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Protecting Indigenous Values in Water Management: A Challenge to Conventional Environmental Flow Assessments

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Abstract

Although environmental flow assessments and allocations have been practiced in Australia for nearly 20 years, to date they have not effectively incorporated indigenous values. In many cases, even though indigenous people rely substantially on aquatic resources, environmental flows have been assumed to be an acceptable surrogate for the protection of indigenous interests. This paper argues that the need to adapt flow assessments to account for linkages and dependencies between people and rivers is equally applicable to developed world indigenous contexts such as Australia as it is to developing countries where there has been some attempt to address indigenous or subsistence water requirements. We propose three challenges to conventional environmental flow assessments that, if met, will improve the ability of water resource planning to address indigenous interests. The first challenge is to recognize that in an indigenous context a different suite of species may be considered important when compared to those valued by other stakeholders. Although conservation status or rarity may be important, it is common and widespread species that make substantial contributions to indigenous household incomes through customary use. The second challenge is to accommodate a different set of management objectives in environmental flow allocation. Environmental flows will need to meet the requirement of hunting and fishing activities at rates that are socially and economically sustainable. The third and arguably most theoretically challenging task is for environmental flow assessments to take into account indigenous worldviews and the quality of people–place relationships that are significant in indigenous cultures. Meeting these three challenges to environmental flow assessment will assist water management agencies and other practitioners to protect indigenous interests as water allocation decisions are made.

Key words: Environmental flow; Northern Australia; Indigenous; Water; Values; ELOHA.

Introduction

Heightened water resource pressures world-wide have elevated the role of flow regimes in sustaining aquatic ecosystem health and, as a result, the scientific discipline of instream or environmental flow modelling and design has emerged (Richter and

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others 1997). As global water resource pressure increases and greater effort is devoted to meeting human development goals under sustainable development frameworks, there is a pressing need to adapt environmental flow assessment (EFA) to embrace a wider set of socio-economic concerns than previously addressed.

In the recent literature on integrated flow assessments (King and Brown 2006, 2010), a distinction is made between developed and developing countries in the strength of the socio-ecological relationships between people and river systems. King and Brown (2010) argue that water resource planning in African and Asian countries should recognize the greater human dependency on the environmental resource base; that 'human links with the river are strongest in developing countries, where livelihoods respond to the annual cycle of flows; cultural, religious and recreational ties to the river have deep meaning; and the river's resources provide a back-up in times of family trauma such as death of a bread-winner or loss of a job' (King and Brown 2010, p. 128). Acknowledging the strong reliance on river systems for local livelihoods, King and Brown (2010) call for flow assessments to account for the full suite of environmental and social costs in water resource decisions; giving these matters equal weight to that given to orthodox economic and social benefits.

This paper argues that the challenge to adapt flow assessments to understand, reveal and more fully account for the socio-ecological linkages and dependencies between people and rivers in developing countries is equally applicable to developed world indigenous contexts. In some developed countries, such as Australia, North America, Canada, Sweden and Finland, indigenous subpopulations, including nomadic, pastoral and hunter-gatherer peoples, live beyond the modern industrial norm and for a multitude of reasons are socially excluded from wider national society. It is these social groups, many of whom depend on aquatic resources for their livelihoods, that are most vulnerable to the impact of water resource development projects and may benefit least from river development (WCD 2000 in King and Brown 2010; see also Thomas and Twyman 2006).

In the northern Australian regions under examination in this paper (Figure 1), EFAs undertaken by water resource agencies have made little attempt to understand the pattern and significance of indigenous resource use and its role in the flow ecology, nor indeed the wider socio-cultural context which informs the development of values, beliefs and ideas about the environment and gives rise to differences in environmental philosophy across cultures. As a result, the choices made in the selection of target species and management objectives reflect priorities and values of non-indigenous scientists, conservation agencies and dominant user groups such as recreational fishers. These dominant non-indigenous priorities and values can differ from those held by indigenous groups, and it is these differences that need to be explicitly addressed in EFAs, rather than being overlooked on the assumption that environmental flows will serve as a surrogate for the protection of indigenous instream values (NWI 2004; NRETAS 2009).

The aim of this paper is to suggest modifications to EFA methods that should improve their capacity to account for indigenous interests in northern Australia. We provide a short description of the importance of water and rivers to Australia's indigenous people, Australian national water reform in the context of addressing indigenous needs, and current EFA methods. We then draw on cases in northern Australia, where aquatic resource dependency is high amongst indigenous groups and water resource development is increasing, to propose three challenges to current EFA methods. The challenges are each discussed with respect to the Ecological Limits of Hydrological Alteration (ELOHA) framework; a new EFA technique proposed by leading environmental scientists (Poff and others 2010). We use the ELOHA framework as an example of a recent and relevant EFA framework to which our suggested challenges may be applied. The challenges, if met, should assist EFA methods to more adequately incorporate indigenous values into flow management.

Australian Indigenous Water Values

In any given catchment there may be numerous indigenous groups with rights and interests in particular river locales, and a high reliance on riverine environments (Langton 2002). River valleys have been the main focus in the landscape for indigenous Australians for tens of thousands of years. Examples of early association with riparian environments includes fossils, middens and the sophisticated in-stream fish traps constructed with rock found on the Darling River in NSW (Humphries 2007). Indigenous groups lived amongst a complex network of rivers and creeks on south-east Australia's Murray-Darling riverine plains for more than 35,000 years (Lloyd 1988). Early European explorers in Australia noted the prevalence of indigenous people in proximity to rivers and other aquatic habitats, and in many cases

Figure 1. Australia, with northern Australian coastal catchments shown in *grey*. Catchments where authors are conducting research on the quantification of customary aquatic resource use are shown in *dark grey* and labelled.

also noted that the principal source of food for these groups was fish and other aquatic species (Humphries 2007). A form of fish farming was undertaken by fashioning the waterways to form fish traps like those in Brewarrina, north-western NSW (North 1916). Another means of catching fish, still practiced in parts of northern Australia, involved the use of narcotic leaves and barks infused into small pools to stun fish and eels (Lloyd 1988; Toussaint and others 2005). Surplus aquatic foods and plants were traded with people from other regions.

