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The Ethics of Instream Flows: Science and Policy in Southern Alberta, Canada

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***Abstract*—**Securing instream flows for aquatic ecosystems is critical for sustainable water management and the promotion of human and environmental health. Using a case study from the semi-arid region of southern Alberta (Canada) this paper considers how the determination of instream flow standards requires judgments with respect to: (1) The relationship between instream flow indicators and assessments of overall environmental health; (2) The indicators used to determine adequate instream flows, and; (3) The assumptions underlying efforts to model instream flows given data constraints. It argues that judgments in each of these areas have an inherently ethical component because instream flows have direct effects on the water(s) available to meet obligations to humans and non-humans. The conclusion expands from the case study to generic issues regarding instream flows, the growing water ethics literature and prospects for linking science to policy.

***Keywords*—**ethics, instream flows, policy, science, water management

I. Introduction

SECURING adequate instream flows for aquatic ecosystems is critical for environmental and human health. In addition, the sustainable stewardship of aquatic ecosystems presents the two-fold challenge of determining instream flow values and of finding appropriate management and legal mechanisms for achieving them [1]. In basins that are heavily subscribed this can require significant trade-offs, a fact that has increasingly highlighted the role that values play—whether implicitly or explicitly—in efforts towards sustainable water management [2]. These implicit and explicit judgments often extend findings on ‘river health’ beyond the science and to socio-political contexts [3]. In this regard, previous attempts to value instream flows, such as those by economists, have been primarily concerned with the impacts of *implementing* instream flow policies, with conservation gains seen as the beneficial outcome of market mechanisms [4]. Alternately, legal theorists have focused on the *capacity* for adjusting legal and institutional frameworks to reflect broader scientific principles and changing social values [5,6]. Notwithstanding these contributions, along with recent attempts to integrate economic and environmental values in water policy [7], there remains an overlooked aspect of securing instream flows. Namely, it is important to consider the normative implications of *determining* instream flows and the subsequent distributions of water for society and ecosystems.

This paper investigates how the determination of instream flow criteria create and order water in terms of its availability for human use and thereby constrain the inferences of policies aimed at sustainable water management. It considers this issue in light of arguments that when scientists convey findings regarding complex systems they must do so in narrative terms, by which it is meant that there is no single, correct perspective from which coupled, socio-ecological systems may be viewed [8]. Rather, all perspectives evoke personal judgments regarding what to research, when and how to do so, and the level of confidence with which different types of data may be combined in overall assessments [9]. Further, the communities of scientists and decision makers charged with designing environmental policy often work out of different disciplines with accompanying barriers due to idiosyncrasies of language and the interpretive frameworks they use [10]. As such, what is of particular interest in this paper is how the specific standards applied to determine instream flows order water such that agreements over sustainable water policies extend beyond agreements regarding technical definitions and reflect shared judgments regarding the meaning and import of various sources of data. The paper defends the thesis that the need for increased attention to the role of judgments is necessary because instream flow considerations are basic to environmental and human health; And, by reordering water through standards that define instream flows, such policies have the effect of modifying the contexts of subsequent policy problems and thereby carry direct ethical implications because they introduce new norms to policy exercises.

The evidence supporting these arguments relies on data from an analysis of the water management plan for the South Saskatchewan River Basin (SSRB) in Alberta, Canada. Policy documents were analyzed using a content analysis [cf. 11] to identify inferences made from data to policy decisions. With this methodological goal in mind, the paper does not attempt a policy analysis *per se* yet neither is it an assessment of the specific scientific or technical instruments or findings related to quantifying instream flows. Rather, the implications of policy inferences were evaluated in terms of what types of judgments are used to coalesce various scientific judgments into a policy narrative conducive to setting standards for instream flows. The paper begins with an introduction to water issues in southern Alberta, Canada. The remainder of the paper proceeds through judgments affecting: (1) The relationship between instream flow indicators and policy assessments of overall environmental health; (2) The

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particular indicators used to determine adequate instream flows—which include the duration and periodicity of instream flow assessments, and; (3) The assumptions underlying efforts to model instream flows given data constraints. The concluding section considers the ethical features of judgments regarding instream flows in reference to the growing discourse on water ethics [12, 13]. These ethical issues arise, respectively, in each of the three respective areas in which judgments regarding instream flows are operant.

