WP6 Responsible Innovation

Research Plan

Final version for Work Package (WP) 6 Responsible Innovation of the Synthetic Biology Applications to Water Supply and Remediation project funded by the UK's Engineering and Physical Sciences Research Council (2013-2018)

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Introduction

Responsible innovation (RI) has been defined as '… taking care of the future through collective stewardship of science and innovation in the present' (Stilgoe et al., 2013: 3). Building particularly on insights from science, technology and innovation studies (STIS), as well as commercial and regulatory experience, advocates argue that various tools and techniques can and should be used to open up scientific research at an early stage allowing a wide range of societal issues to steer or shape innovation pathways (Stirling, 2008; Ely et al., 2014). If this is done, they suggest, new technologies will be better aligned with what society wants and responsibility for them will be spread or shared more widely. In practice this means going beyond relatively familiar concerns such as risk, ethics (narrowly defined), technical feasibility and commercial potential. The policy and academic debate around RI is gathering pace in the UK, Europe and United States and in relation to new frontiers of technology such as geoengineering, nanotechnology, artificial intelligence and synthetic biology (Owen et al., 2013; Von Schomberg, 2013; Stahl et al., 2013; van Oudheusden, 2014).

WP6 Aims and Objectives

Work Package 6 (WP6) will advance existing work by linking RI and synthetic biology in a new and ambitious way. Synthetic biology, involving the design and construction of new biological devices and systems, has the potential to transform society and the environment in positive and negative ways and is emerging in a context shaped by the contentious politics of genetically modified crops and foods. Within government and amongst some academics synthetic biology is thought to have avoided the mistakes that plagued agricultural biotechnology in part due to 'clearer, more palatable goals: to produce green fuels or create new medicines' (Sample, 2011: web; see also Torgersen and Hampel, 2011). That said, whilst some publics may be more accepting of the technology (at least for now) many have also indicated that they want scientists and research funders to take more responsibility for the wider implications of their work in this area (and others) (Bhattachary et al., 2010; Sciencewise, 2013).

For these and other reasons synthetic biology has been identified as an important area where implementing RI is both possible and desirable (Grunwald, 2011; Stilgoe et al., 2013). Many reports and articles have already explored the ethical, legal and social aspects/impacts (ELSAs or ELSIs, as they are known) of synthetic biology (Zhang et al., 2011) and some progress has been made in linking this new frontier of research to RI (Douglas and Stemerding, 2013). However, RI is still at a very early stage, including in relation to synthetic biology. Fundamental questions are still awaiting definitive answers. Not least, is responsible innovation possible? And what does success look like in practice?

Building on the work which has already been done, therefore, our aim is to operationalize RI in relation to a large synthetic biology project (see below) and in so doing (i) deliver new technologies which benefit from a shared or collective sense of responsibility, and (ii) critically assess RI in action contributing to academic and policy debate. In this way we will contribute both to the synthetic biology project of which we are part and to the agenda of RI as it moves from theory to practice. More specific objectives include:

- to establish a dialogue between science and society in a way that allows a wide range of issues, concerns and perspectives to shape the synthetic biology research.

- to steer the pathway of innovation in a way that leads to new technologies which are safe, legitimate, appropriate and commercially viable.
- to test a range of tools and techniques (see below) and combinations thereof to assess their value in operationalizing RI.
- to help create new forms of interdisciplinary working and new institutions that can use such tools and techniques to promote RI.

WP6 builds on prior work of Murphy and Walls. Murphy has explored interactions between science, technology and society in many different ways, including the relationship between environmental regulation, industrial innovation and competitiveness (Gouldson and Murphy, 1998), governance and the EU-US conflict over of agricultural biotechnology (Murphy and Levidow, 2006) and the relationships between governance, technology and sustainability more broadly (ed Murphy, 2007). More recently he has focused on the relationship between social science and public policy (Parry and Murphy, 2013). Walls has worked on the changing governance of new technologies (Walls et al., 2005), evaluation and development of best practise in public engagement in relation to GM crops (Horlick-Jones et al., 2007), nuclear waste management (Bergmans et al., 2008) as well as how to develop effective stakeholder engagement in complex socio-technical issues (Walls et al., 2011).