Few studies have attempted to determine the relative importance of food derived from aquatic environments prior to contact, however, one study in the lower Murray River suggested that 30–40% of dietary protein was sourced from freshwater fish and shellfish (Pate 2000, cited in Humphries 2007). The number of species harvested by indigenous people from aquatic habitats is substantial and ranges beyond fish. For instance, it has been suggested that historically the rhizome of Cumbungi (*Typha* sp.) could have been considered a staple food for indigenous people in southern Australia (Gott 1999, cited in Humphries 2007).

Aquatic species continue to comprise an important part of the livelihoods of indigenous peoples throughout Australia. Customary fishing, hunting and harvesting activities contribute substantially to indigenous household income and diet (Altman 1987; Jackson and Altman 2009). The National Recreational and Indigenous Fishing Survey of 2003 revealed a 92% fishing participation rate for the surveyed indigenous population in northern Australia. Approximately 38,000 indigenous fishers participated in 420,000 fisher days harvesting almost 3 million fish in total (Henry and Lyle 2003). In parts of northern Australia, non-fish species such as magpie goose (*Anseranas semipalmata*), long-necked turtle (*Macrochelodina rugosa*) and lotus lily seeds (*Nelumbo nucifera*) make up a major component of the aquatic foods harvested by indigenous people (Jackson and others 2011).

Altman's (1987) comprehensive research on the contribution of customary use of wild resources to indigenous people in the region surrounding Maningrida in the Northern Territory (NT) made explicit the contribution of customary use of wild resources to indigenous people and their economy. However, it did not discuss in detail the species used or the habitats hunted. The region and work was revisited more recently by Altman and Griffiths with a greater ecological focus on species and habitats. Results showed that although aquatic and semi-aquatic habitats (floodplains, swamps and streams) made up only 15% of the regional area, they were the location of 79% of all hunting and gathering trips. Returns per hunting trip ranged from 2 to 7.5 animals in aquatic habitats as opposed to less than 1 animal per trip in terrestrial habitats (Griffiths 2003). Given the contribution that customary use makes to household incomes and diets and the prevalence of resident species in customary harvest, aquatic habitats could be considered high value areas.

Research in northern Australia has suggested that approximately 80% of indigenous protein intake is derived from subsistence production (Altman 1987; Asafu-Adjaye 1996). Likewise, the contribution of customary harvest to indigenous

household incomes has been found to range from 64% (Altman 1987) in remote Arnhem Land through to 2.9–8.2% in a regional community on the central coast of NSW (Gray and others 2005). It is highly likely that the contribution of customary harvest to indigenous household incomes in many regions of northern Australia would currently fall at the mid to high end of this range, although there are undoubtedly variations across the region, depending on the history of colonization affecting attachment to land and access to resources as well as the productivity of local environments.

Meeting Indigenous Water Requirements Under New National Water Policy

Emerging from a decade of water sector reform, Australia has in place a set of relatively strong institutional arrangements designed to achieve the goal of sustainable water use, including a tradeable water market (Connell and others 2005). Environmental decline, linked to excessive water use and reduced supply in southern Australia, was highly influential in bringing about institutional change in the 1990s. This change saw the range of water management concerns broadened to 'account for larger environmental, social and cultural goals' (McKay 2002).

Australia's latest national water policy, negotiated in 2004, represents a substantial change from previous policy, in part because it recognizes a need for allocations to meet particular indigenous requirements, many of which will have to be quantitatively defined in water allocation plans. The National Water Initiative (NWI 2004) explicitly recognizes the special character of indigenous interests in water. Parties to the NWI have agreed to an over-arching objective: water access entitlement and planning frameworks should recognize indigenous needs in relation to access and management. Indigenous access is to be achieved through planning processes that:

- include indigenous representation in water planning, wherever possible;
- incorporate indigenous social, spiritual and customary objectives and strategies for achieving these objectives, wherever they can be developed;
- take account of the possible existence of native title rights to water in the catchment or aquifer area;
- potentially allocate water to native title holders; and
- account for any water allocated to native title holders for 'traditional cultural purposes' (paragraphs 52–54).

Despite the existence of a national policy, water resource management practice has not yet been markedly affected by the policy change. There is, however, growing interest in addressing Australia's inconsistent and under-developed systems for defining and meeting indigenous water requirements in northern Australia, where indigenous land holdings are substantial, current demand for water is low and seasonal availability high (Jackson 2008; Jackson and others 2009). In the absence of clear guidelines for water managers and little experimentation in determining indigenous water requirements (see Jackson 2008) it is not surprising that there is often an implicit but untested assumption that indigenous interests will be protected through the provision of environmental flows to meet aquatic ecosystem requirements.

Allan and Lovett (1997) argue that in Australian water policy there is a lack of definitional consistency in what an environmental flow is, and that the selection of ecological values is often arbitrary. The National Principles for the Provision of Water for Ecosystems (ARMCANZ and ANZECC 1996) state that the provision of water for the environment should 'sustain the ecological values of the water dependent ecosystems'. However, no guidance is provided on which ecological values should be selected nor by what process(es):

> The general lack of knowledge and data about ecosystems and their relationship to flow, mean that managers are often making decisions on the basis of inadequate information…This can lead managers to choose a particular species about which they have some information, as the basis upon which management strategies, theoretically designed to meet the needs of the ecosystem as a whole, are developed. In some cases, the species selected could see an ecosystem managed purely to meet their needs alone, with the corollary that this could cause damage to other ecosystem components. In cases where there are vested interests, this choice could also be affected by community or political pressure (Allan and Lovett 1997, p. 204).

As research interest in indigenous water management grows (see Jackson and others 2009), and indigenous people advocate for greater manage-

ment control of water resources (Jackson and others 2009; Jackson 2011a), the following question has arisen: 'how can water management systems acknowledge and effectively respond to indigenous water values?' Addressing this question requires consideration of three key issues:

- how values are conceptualized in natural resource management debates, including water management,
- the potentially marked differences in world view between indigenous and non-indigenous people, and
- the theoretical frameworks that can assist us to understand these values and their relationships to water and address them in water use decisions.

Jackson (2006) has described the way in which values are defined in water management discourse, noting the tendency for the separate treatment of indigenous and non-indigenous social values to compound the reification of 'cultural values' often perceived largely within the confines of a cultural heritage paradigm. The heritage paradigm and other common influential theories of value focus on objects, entities and places at the expense of recognition and valuation of relationships, processes and connections between social groups, people and place, and people and non-human entities.

