Section A

Institution: Durham University

Unit of Assessment: 12 Engineering

Title of case study: Soil Health

Period when the underpinning research was undertaken: 2009 to date

Details of staff conducting the underpinning research at Durham:

Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Professor Karen Johnson	Professor	2005 to date

Period when the claimed impact occurred: from 2014 and ongoing

Is this case study continued from a case study submitted in 2014? N

Section B

1. Summary of the impact (indicative maximum 100 words)

Environmental engineering research undertaken at Durham University has led to impact in: Governmental policies on soil health; how land is remediated using novel sustainable technologies; and on the awareness of the effects of soil health on human health. Nationally, the Government has been influenced by the engineering research undertaken, which helped launch the UK's first ever Soil Health Inquiry in 2015. The final report from the Inquiry fed into the UK's 25-year Environment Plan and into the recently launched Agriculture Bill. Regionally, the research also led to direct environmental impact when novel sustainable land remediation technologies were successfully used to remediate and regenerate brownfield (urban) land in Easington Colliery which is now a vibrant community garden dedicated to a WWII war hero.

2. Underpinning research (indicative maximum 500 words)

Brownfield land is wasteland, which is often contaminated with potentially toxic chemicals such as lead and arsenic from industry. Much brownfield land in the UK occurs in cities, is of low economic value and is left untreated, blighting our poorest communities. In 2008, Johnson won an EPSRC Challenging Engineering fellowship for the ROBUST project (Remediation of Brownfield using Sustainable Technologies). The vision was twofold: to develop low-cost sustainable technologies to remediate these low-value brownfield land sites and to investigate links between brownfield land (urban soils) and public health. Johnson focussed efforts on regenerating brownfield land which was being failed by the system, neither being remediated through either the planning system or the contaminated land legislation (Part IIA Environment Act 1990). All brownfield or contaminated land can be remediated with a range of technologies; however, their cost usually makes it prohibitive for low-value land. Local authorities actively seek only to remediate high-value brownfield land as this can be used for housing or other economically viable uses. The key findings of ROBUST were as follows:

1) **Environmental engineering** - soil health can be improved using novel soil amendment technologies which optimise ratios of organic matter and minerals reducing contaminant (e.g. arsenic, lead) bioavailability ([R1, R2] respectively) and improving flood resilience [R3]. Briefly the technologies developed consist of the use of clean "waste" minerals (e.g. residuals from the clean Water Industry which are ordinarily landfilled) in combination with clean organic matter sources (e.g. compost) which together rebuild degraded soils, improving "soil health" [R4].
2) **Community and policy** – the community-led methodology [R5] provides a cost-effective sustainable method for tackling the many brownfield sites which blight local communities thereby improving soil health, potentially improving public health [R6] as well as diverting

waste from landfill and potentially improving flood resilience [R3]. This innovative work was further recognised by the award of a Philip Leverhulme Prize in Engineering in November 2011.

3) **Health** – [R6] is the first UK study on the links between ill health and brownfield land (or urban soils) - if you live in an area with more brownfield land, you are 14% statistically significantly more likely to suffer from a life-long limiting illness (such as arthritis).

A key feature of ROBUST was both regional and national engagement, involving local communities in Durham (organisations and people such as Easington Colliery Council, local councillor David Boyes, Northumbrian Water Group, and the Easington Colliery's Regeneration Partnership) as well as policy-makers in Government. Part of the workplan for ROBUST was identification and regeneration of a low-value brownfield site using the novel ROBUST technologies developed in [R1-R5]. This was successful and a remediated site in Easington Colliery opened as a community garden in tribute to WWII war hero Dennis Donnini in May 2014 and has since gone on to become a vibrant part of the local community landscape. The ROBUST team comprised Johnson, three PhD students and two Postdocs and ran from 2009 to 2014.

3. References to the research (indicative maximum of six references)

[R1] McCann, Clare M., Peacock, Caroline L., Hudson-Edwards, Karen A., Shrimpton, Thomas, Gray, Neil D. & Johnson, Karen L. (2018). In situ arsenic oxidation and sorption by a Fe-Mn binary oxide waste in soil. Journal of Hazardous Materials 342: 724-731. DOI: 10.1016/j.jhazmat.2017.08.066. Rated as 3/4* by external readers in mock REF assessment

[R2] McCann, C.M, Gray, N.D., Tourney, J., Davenport, R.J., Wade, M., Finlay, N.C., Hudson-Edwards, K.A. & Johnson, K.L. (2015). Remediation of a historically Pb contaminated soil using a model natural Mn oxide waste. Chemosphere 138: 211-217. https://doi.org/10.1016/j.chemosphere.2015.05.054. Rated as 3/4* by external readers in mock REF assessment

[R3] Kerr, H., Johnson, K., et al (2016) Flood Holding Capacity: A Novel Concept to Evaluate the Resilience of Amended Soils. Geo-Chicago 2016: pp. 393-409. https://doi.org/10.1061/9780784480120.041 Rated as 2* by internal assessment.