The Wider Project

This work package is part of the Synthetic Biology Applications to Water Supply and Remediation project funded by the UK's Engineering and Physical Sciences Research Council (2013-2018). The aim of this project is to innovate in the basic technology of synthetic biology as applied to water supply and treatment focusing on two generic themes, namely: synthetic organisms as sentinels and signallers, and synthetic organisms as catalysts. It therefore aims to address one of the world's most pressing problems; the supply of safe and clean drinking water. There are 5 scientific/technical work packages (WPs 1-5). Four of these focus on developing various synthetic biology treatments for water and the other focuses on modelling and quantifying the viability of the solutions offered. WP6 cuts across and links WPs 1-5.

Summary of Work Packages 1-5

WP1 – Understanding and engineering biofilms formation and dissolution

This work package will target two areas: (1) using synthetic organisms to degrade or encourage the build-up of biofilms in water supply and treatment systems; (2) the creation of microbial fuel cells with the potential to produce renewable electricity using waste water. Biofilms are important not least because they can cause blockages and degrade pipes. More positively, they can also be used to filter contaminated water. WP1 will use synthetic biology to engineer non-hazardous strains of bacteria (E. coli) such that they will turn blue when they detect molecules that are central in creating biofilms. In response the engineered bacteria will secrete enzymes that can degrade the biofilm before it can cause damage. The microbial fuel cell work will involve E. coli engineered to have enhanced electron transfer capabilities thereby making the fuel cell more efficient and effective.

WP2 – Anaerobic wastewater treatment

Over the last twenty years we have seen attempts to create more sustainable technologies that can treat waste water whilst at the same time producing useful by products. One route is through the development of technologies that are underpinned by anaerobic microbial processes in which waste water is cleaned and microbes used to extract useful products and services such as biogas from the methane that is the by-product. WP2 will begin by focusing on 6 different types of bacteria that can produce methane from waste water to determine which have the most potential. Synthetic biology techniques will then be used to help engineer pathways that can increase the efficiency of methane production in specific chosen microbial communities.

WP3 – Protocell scavengers

Protocells are simple self-organising forms of life created from scratch in the laboratory. They are very simple versions of cells, created from non-living materials, which have lifelike properties and can regenerate themselves from organic and non-organic matter in the environment. This WP will begin by exploring how to construct the most effective ‘chassis’ (a hybrid shell composed of polymers and lipids) to house DNA thus creating a protocell. It will then explore how to ensure that the protocell can function in a range of different environments such as those found in waste water treatment facilities. Finally it will explore the ability of the protocell to scavenge or metabolise pollutants and products from wastewater.

WP4 – Design of minimal inorganic water purification (iCHELLS)

Drawing on cutting edge techniques in inorganic chemistry this work package will focus on creating shells (minimal cells) from inorganic chemicals and using these in relation to a range of environmentally friendly catalyst systems. More specifically, the iCHELL (inorganic chemical cell) system will be used to create ‘inorganic machines’ with the aim of detoxifying water via oxidation of organic waste. Some of the iCHELLs will be designed by a genetic algorithm based on directed evolution. The iCHELLs will be tested under a range of experimental conditions (different pH levels, flow rates etc.) chosen to mimic the waste water treatment environment in order to assess the robustness of different types. The results will be fed into an evolutionary system in order to optimise and enhance subsequent iterations of the iCHELLs.

