Environmental Flow Issues and Science

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Tom is the water management program coordinator for the Wyoming Game and Fish Department. He has worked for the department since 1981 and helped establish their instream flow program. Originally from Iowa, he has a BS degree in fisheries and wildlife management from Iowa State University and an MS degree in aquatic ecology from Utah State University. He has conducted over 100 instream flow studies for the state of Wyoming; written numerous scientific reports, publications, and popular articles on river management; been an invited speaker at international symposia, and has been invited to help address instream flow issues on a variety of projects in the U.S. and Canada. He is a co-founder of the Instream Flow Council and served as that organization's first president. Tom is the senior author of the book Instream Flows for Riverine Resource Stewardship and is a co-author of the book Integrated Approaches to Riverine Resource Stewardship: Case Studies, Science, Law, People, and Policy.

The really great thing about talking about a subject like instream flows is that there are so many experts on the subject. However, one of the things I've found having worked in this area for 30 years is that not all experts are working from the same data set. There is a tendency no matter where you are, whether you are in Oregon or Montana or Nebraska or New Mexico, to try and simplify this really complex subject. I think my responsibility or role today is to try and provide some background and understanding of instream flows so that we can be on the same page when we are talking about the subject. I am going to cover a lot of ground and will start out by providing some perspective and looking at some of the issues without going into great depth. At the end I'm going to wind this up and look at some of the challenges and opportunities and make a pitch for why instream flow legislation is really an important tool in the state's toolbox.

As with any natural resource management issue, we manage water within the constraints of laws, the public input, and science. It is important to involve all three of these elements in decision making in order for us as a society to shape the outcome of our decisions. The extent to which we involve these three elements determines what the world looks like and how well we live.

One of the many messages in Figure 1 is that when you look at population growth in the lower Colorado River basin and plot it against the ability to meet the demands of a growing population, the reality is you don't expect those lines to keep going at the same rate in the same direction. Something has to give. The reality is that we can't figure out where we're going in the future by looking in the rear view mirror; what has happened in the past has been great, but it is not going to be that way in the future. There is a tendency to think that the way things are today is the way things always have been and always will be, but the fact is that is not the case. We are in a situation where we have opportunities today to take care of some things that in the future will be much more difficult to take care of, and if we don't take care of those things today, or even if we do, we are going to have to change how we approach the water management business in the future. This is just a fact of life that some of us have a harder time coming to grips with than others.

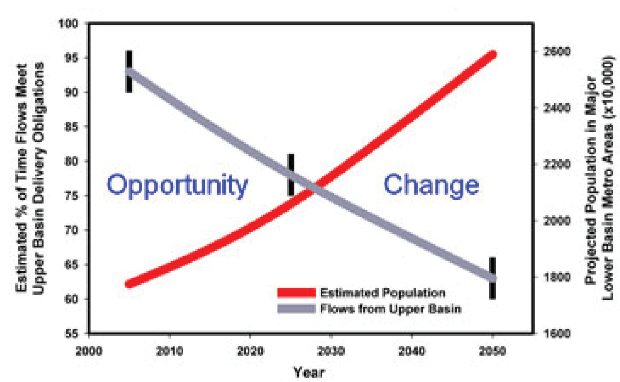

Figure 1. Projected upper Colorado River flows vs. population growth in major lower basin metropolitan areas

When natural resources are abundant, as they have been throughout history, it is easy to look at them as a commodity: what is the economic value that I can get from a buffalo hide or a passenger pigeon or a gallon of water? As natural resources become less abundant, we can no longer look at them as commodities, we need to look at the full range of values of a resource. Water is certainly no exception. There is no one best use of water, it provides an awful lot of uses or services to society. In combination, these are broadly termed ecosystem services. I'll refer to that term from time to time today and it's important to distinguish that these aren't environmental services. Ecosystem services include not only benefits for fish and wildlife, but benefits for irrigation, industry, and municipal uses as well. We as humans are part of the ecosystem and water provides us ecosystem services.

The issue or challenge then becomes one of finding balance and that's where things get difficult because when you have more than one person in the room and more than one value with a resource, you can run into a fairly contentious situation. What makes it even more difficult is that our values are always changing. Our values today are much different than the values 100 years ago when water laws by and large were written. We are now trying to address the public's needs and values based on an old system of law. It's unrealistic and unnecessary to think about a major overhaul of existing law, but we all know it could be tweaked a bit.

