Competing Paradigms of Flood Management in the Scottish/English Borderlands

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Introduction

Technical flood management (TFM) is predicated on the physical control of rivers and their catchments. TFM is the dominant form of flood management in much of the world, though alternatives are emerging, with more sustainable options often the aim. Recently, Scotland has emerged as a focal point for innovative alternatives to TFM (Werritty, 2006; Holstead et al., 2015; Rouillard et al., 2015). Currently missing from this discourse are the opinions of expert decision makers, which we contribute through analysis of expert knowledge-practices. We use the idea of 'framing' (Donaldson et al., 2013) as a way of analysing the co-production of knowledge-practices (Jasanoff, 2004), which reinforce a particular form of flood management to the exclusion of what sits outside that framing. Framing enables analysis of the underlying values, assumptions, arguments, and ideas relative to the practices of flood management, as perceived by decision makers. We use tension between sustainable flood management (SFM) and TFM as an entry point (Werritty, 2006), with the effectiveness of natural flood management (NFM) a debate that links these two framings. We situate our analysis amongst recent debate over the sometimes rapid evolution of flood management (Johnson and Penning-Rowsell, 2010; Johnson et al., 2005; Lane et al., 2013; Penning-Rowsell et al., 2014), demonstrating how a dominant framing co-opts an emerging alternative. We conclude that the fundamental change of a sustainable approach (SFM), which is implicit in the use of natural features for flood management (NFM), is made to conform through practices and expectations associated with pre-existing technical management (TFM).

A predisposition towards technical 'fixes' within the flood management community has been exposed and attacked: in policy (DEFRA, 2004; Environment Agency, 2009; Scottish Executive, 2009; Scottish Government, 2011; Pitt, 2008; DEFRA, 2008), amongst non-governmental analyses and reports (Institution of Civil Engineers, 2001; WWF, 2007a; WWF, 2007b; Cook et al., 2013a), within academic research (Dawson et al., 2011; Lane et al., 2011a; Pardoe et al., 2011; Werritty, 2006; Johnson and Priest,

2008; Landstroem et al., 2011; O'Connell et al., 2007; Rouillard et al., 2013; Holstead et al., 2015; Rouillard et al., 2015), and through direct experience (Glasgow 2002, English Midlands 2007, Cockermouth 2009, Somerset levels and southern England October 2013 to February 2014). Broadly, this amounts to questioning the prevailing interpretation of what flood management should be, how it should be assessed, and, therefore, how it should be practiced. This discourse implies, and in some cases explicitly calls for, a re-framing or re-imagining of flood management (Lane et al., 2011a). Werritty (2006), early to recognise this trend, argued that a 'seismic shift' is taking place in which the "well-established reliance on structural defences [i.e., technical flood management] is being questioned and cheaper and more sustainable alternatives are being sought". Ten years following Werritty's analysis, we contribute to this debate through engagement with a small number of influential experts tasked with reconciling evolving demands with pre-existing knowledge-practices, using the Scottish Borderlands as a case.

Over the last seven years Scottish flood management has evolved rapidly. Philosophically, the Scottish government has endorsed a sustainable approach, in which schemes "must be developed with consideration of catchment processes and characteristics, making all reasonable and practical efforts to enhance the (urban and rural) landscapes' natural ability to slow and store flood water" (Scottish Executive, 2009). Scotland's move toward more sustainable alternatives maps directly on to Werritty's (2006) conclusion: "a weak form of SFM is emerging in England and Wales, but grafted onto an existing paradigm in which structural [i.e., technical] solutions are still privileged". It is this grafting that concerns us, as it implies that the pre-existing root structure remains unchanged (what we refer to as its framing). This accumulation and mixing of potentially incompatible framings (TFM vs./+ SFM), presents an opportunity to explore how flood management is framed and, more broadly, to consider how practitioners reconcile an emerging, critical alternative with pre-existing practices.