WP5 – Prediction and risk

Ensuring the fitness of a synthetic organism in a laboratory is relatively straightforward compared to securing its functionality in a complex system such as a waste water treatment plant where it will have to compete with a range of organisms as well as contaminants and fluctuating physical conditions. This research aims to fill the considerable gaps that exist in the analysis and prediction of the fitness and evolution of synthetic organisms in real world settings. The first step will be to understand how adding and expressing new genes affects the energy allocated to the core metabolism and fitness aspects of the organism. This will be achieved by comparing the performance of a chassis with and without additional bio parts added, providing vital information on how energy is used in a cell and the impact on it of expressing foreign genes. WP5 will build on this knowledge by testing a number of different synthetic organism designs created by WP 1-4. Finally, the basic experiment will be expanded to explore how the organisms react to competition, predation, and substrate fluctuations typical of waste treatment systems.

Water, SynBio and Responsible Innovation

What WPs 1-5 will discover is uncertain but it is clear that synthetic biology has the potential to transform the water industry. This matters because the sector is facing a number of challenges which are driving up costs and increasing environmental impacts – amongst other things. Many of these are associated with supply and treatment approaches/infrastructures which have their origins in the Victorian era. A recent review of the water industry in the UK, the so-called Cave review (Cave, 2009), made the case for greater R&D spending in order to generate new technologies to solve such problems. At the same time, however, it acknowledged barriers to innovation such as conservatism and risk aversion. This in turn can be explained by such things as regulatory frameworks, fear of losing public trust and the assumption that consumers are ignorant of the challenges and unwilling to endorse or pay for new approaches (Molyneux-Hodgson and Balmer, 2013). As a result incremental improvements to existing approaches rather than radical alternatives are the norm.

It is partly in recognition of such barriers to innovation that the UK research councils have begun to invest in interdisciplinary scientific research that may contribute to new technologies based on fundamental research in synthetic biology. However, exploratory research by the EPSRC suggests that the water industry (in England) and their academic collaborators tend to structure research projects (and potential technologies) in relation to anticipated and assumed negative public reactions to synthetic biology (ibid). In this project we want to encourage a more nuanced and accurate appreciation of public and stakeholder concerns in order to encourage research and innovation across the widest range of possibilities.

WP6 Responsible Innovation is therefore concerned with substantive issues that arise when water and synthetic biology are linked. As mentioned above, these can be referred to as ELSAs or ELSIs (ethical, legal, social aspects/issues). The WP aims to inform scientific research about these at an early stage to encourage more responsible innovation (Deplazes et al 2009). We will do this by making a rich multidisciplinary investigation an integral part of the project (Newson 2011). However, in relation to ELSAs/ELSIs it is important to note that our approach is to consider these things in the present, as they are found, for example, in visions, practices and experiments, rather than speculating about future technologies and societies which are unknowable.

Whilst every new technology engenders specific issues and concerns a number that are likely to arise when water and synthetic biology are linked are already known – at least in general terms. These include physical and non-physical harms (Parens et al., 2009). Physical harms involve safety and security of humans or the environment. They raise the issue of what constitutes safe/unsafe and who should be involved in setting standards and determining responsibility. Non-physical harms involve broader notions of well-being and ideas of a good life/society. Examples include how new entities may affect conceptions of self and our relationships to the environment (Royal Academy of Engineering, 2009) as well as questions of justice (Newson 2011). Although sometimes called ‘soft’ impacts, non-physical changes are nevertheless real, as illustrated by the way Facebook has changed the idea of friendship.

There is already a rich literature on the societal dimensions of bio objects and this will be an important starting point for WP6 (for example Dabrock et al., 2013; Newson 2011). It is important to note, however, that public and stakeholder acceptance involves more than merely having a range of issues considered. It can be conditional and thus responsible innovation cannot be reduced to process, it must also engage with the problem of how plausible it is that the conditions will be met (Macnaghten and Szerszynski, 2013).