It has always struck me as to how much controversy there can be over instream flows. Instream flows provide for ecosystem services both directly with water in the creek, and indirectly in terms of conveying water to people who use it for different human-based needs. No matter what state or country you're in, you hear a lot of reasons why instream flows won't work and a lot of arguments against it. The following is a list of the many claims I've heard over the years. The reality is that these reasons are essentially all false or rhetorical red herrings with no credible basis made by people or groups who are just opposed to environmental use of water.

- Water needs to be diverted
- Costs too much to measure
- Will cause streams to go dry
- Will impact interstate compacts
- Will stop economic development
- Need dams to get an instream flow
- A government plot to take back water rights
- That won't work in (fill in state name)

To provide some perspective on this, I'll talk a bit about Wyoming's history with instream flows. We've had 41 years of history with instream flows so you'd think that if any of those claims were valid, we would have seen proof by now. The debate in Wyoming began long before 1986 when we finally had an instream flow law and used that law to begin protecting water around the state.

Let's look at what has happened in the last 24 years since we've had an instream flow law. To begin, we've protected habitat for game fish species on over 100 different stream segments with current day priority dates without injuring or taking away anybody's water rights. We also found that instream flow legislation has been critical for the permitting process of new dams and the ability of the state to control the amount of water coming out of reservoirs under a state system of law and administration. We've used the instream flow law to protect habitat for the four native cutthroat trout species in the state, all of which have petitioned for listing as federal threatened or endangered species. Our state instream flow law has been critical for keeping state ownership and control over habitat for those organisms and the lands through which those streams pass.

We've also found that it was useful to have a state mechanism to help quantify federal water rights in one Wild and Scenic River segment. We're working on a second quantification process on the Snake River right now, again under state authority.

The list of things that haven't happened in Wyoming is probably longer than the things that have happened. Nobody lost a water right in spite of all the claims that instream flow was a threat to private property owners. We still haven't protected most of the streams in the state and I'm not sure we ever will. But what we have seen is that once an instream flow application has gone through the system and been approved, it just hasn't been a big deal.

Let's dig a little deeper into what is an instream flow and talk about some of the definitions and concepts that I think people a lot of times know but may not realize they know. We'll begin with the question of "what is an instream flow?" At the most basic level, it can simply be water in the creek from a natural source or maybe the water is kept in the river as part of an informal agreement.

In other situations when you talk about instream flow, you are talking about getting a water right or some form of legal or regulatory authority. It's possible to get an instream flow water right on streams that are already depleted, but that doesn't put any water back into the stream.

Or, you can have a combination of these two aspects - water in the creek that is protected by some legal mechanism or permit or right.

When you are talking instream flow, there is also the question of how much you need. It could be a little water, that's an instream flow. It could be all the water, that's an instream flow too. Or it could be a seasonally appropriate flow regime. Each of these flow levels or patterns has different consequences and different issues associated with them.

When talking about the purpose of an environmental flow it's also important to distinguish between whether we are trying to protect part or all of the flow regime that's still available or if we're trying to restore some measure of flow regime to a stream that experiences some level of depletion. There can be a big difference between these two concepts depending on the desired outcome. When we talk about flow protection, you already have water in the stream and you are trying to figure out how much you can take out and still maintain whatever ecological function water managers have set for the stream. In Wyoming, these usually are public lands. Protection typically is not a private lands issues but it could be if there is still water available to protect. It doesn't mean you are protecting the entire river; it is a flow level to meet a specified objective.

Flow restoration is the more traditional view of instream flow management. When restoring flow and riverine function to a stream, almost any level of increased flow will be beneficial for environmental purposes. These situations typically exist on private lands where water has been allocated for consumptive human uses and involve finding ways to put water back in the stream – either by creative management plans or redirection of existing water rights or permits. Because most of the streams and rivers in need of habitat restoration are on private lands, it's important that private landowners be able to have a role in this flow management strategy. It's also important that they have the flexibility to do this on a temporary basis and not be forced to give up existing water rights permanently, unless that is their sincere intention.

Instream flow isn't just about the science either (Fig. 2). If you are going to have an effective instream flow capacity in a state or country, you need to have trained staff and a budget to do the work. You must involve the public and you need to have laws and policies that provide for and regulate the instream flow. Today I'm going to talk about the science, but I want you to realize that I'm only talking about one leg on the proverbial stool.

