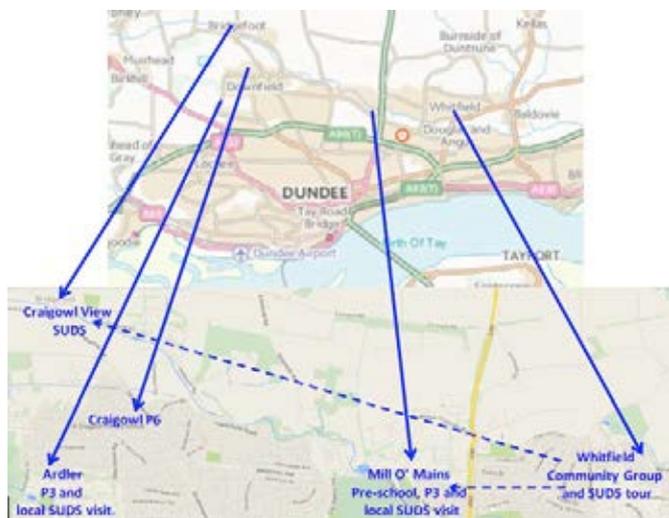


Figure 5 North Dundee SUDS catchment extent and locations of pre-school, primary schools and community group.

3.0 The Water and SUDS Learning Packages

As identified in the project proposal, given the quick turnaround of the call, the key risk to achieving success was if the project did not align with current curriculums as the Spring sessions had already been developed and agreed in Dundee schools. It was important to demonstrate clear /complimentary links with a particular topic that was being delivered during this time. Liaison with the DCC Schools and Skills Development Officer had initially resulted in a very positive response to this proposal and alignment with the Curriculum for Excellence was quickly established following the award by the OPEN / STEM Coordinator. This alliance ensured that the lesson plans addressed several STEM topics and as many Es&Os as possible such as:

- People, place and the environment – exploring features of the local environment to develop an awareness of the world around me (SOC 0-07a)
 - Earth's materials – understanding the characteristics and uses of soil (SCN 3-17a)
 - Chemical changes – monitoring the environment by analysing samples (SCN 4-18a)
 - Topical Science – how scientists from Scotland contribute to innovative research (SCN 4-20a)
 - Planet Earth – learning about climate change, human activities and the dynamic nature of earth
- (For the full list see Appendix 7.1: Water in the Community and the Nation: Teacher Engagement Letter).

In addition, the outreach programme was organised to coincide with an annual STEM careers event for the Craigowl P6A and P6B classes. Whilst still addressing E&O's, lesson content was more focused on the multi-disciplinary nature of SUDS and defining the differing career paths available e.g. scientist, engineer, landscape architect, city planner, technician and maintenance staff in various types of responsible bodies and organisations such as the Scottish Environment Protection Agency (SEPA), Local Authorities, Scottish Water, consulting engineers and land management companies.

3.1 Developing the Learning Package

Educational psychology literature has shown that active engagement and diversity of learning practices are powerful for facilitating enthusiasm, knowledge retention and empowerment (Handelsman et al. 2004, Michael 2006, Reynolds 2009). The Water and SUDS learning package incorporated units that explained (in simple language) the hydrological water cycle, urbanisation and the urban water cycle - including water services such as water supply, use and disposal, impacts on the environment (such as flooding due to development and diffuse pollution related to anthropogenic activities that pollute our watercourses,) and the new management process such as SUDS that help mitigate these impacts.

School sessions introducing the Hydro Nation and SUDS agendas varied with content and activities to suit the knowledge level (and age) of the target audiences. This involved reworking / adapting existing materials and developing new content to ensure that the desired impact was achieved. This included:

- Suitable and simple language and terminology at the outset and introducing technical terms (such as 'engineer', 'pollution', 'swales', 'inlet', 'outlet' and 'infiltration') where appropriate which were reinforced during the show and tell walks.
- A strong emphasis on visual information; photographs, diagrams and videos that were used to communicate key messages and learning points.
- "Hands on" sessions were designed to complement the lessons and the local show and tell walks. Examples included:
 - Building a model of the local SUDS basin or pond for P3's
 - Modelling the local river using plasticine and then changing the shape of the river and comparing the speed in which a foam ball would "flow" down the river for the Nursery.
 - Total suspended solids (TSS) experiment to show P6 children how rainwater is polluted.

A competition was originally devised as a challenge for children to nominate local developments which they considered to have the most beneficial SUDS from an ES perspective following knowledge gained during the lessons. The project, competition and results of the competition were to be promoted via local school websites, social media (Facebook, Twitter, Instagrams etc.), and the local press and radio. However, on consultation with DCC Schools Skills and Development Officer it was accepted that utilising social media would bring social inclusion issues into play (in that many schoolchildren may not have access to mobile phones or other e-media). In addition, not all schools used a Twitter feed or Facebook for communication, and this could have imposed significant limitations to responses and could skew results in favour of one school. Two alternative competitions were devised aimed at the P6 and P3 levels. The P6 competition was in the form of a poster competition based on the design of an information leaflet highlighting the benefits of the local watercourse (the River Tay). These were sent to the Abertay team for judging at the final stage of the project. The P3 competition was based on the SUDS modelling exercise undertaken during the class sessions following the Ardler and Mill O' Mains show and tell visits. The posters and models (in the form of photographs) were also judged by the Science, Engineering and Technology (SET) Head of School and Head of the Graduate School. The winners were Craigowl P6B and

Mill O' Mains Primary School. The winner will be announced shortly as the summer term is just underway in Dundee and the local media will be invited to attend presentation ceremonies. Competition posters and model images can be found in Appendix 6.