The novel organisms produced by synthetic biology and the issues which arise have perhaps inevitably led to calls for novel forms of social and ethical inquiry and deliberation which implementation of responsible innovation can draw on (Kera, 2014). A variety of experimental forms of analysis have been suggested, from ‘ethobricks’ (Vallverdú and Gustafsson, 2009) and ‘reflective equilibrium’ models of justification (van der Poel and Zwart, 2010) to interdisciplinary and interactive ‘socioethical engagements’ (O Malley et al 2007). The ethical and social reflection on cutting edge research and innovation poses particular and novel problems, however, in that the ‘ethical assessment of emerging technologies is by definition focused on an elusive object. Usually promises, expectations, and visions of the technology are taken as a starting point’ (Lucivero et al

2011). However as the sociology of expectations has suggested one cannot take these visions and expectations for granted (Brown and Michael, 2003) not least because they are coloured by the strategic aim to mobilize support and funding (Lucivero et al,2011) and of course are often wrong (Brown and Michael, 2003). One needs to explore the desirability, feasibility and usability of potential technologies through stakeholder engagement.

WP6 Themes and Questions

Implementing Responsible Innovation

Owen et al. (2012; 2013) propose a framework for RI with four dimensions which open a space to explore the implications of research at an early stage. These are anticipation, reflexivity, inclusion and responsiveness (ARIR). In October 2013 the EPSRC published its policy on RI and in doing so built on but also modified ARIR leading to anticipate, reflect, engage and act (AREA). WP6 will operationalize RI through ARIR and AREA; an approach which is reflected in the suite of methodologies outlined below. The WP may, in time, also move beyond ARIR/AREA, which are only starting points.

Although key themes or dimensions of RI have emerged much more work needs to be done around implementation (although see Stahl et al., 2014; Owen et al., 2012; 2013). Further research is needed, for example, to understand the appropriate combination and sequencing of interventions and which methods are appropriate for particular types of scientific research. Beyond methodological issues, significant problems are likely to arise around power and authority in mixed teams working across disciplines and with publics and stakeholders being included earlier in the research process than is usual. These and other issues require urgent attention. At the same time it is the case that not all interests and/or values can be maximised (Stirling, 2012) through RI, rather, we can open up choices, catalyse and provoke dialogue in order to create a more robust and legitimate decision making process in relation to new technologies (ibid).

The Micro-Dynamics of Collaboration

Beyond implementing RI in relation to a large synthetic biology project (the first part of our aim) WP6 will step back and critically assess RI in action (the second part of our aim). This more theoretical strand will, nevertheless, have analytical *and* normative value because better understanding of the processes involved will inform practical recommendations as well as scholarship. One starting point will be to focus on the micro-dynamics of collaboration within and close to the project. In relation to this we will draw particularly on research around 'trading zones' and 'interactional expertise'.

Peter Galison developed his theory/metaphor of the 'trading zone' to explain interactions between different branches of physics across the 20^{th} century. Galison (1997: 784, 803) defines a trading zone as '… the site – partly symbolic and partly spatial – at which the local coordination between beliefs and actions takes place'. 'My focus throughout,' he continues, 'has been on finite traditions with their own dynamics that are linked not by homogenization, but by local coordination'. A working hypothesis is that RI is (or must become) such a trading zone. Galison's research suggests that trading across boundaries is to a large extent a problem of language and communication and we will be following this line of argument. That said, it is important to note that Galison's research focused on branches of physics which were perhaps more likely to treat each other as equals (at least nominally) compared to the diverse subcultures involved in our synthetic biology/responsible innovation project.

The second aspect of the micro-dynamics of collaboration which interests us is the role of 'interactional expertise'. Research in science and technology studies (including in relation to trading zones) shows that dialogue across boundaries improves when one of the actors develops this – for example a social scientist working with a group of scientists as a laboratory technician. Such expertise is also a necessary if not sufficient condition for a social scientist to observe when decisions made by scientists whilst being justified as 'scientific' are in fact shaped by extra-scientific influences – values, interests, politics and so on (Collins et al 2007). A working hypothesis in this area is that RI needs a new generation of academics with interactional expertise capable of working across the boundaries involved.