Our analysis opens with a definition and discussion of technical, sustainable, and natural flood management (i.e., TFM, SFM, and NFM; see Box 1). We then present findings

from interviews with practitioners responsible for flood management in the Scottish-English Borderlands region. We show that efforts to adapt flood management are encumbered not through open opposition to SFM, but through self-discipline rooted in norms and values associated with TFM knowledge-practices. Even in instances where flood managers are explicitly seeking innovative alternatives, we see TFM reasserted via an underlying framing, in ways that are often implicit or positioned as non-negotiable tenets of 'good flood management'. Complementing recent analyses of Scottish farmer and landholder perceptions (Rouillard et al., 2013; Holstead et al., 2015; Rouillard et al., 2015; Kenyon and Langan, 2011) our analysis helps to explain the persistence of technical flood management. We show that while arguments in favour of sustainability are persuasive, numerous factors belie the ease with which such fundamental change occurs.

[**insert Box 1 here**]

The co-production of different forms of flood management

The co-production of knowledge-practice

Despite widespread acceptance that floods are *socio*-ecological hazards, management remains biased towards the physical nature of rivers and floodplains (Lane et al., 2011a; Wescoat and White, 2003; White, 1945; Purseglove, 2015). Whether labelled as technical, scientific, normal, linear, objective, dominant, or as an accounting calculus, floods and their management tend to be interpreted in a specific way that, in turn, shapes what counts and what does not count. This relationship is elsewhere described as the co-production of knowledge-practice (Jasanoff, 2004; Landstroem et al., 2011), in which the range of imaginable alternatives is constrained. Co-production helps to make explicit the mutually-constituted nature of a framing, which combines assumptions, aims, expectations, studies, and knowledge production with the practices that result from that framing (i.e., dams, embankments, canalisation, but also education campaigns, newspaper editorials, and political activities).

The interplay between competing forms of flood management is complex, requiring analysis of the knowledge claims that persist (Whatmore, 2002; Cook et al., 2013b). Persistence is important given the normalisation of 'knowledge-practice' (Foucault, 1977) in which: "power is most effective and most insidious where it is '*normalised*'; where self-expectation, self-regulation, and self-discipline generate compliant subjects who by their own thought, words, and deeds actively reproduce hegemonic assemblages without being 'forced' to do so" (Kesby, 2005). It is the normalisation of TFM, the tensions that arise with SFM, and the materialisation of this tension through attempts to implement NFM that is central to this analysis.

The establishment of technical flood management

As a dominant framing, technical flood management originated with the US Army Corps of Engineers' adoption and export of large-scale technical infrastructures (Wescoat and White, 2003; White, 1945). While technical practices predate this era, for instance in the Netherlands and lowland UK (Purseglove, 2015), TFM became dominant in the 20th century as governments and publics became accustomed to the benefits associated with the physical control of catchments, particularly the profits enabled. Technical flood management can be said to have become dominant, not simply due to its practices, but because of the framing, what is elsewhere termed an 'imagining' (Lane et al., 2011a) or 'logic' (Barry et al., 2008).

A paradigm arose, with associated disciplines, disciplining, and disciples (Kuhn, 1962; Barry et al., 2008), which affirmed and reaffirmed the practices, policies, and existing knowledge of TFM. This deflected critiques by shaping what to count, consider, and admit into the discourse. During this period, earlier efforts to adjust human behaviour to accommodate environmental variability (Wescoat and White, 2003; White, 1945) were replaced with faith in the control of the natural environment (e.g., dams and embankments). Flood management was re-framed as the 'control of rivers' through technical interventions. This marked a fundamental transformation. Success allowed TFM to proliferate, becoming similarly dominant in the UK (Johnson and Priest, 2008;

Parker, 1995; Purseglove, 2015). With control of rivers as the central objective *and* approach to flood management, the experts in charge were the engineers and hydrologists able to model and predict river behaviour in response to human interventions (e.g., dams, embankments, pumping, river straightening, canalisation).

The emergence of sustainable flood management

In the US, TFM first came into question around the mid-point of the Twentieth Century (White, 1945) with criticisms taking four main forms: 1) technical management locks governments into perpetual support because the public becomes accustomed to protection from flooding (Tobin, 1995); 2) technical interventions are 'contagious' because up and downstream communities seek similar protection from floods (Smith and Ward, 1998); 3) the ecological harm done by disconnecting rivers from floodplains outweighs the benefits (Acreman et al., 2007); and 4) technical control transfers responsibility from individuals to the state, leading to the subsidy (i.e., through construction of protection measures and the provision of disaster relief) of high-risk private investments by the taxpaying public (Parker, 1995).