3.2 Delivering the Learning Package

At the initial stage of the project, the Abertay STEM Coordinator and the School Skills and Development Officer contacted the local schools within the catchment area via the Teacher Engagement Letter (See Appendix 7.1) to identify those who would be interested in hosting the Hydro Nation sessions. As already discussed, lesson plans were developed depending on age and specifically the time available as this influenced our approach to developing the plan. Session duration varied from 1.5 hours to 5 hours and all sessions were delivered at the local venues (pre-school, primary schools and community group).

Lesson content and activities were split into key learning areas (Table 1 and see sections 3.2.1 to 3.2.3 below) and were delivered by all three members of the Abertay team, thus changing the "voice" and style of delivery and topics presented to maintain interest from the group. A variety of delivery mechanisms and style were used to suit the target audience and the show and tell walks, discussion sessions, hands on experiments and art and crafts activities were used to break up the lessons / presentations. Additional materials (for example video content and photos) were prepared and used on an ad hoc basis to emphasise and clarify points during discussions with the children and Community Group. One example of this was during the Mill O' Mains Primary School session where video footage was used to show swales running full of water in Ardler Village to illustrate the flood reduction potential of SUDS in the community. This exercise in particular excited several of the school children as they recognised relatives' houses in the video (grandparents, aunts etc.) which facilitated a personal relevance to the issue and helped to capture attention surrounding flooding and the benefits that the swale provided as a flood prevention mechanism.

On completion of each learning package school teachers were provided with certificates for each of the schoolchildren (See Appendix 7). The Primary 3 school children received their certificates at the end of each session. Craigowl primary 6 school children were presented with their certificates during school assembly where images of children receiving their certificates were posted on the school twitter page.

Table 1 Lesson plans for schools and the Community Group

Public Outreach	CREW	HN	HWC	Urb	UWC	F&P	SUDS	S&T	TD	VG	Ex	MB
Happy Days Nursery			•			•			•			•
Mill O'Mains Primary School P3		•		•	•	•	•	•	•			•
Ardler Primary School P3		•		•	•	•	•	•	•			•
Craigowl PS P6A	•	•	•	•	•	•	•		•	•	•	
Craigowl PS P6B	•	•	•	•	•	•	•		•	•	•	
Whitfield Community Group	•	•				•	•	•				

HN = Hydro Nation, HWC = Hydrological Water Cycle, Urb = Urbanisation, F&P = Flooding and Pollution, S&T = show and tell (study tour), TD = Turf / concrete demonstration, VG = Video Game, Ex = TSS (Total Suspended Solids) Experiment, MB = Model Building.

CraigowlP5Dundee @CraigowlPrimary Mar 13
 P6 all received 'Hydro Nation' certificates for their effort during careers week. Thanks to Abertay Uni. 😊



CraigowlP5Dundee @CraigowlPrimary Mar 13
 Some more 'Hydro Nation' certificate recipients at this morning's assembly. 🍌🍌🍌🍌



View more photos and videos

Figure 6 Craigowl tweets showing school children who had received their Hydro Nation certificates during assembly.

Time available for the Whitfield Community Group public outreach session was limited to 2 hours and the session was split into a presentation that focussed on:

- drainage design (combined, separate systems and transition to SUDS)
- the function of SUDS (pollution and flood prevention plus the social and biodiversity benefits)
- the different types of SUDS for use at the source, site and regional control
- management of SUDS – maintenance activities required for function (blockage prevention etc.)
- global examples of best practice

The study tour included visits to two local SUDS – the Mill O' Mains regeneration SUDS and Craigowl View SUDS (swales, basins and a pond) which are part of an ongoing development on a Greenfield site.

3.2.1 Pre-School (Nursery)

The pre-school session was delivered to Happy Days Nursery on 13th March 2015. The session duration was 1.5 hours and it was delivered to 20 children aged 3-5 years.



Figure 7a Learning about porous surfaces.



Figure 7b Learning about river morphology.

3.2.2 Primary School

Four sessions were delivered to three primary schools in the north Dundee catchment as follows:

3.2.2.1 Sessions 1 & 2: Craigowl Primary 6 Class 6A and Class 6B (24th February 2015)

Two sessions were arranged with Craigowl Primary School. The sessions coincided with the annual STEM careers event for Primary 6 classes. Session durations were approximately 1.5 hours and it was delivered to 63 school children in total aged 10-11 years.



Figure 8a P6 Practical demonstrations: analysing surface water runoff for suspended solids.



Figure 8b P6 Practical demonstrations: playing the WaterTown interactive video game.