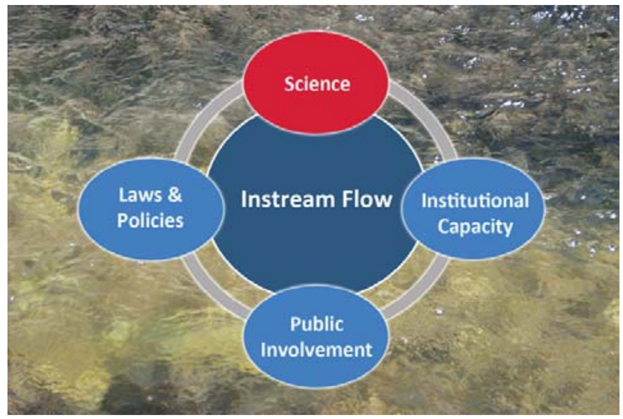

Figure 2. Instream flow is a product of the combined interaction of four primary components

The science is clear that rivers change over their length spatially, and over time. As you proceed down a river, the habitat changes and the organisms that live in each progressive segment of the river system change as a function of flow and a variety of other variables. To describe the conditions in a river and the ecological characteristics, there are five main elements that biologists and instream flow practitioners consider.

- **Hydrology**
  - Short and long-term water availability
- **Biology**
  - Short-term physical habitat availability
- **Geomorphology**
  - Long-term trends of channel conditions
- **Water Quality**
  -Short and long-term
- **Connectivity**
  -Multiple elements and concepts

Models are used to deal with the uncertainty associated with instream flow issues, but they don't always tell you everything you need to know. In spite of that limitation, there's a tendency among some managers to expect models to do the heavy lifting for them when it comes to decision-making. Unfortunately, models provide limited information about the relationship between flow and a particular environmental condition and considerable professional judgment is usually needed to apply the results.

It's also important to understand that sometimes more is not better, and the flow/habitat relationship is hardly ever a straight line. It's important to realize, too, that a flow that is good for one species or life stage of fish in one river can't be used in another segment or another river. Each river and river segment is unique so site-specific studies are needed for each situation. Another critical fact is that in most cases, a single flow at all times of the year will not maintain the ecological characteristics of a stream. If you are looking at restoring or protecting an ecological function, you need to be talking about an instream flow regime.

Interpreting the output from models to come up with recommended flows is handicapped by our limited ability to define nature. The way we define nature is based on our ability to perceive it. A 1998 paper by Kull talks about four "faces of nature" that relate to our association with the world we live in (Fig. 3). We often come up with recommendations that look good to us – and may be fine – but that perform much differently than we intend simply because we don't fully understand the complex interactions of natural, ecological form and functions. Laws and policies typically lag scientific knowledge and probably place the biggest limitation on our ability to achieve more natural conditions.

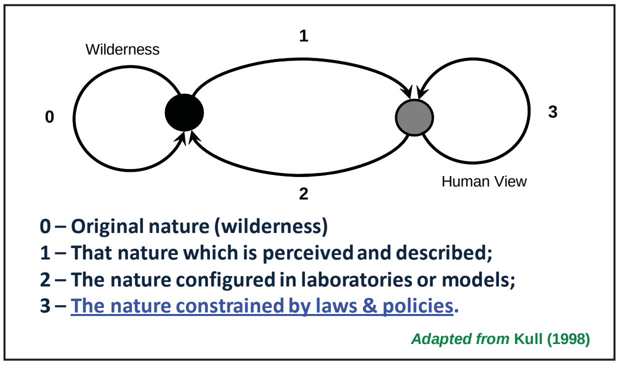

Figure 3. Defining nature is a major limitation

The message here isn't necessarily that you want to move all the way back to wilderness times. The reality is that we are human and we are going to use water so the goal with defining and managing nature is to maximize ecosystem services by maintaining healthy ecosystems, which are linked to healthy economies. We achieve this by fine-tuning our legal system, though that is a very challenging process with imperfect results.

Those five elements I talked about earlier aren't stand-alone elements, they are interrelated in complex ways. In essence, you can't do one of these things or one kind of study and get the complete answer you're looking for.

When talking about hydrology, we discuss the pattern and process, the way water flows through a stream, with each level of flow having a different ecological function. High flows are just as important as low flows; you don't want a low flow all the time and you certainly don't want or need a high flow all the time. These different flow levels need to come at a seasonally appropriate time, amount, and rate of change. We hear a lot about the "minimum flow," though this term is slowly disappearing from flow management conversations. The problem with minimum flow is that you are allowing water to be depleted down to some minimum level. But once that happens, the minimum flow becomes the maximum flow. A more appropriate question or perspective is how much water is needed at each time of the year and how that will relate to maintaining the environmental qualities that are desired by water managers.