The focus of this paper is on one specific water management practice: the scientific determination of environmental flows. There are other scientific practices and bodies of literature that one can also turn to for insight into this question. In Australia, the predominantly anthropological literature represents a valuable source of knowledge (see Strang 2001; Langton 2006; Toussaint and others 2005). This growing body of literature explicitly documents and analyzes the ways in which indigenous societies attribute meaning to water as well as the place of water in their formalized systems of knowledge and social institutions (Jackson and Altman 2009). Within the frameworks applied by social scientists, water is examined as a feature of the indigenous landscape with significant attention devoted to the symbolic dimension of individual and group attachment to customary estates and their water bodies. Northern Australian studies describe and interpret stories relating to water represented in myth, painting, film, and dance, and the local customary practices, beliefs and ideas associated with water (Yu 2000; Strang 2001; Barber and Jackson in press). Many commentators, such as Altman and Branchut (2008), also refer to water's economic significance as a vital element underpinning the indigenous harvest and intra-community distribution of aquatic life, noting that:

> there is an overarching Aboriginal view that water is a resource with inseparable cultural and economic values, significant water places have high religious and livelihood values. This is in marked contrast to western notions of water as a resource with competing commercial and environmental/recreational values (2008, p. 2).

These studies of the significance of water provide a rich account, narrative and qualitative in style, but provide little guidance to water planners who currently seek to understand the contribution of flow to indigenous *use* of rivers, water bodies and resources. The Australian anthropological literature has not set out to answer the water planner's question: a question that is a considerably narrower one to that posed above—are indigenous instream values protected by environmental flows? Instead, these studies have sought to understand and describe the significance of water and rivers within indigenous belief systems and cultural practice, and to analyze indigenous water management institutions, including customary rights (see Jackson and Altman 2009). And in international social research, attention is being given to conflicts over water arising from the articulation of market mechanisms and local, customary formulations of rights and equity (Boelens and Doornbos 2001; Boelens and Hoogendam 2001). The focus of all these social studies is broader than that found in EFAs, or indeed many water allocation decisions, which are concerned with instream uses and, in theory at least, the direct use of a place or resource by water users such as indigenous people and impacts upon those uses by altered flow regimes. Sociological and cultural studies approaches will also differ from a more technical approach that favors quantification because value concepts are treated differently in the social sciences than in resource management discourse (Jackson 2006; Norton 2000).

Relying on insights gained through a study of indigenous water values in northern Australia (Jackson and others 2011), we outline the limitations of and challenges to current environmental flow determinations for their capacity to assess and protect indigenous instream values. We focus on the economic benefit derived from customary resource use, noting that under Australian law, the *Native Title Act (Cwth) 2004* guarantees native title holders unfettered customary rights in water (Jackson and Altman 2009).

Environmental Flow Assessments

Before turning to a discussion of our challenges, we provide an overview of EFA methods. Environmental flow allocation began in the United States in the 1940s, but only came to prominence in Australia during the 1980s (Tharme 2003). The term environmental flow, or environmental flow allocation, commonly refers to a flow regime designed to maintain a river system at an agreed level of ecological condition (Smakhtin 2007). Australian national water policy mandates that the environment be treated as a water user and all Australian jurisdictions have commenced environmental flow programs (Schofield and Burt 2003).

Although the stated aim of environmental flow allocation is to restore or maintain the important biophysical components and ecological processes supported by natural flow regimes (Arthington and Pusey 2003), social values and cultural perspectives on human–nature relations will clearly have a significant bearing on allocation frameworks, assessment methodologies and resulting water sharing decisions (see van Wyk and others 2006). Where hydrological regimes have been altered, the concept of environmental flow allocation, including which features should be protected and how much water should be applied, entails consideration of a set of choices and preferences driven by human objectives (Schofield and Burt 2003).

More recent environmental flow allocation definitions encompass the concept of ecosystem service provision and the reliance of human systems on aquatic health and integrity. The 2007 Brisbane Declaration, for example, defines an environmental flow as 'the quantity, timing and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on those ecosystems' (http://www.riverfoundation.org.au/images/stories/pdfs/bnedeclaration.pdf). Assessing and specifying the flows that provide mutual benefits to diverse human groups and the ecosystems they rely upon should be the task of multidisciplinary teams that can trace, and where possible, quantify the relationships between river flows and system changes (http://www.riverfoundation.org.au/images/stories/pdfs/bnedeclaration.pdf), although some valued associations and relationships indigenous people maintain with river systems will not be amenable to quantification. Multi-disciplinary efforts will therefore need to examine the potentially marked differences in world view between human groups such as indigenous and non-indigenous peoples and consider what bearing epistemology and ontology have on the complex inter-relationships that create systems of value.

With a few exceptions (for example, the South African DRIFT process—King and others 2003), the practical application of EFA has solely addressed the flow requirements of river ecosystems, with practitioners seeking to answer the question 'how much water does the environment need'? More recent and widespread recognition of the importance of a dynamic, variable water regime has expanded this question to include the magnitude, frequency, timing and duration of flows required to maintain river ecosystems (Arthington and others 2010). In outlining these advances, however, Arthington and others (2010), emphasize the ongoing need to advance the ''social side'' of environmental flow allocation techniques.

In Australia, as in many parts of the world, there has been a gradual evolution of environmental flow methods from using hydrological metrics and look-up tables to keep flow impacts under a relatively arbitrary magnitude (Acreman and Dunbar 2004), through to the more holistic and expertise-based methodologies that emerged during the 1990s (Arthington 1998; Arthington and others 2010). Transect-based habitat modelling falls into either the 'hydraulic rating methodologies' or 'habitat simulation or microhabitat modelling methodologies', depending on the complexity of the modelling (Tharme 2003; Arthington and others 2004). Typically, one or more hydraulic variables are modelled to assess flow-related changes in the habitat of target species, life history stages or activities. Applications of these methods have commonly been biased towards the flow requirements of target fish species, and have in some cases been criticized for their lack of broader ecological predictive capability (Arthington 1998; Tharme 2003). Transect-based modelling methods range from the simple wetted perimeter method comparing discharge with the quantity of wetted perimeter in an area (as a surrogate of aquatic habitat), through to the more complex use of models in the Instream Flow Incremental Methodology (IFIM) (Tharme 2003). As a group, transect-based modelling methods deal purely with the biophysical relationships between discharge, hydraulics and ecology and, to our knowledge, have not incorporated social or cultural values into their assessments. However, transect-based modelling approaches have been embedded into more holistic EFA methods such as the Downstream Response to Imposed Flow Transformation (DRIFT)

and used to identify the impacts of flow transformations on species of social importance (Arthington and others 2003).