Governance of Science and Technology

The debate over the appropriate relationship between science, technology and society is long-standing and recurring; from Bernal's (1939) suggestion that science should act in the interests of society to Polanyi's (1962) plea for respecting the 'republic of science' – and by implication the autonomy of scientists. In the past the production of reliable and beneficial knowledge and technologies tended to mean that arguments around autonomy were taken more seriously than alternatives (Douglas, 2003). However, across the latter half of the 20th century the governance of science and technology emerged as a key issue, not least because of growing public concern and disquiet around environmental issues. We will engage with wider debates around the governance of science and technology focusing on responsibility and innovation and in this way place RI in its wider context.

RI is just part of a much wider debate around the responsibility in relation to science and technology (Jonas, 1984). For example, in what has become a seminal work, Beck (1992) argued that science and technology are implicated in the creation of a 'risk society'. Notwithstanding the accuracy of such claims, the debate over what form responsibility should take has once again become central to the contemporary debates over scientific governance (Kaiser and Moreno, 2012; Stilgoe et al., 2013; Hajer, 2003). This has led to attempts to develop forward, future orientated forms of governance, such as RI, that can anticipate and avoid problems before they arise. However, recasting responsibility in this way is vulnerable to criticism, for example from those who object to 'barriers' or 'constraints' on innovation, and prefer the market as a mechanism of choice, to those who detect a political-economic agenda of making society responsible for things that they have few or no real opportunities to shape (Grinbaum and Groves, 2013; Mitcham, 2003).

RI focuses 'upstream' and on research projects but in relation to innovation a vibrant debate is underway regarding socio-technical transitions and transition pathways which shape society as a whole over decades (Geels, 2002; Geels and Schot, 2007). Much of this debate focuses on transitions to sustainability and transition management in areas like food, energy, transport and housing (Elzen et al., 2004; Kemp et al., 1998; Rotmans et al, 2001). We are interested in this because the project is built on and justified by the vision of bringing about a socio-technical transition in the domain of water – replacing an old infrastructure with a new one based on synthetic biology. WP6 will therefore link RI and work around socio-technical transitions and in this way underpin the project with an understanding of not only how research might be shaped at an early stage but also how innovations change society (or fail to). This is particularly important for WP6 in years 4 and 5 as attention moves from the laboratory to issues around wider adoption of the most promising technologies.

Research Questions

The three themes discussed inform the following research questions:

- What methods can operationalize RI? How should these be used in relation to each other and in relation to particular types of scientific research?
- What are the implications for research practise and power dynamics of opening up discussion about scientific and technological trajectories?
- Is it possible to specify pathways of responsible innovation and irresponsible innovation? Where do the normative underpinnings for these come from?
- Does the 'collective stewardship' of science and innovation which RI calls for require new institutional arrangements? If so, what should they be?
- What role is RI playing in the governance of science and technology, and, in relation to this, what are the implications for social science?
- How can those involved in RI work across the boundaries which divide disciplines and stakeholders and their different cultures and priorities?

Activities

In-house

A number of WP6 activities can be understood as 'in-house' in that they are not concerned with implementing AREA/ARIR but with running the work package more broadly. The list includes:

- Writing the research plan
- Getting ethics approval
- Literature reviews
- Publications for social science audiences
- Developing interactional expertise
- Baseline conversations – entry and exit assessments to evaluate change

Many of these are self-explanatory but not all. Developing *interactional expertise* (see above), for example, will involve Walls undertaking some study in the area of synthetic biology. The *baseline conversations* are important because in addition to implementing RI we want to assess if and how it shapes the research and things change as a result.

Anticipate/Anticipation

In relation 'anticipate' EPSRC's policy on RI suggests:

> *… describing and analysing the impacts, intended or otherwise, (e.g. economic, social, environmental) that might arise. This does not seek to predict but rather to support an exploration of possible impacts and implications that may otherwise remain uncovered and little discussed.*

In relation to this dimension we will undertake the following activities:

- Desk study – Drawing on secondary sources. An overview of the wider issues that arise when synthetic biology techniques are used in relation to water.
- Scenario planning – Drawing on the desk study and key informant interviews. A small number of plausible water scenarios for 2050.