Some of the key points to keep in mind with hydrology models are that they are typically based on analysis of flow statistics. They aren't capable of providing information about incremental trade-offs in terms of benefits for organisms or processes and aren't directly tied to any other riverine processes. These models can tell what kind of flow is needed for things like channel maintenance flows, but there are strict limitations to the information you can glean from hydrology models. That's why you typically don't just use hydrologic statistics to set instream flows.

The majority of instream flow models address only fish. But biology relates to all of the organisms that are associated with a river and help define it, including fish, aquatic insects, and vegetation along the banks. These combine to define the face of a river and how a river functions. Remember that biology models primarily look at habitat, they don't typically address how many fish will result from a particular flow regime. You can't make this jump from habitat to fish because fish populations are dynamic – they fluctuate over time for a variety of reasons. However, the inability to quantify organisms is not a failure. Rather, the goal is to look at habitat and consider relative changes in habitat as opposed to some absolute number. And again, you need other models to address other elements of the stream ecosystem – like geomorphology, which is the study of how sediment moves through a stream channel.

Basically, three factors go into geomorphology models. These include the amount of flow, the amount of sediment addition or removal, and the shape of the channel. For example, if you change the depositional processes, the habitat changes and you will almost certainly have different animals living in a straightened channel than you have in a natural channel. Geomorphology models are designed to look at long-term processes, not instantaneous goodness or badness of a flow. Professional judgment also is needed to determine when a particular flow is needed, the ramping rate, and the duration of this flow.

When we look at water quality models, the tendency is to think about pollutants. Certainly there are a lot of models that deal with water quality. But temperature and dissolved oxygen are also important water quality factors, as are ice forming processes. The point to make with water quality is that not every species sees any one attribute the same. What is good for one species may not be so good for another species. Again, you are left to rely on professional judgment to decide what species or communities of aquatic organisms you are managing.

An important consideration regarding water quality models is that they look mostly at threshold flow, and minimum flows, but they don't identify ecological trade-offs of how much better the stream will function with more or less flow. Again, you must integrate water quality models with other models.

The last of the five elements is connectivity. In many ways, it is possibly the most complex because we tend to think of connectivity as just the ability of fish to swim up and downstream unencumbered by dams and diversions. Instream flow also relates to the connectivity of groundwater to flow in the stream, the ability of the stream to connect to the floodplain (lateral connectivity), and connectivity over time. It may be important for streams to flow all the time, but in some streams, temporal disconnectivity in the form of seasonal periods of no flow actually favor some native species. Connectivity isn't just about fish. It also relates to connectivity patterns that provide energy, sediments, and chemical cues to organisms throughout the stream system. Connectivity to the flood plain also recharges water tables in the riparian areas adjacent to the streams and where bed-load comes from that helps maintain the channels. Connectivity can be really complex. The problem is there aren't many good models to address connectivity needs in freshwater streams. Most connectivity models are designed for estuaries and so to address connectivity issues in streams, we usually use other models that relate conditions of stage and flow. Again, connectivity flow needs rely on professional judgment to decide when and how long it's needed, what species you need it for, or if you need it at all.

The last group of models I want to talk about are holistic models. These models integrate many of the five riverine elements we've talked about previously. Examples of holistic methods include: downstream response to imposed flow transformation (DRIFT), demonstration flow assessment (DFA), Bayesian probability models, and ecological limits of hydrologic alteration (ELOHA).

I want to talk about the Bayesian probability models because they are not only intriguing but offer a lot of potential (Fig 4). They basically function by identifying the probability of an outcome of a certain action, and from that action, there are probabilities associated with the next outcome and so on and so forth. Instead of coming up with an amount of habitat, you come up with a probability that a certain condition will result. These can get messy in a hurry. Anytime you model ecosystems, there are more things to model then you can credibly account for in a mathematical model.

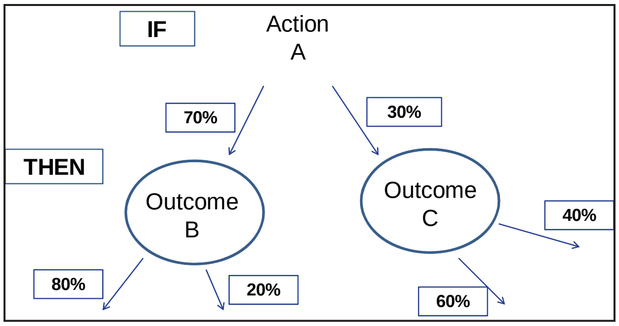

Figure 4. Bayesian probability models

Figure 5 is a construct from a project I helped the USGS with on the Flint River in Georgia. This is a simplified version of the model we started with. The initial model had a lot of lines and pathways that aren't shown. We left the main pathways, but you will see we still included hydrology, connectivity, geomorphology, habitat, and water quality. We came up with the desired outcomes where we wanted to know something about the animals in the stream. We also identified an outcome for water quality.