II. Context: Southern Alebrta

Water experts in Canada are increasingly challenging the so-called 'myth of abundance' claimed to underlie many aspects of water policy in the country [14]. As a case in point, the semi-arid region of southern Alberta, which experiences chronic water shortages, has been used to demonstrate the incongruence of this 'myth' with actual water resources. However, to state that there is any 'myth' is historically inaccurate, especially for southern Alberta. Limited water resources in the region were officially documented in the mid-19th century [15] and the architect of the region's first water law, William Pearce, was very much aware of the limited water resources and counseled against settling the region too densely for that reason [16]. Rather, any 'myth of abundance' should be understood as the failure of a certain set of policy standards to adequately manage water resources. From this perspective, the ordering of water through allocation regimes for irrigation, industry and municipalities is indicative of how influential the judgments that legitimate one set of standards can be in supporting policy inferences and governing conduct.

In southern Alberta, the four major watersheds comprising the SSRB find their headwaters in the Rocky Mountains to the west, where annual snowmelt accounts for 87% of surface water flows [17]. The remainder is derived from glacial melt, which in dry years can account for up to 56% of the flow in late summer months [18]. The largest human water use in the region is irrigation, which accounts for roughly three-quarters of total water withdrawals from the region's arterial rivers. Licensed water allocation began in the late 19th century based on a system of prior appropriation (first in time, first in right) using the date of application for a license to set priority [19].

Concern over water in southern Alberta is growing. Total licensed withdrawals vary from 75-118% of the median annual flows on Alberta's southern most rivers [20]. And after a severe drought in 2001, Alberta Environment commissioned a study to assess surface flow trends. The results of the study for three of the major rivers in the SSRB concluded that no trend towards increased or decreased flows existed for the period 1912-2001 [21]. Shortly after the Alberta Environment study was published, a similar study contested that there has in fact been a negative trend in stream flow during the 20th century and that the southernmost of Alberta's rivers were experiencing the sharpest declines [22]. Conflicting views over flow trends in the region have been augmented by historical climate studies that confirm water availability in southern Alberta during the 20th century was abnormally high and is now returning to lower flow regimes [23,24,25]. Compounding this problem is a recent rise in mean average temperature that increases water demands both through increased evapotranspiration rates [26], increased urban demand [27] and the potential for decreased surface water flows as precipitation regimes shift [28]. A final set of challenges issue from the negative externalities of the region's large agricultural feedlots and industrial developments on water quality [29].

After the passage of Alberta's 1996 *Water Act* and alongside the production of its 2003 *Water for Life* strategy, a series of background studies to policy reforms in southern Alberta were conducted and, subsequently, implemented in two phases. In the first phase, the province employed new legislation to rescind the appurtenance of water licenses to land titles; under the new legislation, water license holders may now sell or lease any part of their license to a willing buyer without corresponding transactions over land [30]. An interesting feature of this new market for water licenses was the province's creation of a "conservation holdback" that allows the province to annex up to 10% of a traded water license [30]. In effect, this holdback makes possible the recuperation of previously over-allocated water and enables targets set for conservation to be meaningfully pursued (at least to the extent that market transactions make water available).