[R4] Clarke, Catherine E., Stone, Wendy, Hardie, Ailsa G., Quinton, John N., Blake, Lynsay I. & Johnson, Karen L. (2019). Better Together: Water Treatment Residual and Poor-Quality Compost Improves Sandy Soil Fertility *Journal of Environment Quality* **48**(6): 1781. https://doi.org/10.2134/jeq2019.03.0147 Rated as 2/3* by internal assessment.

[R5] CL:AIRE Research Bulletin 19, March 2016, "Regeneration Of Brownfield Using Sustainable Technologies". https://www.claire.co.uk/phocadownload/rb19-robustweb.pdf. Rated as 2* by internal assessment.

[R6] Bambra, C., Robertson, S., Kasim, A., Smith, J., Cairns-Nagi, J.M., Copeland, A., Finlay, N. & Johnson, K. (2014). Healthy land? An examination of the area-level association between brownfield land and morbidity and mortality in England. Environment and Planning A 46(2): 433-454. https://doi.org/10.1068/a46105. Rated as 3* by external readers in mock REF assessment.

Funding
PI: Karen Johnson
Title: ROBUST: Regeneration of Brownfield Using Sustainable Technologies
Sponsor: EPSRC, Challenging Engineering, EP/G028958/1
Period of the grant:16 March 09 – 15 December 14
Value of the grant: GBP1,011,999

PI: Karen Johnson
Title: Community-led regeneration of brownfield land using sustainable technologies
Sponsor: The Philip Leverhulme Prizes 2011
Period of the grant: 1 November 2011-31 October 2014
Value of the grant: GBP100,000

4. Details of the impact (indicative maximum 750 words).

The ROBUST team's research has led to impacts in the following areas.

Impact on environmental policy – Johnson's research has significantly impacted the debate at policy-making level and in Parliament on the topic of soil health. It has also impacted priorities for members of UK Research and Innovation (UKRI). In May 2014 Johnson met with Joan Walley MP, who was at that time Chair of the Environmental Audit Select Committee (EAC) to discuss the links between contaminated land and ill health [R6]. Joan's constituency of Stoke on Trent is littered with low-value brownfield land and this research was of great interest. Joan agreed that "this was area of policy that deserved attention" and encouraged Johnson to engage with the next Chair of the EAC, Huw Irranca-Davies MP. After meeting with Huw in October, Johnson pressed for the Committee to launch the UK's first Parliamentary Inquiry into Soil Health and proposed a Parliamentary debate, which Irranca-Davies agreed to Chair. Johnson advised on the Terms of Reference for the Inquiry in November 2015, specifically recommending that as soil is an overlooked public health determinant, more research was required to understand how we might improve community wellbeing by maintaining and enhancing soil health. The Terms of Reference for the Inquiry were then released online on 2nd Dec 2015 [E1]. Johnson organised all speakers for the Parliamentary Panel debate, including many who were ROBUST stakeholders such as Sarah Dack (Public Health England) [E2] and it was advertised on the UN Food and Agriculture Organisation website [E3].

Johnson's engineering work and engagement with the EAC led directly to be being invited to submit written and oral evidence [E4] to the Soil Health Inquiry on Urban Soils, specifically on: the importance of remediating brownfield and protecting our urban soils; engaging engineers with sustainable soil management; communities using locally available "waste" minerals and organic matter in the novel technologies developed in [R1-R5]; and most importantly on the previously overlooked links between public health and prevalence of brownfield land [R6]. Peter Lilley MP questioned Johnson about [R6, E4] and coverage on Johnson's work on this issue also appeared in the Guardian [E5].

Photos showing Johnson (middle left) in the Urban Soils session at Government's Soil Health Inquiry in April 2016 and Gove (right) launching UK's first soil health targets in Jan 2018

Johnson's identification of the problems with low-value brownfield land not being remediated leading to "lots of pieces of wasteland in communities of lower socio-economic status…exacerbating inequalities" were quoted in the final report from the Inquiry [E6].

Sarah Dack (PHE) has said that the Soil Health Inquiry "instigated a more joined up policy-making around soil….both ourselves and the Environment Agency are more joined up on the effects to public health from soil. At the time of the launch of the Inquiry the planned 25-year Environment Plan and Agriculture Plan were not linked and did not include for soil protection.