- Design fictions – Drawing on the desk study, interviews and scenarios. Creation of objects/artefacts which explore the wider issues arising.

The *desk study* will collate scientific, ethical, cultural, political and economic possibilities and implications of the application of synthetic biology to water supply and remediation. This will be undertaken early in the project as an initial point of reference to foster reflection and anticipation within the WPs. As a result we will begin to ask what is known, what is likely, what is plausible and what is possible with the technology (Ravetz, 1997; Stilgoe et al., 2013). The desk study will be followed by *scenario planning*; a process that produces a range of plausible futures and pathways to provoke reflection in the present. Scenario planning has already been used effectively in relation to the governance of nanotechnology (Selin, 2011; Ramirez and Selin, 2014). The outcomes of these and other activities will be fed back into the project in various ways particularly into the reflect/reflexivity component (see below). In addition to the desk study and scenario planning we will use *design fictions* (Ginsberg et al., 2014; Revell, 2013). These emerge from collaborations between designers and scientists in which new objects and artefacts are produced and used to stimulate anticipation and reflection (Dunne and Raby, 2013; Ginsberg et al., 2014). Dunne and Raby suggest that this new kind of design not only creates 'things' but also ideas; here design is a way to speculate about how things could be – to imagine possible futures. Design fictions are similar to scenario planning in that they *do not* attempt to predict or forecast, rather they pose 'what if' questions that are intended to open debate and discussion about the kind of future people want or do not want. The design fictions will be fed back into the project in various ways for example in workshops as part of the engage/Inclusion strand (see below).

Reflect/Reflexivity

In relation to the 'reflect' EPSRC policy on RI suggests:

> *… reflecting on the purposes of, motivations for and potential implications of the research, and the associated uncertainties, areas of ignorance, assumptions, framings, questions, dilemmas and social transformations these may bring.*

In relation to this dimension we will undertake the following activities:

- Reflexive briefing – Drawing on secondary sources and the results/outputs of other activities, write short briefs which reflect on key issues, findings and assumptions.
- Lab. engagement – An embedded social scientists working alongside the researchers on each of the scientific/technical work packages.
- Multidisciplinary training – Develop an education package around responsible innovation to be delivered initially to the researchers working on other work packages.

As issues emerge from interviews, workshops and other activities we will produce *reflexive briefings* (roughly 1000 words or 4 pages in length) to be distributed to all members of the team. These will examine key issues and summarise findings to enable colleagues to reflect. This can be built on through fostering 'second order reflexivity' (Schuurbiers, 2011) in which the values, ethics and practises that shape science and innovation are themselves scrutinised. This will be achieved through *laboratory engagement* in which Walls will work alongside the scientists in the laboratory. The aim will be to foster mutual learning where the social and ethical aspects of the research can be explored. This process can create what has been termed 'midstream modulation' which extends the 'more traditional laboratory ethnographies by augmenting participant observation methods with distinct engagement tools that allow for feedback, discussion and exploration of research decisions in light of their societal and ethical dimensions' (Schuurbier, 2011). An 'embedded' social scientist interacts with laboratory practitioners by closely following and documenting their research, attending laboratory meetings, holding regular interviews and collaboratively articulating decisions. This can enable research participants to reflect on the broader context and implications of the research, possibly influencing the research process itself. The laboratory engagements will be supplemented with *multidisciplinary training* because research suggests that scientists need support to implement RI (Owen et al., 2013). We will explore what support, training and mentoring needs to be put in place and a number of training sessions will be facilitated to this end.