3.2.2.2 Mill of Mains Primary 3 (25th February 2015)

One session was delivered to Mill O' Mains Primary 3 school children. The session duration was 3.5 hours and it was delivered to 23 children aged 7-8 years.



Figure 9a Mill O' Mains P3 Show and tell of the local SUDS.



Figure 9b Model building of a SUDS pond.

3.2.2.3 Ardler Primary 3 (26th February 2015)

One session was delivered to Ardler Primary 3 school children. The session duration was 5 hours and it was delivered to 20 children aged 7-8 years.



Figure 10a Ardler P3 learning about water pollution.

3.2.3 Whitfield Community Group

One session was delivered to the Whitfield Community group on the 15th April 2015. The session duration was 2 hours and it was delivered to 8 adults.



Figure 11a Whitfield Community Group Study tour of Craigowl View SUDS pond.



Figure 10b Show and tell of the local SUDS.



Figure 11b Tour of Craigowl View SUDS swales.

4.0 Feedback and Evaluation

Dissemination of the Hydro Nation agenda and the benefits of SUDS was delivered to a total of 106 children between the ages of 3-10 and fourteen adults (community group, parent helpers and teachers) between 24th February and 15th April 2015. Feedback was solicited from all groups using a range of formal and informal mechanisms including pre and post-visit questionnaires, email and direct discussion in order to evaluate and therefore improve future schools and Community Group outreach effectiveness (Keeley 2008, Asiney et al. 2008, Varner 2014, Daly et al. 2015).

4.1 Schools

Schools were asked to give feedback via questionnaires. Two questionnaires were designed: one for the teachers focussed on both knowledge of topic materials and organisation of the sessions; and a 3 point image based likert scale type questionnaire to evaluate the school children's knowledge prior to and following the visit (See Table 2 and Table 3 for results and Appendix 4 and 5 for examples of the pre / post visit school children questionnaires). The final question in the post visit questionnaire was open ended so that children could leave their own feedback.

4.1.1 School Skills and Development Officer and Teachers

One of the Craigowl Primary 6 teachers provided a testimonial following delivery of the learning package:

"Fabulous exercise. The children were very interested and engaged well with all activities."

The DCC School Skills and Development Officer sent a testimonial which clearly indicates that there is a role for this type of academic / professional outreach when planned and delivered effectively:

"Further to my earlier email regarding your delivery during our 'STEM Careers Week' to the P6 school children at Craigowl Primary School, I would also like to thank you both for delivering an excellent learning package to our P3 school children from Ardler Primary and Mill of Mains Primary. I was most impressed with the learning materials that your team developed, as you clearly took the time to fully align this to Curriculum for Excellence BGE experiences and outcomes in Science, Technology and Social Studies. It has been an absolute pleasure to work with you and I look forward to future initiatives."

Two feedback questionnaires were returned from the Primary 3 teachers and results are provided in Table 2. Key messages from the teachers regarding the learning packages delivered include:

- Awareness of the Hydro Nation agenda was low prior to the visits.
- The learning packages were regarded as very useful and materials were suitable for future use.
- Further educational packages / visits are desirable.

Table 2 Teacher feedback questionnaire results

Question	N/A	No / Inadequate			Yes / Excellent	
		1	2	3	4	5
1. Did you feel you were given adequate information about the learning package?					✓	✓
2. Were you kept informed of progress in the lead up to the visit?					✓	✓
3. Were your questions answered prior to the visit?	✓					✓
4. Was the visit well planned?						✓✓
5. Did your children seem to enjoy the sessions overall?						✓✓
6. Did your children learn new things today?						✓✓
7. Have you heard of Hydro Nation before you received the learning package?		✓✓				
8. Will you use materials created for today's visit in future lesson plans?					✓	✓
9. Would you be interested in future visits from the Water & Environmental Scientists?					✓	✓
10. Would you be interested in other learning packages from Abertay's Outreach Office?					✓	✓

4.1.2 School children

Results from the pre and post session delivery questionnaire that was developed by the OPEN/STEM Coordinator for Ardler and Mill O' Mains Primary 3 school children are provided in Table 3 and some of the open ended comments to the final question in the post questionnaire are provided in Figure 12.

Key messages from the P3 school children questionnaires and comments include:

- Awareness of the Hydro Nation agenda, the impacts of anthropogenic activities on the water environment in urban areas, and SUDS was low prior to each visit and high following the visit.
- The diverse lesson plans and activities were a successful strategy and contributed to the schoolchildren becoming engaged with the topics – learning whilst also having fun.
- The show and tell visits were a powerful delivery mechanism as they provided a direct and personal connection with the local SUDS and the benefits they provided, particularly nature (swans and ducks etc.) They also helped foster learning by embedding key messages.