If, as White (1945) so presciently argued, "floods are 'acts of God', flood losses are largely acts of [hu]man[s]", then Scottish and UK flood management has historically prioritised *flood management* rather than *flood loss/risk management*. Flood managers have sought technical solutions to socio-ecological problems (Weinberg, 1967) and, in the short term, been successful. But recent floods have prompted researchers, practitioners, and publics to re-frame flood management, advocating socio-environmental sustainability (Dawson et al., 2011; Johnson and Penning-Rowsell, 2010; Johnson and Priest, 2008; Kenyon, 2007; Lane et al., 2011b; Pardoe et al., 2011; Werritty, 2006; Johnson et al., 2007; Kenyon and Langan, 2011).

Natural flood management (NFM)

SFM fundamentally differs from TFM in its aims and in how effectiveness is measured, rather than in terms of the specific interventions employed. To be clear, embankments

and dams will undoubtedly be part of a SFM strategy, but are included only when necessary and not by default. Instead, SFM prioritises risk reduction (Howgate and Kenyon, 2009; Werritty, 2006) rather than affecting the physical flow, height, and extent of floodwaters. This is a subtle distinction, as TFM practitioners would also claim to prioritise risk reduction, but in practice TFM uses the control of river behaviour as a proxy for risk reduction. Entwined within this debate over 'sustainability' is the use of natural features such as wetlands, river meanders, ponds, debris, and woodlands to more naturally, and ideally sustainably, conduct flood management: a group of techniques referred to as Natural Flood Management (NFM) (Pescott and Wentworth, 2011; Howgate and Kenyon, 2009; Pattison and Lane, 2011; Holstead et al., 2015; Rouillard et al., 2015; Pyle and Wentworth, 2014).

NFM is connected to wider efforts to make space for water (DEFRA, 2004; DEFRA, 2008; Pyle and Wentworth, 2014) or to live with flooding (Institution of Civil Engineers, 2001; Pescott and Wentworth, 2011), emphasising land-use as a means of influencing flooding. It is accomplished "through measures such as [the] restoration of upland wetlands, rehabilitation of river channels, and re-forestation" (Howgate and Kenyon, 2009), with the aim of extending flood management into catchments in order to re-shape water pathways (Rouillard et al., 2015). In England, NFM is defined as "the alteration, restoration, or use of landscape features" for the purposes of reducing flood risk (Pescott and Wentworth, 2011), and is increasingly seen as part of a catchment-wide approach (Pyle and Wentworth, 2014). NFM can be divided into four categories: 1) storing water, using ponds, ditches, and reservoirs to intercept water flowing into rivers; 2) increasing infiltration, using forests and other plants to increase soil saturation and evapotranspiration; 3) slowing water, using debris, woodlands, or shrubs to inhibit flow; and 4) reducing hydrological connectivity, using buffer strips and wetlands to disrupt source-pathway water corridors (Pescott and Wentworth, 2011).

NFM is incorporated directly into Scottish policy (Scottish Executive, 2009; Werritty and Chatterton, 2004), and the Scottish, UK, and Welsh Governments have each begun

emphasising NFM as a part of more ecologically and economically sustainable flood management (Pyle and Wentworth, 2014). In the UK, perhaps the most influential comment on NFM was DEFRA's 'Making Space for Water':

> "The results of the strategy will be seen on the ground in the form of more flood and coastal erosion solutions working with natural processes. This will be achieved by making more space for water in the environment through, for example, appropriate use of realignment to widen river corridors and areas of inter-tidal habitat, and of multi-functional wetlands that provide wildlife and recreational resource and reduce coastal squeeze on habitats like saltmarsh" (DEFRA, 2004).

A premise reiterated in the influential Pitt Review (2008):

> "One flood defence measure which has proved to be increasingly successful is use of natural processes such as using farmland to hold water and creating washlands and wetlands. Keeping water away from urban areas and slowing its progress to minimize runoff proved successful in the summer".

In the Scottish context, NFM is incorporated into legislation, which aims to adopt flood management that incorporates:

> "features and characteristics which can assist in the retention of flood water, whether on a permanent or temporary basis, (such as flood plains, woodlands and wetlands) or in slowing the flow of such water (such as woodlands and other vegetation), those which contribute to the transporting and depositing of sediment, and the shape of rivers and coastal areas" (Scottish Executive, 2009).