Engage/Inclusion

In relation to 'engage' EPSRC policy suggests:

> *… opening up such visions, impacts and questioning to broader deliberation, dialogue, engagement and debate in an inclusive way.*

In relation to this dimension we will undertake the following activities:

- Social media – Make regular contributions via blogs, twitter or similar in a way that encourages a dialogue with a wide variety of actors.
- Stakeholder workshops – Convene meetings initially of types of stakeholders and later of mixed stakeholders to explore particular issues such as IPR, regulation and 'soft' impacts.
- Reconvened focus groups – Invite members of the public to participate in open discussions around synthetic biology as applied to water and the research being done in WPs 1-5. The groups will reconvene later for further discussions.
- Deliberative workshops – One-off larger open meetings with members of the public to explore synthetic biology as applied to water and the research being done in WPs 1-5.

Social media has emerged as a new way of deliberating science and technology. There are a number of instructive precedents including 'the reluctant geoengineer' blog which paralleled the SPICE project – Stratospheric Particle Injection for Climate Engineering – and the interactive website 'Nano & Me' which forms part of an EU funded nanotechnology project. In addition to such approaches a YouTube page will be created with short videos uploaded of brief interviews with researchers talking about their research. We will supplement our use of social media by running *stakeholder workshops* first of all with key stakeholder (business, NGOs, policy) and later focused on key issues. In order to assess public perceptions and reactions to the innovations we will in addition run *reconvened focus groups* which are focus groups that meet over a period of usually 1-2 weeks. On the first occasion participants will be asked about perceptions of synthetic biology and given 'stimulus material' to take away with them to read and research. The groups will meet again a week later to discuss the material in order to assess how they react to different technologies and technological trajectories (Horlick jones et al., 2007). Do perceptions and understandings change when people learn more about the technologies? How? How will particular pathways or trajectories alter perceptions? Finally, *deliberative workshops* will be held after the laboratory research is underway to bring stakeholder and public values in the project; this approach has been used successfully in relation to proposals for geoengineering (Parkhill and Pidgeon, 2011). Participants can be recruited using a professional recruitment agency and be composed of 12 participants recruited using a theoretically informed sampling strategy. Using this method we can interrogate: the likely varied and nuanced perspectives of participants and feed these back to the WPs; provide evidence for the mid-term review to assist the process of assessing projects for redistribution of funds; explore, future media debates notwithstanding, public concerns, questions and conditions for commercialisation of technologies under consideration. All of the above will inform the other dimensions of ARIR/AREA.

Act/Responsiveness

In relation to 'act' EPSRC policy suggests:

> *… using these processes to influence the direction and trajectory of the research and innovation process itself.*

In relation to this dimension we will use the following techniques:

- Team meetings – Contribute to PI meetings, steering committee meetings and team away days in the form of briefings, reports and other feedback on research findings.
- Mid-term review – Develop a procedure for dealing with the RI aspects of the mid-term review.
- Water and society commission – Establish, manage and support a Commission on synthetic biology and water as a practical governance mechanism leading to a landmark publication.

We will feed results back to the project at and between various *team meetings* in the form of briefs and reports. In discussion with colleagues from across the WPs we will also create both a procedure and criteria to deploy RI as part of the *mid term review*. A useful starting point for this could be the five criteria used as part of the SPICE project's 'stage gate panel' (Stilgoe et al., 2013). Finally, a *water and society commission* will be established after the mid-term review as a practical governance mechanism to explore the transition implied by the research and alternatives. Related workshops and meetings will play governance roles but an overall aim will be to publish a high impact report for publics and stakeholders which will generate media and policy interest. The precise composition of the commission will be decided with other members of the project but the idea of such a commission is well established.

In addition we will establish and maintain a database of evidence of impact on behalf of the project anticipating that it will be submitted as (part of) an impact case study in REF2020. Our understanding of impact, however, is bidirectional, as discussed in the project proposal, in that we are interested in how research impacts on society and how society impacts on research.