Since the Inquiry, soil has become a major consideration of the 25-year Environment Bill and the recently adopted Agriculture Bill." [E2]. Dr Wentworth (Parliamentary Office for Science and Technology) said "Johnson's interaction with MPs on the EAC select committee has been instrumental in making soil management policy the focus of parliamentary interest and scrutiny, which has subsequently influenced Government policy" [E7]. Directly after the Soil Health Inquiry final report was released (May 2016), Johnson went on to discuss Urban Soils (and brownfield land) with UKRI, in July 2016, leading a team of 3 academics from across the UK (Rogers from Birmingham, Glendinning from Newcastle and Stewart from Leeds) to highlight that urban soil health which links directly to public health [R6] was missing from UKRI's portfolio. NERC (Natural Environment Research Council) then took urban soil health into their remit and their Soil Security Programme hosted a workshop on urban soils in April 2017. This resulted in Johnson leading the submission of an "Urban Soils Highlight Topic" in May 2017, which was accepted by NERC and launched as part of a suite of major new environmental topics in November 2017 which has since led to several funded projects worth GBP24M. Johnson was a member of the funding panel in 2018 [E8].

Rebecca Pow MP said: "It has taken a long time but we have turned a corner on getting soil on the political agenda" [E9]. She launched the Sustainable Soils Alliance (SSA) in October 2017 and Johnson continues to contribute through working on its Science Panel, notably helping the SSA launch the UK's first ever soil health targets (launched by Michael Gove in January 2018 [E9]). Johnson was invited to take part in the Defra workshop (Oct 2018) to help further define these soil health "indicators" and categorise types of soils. Johnson argued successfully for "Urban soils" (which provide vital carbon and water storage services in cities [E9]) to be a distinct category of "healthy soils" which will form the "central plank" (George Eustice, Farming Minister in 2018 [E9]) of the UK Government's 25-year Environment Plan. In addition, soil features as a "public good" for the first time in the Agricultural Bill which replaces the Common Agricultural Policy when the UK leaves the EU. This means that landowners will receive public money to provide environmental services like flood management and carbon storage [E9].

Community impact - the public, local authority, industry and voluntary sector organisations in Easington Colliery, County Durham, have benefitted directly from Johnson's research by collectively regenerating, with the ROBUST team, a 1000 square metre brownfield site in the village. David Boyes, local councillor said "*On behalf of the community I would like to thank you and your team for the work you have done at the site. The area was not a particularly pleasant place to be, and certainly not one frequented too often by people from Easington. I believe that ….the site may well be a catalyst for further regeneration in that part of the village*" [E10]. The site has indeed undergone a radical change (see photos below of before and after) and is now a memorial community garden for a WWII veteran and a thriving hub of activity each year, especially on the anniversary of Donnini's death [E10].

Before and after remediation by novel ROBUST technologies showing original brownfield site (left) and Community Garden (right - on WWII Hero Donnini's anniversary in January 2020)

5. Sources to corroborate the impact (indicative maximum of ten references)

[E1] Terms of Reference and emails showing Johnson's input

[E2] Testimonial from Sarah Dack, Public Health England, February 2020

[E3] UN website link with Panel Debate invite
http://www.fao.org/soils-2015/events/detail/en/c/350737/

[E4] Panel Debate video (http://www.parliamentlive.tv/Event/Index/f77d63b0-bc6e-425b-aa47-ba63be60be99) plus oral and Written evidence submitted to EAC Soil Health Inquiry and print version

[E5] Guardian Article on brownfield where Johnson states links with public health
https://www.theguardian.com/environment/2016/jun/02/government-cuts-funding-for-making-brownfield-sites-suitable-for-new-homes

[E6] Final report on Soil Health Inquiry
https://publications.parliament.uk/pa/cm201617/cmselect/cmenvaud/180/180.pdf

[E7] Testimonial from Dr Jonathan Wentworth, Parliamentary Office of Science and Technology

[E8] Details of NERC funded projects under the Soil Security funding call NERC - Fourth round of funded highlight topic projects announced (ukri.org)

[E9] Introduction of Soil Health Targets in Guardian article and also embedded Guardian video of '*How soil offers hope for the climate crisis'* where Johnson discusses the importance of community action to maintain urban soil health
https://www.theguardian.com/environment/2018/mar/13/uk-farmers-to-be-given-first-ever-targets-on-soil-health

[E10] Email from local Councillor and video of WWII Hero celebrations (this one in January 2020 but they have happened every year since 2015)
https://www.facebook.com/watch/?v=472110780404168