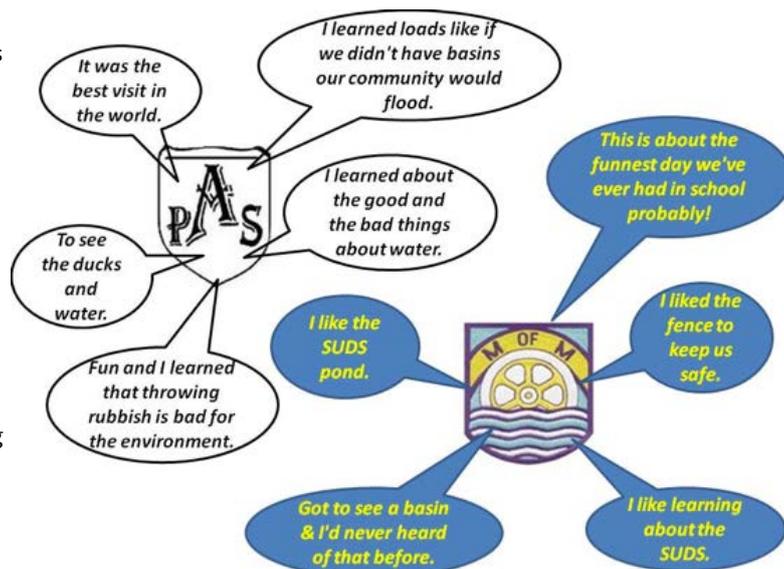


Figure 12 Open ended question feedback from Ardler and Mill O' Mains Primary 3 schoolchildren.

Table 3 Primary 3 School children questionnaire results

Primary 3 school children	Pre-visit				Post-visit			
	not sure	no	yes	% yes	not sure	no	yes	% yes
I know about the water cycle	10	12	20	48%			42	100%
I have heard of Hydro Nation	12	26	4	10%	7	5	30	71%
I have heard of a SUDS pond	24	15	3	7%		1	41	98%
I know what a SUDS pond is for	15	22	5	12%	3	4	35	83%
Building houses can cause flooding	10	14	18	43%		1	41	98%
I think water is important		1	41	98%		1	41	98%
I know what pollutes water	17	20	5	12%	3	1	38	90%
I know where there is a SUDS pond in my community	27	13	2	5%		2	40	95%

Craigowl P6A and P6B schoolchildren were asked to write down what their likes (stars) and wishes were following the sessions delivered. Some comments are provided in Figure 13.

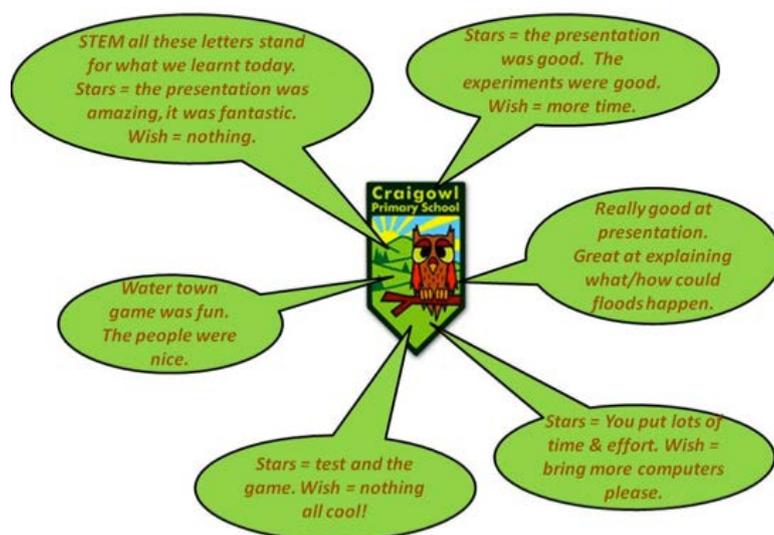


Figure 13 Craigowl P6 school children feedback - likes and wishes.

4.2 Community Group

A discussion following the presentation and study tour centred on the SUDS observed in other local communities. Whitfield already has a 'community' pond that was implemented at the beginning of the regeneration project several years ago. At the moment it is uninspiring and tucked away at the bottom of the development but there are plans to landscape the pond and develop the surrounding area as a public park. We asked which SUDS had made the best impression and the response was unanimously in favour of the Craigowl View pond. This pond is the newest SUDS to be implemented at Craigowl View and is

designed to the latest best practice guidelines. On arrival the members were immediately delighted to see ducks and coots on the pond and there was a frank discussion surrounding the various engineered components such as the inlet forebay that served as a sediment trap and the planted aquatic vegetation on the perimeters of the pond that provide a habitat for wildlife and improve water quality benefits. As with the school children, it was primarily the direct and personal connection with the SUDS pond and biodiversity benefits that it provides that inspired the group.



Figure 14 Whitfield existing pond (left) and Craigowl View pond (right).

5.0 Conclusions and Recommendations

It is clear that this schools outreach project was successful in developing the Scottish water sector knowledge base and furthering the hydro literacy objective in schoolchildren. This was achieved through a water and SUDS learning package that focused on real world issues (the local SUDS and ES benefits to the local area) by delivering a diverse, interactive lesson plan, showcasing cutting edge research and using digital technology. We have also embedded the concept of the Hydro nation agenda and enforced why we should look after our water resources particularly local watercourses and how we can do this by implementing SUDS. The outreach programme also reached a local community group that wished to increase their knowledge of best practice SUDS for future negotiations during public consultation.