Non-governmental organisations are also effusive concerning NFM and the wider adoption of SFM (Institution of Civil Engineers, 2001; WWF, 2007a; WWF, 2007b). In this context, NFM interventions tend to be interpreted as part of a wider agenda to restore wetland biodiversity and to realise multiple benefits from more holistic forms of environmental governance. However, the pervasiveness of *control of water* dominates how NFM is framed. As we will show in the findings below, NFM appears to have

become incorporated into the arsenal of TFM rather than as a transition towards a more sustainable form of flood management.

Natural flood management in development and in practice

Methodology: Scottish expert decision makers grappling with change

The research on which this analysis is based was funded by the UK government's Rural Economy and Land Use (RELU) initiative and received additional funding from the Scottish Government. We analysed existing policy and conducted interviews with eight expert decision makers involved in shaping and delivering flood risk management in the Borderlands region. By expert, we mean that these individuals are responsible for decision-making, funding, studying, and assessing flood risk management in the region; they are members of an extremely small group of experts with power over flood risk management and, as importantly, responsibility for engagement and consultation with the public. Semi-structured interviews of approximately sixty minutes were undertaken to explore perceptions of flooding and flood management.

While the sample may seem small, the case study area is sparsely populated (in total approximately 130,000 people across nearly 5,000 sq. miles) with decision making power highly concentrated amongst these specific individuals. Our respondents, then, are not so much a sample representing some wider population, but a significant portion of the experts who direct decision making. This concentration of power is recognised within the literature (Kenyon, 2007), and is well explained by one respondent:

> "well, the context in [place name] is eighteen hundred or two thousand square miles, with only about one hundred and ten thousand people in it. It's a very incestuous type of operation. Everywhere you go you meet the same people and therefore there's a much greater scope for individuals to have influence" (Government Agency: 07/2011)[1].

This view is echoed throughout the interviews and speaks to the influence of a small number of experts. We utilise discussions over NFM to show how decision makers are

grappling with flood management. The interviews were analysed as part of a mixed-methods approach (see Forrester et al., 2015 for a discussion of the methodology). The responses given by the interviewees are divided into three interrelated themes: 1) NFM perceived as a good, albeit, contested idea; 2) NFM characterised as a socio-political concept; and 3) NFM viewed as 'scientifically uncertain' in terms of its ability to affect river behaviour.

Finding 1: NFM as a 'good but contested' idea

Amongst the respondents, the prevailing interpretation of NFM is that it is a good but contested concept. One respondent provided a representative assessment

> "it's a good idea, a great principle, the idea that there'll be multiple benefits. The concept that people can have this impact and should be looking to reverse it all makes perfect sense. It is a great concept and approach" (SEPA: 06/2011).

Despite a positive view of NFM, each respondent spoke of uncertainty surrounding its effectiveness. For example, a respondent leading a number of projects that incorporate NFM stated that resistance to this 'good idea' is widespread and, unfortunately, limits opportunities for application.

> "[It's] a shame because I think that would really help, you know, to make this more mainstream, because it's very cost-effective. For example the work we're doing in [place], we've spent about three hundred thousand pounds to date. We've got approval to spend up to about six hundred thousand pounds. But a traditional flood scheme is going to cost three and a half million. Compared to that, [NFM] is far more cost-effective and practicality-wise it's far better than trying to build flood walls in people's back gardens, which was a non-starter" (Government Agency: 07/2011).

Respondents appeared to like NFM in principle, but several were hesitant because it does not correspond with their understanding of what flood management is. Furthermore, the respondents struggled to reconcile their personal, technically-validated expertise with

NFM, which challenges many associated assumptions. As a way of dealing with this discordance, respondents advocated a refinement of existing approaches. In this way, rather than challenge TFM, NFM is made a contributory element of existing practices. Echoing Werritty's (2006) grafting analogy, and *leaving the underlying framing intact*, one respondent explained: "it's only one very small piece of the overall picture for flood risk management" (SEPA: 06/2011).

Finding 2: NFM as a socio-political concept

According to the respondents, a critical aspect of NFM is that it does not correspond with expectations amongst the professional flood management community: it is deemed to be from another sphere. Respondents associated NFM with 'popular' (i.e., public) initiatives like river restoration, reconnecting rivers to floodplains, nature conservation, and allowing rivers to be 'more natural'. This characterization portrays NFM as an 'environmental issue' rather than as scientific. Public support for NFM, in this context, is interpreted as well-meaning but largely naive due to a misunderstanding of flood management: meaning a disconnection from an understanding of the physical nature of river systems and the control of flood waters. During one exchange, a respondent who regularly interacts with members of the public explains this view. When asked about support for NFM, they explain that members of the public are:

> "putting it forward the whole time. Which is their role and their job, and it's our job to look a bit more objectively at those" (SEPA: 06/2011).