The second phase of reforms employed several background studies to set direction for three primary areas: (1) Consumptive water use, which is defined as "the balance of water taken from a source that is not entirely or directly returned to that source" [31]. Included under consumptive uses are "non-irrigation" uses including municipal, industrial, wastewater, and agricultural uses unrelated to irrigation such as for livestock [32]. In the short term, consumptive water use is forecast to increase 35-67% in southern Alberta due to industrial expansion and an expected population increase [32]. And while efficiency gains are expected, aggregate water increases from development and population will lead to increased consumptive use. Middle-term scenarios, which policy exercises delimit as 1996-2046, forecast increases in consumptive water demands of 63% to 132% [31]. (2) Non-consumptive water use by the aquatic environment, which was determined by calculating how much water is needed for aquatic and riparian ecosystems in two respects. The first assesses the current ecological status of river reaches. The second defines Instream Flow Needs needed to maintain healthy aquatic ecosystems. (3) Modeled projections of future allocation scenarios, which use the province's "Water Resources Management Model" to run scenarios reflecting different allocation regimes and/or water availability conditions. Upon completion of both policy phases, Alberta approved a new watershed management plan for the SSRB in 2006 [33, 34]. The remainder of this paper considers how, especially in the second phase of its reforms, instream flow needs were determined.

III. Instream Flow Indicators and Environmental Health

Defining the relationship between instream flow indicators and environmental health requires establishing an evaluative standard. For instance, indicators may be chosen for specific policy goals, such as protecting a particular species, reducing certain pollutants, or adjustments to the timing or extent of diversions and so on. Alternately, they may be chosen to provide certain levels of water quality for health, sanitation or for ecological systems in general. In this process of linking indicators to environmental health, what is taken as baseline data for defining the relationship between instream flows and environmental health has direct effects on what types of obligations policies are designed to fulfill [35]. However, a straightforward, analytical definition of the relationship between instream flows and environmental health is not particularly helpful given that there are few, if any natural landscapes that might provide an objective opportunity for comparison [36]. Given this, determining instream flows requires establishing standards in a value-loaded context and highlights the fact that multiple judgments inform the qualitative inference from available data to broader claims regarding the norms underlying environmental management policies [37]. The practical outplaying of this argument can be seen in Alberta.

In 2003, Alberta's Ministry of Environment published the Strategic Overview of Riparian and Aquatic Conditions (SORAC) report [38]. The report was designed to provide background information regarding the current state of aquatic conditions in southern Alberta as a support tool for setting instream flows and water conservation objectives. The report solicited qualitative assessments from participants in the sciences and government who were referred to as the "Best Judgment Panel." Participants were asked to evaluate the ecological status of southern Alberta's riparian environments using categories of: Unchanged/Recovered, Moderately Impacted, Heavily Impacted or Degraded. Participants were also asked, given their particular knowledge and scientific expertise, whether the trend for specific river reaches was towards increasing or decreasing health over the last 5-10 years. The study divided the SSRB's four sub-basins into 33 river reaches and asked experts for their best estimates on each. Of 33 river reaches, 32 were estimated to be somewhere between "moderately impacted" to "degraded;" which led the SORAC study to conclude that Alberta's southern rivers were in declining ecological health [38].

The rationale for Alberta's assessment method was, at least in part, based on expediency. That is, it was important to get a sense of the sustainability of the current activities as part of the larger agenda of implementing policy reforms. Thus, even though the Best Judgment Panel returned low response rates on issues of biodiversity and riparian needs, their assessments operated as the *de facto* definition of the relationship between ecological indicators and environmental health during the process of policy development. As such, it provided the baseline for estimating the current status of southern Alberta watersheds [38].

Given considerations of expediency, which merit attention due the fact that resources, time and competence are limited, what is of interest here are the ethical implications that arise from determining how instream flow indicators are linked with environmental health. In Alberta, this determination was made by asking the Best Judgment Panel for their judgments regarding whether the cause of changes ecological health were natural or due to water resource developments [38]. In terms of linking science to policy, such judgments are morally loaded because they rely on the distillation of (in this case) roughly a century of western settlement and climatic change/variability into a single, normative estimation of the trajectory of ecological health. This raises two generic and relevant issues. First, the type of judgment requested from experts rested on the assumption of change from some pristine landscape (i.e. one unaffected by humans) to the one presently under management. Recently, Falkenmark and Folke [39] have argued that beginning from this premise presents policy roadblocks that prevent ethical water management by attempting to artificially segregate human and natural systems. Second, the inference from an assessment of current activities to overall ecological health is, in operational terms, a normative standard. Yet the inference fast outpaces either deductive or inductive resources typically used under different hypothesis testing scenarios. It is interesting to note that this standard is recognized as a judgment in the naming of the "Best Judgment Panel," yet it is also important to consider, as will be done in the conclusion, what types of judgments they entailed and the ethical implications of determining ecological health under persistent conditions of social and environmental change.