Following evaluation of feedback and our own hindsight from experiences gained when delivering the learning packages, our recommendations for improving future outreach initiatives to school children and local community groups include:

- Delivery of sessions to schools must complement the existing curriculum and this is best negotiated with the schools/ teachers prior to the start of the academic year (August) to ensure that it aligns with lesson plans and that there are available time slots. This has particular importance to high school children, especially towards the S3 – S5/S6 years given the very tight scheduling of classes and topics ahead of national examinations. Timing of delivery for other age ranges has different implications. For S1 – S2, delivery of these sessions is best ahead of subject-choice times (January/February) as this gives the children an opportunity to experience the topics in an inspirational and real-world context thereby potentially changing the subject choices of these children and changing the path of their learning and interests as they progress towards further and higher education. For Primary School children, in the younger years (P1 – P6) lesson plans are designed to build upon the prior learning of previous years, which could potentially lend itself to repeated exposure to water-focussed sessions of increasing complexity over several years thereby firmly embedding the importance of water in the Scottish economy and environment in the minds of the children. Building on this, P7s undertake transition events with their secondary schools which again offers the opportunity to use water as a context for creating cooperative learning events between P7 and S1s, bridging the learning from Primary into Secondary school.
- Longer lead-in times would allow teachers to plan lessons that incorporate sessions from external organisations. Feedback from the teachers was very positive, and they remarked that other classes had just done the water cycle, or had just completed an environmental learning topic and that this would have been a great addition to their lesson plans.
- Contact with secondary schools was directed to the head and/ or deputy head of schools and it was not clear if the offer of sessions was cascaded to the class teachers. Future contact would most likely be more effective by way of a poster and or leaflets to be displayed in the staff room, with a follow up email to remind teachers of the offer, and present additional information in more detail. This again requires more lead in time.
- “Hands on” sessions related to real life problems (for example the model building, permeable surfaces demonstrations and practical laboratory experiment) received the most interest from the school children and, that when these were delivered following the local walk of the area (visiting SUDS and/or local river) then this helped to embed learning concepts and new terminology.
- Model building of the local SUDS promoted the learning concept of multiple benefits from green infrastructure for local communities. The P3 children developed models which included: amenity space (including picnic areas, tables and chairs, bins, paths, etc), habitat areas (where they incorporated birds and small mammals), water treatment aspects (of polluted water within the SUDS), designs for safety (physical barriers, visibility lines and splays).
- Using interactive (web-based) digital technology was welcomed and the school children very much enjoyed these sessions however there was limited access to laptops. This resulted in children waiting in turn to play the games. More computers would have improved the experience for school children during this session. Lack of time was also an issue for the laboratory experiment with several school children missing out on the experience.
- The show and tell visits were a powerful strategy as they provided a direct and personal connection with the local SUDS and the benefits they provided, particularly nature (swans and ducks etc.) They also helped foster learning by embedding key messages. Unfortunately, due to time, the P6 schoolchildren did not benefit from this activity. Again, a longer lead in time would have meant that we could have included this into the learning package.
- Time was very limited time for the Community Group as this session was slotted into the monthly meeting with DCC planners scheduled for two hours following the SUDS presentation and study tour. Additional time would have benefitted the group members, particularly for discussing the pros and cons between the existing SUDS and those observed during the study tour to better inform the members for later discussions with the planners. We were invited to join this meeting but due to prior evening commitments this was not possible. However, members of the group went into the meeting better informed regarding SUDS best practice details and more able to influence the type of SUDS scheduled to be implemented in the next phase of the regeneration programme.

A final comment to this outreach project comes from the DCC Schools Skills and Development Officer. Often initiatives such as this in schools do not leave a legacy or sustained outcome that teachers can build on to enhance the curriculum and subsequently raise ambitions of schoolchildren. From the teacher feedback questionnaires, teachers indicate that we have provided materials that can be utilised in future lesson plans – but the reality of this may be unrealistic without further interactions with Abertay to guide integration to existing lesson plans. We further propose follow up work that would be particularly beneficial, specifically delivery of a practical legacy teaching asset to school teachers: a SUDS learning package including installation of source control SUDS such as a raingarden for both primary and secondary schools. This would be a 1-2 year project where Abertay would deliver technical and teaching support for schools to construct a raingarden(s) and facilitation of a monitoring programme including follow up lessons. This initiative could then be upscaled/ rolled out across Scotland.

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7.0 Appendices

Appendix 1: Water in the Community and our Nation – Teacher Engagement Letter



SUDS : Sustainable Urban Drainage Systems

Water in the community and our nation

It is estimated that the Water Technologies Industry could be worth around £900 million per year for Scotland in the water technologies alone.

--HTechO: Tapping the Potential 2014

Dear Teacher,

The Scottish Government has a policy to develop Scotland as the world's first **Hydro Nation**. In Scotland we are highly skilled and experienced in looking after our rivers, lochs and the sea.