Expert panel and holistic approaches cover a relatively wide range of methodologies. Arthington and others (2004) list a subset of 12 methodologies that have been developed based on holistic principles, noting that there are many more. Two of these methods have been applied in northern states of Australia: the Benchmarking Methodology (Brizga and others 2002) in Queensland; and a modified version of the Flow Events Method (Stewardson and Cottingham 2002) in the Ord River of Western Australia (Department of Water (DoW) 2006). These methods typically involve the engagement of an expert panel to derive environmental flows (DoW 2006) and take a broader perspective, investigating the interacting components of a complete river ecosystem (Arthington 1998). Components often include fish, invertebrates, riparian vegetation, geomorphology, aquatic macrophytes, water quality, and in some cases, social impacts (van Wyk and others 2006). As with transect-based habitat modelling methods, the implementation of holistic techniques in Australia has focussed mainly on flows that meet the ecological needs of river systems. There is at least one holistic method that incorporates socio-cultural assessment (King and Brown 2006), however, Australian implementation of holistic environmental flow methods has so far not included a socio-cultural component. This has resulted in the omission of indigenous social, economic and cultural values from Australian EFAs (Jackson 2008). The neglect of indigenous values might be attributed to the perception amongst scientists and practitioners working in southern Australia, where holistic methods have been applied, that indigenous people do not rely heavily on aquatic resources. It may also reflect a pragmatic approach: addressing the significant environmental impacts of over-consumption of water in the developed agricultural regions of Australia on the premise that any improvement to environmental health via increased environmental water allocations will be of benefit to indigenous people.

Although EFA methods in Australia have advanced and become more encompassing in the 20 years since their implementation, the existing methods have not included a socio-economic component, and most have failed to specifically address indigenous interests (for example, DoW 2006; NRETAS 2009). Given the large indigenous land holdings in northern Australia and increasing demand for water based economic activity (CSIRO 2009), there are compelling reasons for testing and improving water planning and allocation decisions. Below we set out three methodological challenges to conventional EFA that, if addressed, would contribute to meeting the requirements of Australia's NWI. We also suggest that the consideration of these challenges within the social process and scientific components of the Ecological Limits of Hydrological Alteration (ELOHA) framework (Poff and others 2010) will increase the likelihood that indigenous interests are met by flow allocations.

Putting Indigenous People at the Center of Flow-Ecology Relationships

Challenge 1: Selection of Species of Interest for Determining Flow Requirements

Indicators of the effectiveness of environmental flows have included the level of hydrological alteration, whether the flow requirements of individual species will be met, or whether the flow requirements of a suite of species, and in some cases river function, will be met (Acreman and Dunbar 2004). The species and other parameters selected as indicators may be based on the objectives of highly visible stakeholder groups seen as having an interest in environmental outcomes (Allan and Lovett 1997). These groups most commonly consist of environmental organizations, scientists or government departments tasked with meeting environmental or conservation obligations, and may include recreational fishers (Smith 2009).

In the Daly River of the Northern Territory, the region in which the authors have examined indigenous water values, initial research on environmental water requirements (Erskine and others 2003, 2004) focussed on the flow requirements of the pig-nosed turtle (*Carettochelys insculpta*), riparian trees, periphyton/phytoplankton, and an aquatic macrophyte (*Vallisneria nana*) that is a food source for pig-nosed turtle. The process included a wetland inventory, but there was no discussion of flow requirements for those wetlands.

Erskine and others (2003) considered pig-nosed turtle, freshwater whipray (*Himantura chaophraya*) freshwater sawfish (*Pristis microdon*) and the strawman (*Craterocephalus stramineus*) as appropriate target species for environmental flows due to their threatened nature. Thus, species that had high conservation value due to their low abundances and restricted distributions were seen as the

most important endpoints for environmental flow protection. The EFA did not investigate the flow or habitat requirements of other turtle species such as the long-necked turtle (*M. rugosa*), an abundant and most important turtle food source for many of the eleven indigenous language groups in the region. Likewise, barramundi (*Lates calcarifer*) was regarded as a valuable fish species, favored by the recreational fishing sector. Although barramundi are harvested by indigenous people for food, no mention was made of fish species that our on-going research indicates makes up a larger percentage of indigenous catch, such as the black bream (*Hephaestus fuliginosus*) or the fork-tailed catfish (*Neoarius* spp.).

We are not suggesting that species used by indigenous people should be the only focal species in setting environmental flows. To do so may encourage a situation similar to that in northern Scandinavia where reindeer (*Rangifer tarandus*) and moose (*Alces alces*) were used as indicators of forest condition, due in large part to their high cultural and customary use values. Moose and reindeer could thrive in secondary forest whereas other important species could not, so there was a gradual loss of species and key forest components even though the indicator species were not affected (Dudley and others 2005). Largely unpublished work on EFAs in East Africa and South America has selected indicator species based on their ability to be sensitive to, and represent, components of ecosystem functionality rather than due to their value to stakeholders. However, an explicit recognition of species important to indigenous people may prompt analysis that ensures their water requirements are met (M. McClain, pers. comm.).

In the Daly River, long-necked turtle are the species most commonly harvested by indigenous people (Jackson and others 2011), but pig-nosed turtle are the species of most concern to conservation groups and scientists. Additionally, black bream are the fish most commonly caught and eaten by indigenous people, but barramundi are the iconic species sought in the recreational and commercial fisheries. These species have different flow requirements, but so far EFA in the region has focussed on the species of conservation concern rather than those most commonly utilized by indigenous people. More recent research in the Daly River involving the authors (Chan and others 2011) specifically assessed the flow requirements of the black bream as a result of their popularity with local indigenous people. A fuller understanding of the complete set of valued species and impacts of water use changes on those species can provide the basis for more rigorous and balanced trade-offs between species conservation and the more direct needs of particular social groups.