IV. Instream Flow Indicators

Different instream flow indicators vary in terms of the scope and type of data gathered and (as in other jurisdictions) this has prompted Canadian researchers to propose frameworks for supporting legitimate policy inferences [40]. In addition, the choice of particular indicators used to determine adequate instream flows necessitate deliberation because they constrain the quantity and quality of water considered adequate for meeting instream flow requirements. In this sense, there is an inherently qualitative aspect to instream flow science because limited data are judged suitable for making claims regarding complex systems. Where these inferences are linked to moral issues, such as human health in drinking water, the choice of instream indicators is more obviously ethical. However, in less clear cases it is also important to consider how the setting of different instream flow criteria affects policy obligations. In Alberta, choices regarding instream flow indicators reflect a motley of political, practical and feasibility concerns, each with consequences on the water deemed necessary for instream needs.

As noted above, there was a certain political expediency attached to determining acceptable instream flows in Alberta. Given this, the province opted to rely on previously collected data, rather than new studies, when determining Instream Flow Needs (IFNs) [41]. According to the policy reports, IFNs are "the quantities of water and water quality conditions needed to sustain riverine processes and associated ecosystems over the long term" [41]. A technical study was prepared using a weekly time step from 1912-1995 to determine IFNs for four variables: water quality IFN, fish habitat IFN, riparian IFN, and channel structure IFN [41].

Determining IFNs was based on the assumption that river ecosystems are “adapted to, and dependent on, the natural range of flow variability to sustain the ecological processes and diversity within the system” [41]. While no new studies were conducted in order to determine IFN values, improvements to models and the refinement of previous findings (i.e. Biological Oxygen Demand for certain fish species) the IFN report was “believed to be comprehensive by today’s standards” and acceptable for achieving a high level of aquatic protection [42]. Further, even though the “natural” flow of water in the SSRB has been altered by numerous dams and diversion projects for decades, the long-term effects of these structures on evolution of the channel or ecosystems of local hydrologic systems were not considered when determining IFN values.

The results of Alberta’s Instream Flow Needs reports found that 85% of natural streamflow was required for maintaining biodiversity and riparian health [41]. In 2007, the initial IFN report was followed up by a subsequent study that used the ‘best representations’ of river reaches for visual inspections of aquatic conditions over an estimated 5% of the total river length [42]. This latter study conceptualized riparian health as a ‘jigsaw puzzle’ comprised of three factors: riparian health, water quality and hydrology [42]. For each of these three factors the study considered particular sample sites of southern Alberta rivers and again rated many river reaches as unhealthy. Nevertheless, the approved management plan for the SSRB has set Water Conservation Objectives at 45% of natural flow, alongside the caveat that achieving even this goal would be challenging given the extent of licensed withdrawals in the region [33].

While the disjunction between the government IFN reports and subsequent policy objectives may be linked to issues of power or political interest, there is perhaps a more fundamental issue regarding the ordering of water. This can be seen in light of previous policies and the rationale for licensing throughout the 20th century, which used no ecological limit for the allocation of water. Rather, the province had previously relied on Instream Objectives (IOs) to limit allocation but had never studied the effects of IOs on the environment [43]. Instead, these objectives were set according to development concerns. In this regard, the previous legislative order classified all water as available for licensed allocation (in principle). Hence, the determination of IFNs took place within a context that was not ‘pristine’ or unperturbed by human uses. As such, the determination of IFNs carried the burden of functioning as the first environmental standard regarding water and, *ipso facto*, created the first ordering of policies wherein not all water was available for human use. This is a significant normative shift since prior to the establishment of IFNs, IOs were set to prevent water withdrawals that would affect other water users (i.e. industrial, municipal and agricultural) and not based on any environmental considerations per se.