Abertay University, as part of the Hydro Nation agenda, has put together a **fully-funded** learning package for school children to raise awareness of the importance of Scotland's water, where it comes from, where it goes, and why it is important to protect our natural resources.

The learning package will be delivered by a series of classroom talks and discussions, interactive activities, and hopefully a local show & tell walk-about in the community.

In addition to contributing to literacy and numeracy skills, general Science Es&Os that can be addressed are:

- > develop curiosity and understanding of the environment
- > develop skills in the accurate use of scientific language
- > recognise the impact the sciences make on my life, the lives of others, the environment and on society
- > develop an understanding of the Earth's resources and the need for responsible use of them
- > express opinion and makes decisions on environmental issues based upon sound understanding
- > develop as a scientifically-literate citizen with a lifelong interest in the sciences
- > establish the foundation for more advanced learning in the sciences & technologies

(specific Es&Os are detailed on the accompanying page)



The project runs from **February to end of March 2015**, and we would like to visit your school to deliver a **FREE Water Learning Package** which can be tailored to the level and previous knowledge of your learners. Units in the learning package are:

The Water Cycle	Water supply & use	Urbanisation and the Urban water cycle	Water Impacts and the Environment	New Water Management Processes
Introduction to the water cycle with interactive activities to explain and check understanding.	Discuss water use in school and at home. Where does water come from, what is it used for, and where does it go once we've used it? Water explorer survey sheet and discussion.	Towns and Cities – with specific emphasis on Dundee. What impact has the building around the city had on the water cycle? (e.g. flooding and pollution). Videos, interactive activity demonstrating flooding and infiltration.	Water and Pollution – Water as a resource, and sources of pollution: interactive activity to show impact of adding pollutants to water and what this means in the environment. Flooding – why do areas flood and demonstration of different types of flooding (from rivers, sea, land and sewers). What can we do about flooding? Actions we can take to prevent flooding (SUDS, flood defences).	Sustainable Drainage – traditional drainage systems are underground, sustainable green drainage systems are above ground, contributing not only to flood defences but also the natural habitat of wildlife, and creating green spaces for humans. Walkabout of locals SUDS in the area (following confirmation of location).

To arrange a visit by the Abertay University Urban Water Specialists and discuss requirements for your school, please contact:

Dr Patsy Sterpaio

01382 308527

p.dellosterpaio@abertay.ac.uk



Thank you

Appendix: Specific Es&Os that can be addressed through this learning package.

At a glance Level Key: **Early** **First** **Second** **Third** **Fourth**

Planet Earth: Processes of the planet Learners explore the changing states of matter and the physical and chemical processes which influence Earth's atmosphere and oceans. They learn about climate change as a natural process in time as well as the result of human activity. Through connections with collaborative studies of landscape, weather and climate in social studies they build up an integrated picture of the dynamic nature of Earth.	SCN 2-05a	I can apply my knowledge of how water changes state to help me understand the processes involved in the water cycle in nature over time
	SCN 3-05b	I can explain some of the processes which can contribute to climate change and discuss the possible impact of atmospheric change on the survival of living things
Earth's materials Learners develop their knowledge and understanding of substances that make up the Earth's surface.	TCH 1-02a	Throughout all of my learning, I take appropriate action to ensure conservation of materials and resources, considering the impact of my actions on the environment.
	SCN 2-17a	Having explored the substances that make up the Earth's surface, I can compare some of their characteristics and uses.
	SCN 3-17a	Through evaluation of a range of data, I can describe the formation, characteristics and uses of soil [...]
Chemical Changes Learners gradually develop an understanding of chemical changes. They consider the processes which take place in the environment and in the laboratory, and develop their understanding of the environmental impact of some changes.	SCN 2-18a	I have investigated different water samples from the environment and explored methods that can be used to clean and conserve water and I am aware of the properties and uses of water.
	SCN 4-18a	I can monitor the environment by collecting and analysing samples. I can interpret the results inform others about levels of pollution and express a considered opinion on how science can help to protect our environment.
Topical Science By considering current issues of science, learners increasingly develop their understanding of scientific concepts and their capacity to form informed social, moral and ethical views. They reflect upon and critically evaluate media portrayal of scientific findings.	SCN 0-20a	I can talk about science stories to develop my understanding of science and the world around me.
	SCN 1-20a	I have contributed to discussions of current scientific news items to help develop my awareness of science.
	SCN 2-20a	Through research and discussion I have an appreciation of the contribution that individuals are making to scientific discovery and invention and the impact this has made on society.
	SCN 3-20a	I have collaborated with others to find and present information on how scientists from Scotland and beyond have contributed to innovative research and development.
	SCN 4-20a	I have researched new developments in science and can explain how their