Challenge 2: The Determination of Management Objectives

Surveys of indigenous land managers across north Australia (Jackson and O'Leary 2006) show that there is an expectation that fish will be abundant and accessible. Consider the following comment from a Wagiman traditional owner from the Daly River region:

> The fish been here a long time. I think about that. These fish have been here and we can go and get them. In other places you have to go a long way. I been fishing here last year, we know where that fish is and we go back next year and we catch fish there. In that same spot where it's started and we catch a big mob, get some catfish, bream. You know that, you get plenty tucker there…
> When we come out we go where we went last year. We know there's a big mob of water there, we know we can get a big mob of fish or turtle. We take our time. We got to a place where the water's shallower and we know you can still get fish there. We know and we go back there next year (23 July 2006).

As this comment reveals, amongst indigenous traditional owners there is confidence in the knowledge that fish are abundant and will be reliably caught under the correct protocols. Environmental knowledge about fish and flow relationships informs the selection of fishing locations, target species and technique.

Based on results of our research on the customary use of aquatic resources, many of the aquatic species that are extensively harvested and consumed by indigenous households are quite common and abundant (for example, long-necked turtle; *M. rugosa*). Rare and threatened freshwater species that are significant from a conservation stand-point are not large components of the harvest. Given the difference in target species and the expectation that fish will be abundant and easily caught, it is therefore likely that indigenous people will have different management objectives to other stakeholders.

In the Daly River example given above, the flow requirements of the pig-nosed turtle were deter-

mined by modelling flows that resulted in 'bust' conditions (sensu Erskine and others 2003, 2004). Bust conditions were considered as low flow conditions resulting in some restriction of pig-nosed turtles' home range and longitudinal passage. These flows occur naturally in 3 of 5 years (Erskine and others 2003), and acceptable environmental flows were considered to be those that minimized any alteration to the frequency of bust conditions for pig-nosed turtles; providing flows expected to maintain their population at current levels.

Indigenous people in northern Australia usually harvest relatively common species from river systems (Griffiths 2003) as they have population sizes and spatial distributions that maximize catch rates whilst minimizing effort. It is possible that river flows that maintain a biologically sustainable population of pig-nosed turtles in the Daly River may not provide a sufficiently large population of pig-nosed turtles or, importantly, other harvest species from which to achieve a socially desirable and economically viable catch per unit effort (CPUE). The concept of biological sustainability (that is, of plant and animal populations) is predicated on the fact that a population will persist through time, rather than a population that is maintained at its highest possible carrying capacity or distribution (Bue and others 2008). Ensuring continued access to wild resources and a carrying capacity that maintains rates of harvest is likely to be a high priority for indigenous people, and this objective will have a bearing on EFAs.

Disparity between the objective of ''biological sustainability'' and that of ''maintained harvest rates'' has an analogue in commercial fisheries management. Management objectives in many commercial fisheries have transitioned from the biological objective of managing fish populations for maximum sustainable yield (MSY), to a more socio-economically focussed objective of managing population size for maximum economic yield (MEY). Commercial fisheries have been traditionally managed under the biological objective of MSY: the point at which the largest quantity of fish can be taken from a fishery without the spawning population declining over time (Bue and others 2008). Although MSY will maximize the production of a fishery, it does not necessarily maximize employment, ecosystem preservation or economic profitability (Hilborn 2007). Utilizing a fishery at MEY usually involves reducing the total annual catch of the fishery and maintaining a larger population size. A resulting benefit is an increase in CPUE and the marginal income obtained by each fisher (Hilborn 2007). Although the total catch of the fishery may be reduced, the economic benefits for individual fishers are increased by maintaining the standing stock or current biomass at a higher level.

The analogous component of this comparison is the potential need for environmental flows that hold the standing stock of a species at a level that enhances the marginal benefits obtained by indigenous harvesters, rather than flows that simply maintain a biologically sustainable population. We caution here that we are not suggesting that environmental flows should be only targeted to optimize indigenous fisheries objectives. Simply that a key objective from an indigenous perspective is more likely to be to maintain harvested species at a population size that maximizes CPUE, minimizes harvest costs, and minimizes environmental impacts, rather than maintaining a population that is persistent through time, perhaps at the expense of its total biomass or spatial distribution.

Challenge 3: The Consideration of People–Place Relationships

Jackson's (2008) review of Australian water management argued that 'where indigenous interests have been considered for assessment and planning purposes, indigenous values have tended to be overlooked in a scientific process that leaves little room for different world views relating to nature, intangible environmental qualities and human relationships with river systems that are not readily amenable to quantification' (p. 874).

Some of the landscape qualities that are important to indigenous people may be perceived as intangible, subjective and even outside the realm of water management agencies' legislated responsibilities. Important features of a site, for example, its religious significance, and the custodial obligations flowing from maintenance of that site may be viewed as independent from the flow regime and indeed environmental flows. However, flow regimes can be closely linked to factors seen as extraneous by water management agencies. A fishing trip is an opportunity to catch fish as well as visit and interact with ancestral landscapes and with members of family, to socialize, to educate children in the protocols of fishing and hunting while fulfilling custodial responsibilities. The quality of a fishing expedition is therefore multifaceted, and the continuation of seemingly disparate aspects like social well-being and cultural connection can be closely tied to flow management.

Traditional owners have a responsibility to look after significant cultural sites and to carry out cus-

tomary management activities. In the Katherine River area, upstream from the Daly River, significant cultural water sites include rivers and creeks and their associated features, including gorges, waterfalls, plunge pools, waterholes, billabongs and springs; and areas away from river and creek beds such as seasonally inundated swampy areas and isolated rockholes and springs (Cooper and Jackson 2008). Cooper and Jackson (2008) reported that the underground waters, including the water of the Tindall Aquifer, are themselves significant and feature in indigenous ritual knowledge. Cultural practices are undertaken at these water sites, including calling out to the ancestors upon approach, 'watering' strangers and others when visiting a place, restrictions on taking and eating species, protecting others from harm and management and protection of sites, for example, burning the grass around sites to 'clean them up', cleaning springs and soaks, and carrying out ritual and ceremonies associated with sites (Cooper and Jackson 2008).