There are two aspects of the southern Alberta case that are germane to determining instream flows in general. First, partial knowledge (including uncertainty) leads unavoidably to policy judgments that extend scientific data beyond its empirical basis. That is, in the determination of instream flows is made by judging limited data as suitable for estimating the health of complex systems. In Alberta this was made by determining IFNs for four variables (and their subcomponents). But regardless of the number or type of measurements taken, there is no set of management principles that is as complex as the system it seeks to manage [44]. There is therefore always an element of judgment in water management. Second, the determination of instream flow needs may be done for multiple purposes and under the guise of different agendas. For instance, instream flows may be set to limit withdrawals, as a cap to licensing or for the achievement of ecological, hydrological or efficiency targets. Moreover, setting criteria for instream flow indicators and linking this data to policy is critical for achieving goals related to environmental protection whether it is for ecological values, anthropocentric needs or a combination thereof. In the Alberta case—which is reflective if not representative of many regions where development has proceeded without regard for instream flow requirements—determining instream flow values brought distinctly different visions of what water is for into confrontation. Throughout 2009-10, the Alberta government initiated a broad review of its allocation system in light of the need to re-order water uses in the province. At the time of this writing, the results were not yet released. As a means to navigating the effects of different instream flow regimes on economic development, and as is considered in the section below, Alberta used model scenarios to (attempt to) overcome data constraints.

V. Modeling Instream Flow Scenarios

A third issue confronts the determination of instream flows: the effects that particular instream flow levels will have on the social and ecological systems of which they are a part. Modeling exercises, such as those promoted in adaptive management, often work by constructing various scenarios and seeking consensus across a range of social and ecological variables. In Alberta, the development of a new management plan for the SSRB was done in a similar vein using the Alberta government’s Water Resources Management Model to develop eight different allocation scenarios and to consider their impacts on meeting Instream Flow Needs [43]. The model scenarios ran on a weekly time-step that calculated total demand against total supply for a 68-year period from 1928-1995 using collected runoff data and existing infrastructure capacity [43]. In cases where water deficits arise the model removed water from junior licenses until all senior water licenses received their allocations in full [43].

The scenarios can be grouped and explained as three sets. It is the third set that is the most interesting for the purposes of this paper, but the first two are introduced briefly. The first represents a base case where current water allocations and the instream objectives (IOs) of the management regime in place prior to the current reforms are retained. In this set of scenarios, IOs are usually met, except where frequent and substantial deficits already exist given the current level of allocation. The second set of scenarios plot the trajectory of water resources in the SSRB under the status quo regulatory regime. In these scenarios—which essentially assess potential future development—deficits require further water allocations for irrigation expansion in some regions while other rivers begin experiencing deficits as increased pressure is put on the storage capacity of reservoirs. After fifty years of business-as-usual there are substantial deficits for all junior water license holders [43].

The third set of scenarios is exploratory and consider: (A) Replacing the non-scientific IOs with the IFN values, (B) Giving priority to IFNs over existing licenses, (C) The effects of reducing consumption by 20%, and (D) Current inter-provincial agreements with Alberta's downstream neighbor, Saskatchewan. As per the 1969 *Master Agreement on Apportionment,* Alberta is currently legislated to deliver half of the natural surface flow of water to the provincial border. In terms of the SSRB, regulators are here concerned with how the four sub-basins in the SSRB may be given differential treatment such that in-province demands are made without compromising the 1969 agreement. Finally, scenario: (E) Considers the effects of replacing IOs with IFNs on new allocations and back-fitting IFNs onto old licenses where possible.