		current or future application might impact on modern life.
People, place and environment	SOC 0-07a	I explore and discover the interesting features of my local environment to develop an awareness of the world around me.
	SOC 1-07a	I can describe and recreate the characteristics of my local environment by exploring the features of the landscape.
	SOC 2-07b	I can describe the physical processes of a natural disaster and discuss its impact on people and the landscape.
	SOC 0-08a	I explore and appreciate the wonder of nature within different environments and have played a part in caring for the environment.
	SOC 2-08b	I can consider the advantages and disadvantages of a proposed land use development and discuss the impact this may have on the community.
	SOC 3-08a	I can identify the possible consequences of an environmental issue and make informed suggestions about ways to manage the impact.
	SOC4-08a	I can discuss the sustainability of key natural resources and analyse the possible implications for human activity.
	SOC 3-10a	I can investigate the climate, physical features and living things of a natural environment different from my own and explain their interrelationship.
	SOC 4-10a	I can develop my understanding of the interaction between humans and the environment by describing and assessing the impact of human activity on an area.
	SOC 4-10b	I can explain the development of the main features of an urban area in Scotland or elsewhere and can evaluate the implications for the society concerned.
	SOC 1-13a	Having explored the landscape of my local area, I can describe the various ways in which land has been used.
	SOC 1-13b	By exploring a natural environment different from my own, I can discover how the physical features influence the variety of living things.
	SOC2-13a	I can explain how the physical environment influences the ways in which people use land by comparing my local area with a contrasting area.

NB. This is not a fully comprehensive list, however shows the wide range of Es&Os that can be addressed through this learning package.

7.2 Appendix 2: Lesson Plans

Session Pre-school (Nursery)	Content
(i) Where does water come from?	Discussion with the children about rainfall and ponding on hard surfaces (flooding) using photos to illustrate problems.
(ii) What happens when it rains?	Interactive session: Turf, tarmac and leaky surfaces. Practical demonstration of what happens when rain falls on different surfaces.
(iii) Rivers near our houses	Discussion (using photos of the local river) about rivers and benefits. Interactive session: River shape. Physical demonstration of how changing the shape of rivers impacts on flow and the type of animals that may inhabit the river.

Session Primary 6	Content
(i) Introduction	Staff introduction and overview of the project and funding body.
(ii) Hydro Nation – the importance of water in our community	Presentation covering: What is a Hydro Nation, the water cycle and the urban water cycle, flooding & pollution. Interactive session 1: Urbanisation and rainfall. Practical demonstration of how different surfaces (impermeable & permeable) can be used to manage rainfall in our towns and cities. Interactive session 2: WaterTown ¹ – flood decision making game (web based) & Stormville ² – Pollution impact game (web based). Interactive session 3: Testing for Pollution – practical chemistry experiment to assess the level of total suspended solids (TSS) in urban runoff.
(iii) Session Re-cap & career opportunities in STEM	Presentation and group discussion summarising the session and discussing career options for school children studying STEM subjects at high school.

¹ Interactive learning game WaterTown was developed within the Project Skills Integration & New Technologies, an EU North Sea Region Programme.

² Developed by Smart WaterWays Chittenden County's Stormwater Website. Available at smartwaterways.org

Session Primary 3 Mill O' Mains	Content
(i) Introduction & The Hydro Nation Agenda	Staff introduction, what do we mean by Hydro Nation, and overview of the project and funding body.
(ii) Flooding and pollution challenges in our communities	Presentation: The urban water cycle, flooding & pollution challenges using national and local examples. Interactive session: Urbanisation and rainfall. Practical demonstration of how different surfaces (impermeable & permeable) can be used to manage rainfall in towns / cities.
(iii) Local SUDS visit	Show and tell walk to the Mill of Mains SUDS basin.
(iv) What have we learned?	Discussion with school children and re-cap of the key lessons from the session. Interactive session: Model building. School children split into two groups to build physical model of the local SUDS.

Primary 3 Ardler	Content
(i) Introduction & The Hydro Nation Agenda	Staff introduction, what do we mean by Hydro Nation, and overview of the project and funding body.
(ii) Introduction to sustainable drainage systems (SUDS) & flooding and pollution challenges in our communities	Presentation 1: Introduction to SUDS – examples of common techniques that we will visit on the walk. Presentation 2: The urban water cycle, flooding & pollution challenges using national and local examples.
(iii) Local SUDS visit	Show and tell walk around the Ardler redevelopment area, visiting the west pond, community detention area and roadside swales..
(iv) What have we learned?	Discussion with school children and re-cap of the key lessons from the session. Interactive session: Model building. School children split into two groups to build physical model of the local SUDS.

Session	Content
(i) Introduction & The Hydro Nation Agenda	Staff introduction, what do we mean by Hydro Nation, and overview of the project and funding body.
(ii) Brief overview 'Draining our cities'	Presentation 1: Separate / combined sewers and SUDS types (source, site and regional controls).
(iii) Benefits of SUDS	Pollution control, flooding and social amenity / biodiversity benefits.
(iv) Managing SUDS	Maintenance activities.
(v) SUDS Examples	Neighbouring Local and global SUDS.
(vi) Whitfield case study	Look at DDC Regeneration phasing plan, existing SUDS and propose locations and types of new SUDS.
(vii) Local Study Tour	Mill O' Mains regeneration SUDS and Craigowl View new development SUDS.