A stated objective of the Katherine Water Allocation Plan is to ensure that ''water dependent sites with identified indigenous cultural importance…are preserved'' (NRETAS 2009, Outcome 5). The NT's *Water Act (2000)* also provides for cultural values to be taken into account in setting management objectives for a water body. This is achieved through the declaration of cultural beneficial uses. Maintenance of such values and uses ultimately depends on ensuring continued access, the application of local ritual knowledge and appropriate flow allocation. This is in line with the provisions of National Water Initiative, to which the NT Government is a signatory: to incorporate indigenous social, spiritual and customary objectives and strategies for achieving these objectives wherever they can be developed (NWI 2004).

Australian water management agencies have legislative responsibility for water resources and powers to influence river discharge (via water licensing and allocation), but little power to directly influence other land management practices or tenure conditions such as access to cultural sites. Indigenous people have been critical of the separate treatment of land and water within natural resource management and the way in which social considerations, like access to country, are so readily divorced from environmental management (for example, Barber and Kennedy 2006). Aligning the worldviews to more appropriately manage river discharge and to set appropriate environmental flows will require management agencies to (1) be more willing to build qualitative assessments into their environmental flow assessments by scrutinizing the qualities and features of the places that indigenous people use and value highly, and (2) be more supportive of indigenous land and water management practices.

Qualitative assessments of indigenous people's interaction with the flow regime will contribute to the overall understanding of the socio-ecological system, and complement scientific approaches by filling gaps in knowledge of the seasonal flow regime, particularly in remote regions where the science base may be low (Berkes and Berkes 2009; King and Brown 2010).

In our research, a range of site-specific qualities have been identified and many of these relate to amenity. At some fishing sites used by indigenous people on the Daly River, the qualities include: shade (for sitting quietly), the number of fish caught, whether it offers privacy (quiet and away from tourists and other outsiders), and whether the water is appropriate for drinking and bathing (M. Finn pers. obs.). It is possible to consider the range of aforementioned features or qualities that affect values and begin to assess their flow requirements (Table 1).

Although the intangible and subjective nature of some indigenous values has been seen as insurmountable barriers to their inclusion in EFA, we suggest otherwise. Establishing potential links between flow regimes and water landscape qualities would provide a useful qualitative analysis and identify components of the flow regime that are a critical feature of socially valuable flows for the area. A qualitative component would illuminate the way in which the consumption and distribution of resources is underpinned by beliefs, values and social relations, and improve our understanding of value concepts in cross-cultural contexts. Schofield and Burt (2003) affirm the importance of social analyses conducted in parallel with studies of the benefits of environmental water allocations.

Qualitative research could be undertaken as a scoping exercise to identify key indigenous issues. In many cases, even values conventionally perceived to fall outside the scope of environmental flows, such as creation stories about a site and custodial responsibilities like calling to ancestors upon approaching a site can be linked back to flow regimes. A qualitative understanding of people–place relationships during environmental flow assessments may provide opportunities to formally support indigenous customary management practices in subsequent water plan implementation and to mitigate any adverse effects arising from flow alteration.

Table 1. A Subset of Valued Features of Significant Sites Along the Daly River, NT, and Their Relationship with Flows

Feature	Indigenous perspective/value	Link to flows
Shady place	*Those trees are important, there will be no shade for fishing and talking if those trees go*	Permanent flow maintains riparian vegetation
Fishing spot	*The main thing here is to make sure there are still bream, turtle, barramundi and other things. Sometimes when we can't get fish down the Daly because there are too many tourists there, we say ''well, we will go down to [named place] to catch fish, because we know we will get them there''*	High abundances and catch rates of targeted species. At least one of these (barramundi) requires access to saline water for spawning (that is, longitudinal connectivity)
Story place	There is a dreamtime (creation) story associated with this place. A central element of the story is the presence of permanent water, and how the actions of a creation being resulted in the spring upwelling at this location.	Groundwater extractions that affected spring discharge would affect people's view of the health of this site, as well as the happiness/health of their ancestors, and their own cultural and physical wellbeing.
Historical significance	*This was an old camping site. [Named person]'s nanna and uncle are buried upstream. We come down here fishing and call out in [named traditional language] to them old people*	The general health or condition of the site is related to how well people feel they are fulfilling their custodial responsibilities to care for country and their ancestors. Impacts at the site (including, but not limited to, impacts to the flow regime) will be seen as a neglect of custodial responsibilities, with negative consequences for those concerned
Drinking and bathing	*Can't get water from here for a cup of tea or lunch anymore. The birds and animals have ruined the water quality. [Named person] has a photo of [named person] having a bogy [swim/wash] in the water from years ago, and the water is a deep blue colour. Now it is dirty*	Water quality is assessed visually, and by taste. There is a recognition that different types of water are present at different times of the year, and that the timing often reflects wet/dry season cycles within the annual flow regime

Italicized text is interviewee quotes from M. Finn's field notes: 1 Aug 2009 to 30 Nov 2009.

As will be apparent from the very broad scope of issues requiring attention, and the intangible nature of some of them, there are many factors that will have a bearing on the quality of indigenous relationships to water and river systems. We contend that water managers, scientists and planners can all play a part in designing research, management and monitoring programs in such a way that indigenous values are affirmed and sustained by those activities. For example, applying both indigenous and research-based knowledge to a contemporary management problem will affirm the importance of indigenous perspectives and epistemologies. It might also provide a forum through which tacit indigenous ecological knowledge and underpinning values and beliefs are passed on to younger generations. There is a risk that indigenous values may be adopted or incorporated as a relatively fixed set of propositions, whereas in reality such values will always be dynamic in nature. Environmental water management practices, including scientific assessments, should allow for the actualization of complex and distinct values; requiring of course the appropriate resourcing of long-term processes that maintain, affirm, and, in some cases, restore and enhance, indigenous relationships with water and water bodies (Barber and Jackson 2010). Indigenous participation in long-term monitoring of environmental flow outcomes could provide such opportunities; allowing for articulation of both indigenous and non-indigenous values, direct indigenous participation in data collection and processes of exchange and learning across cultures to inform and adapt management actions.