The results of model allocation scenarios, which combine historic water availability with current levels and projected levels of water use in the SSRB, indicate that the risks of water scarcity in the region present a significant problem in balancing human use and environmental protection. While a detailed explanation of each scenario is too lengthy an item, scenarios A, B & E, which replace IOs with IFNs, all indicate that when IFNs for the aquatic environment are applied they cannot be met given current allocation levels [43]. Even if water consumption was reduced by 20% (scenario C) there would only be moderate relief as most of the water returned would be claimed by junior licenses previously deprived. As Schmidt [45] has argued, this means that if current economic instruments are the primary means of achieving environmental conservation, then the provinces "Conservation Holdback" (which allows the province to capture 10% of traded allocations) will require all of the water to be traded twice before substantial gains begin to be made towards improved instream flows.

The above policy issues are important, but it is also necessary to consider the judgment that lends confidence to the data used to model scenarios as these are critical to the credibility of model result and depend on time periods and other variables adequately representing likely future conditions [46]. In this respect, Alberta's management plan for the SSRB uses the period from 1928–1995 to model future allocation scenarios. Critically, and as was introduced above, the 20th century stream flow record is not as representative of previous conditions, or of likely future conditions under climate variability, as may be desired. Most climate models for the region forecast temperature increases in the 21st century, which would increase potential evapotranspiration demand and outpace forecasted increases in precipitation [26]. Consequently, even if we accept that the instrumental record available in Alberta afford a starting place, it is important for technical studies and modeling exercises to be explicit about this data and its clear empirical limitations. In this sense, the implicit judgments of data as suitable for scenario building and modeling exercises requires attending to the assumptions and values that assert their reliability for ordering future policy priorities.

VI. Conclusion: The Ethics of Instream Flows

This paper has identified three key normative challenges for the determination of instream flows and the judgments affecting: (1) The relationship of instream flow indicators to environmental health, (2) The choice of instream flow criteria, and (3) The assertions of reliability regard the data used when modeling instream flows. These judgments, it was argued, were not entirely avoidable but reflected the constraints on resources available to decision-makers in practical contexts. Nonetheless, the fact that determining instream flow values is so closely linked with various environmental and human health concerns, it is important to consider the ethical implications of these judgments.

One of the central inferential problems in determining instream flow values arises due to the manifold types of data that bear on different aspects of aquatic health. Thus, although complex systems are often characterized as being "driven" by a few key variables, such assessments do not reflect an objective state of affairs. Rather, they reflect commitments regarding which dimensions of complex systems are under consideration and from what comparative vantage point different factors are viewed. In the case of complex hydrological systems, articulating and recognizing the intrinsic ethical content in assembling data in one manner rather than another is critical for an explicit and fair assessment of the likely impacts that instream flow standards will have on subsequent distributions of water.

In many jurisdictions water policy has evolved without consideration for instream flows or with primarily instrumental views where instream flows were deemed necessary for some specific function (i.e. sanitation). Where theses types of policy histories exist the normative aspects of instream flow standards are both opportune and nuanced. In regards to the former, they present a policy window for introducing new, and often competing, standards for making water use decisions. In regards to the latter, instream flow policies must be introduced in a manner that draws on the normative resources at the root of existent policies—whether these are formalized in law or the result of customary decisions. This emphasis on taking a nuanced, contextualized approach is reflective of the fact that there is no neutral starting point and, therefore, existing practices must be recognized as legitimating certain water norms that may or may not provide resources for collaborating for determining instream flow standards.

The emerging discourse on water ethics is, in many ways, targeting the basic narratives of water management and the various traditions and worldviews that affect how complex systems are characterized and the allocation regimes protected by formal and informal rights [12]. Especially where water governance and management is decentralized, conflicts over central values are a key aspect to successful institutional arrangements [47]. As such, the determination of instream flows requires attending to the basic normative attitudes that conceive of water as fully available for human use versus those that characterize instream flows for their instrumental or inherent value. This does not suggest an expansion of the current activities promoting the protection of aquatic ecosystems. Rather, it suggests an explicit articulation of how judgments used to assess aquatic health are concordant with the flourishing of human and non-human life.

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