The socio-political basis of NFM emerges most often with reference to Scottish legislation, which acts as a touchstone for debate over SFM. One respondent explained:

> "legislation will require that we see much more of that type of work [i.e. NFM] going forward in catchments so that we have a greater variety of measures being used to tackle flooding than we have used in the past" (Local Government 06/2011).

Another explained how the Scottish government came to endorse NFM, describing the development of the Scottish Flood Risk Management Act (Scottish Executive, 2009). NFM is portrayed as a 'cause' championed by groups from outside the flood management community: NFM

> "was being proposed very heavily as part of the bill by the very successful environmental lobbying by [name of specific environmental NGOs]" (Academic & Government Advisor: 06/2011).

As a result of the lobbying, the Scottish government is said to have incorporated SFM into policy with the aim of 'working with nature': that is, by adopting NFM.

Providing an economically-driven assessment of the English government's efforts to adopt more sustainable flood management, one respondent explained that NFM will eventually be accepted by the flood management community, primarily because expensive interventions are no longer justified. He stated that NFM

> "will get there [...] because costs are such that we're going to have to do more of this. You know, we can't afford big flood schemes anymore, so the time will come" (Government Agency: 07/2011).

Returning to NFM's social backing, one respondent described the tension between the public interests behind NFM with those of individuals responsible for flood management, explaining that NFM is

> "kind of common sense. You are returning the systems to a more natural state whereby floodplains are allowed to flood. You know, so it's quite a lot of common sense and that is the point: that there isn't a lot of science behind it (NGO: 04/2011).

NFM is made to sit apart from what is considered scientifically legitimate: not fulfilling the standards to which flood management is judged. This is not to suggest that alternate opinions are disregarded; the respondents clearly value public opinion, but they maintain a division based on a hierarchical interpretation of legitimate 'evidence', which for them places scientific and economic figures above personal and public perceptions. The debate

over NFM, then, is not strictly a science-policy debate, but construed as a debate between a scientific framing relative to a public or political movement.

Finding 3: Knowledge of NFM is scientifically uncertain

For the respondents, NFM is interpreted as uncertain and unlikely to affect flood frequency, inundation, or flow at the catchment scale. The respondents emphasise that NFM is unlikely to affect large-scale flood events. Even those who are disposed towards NFM communicate growing exasperation with advocates of NFM, characterising the concept as unsubstantiated. The respondents state repeatedly that 'no one knows' the effectiveness of NFM, particularly in relation to attenuating peak flows. Respondents typically state that "there's not that much evidence [for] how effective those kinds of approaches are" (SEPA: 06/2011) and go on to argue that analyses are underway, but that it is too soon to make any judgements. The need for evidence is, more accurately, reference to a type of evidence that corresponds with what is expected and with what has traditionally fulfilled expectations.

> "From the [government department]'s perspective, it comes down to cost benefit analysis. Like it or not, it's a fact of life and the farmers kind of accept that the cost-benefit analysis from at least the ones that are done by the [department] don't particularly add up to protecting agricultural land" (Government Agency 2: 05/2011).

This view alludes to the persistence of scientific metrics and to the role of scientific and economic evidence in determining what is effective. The uncertainty with which the respondents characterise NFM is often explained with reference to either science or to scientific method, for example:

> "natural flood management? Well, yes, sounds good but where's the science behind it? We shouldn't really be adopting this thing until we understand exactly how it works and because instead of decoupling flood flows you could actually be having the opposite effect if you don't understand the full impacts of the interventions that you are taking" (NGO: 04/2011).

Yet another respondent characterises scientific evidence as a precondition. The respondent argued that assessing NFM and flood management more generally meant measuring the ability to control river behaviour by affecting 'the flood hydrograph':

> "There are certainly interventions where you can show at a small scale that it has an effect on the flood hydrograph, that I'm absolutely convinced of and there are examples of that, but I go along with DEFRA's view that once you start taking it up to the catchment, there is very little to show that at the catchment scale – so far – these actually have a demonstrable effect" (Academic & Government Advisor: 06/2011).