Unpublished examples of the relationship between intangible cultural values and environmental flows from other countries include the relationship between flow requirements of (1) sacred places and those required to maintain ecological conditions in South Africa; (2) ghats used in ritual ablutions in India; and (3) culturally significant aquatic biota such as river dolphins (J. O'Keeffe, pers. comm.) Examples of attempts to include cultural objectives into stream management from the published international literature include the development of a Cultural Health Index (CHI) with the Maori of New Zealand (Townsend and others 2004), and the use of Native American cultural knowledge for setting water management priorities in the Wind River Indian Reservation in Wyoming (Flanagan and Laituri 2004). Both these examples highlight an ability to incorporate different cultural perspectives into water resource management, even if on a relatively preliminary basis. The Maori CHI in particular, showed a strong relationship with a Western science-based indicator of measures of stream health (Townsend and others 2004), suggesting that indigenous qualitative information previously perceived as intangible and subjective by water managers may have much to offer EFA.

Inclusion of Indigenous Values in the ELOHA Framework

The recently developed ELOHA framework (Figure 2) synthesizes a number of existing hydrological techniques and environmental flow methods to arrive at ecologically based and socially acceptable standards for the management of environmental flows (Poff and others 2010). The method involves a four-step scientific process: defining hydrology; river classification; establishing the degree of flow alteration; and the establishment of flow alteration–ecological response relationships. Environmental flow standards are then set that maintain or create socially acceptable ecological conditions. The ELOHA method explicitly recognizes that societal needs and values will define the ecological goals applying to each river or management segment. We suggest that each of our first two challenges to conventional EFA can be readily integrated into the ELOHA process (Figure 3), whereas the third challenge will take further experimentation to test how amenable the process and its underpinning theoretical frameworks are to addressing the complex social dimensions of cross-cultural environmental inquiry.

Social Process: Societal Values and Management Needs

There are two stages of the ELOHA framework where our three challenges can be utilized to more effectively account for indigenous values. The first of these is during the social process component, where societal values and management needs are to be considered (Figure 3). As demonstrated above, where species are the focal point of flows for the protection of ecological condition, there is a tendency to focus on species of conservation concern rather than the more abundant and widespread species that are commonly harvested by indigenous people. It is possible that without specific consideration of indigenous people's highly valued species, the ''acceptable ecological conditions'' generated during the social process (Figure 3) will not protect these species. So, the first step is to include the protection of key indigenous harvest species as important societal values. At a minimum, this will require that indigenous people's customary resource use patterns are well understood.

Secondly, we suggest that differing stakeholder objectives will also clearly influence the social process stage envisaged by the ELOHA framework, and that indigenous management objectives should be sought during the social process (Figure 3). In setting the ecological conditions leading to environmental flows, indigenous interests are more likely to be well accounted for if there is direct representation of indigenous people in the water allocation processes that generate agreed upon water management objectives. Other authors have highlighted the need to involve all stakeholders at the outset of EFA planning to maximize success (see for example, Poff and others 2003). However, in Australia at least, water resource management practice has so far not been markedly affected by the inclusion of indigenous interests in national water policy, and approaches to incorporating indigenous values into water allocation are ad hoc, inconsistent and under-developed (Jackson and Altman 2009).

We do not suggest that indigenous management objectives will never accord with those of other stakeholders (there is particular potential for overlap with recreational fishers and hunters), only that methods like the ELOHA framework will need to explicitly consider indigenous objectives to ensure that any differences with other stakeholders are not overlooked in environmental flow assessments.

Thirdly, and quite clearly, the unique relationship Australia's indigenous people have with rivers

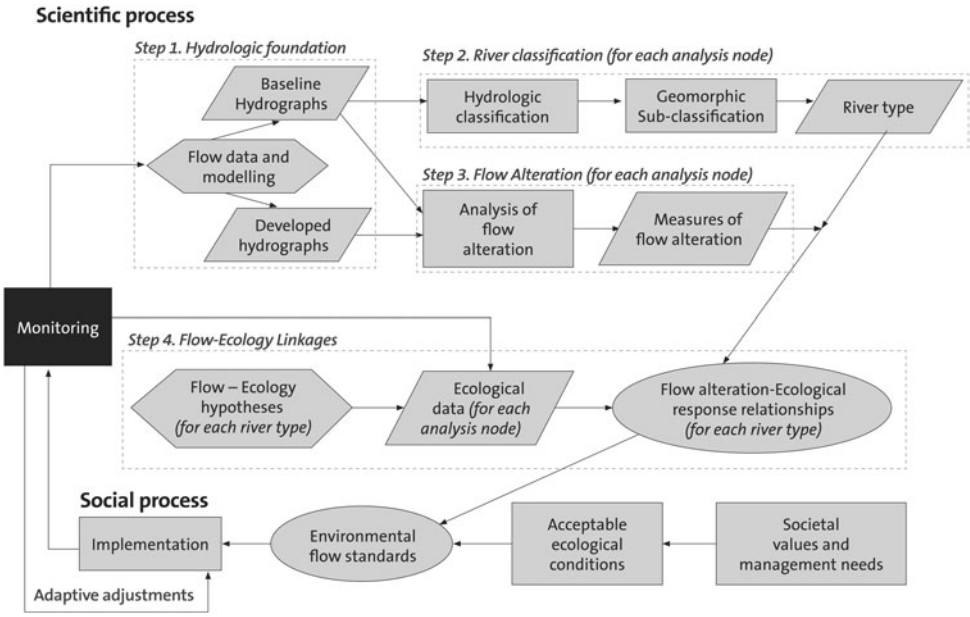

Figure 2. The ELOHA framework (from Poff and others 2010, p. 151).