Timetable, Workload and Outputs

		2014				2015				2016				2017				2018			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	2Q	Q3	Q4
Activities																					
In-house																					
Research plan																					
Ethics approval																					
Literature reviews		Lr1				Lr2				Lr3											
Publications				Pb1				Pb2				Pb3				Pb4		Pb5			
Interactional Exp.		Ie1			Ie2	Ie3															
Baseline conversations			Bc1																Bc2		
Anticipate/Anticipation																					
Desk study																					
Scenario planning																					
Design Fictions																					
Reflect/Reflexivity																					
Reflexive briefings																					
Lab. engagement																					
Multidisciplinary training																					
Engage/Inclusion																					
Social media																					
Stakeholder workshops			Sw1							Sw2					Sw3						
Reconvened focus groups					Rfg1						Rfg2										
Deliberative workshops							Dw1					Dw2									
Act/Responsiveness																					
Team meetings																					
Mid-term review																					
Water commission														SC1		SC2		SC3		SC4	
Evidence of impact																					

Lr1 – ‘Implementing responsible innovation’, 5000 words; Lr2 – ‘The micro-dynamics of collaboration’, 5000 words; Lr3 – ‘Governance of science and technology’, 5000 words.
Pbs1-3 – Building on Lrs 1-3 and focusing on aspects of the project; Pb4 – Reflecting on the project as a whole; Pb 5 – Book. Journals include *Social Studies of Science*, *Science Technology and Human Values*, *Research Policy* and *Journal of Responsible Innovation*.
Ie1 – Self-directed learning; Ie2-3 – Courses to be agreed.
Bc1 – Baseline conversations with core members of the project team (approx. 10). Bc2 – Exit conversations with all members of the project team (approx. 10).
Ds – Review of wider issues that arise when synthetic biology techniques are applied to water, 5000 words.
Sp – 10 key informant interviews. 3-5 scenarios at 2000 words each.
Dfs – Outside provider. 3-5 objects/artefacts.
Rbs – A brief every quarter. 1000 words (or 4 pages) x 18.
Les – 5 ethnographies. 1 month each. 5x2000 words feedback reports.
Mt – A 4 hour RI training package delivered annually to different groups.
Sm – Regular tweets and minimum 500 word blog every 2 weeks. Also interviews with scientists on a YouTube page.
Sw1 – 1xbusiness, 1xNGOs, 2x2000 word reports; Sw2 – 1xpolicy/regulators, 1x2000 word report; Sw3 – 3xissues e.g. risk, IPR, culture, 3x2000 word reports agreed with member of the Commission.
Rfg1 – General. 8 people (meeting twice). 1x2000 word report; Rfg2 – Specific. 8 people (meeting twice). 1x2000 word report.
Dw1 – General. 25 people. 1x2000 word report; Dw2 – Specific. 25 people. 1x2000 word report.
Sc1 – Meeting papers and indicative table of contents for final report; Sc2 – Draft introduction and conclusion and sketch of content. Sc3 – Full draft. Sc4 – Publication and launch of final report.

Potential Difficulties

Reluctance on the part of other members of the team to cooperate with the RI work package is perhaps the most obvious potential difficulty. This could happen for various different reasons ranging from time pressure to deeply held beliefs around scientific autonomy. Avoiding this problem will require effective communication regarding WP6's role and negotiation regarding implementation. A second and related potential difficulty is the idea that social scientists are involved in the project to 'sell' technology to the public (Rabinow and Bennett, 2012) or to deal with the ethical, legal and social issues on behalf of the scientists. This is a common problem and will also require effective communication of WP6's role. More broadly it is likely that trying to open up assumptions, for example around inclusion of different stakeholders and IPR, will present challenges but these are in many ways part of RI in practice.

Ethical Issues

There are a number of issues in this regard. For example, can all meetings and interactions between team members be treated as part of the research? Or are some to be excluded? These issues will require some discussion and agreement. As part of the process WP6 will go through the UoG ethical approval procedure.

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