Pre-visit Survey

School
Age

Circle your smiley answer

not sure

no

yes

Q1.
I know about the water cycle



Q2.
I have heard of Hydro Nation



Q3.
I have heard of a SUDS pond



Q4.
I know what a SUDS pond is for



Q5.
Building houses can cause flooding



Q6.
I think water is important



Q7.
I know what pollutes water



Q8.
I know where there is a SUDS pond
in my community



Post-visit Survey

School
Age

Circle your smiley answer

not sure

no

yes

Q1.
I know about the water cycle



Q2.
I have heard of Hydro Nation



Q3.
I have heard of a SUDS pond



Q4.
I know what a SUDS pond is for



Q5.
Building houses can cause flooding



Q6.
I think water is important



Q7.
I know what pollutes water



Q8.
I know where there is a SUDS pond
in my community



What did you think of today's visit? What did you learn?

7.5 Appendix 5: Pupil Feedback Post-Visit Survey

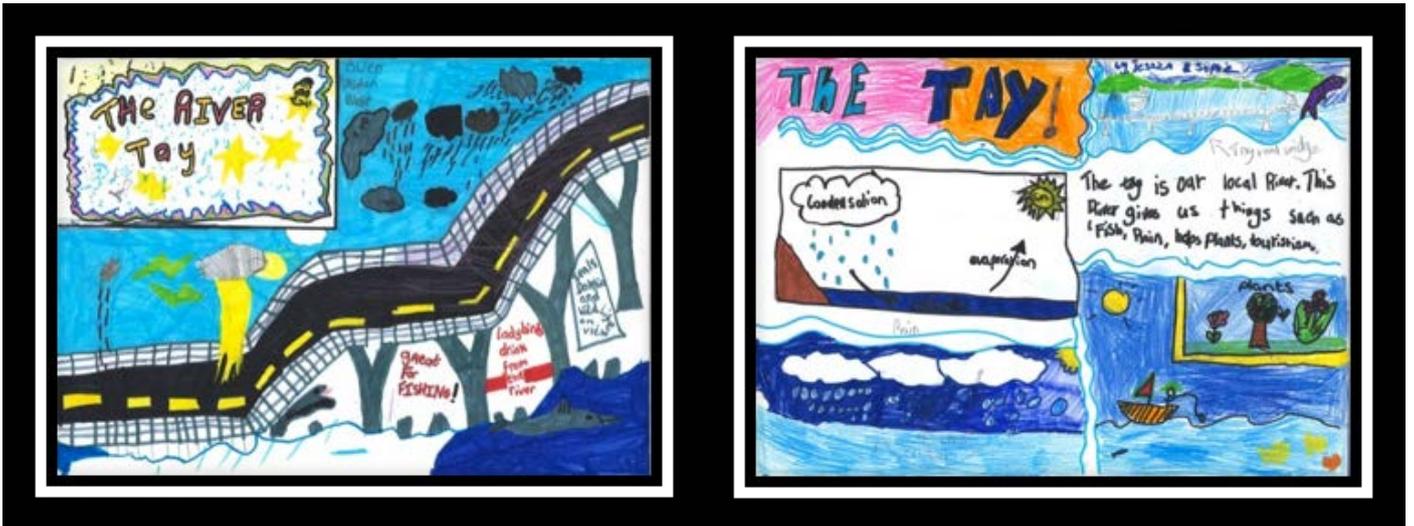


Figure 15 Craigowl P6A (left) and P6B (right) posters. P6B is the winning poster.



Figure 16 Open ended question feedback from Ardler and Mill O' Mains Primary 3 schoolchildren.

7.6 Appendix 6: School children Certificates following delivery of the learning packages

  <p>The Centre of Expertise for Waters (CREW) is funded by the Scottish Government.</p>  <p>This is to certify that _____</p> <p>has successfully completed</p> <p>Hydro Nation:</p> <p>The Importance of Water in our Community</p>  <p>Learning Activity at Happy Days Nursery on 13th March 2015</p> <p>Signed   </p> <p>www.uwtc.abertay.ac.uk www.abertay.ac.uk/open</p>	  <p>The Centre of Expertise for Waters (CREW) is funded by the Scottish Government.</p>  <p>This is to certify that _____</p> <p>has successfully completed</p> <p>Hydro Nation:</p> <p>The Importance of Water in our Community</p>  <p>Learning Day at Ardler Primary School on 26th February 2015</p> <p>Signed  </p> <p>www.uwtc.abertay.ac.uk www.abertay.ac.uk/open</p>
  <p>The Centre of Expertise for Waters (CREW) is funded by the Scottish Government.</p>  <p>This is to certify that _____</p> <p>has successfully completed</p> <p>Hydro Nation:</p> <p>The Importance of Water in our Community</p>  <p>Learning Day at Mill of Mains Primary School on 25th February 2015</p> <p>Signed  </p> <p>www.uwtc.abertay.ac.uk www.abertay.ac.uk/open</p>	  <p>The Centre of Expertise for Waters (CREW) is funded by the Scottish Government.</p>  <p>This is to certify that _____</p> <p>has successfully completed</p> <p>Hydro Nation:</p> <p>The Importance of Water in our Community</p>  <p>STEM Event at Craigowl Primary School on 24th February 2015</p> <p>Signed _____</p>



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