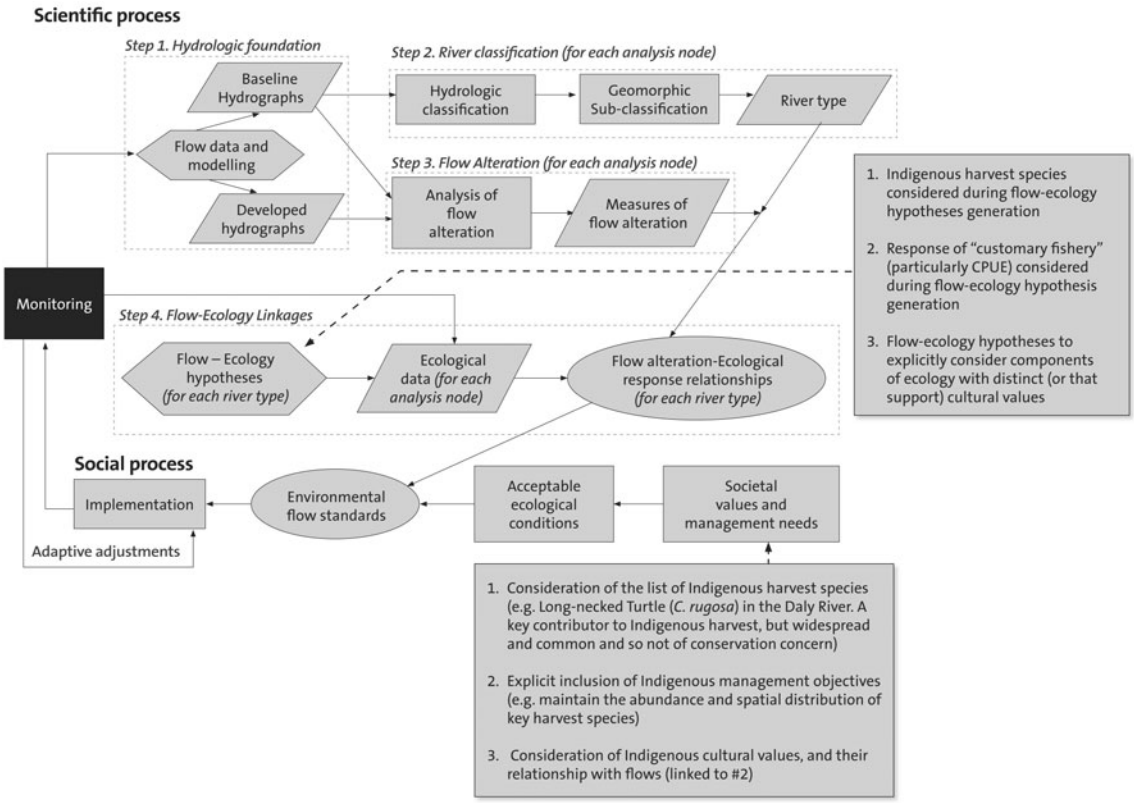

Figure 3. Suggested inclusions in the ELOHA framework to improve its ability to account for indigenous needs.

and water will result in a set of societal values and management needs that may well be distinct from any other stakeholder group. If methods such as ELOHA are truly to account for indigenous needs, the consideration of indigenous socio-cultural values will need to be an integral component of the social process (Figure 3). An example can be seen in the DRIFT process, where values accorded to all

fish species by Lesotho people were incorporated into the environmental flow assessment (Arthington and others 2003).

Flow-Ecology Linkages: Flow-Ecology Hypotheses

The second stage of ELOHA where our three challenges may be readily incorporated is during the setting and testing of flow alteration–ecological response hypotheses. Poff and others (2010) suggest that the relationship between flow alteration and the ecological features of a river is a key element in linking the hydrological, ecological and social aspects of EFA. Further, they suggest one of the key criteria of an ideal ecological response variable is its value to society, and list the availability of culturally valuable plants and animals and fisheries production as important social values. So, firstly, species valued by indigenous people should be considered during the setting and testing of flow-response hypotheses to ensure that EFAs are inclusive of all social values, not merely those held by dominant groups.

Secondly, and related to the need for the abundance and distribution of key species to be maintained to ensure indigenous harvest is not affected, the response of the customary fishery (and hunting of aquatic species) should be considered as a relevant ''ecological response''. The application of this principle within ELOHA could involve exploring, as flow-ecology hypotheses, the flow requirements of the key species harvested by indigenous people, the relationship between people and the aquatic food web, and relationships between flow and CPUE for key harvest species (Figure 3). Such a change in objectives would consider people as a component of functioning ecosystems (Humphries 2007), explicitly take into account the worldview of indigenous people, and may challenge the perception that the needs of people compete directly with the flow requirements of river ecosystems (van Wyk and others 2006).

Finally, we argue that the ELOHA framework should be tested to ascertain whether it is also capable of addressing the qualitative elements of indigenous people's socio-cultural relationships to water and rivers. Social and cultural values have developed over many centuries of close interaction with aquatic ecosystems and are sustained by the maintenance of flow-ecology linkages. The characteristic features of the system upon which the values are based, are at least in part defined by ecological condition and function. Within ELOHA, the consideration of the components of riverine ecology that support indigenous values will enable the formation of flow-ecology hypotheses relevant to those values, and subsequent collection of ecological data to inform the setting of environmental flow standards (Figure 3). EFAs revised in such a way will then accommodate an important aspect of indigenous relationships to water resources. Further research will demonstrate whether scientific approaches to resource assessment are amenable to understanding the wider complex of ideas, beliefs and values held by indigenous peoples.

Conclusion

Throughout Australia environmental flow allocations continue to be used as a surrogate for the protection of indigenous interests in water management (for example, DoW 2006; NRETAS 2009). The difficulty that EFA practitioners have in incorporating indigenous interests is attributable to a number of factors. Firstly, most EFA methods in Australia have been developed and implemented in parts of Australia where indigenous people have been effectively marginalized from water resource development (Jackson 2011b; Weir 2010), and as a consequence, there has been less emphasis on the significance of continued customary use of aquatic wild resources and other important links between rivers and indigenous people. Secondly, lack of research attention to the relationship between indigenous values and water has hampered efforts to specify and quantify indigenous water requirements and then incorporate and protect those values during water resource planning and EFA. Finally, in Australian conservation policy there has been a tendency to view indigenous people's use of aquatic systems as an activity in direct conflict with the environment (van Wyk and others 2006), so the provision or protection of flows to sustain the harvest of aquatic species has likely been seen as outside the purview of EFA.

If EFAs are to be more inclusive of indigenous values and thereby provide greater protection of indigenous interests, concerted research, experimentation and cross-cultural engagement will be required. Our early research shows that indigenous values and uses of aquatic systems can be quite distinct from the benefits derived by non-indigenous people. These differences can range from the suite of species regarded as important, the contribution that direct use of wild resources makes to household incomes, and the inter-relationships between ecological, spiritual and social wellbeing. Current methods of EFA that tend to focus on ecological and conservation values and overlook

the social, cultural and economic dimensions of instream values, may produce a flow regime that fails to protect indigenous interests and aspirations. Incorporating the critique offered in this paper into ELOHA and other EFA methods will test the suggestions made here and, if successfully applied, the results will assist water management agencies to more effectively address indigenous water requirements in water allocation decisions and plans.

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