In summary, within wider discussions of SFM, the respondents show that NFM interventions have support, but that they are interpreted as part of a socio-political movement that is impaired by a scarcity of 'legitimate' evidence. For some of the respondents, as a result, NFM is unjustified. Others, who appear more optimistic concerning NFM, explain this lack of scientifically valid information with reference to a deep hold of a framing that disciplines the flood management community. This view was represented in a reflexive assessment of river managers.

> "It's got limited take-up because when you analyse this type of approach it's difficult to demonstrate the benefits. It's hard to show that by putting in six leaky ponds and some willow strips and some grass and things that you're actually going to reduce the flood peak by three hundred millimetres. We have got quite a quantitative, risk averse culture within the [government] department; it likes to base things on analysis: what they call 'sound science'" (Government Agency: 07/2011).

Respondents, despite nominal openness toward NFM and sustainable management, appear to revert to preconceptions associated with TFM. The findings suggest that, for this group of practitioners in this location, TFM remains a key influence by providing the basis for assessing the legitimacy of alternatives. Most importantly, despite policy

changes and openness towards alternate flood management, NFM is challenged using an institutionalised and often internalised framing.

Discussion: what knowledge 'counts'

Our analysis shows that SFM and NFM are being judged using criteria, knowledge, and expectations associated with TFM (i.e., the framing). This is most clear with reference to the effect of NFM interventions on the stream hydrograph, but is most significant with reference to *the need for evidence* and *what is accepted as legitimate evidence*. TFM, then, remains dominant by shaping the context in which SFM is considered. The respondents, from this admittedly small but influential sample, show that the fundamentally different framing underlying SFM, and brought to the fore through debate over NFM, is perceived as outside or 'overflowing' the realm of professional practice (Donaldson et al., 2013). The flood management experts have responded to this situation by developing tests and demonstration sites, with the aim of calculating the impact of various NFM interventions, but the most trusted metric remains the ability to affect river behaviour, rather than attempt to alter or amend the human-environment relations that produce risk. What is evident is a paradigm (Kuhn, 1962) of flood management that is co-produced by a science-based assumptions, by historical practices, by a concentration of power, and by pre-existing institutions, practices, and expectations.

The default assumption amongst our respondents remains that flood management is the affecting of river behaviour. With emphasis on river behaviour, White's (1945) differentiation between 'flood management' and 'flood loss/risk management' resurfaces. What these practitioners show is that, in the parlance of the flood management community, if Risk = (Hazard) x (Vulnerability), then there is a bias towards 'Hazard' relative to 'Vulnerability'. Thus, the technical framing biases management by prioritising control of flood waters at the expense of considering flood risk.

Bias towards the physical behaviour of water undermines the potentially radical contribution of SFM by obscuring the possibility that the effectiveness of flood

management may be assessed using different criteria (i.e., vulnerability through behavioural change). For example, *if NFM interventions (e.g., plant riparian woodlands) prompt changes to human perception (e.g., accept periodic flooding) and to human behaviour (e.g., making structures more flood resilient), flood risk/loss may be reduced without any change to river behaviour*. However, such a situation would require a reimagining of what flood management is. Most importantly, at present, the effectiveness of such an intervention as framed by TFM would be nil because the framing prioritises physical measures of river behaviour.

Experts and the public in the context of flood risk

The perceptions of expert decision makers are critical for understanding efforts to develop alternate forms of flood risk management: a necessary complement to recent analyses of farmer, community, and landholder perceptions (Holstead et al., 2015; Howgate and Kenyon, 2009; Rouillard et al., 2013; Rouillard et al., 2015; Spray et al., 2009; Kenyon and Langan, 2011). Practitioners are especially important in this case, in which it appears that policy has evolved only to leave decision makers to reconcile existing expectations with interventions that do not align with professional standards.

While flood managers are essential stakeholders, they are also highly disciplined (Cook et al., 2013b). Their authority is connected to existing practices, which during periods of change or controversy, places them in a precarious position. If all that was needed was refinement of current practices, practitioners would be ideal leaders, but the potential discordance implied by SFM suggests that the emerging debate is a fundamental critique of existing practices. For the respondents, the technical framing provides a stable basis for consistent and fair management, but the 'stickiness' (Waylen et al., 2015) of the framing requires further consideration.

If flood management is undergoing upheaval in line with that proposed by Werritty (2006), then those accustomed to applying TFM will be significantly affected if/when it is replaced. It should be expected that their dependence on the existing framing would

generate scepticism and resistance toward the legitimacy of an alternative (Kuhn, 1962). This resistance is not emotional or self-serving; instead, it is rooted in logic, rationality, and the desire to continue 'doing a good job' (Johnson et al., 2007), and is therefore a much more challenging barrier. Recent flood disasters in Scotland and England have drawn attention to flood management and to debates over alternatives. While these debates centre on practices such as dredging and embankments, they are also rooted in values and, less explicitly, in assumptions concerning what flood management is or should be.

Conclusion: the future of flood risk management

This case is an example of the type of debate that arises when a framing founded on sustainability is promoted as an alternative to an existing, technical framing (Johnson et al., 2007). With recent floods and calls to improve management, further debates loom. Our case shows that the individuals practicing flood management, as well as their framing, should be incorporated into the growing literature exploring flood management. Despite Werritty's (2006) suggestion that SFM is part of a reconfiguration of flood management, we observe that there has been little movement in the practices of these decision makers, though a receptiveness towards critiques of TFM is evident.

Johnson, Penning-Rowsell, and colleagues (Johnson and Penning-Rowsell, 2010; Johnson et al., 2005; Penning-Rowsell et al., 2014) have contributed greatly to discussions of floods and policy change, addressing the common assumption that disasters trigger fundamental changes to policy and practice. Lane et al. (2013) have responded by problematizing the assumed 'revelatory' role of disasters, arguing that risk researchers must focus equally on the ability of systems to reproduce themselves. Lane et al. (2013) argue that the periods 'in between' events are at least as important as specific disasters because of the consolidation of knowledge-practices that occurs during periods of 'normalcy'. Our findings contribute to this discussion by showing how flood managers prepare for future floods and flood risk reduction during periods of calm. Our case supports both Johnson and Penning-Rowsell, as well as Lane et al.. With on-going efforts

to validate NFM, following the next flood disaster, the expert decision makers may have legitimised NFM; alternatively, without such 'evidence', calls for alternatives are likely to be closed-down for failing to meet expectations. In both scenarios, the centrality of the decision maker and events are critical, as are the everyday practices that shape the context in which flood events occur.

Calls for SFM must overcome the persistence of an existing, though often implicit, framing (Cook et al., 2013b). With this situation in mind, calls to incorporate or refine existing practices are shown in a different light: with the viability of alternatives judged according to pre-existing criteria rooted in TFM. It bears repeating that in this case study, the persistence of TFM is evident not simply in terms of interventions and behaviour of catchments – embankments, dams, and river straightening will have a role in any flood management strategy – but through the establishment and maintenance of the criteria that determine 'what flood management is', 'how it is informed', 'how it is practiced', and 'how effectiveness is measured'. Turning to the debate over NFM, despite its outward appearance as aligned with SFM, it appears more accurately to be a reassertion of TFM using more natural interventions.

We conclude that in discussions of regulatory change pertaining to flood management, we require further accounting of the perceptions that discipline the policy-practice relationship. This is particularly important when considering the two-fold issues of rapid policy change (Johnson et al., 2005; Lane et al., 2013) and the debates that have arisen following the 2013-2014 flood events (Penning-Rowsell, 2014). It is our view that the individuals responsible for practicing flood management show how regimes affect flood management practices, but also for how practitioners currently combine flood events with everyday practices to reproduce allegiance to a technical form of flood management.

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[1] Given the concentration of power and influence, for this analysis, names and identifying references have been removed.

Term	Acronym	Definition
Flood Risk Management	FRM	The philosophy, policy, and practices used to eliminate, limit, or cope with flooding.
Technical Flood Management	TFM	A philosophy guiding flood risk reduction grounded in the physical control of river systems. Measured through quantitative – usually scientific – and economic cost-benefit analyses to justify interventions.
Sustainable Flood Management	SFM	An alternative philosophy to technically-focused management, which prioritises risk reduction. Willing to incorporate technical control of river systems, but emphasis on behavioural adaptations.
Natural Flood Management	NFM	The use of natural features or processes as part of flood risk management. A suite of techniques that emphasise land-catchment interactions for flood risk management.