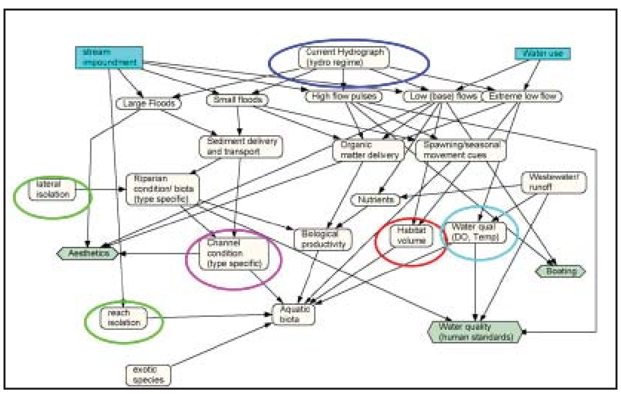

Figure 5. Ecosystem modeling can be complicated

The problem with holistic models is that they still address a limited range of elements and inputs and the outcomes are still relatively imprecise. But again, the goal here isn't to achieve precision as much as it is accuracy. If you can accurately predict the relative goodness of a certain flow regime on the organisms or habitat in the stream that you are trying to manage, that is an acceptable goal. When you get hung up on precision, you are dooming yourself to failure because you are almost always going to be wrong.

To wrap up this talk, I want to discuss some of the challenges and opportunities faced by states today. I worked on a project with the Instream Flow Council (IFC) to assess many of the trends and activities of state fish and wildlife agencies. We surveyed all 50 states and six of twelve Canadian provinces and territories. The participants were instream flow or water management specialists with state and provincial officials in fish and wildlife agencies who are the members of the IFC. Thus, the results may be skewed a little by that group's perspectives and knowledge of water management. We wound up with a great big report that is posted online. You can download the report by visiting the Instream Flow Council website at www.instreamflowcouncil.org.

This study looked at a variety of things including the top things that state agencies feel they need in order to deal with instream flow issues. The top need in nearly every region and almost every state was the need for better laws and policies to deal with environmental flows. The next most important need was improved institutional capacity. Agencies need formal commitment to protect and restore environmental flow, well trained people, and financial support to conduct instream flow studies. Right now, New Mexico is losing instead of adding staff that can do instream flow work.

The other thing that participants said was needed was a more informed and active public. Oftentimes the public is supportive of environmental flows, but they aren't active in their support. In essence, the public isn't very vocal, and everybody here knows that it is only the vocal advocates who usually are heard in a public forum.

Interestingly, one item that didn't rise to the top was better science. You always need the best possible science, but when it comes to states addressing instream flow issues, it just didn't make the top of the list.

Lastly, we did a ranking in 2008 of the capacity of the western states in terms of their ability to address instream flow issues based on four elements: legal opportunity, institutional capacity, public involvement, and the status of stream protections (Fig 6). We found that while every state is challenged to do instream flow work, Alaska, not surprisingly, was top of the list and New Mexico is wagging the tail on the list of western states.

Alaska Colorado Washington Oregon Montana Wyoming California Hawaii Idaho Utah Arizona New Mexico

Figure 6. Ranking in 2008 of capacity of the western states in terms of their ability to address instream flow issues based on legal opportunity, institutional capacity, public involvement, and the status of stream protections

So what's the take-home message? There are probably several messages. One of the things that strikes me is the importance of keeping conversations realistic. We need to at least try to stay away from the rhetoric and if you are going to make a claim for or against instream flow, make it a valid one based on defensible fact.

It's also important to be specific when we are talking about instream flows so that we are at least talking about the same thing. It's important to know if we are just talking about naturally flowing water in the creek with no legal protections or if we are talking about an instream flow water right. These are both legitimate definitions but very different aspects of instream flow.

Let's use all the words when having these conversations. We need to say, "instream flow regime," when we're talking about managing for ecosystem form and function. Just saying, "instream flow," leads many of us to think we're talking about a single year-round minimum flow that may work in some settings but typically won't maintain a fully functional aquatic environment.

We also need to be very specific about whether we are talking protection or restoration. In Wyoming, we have an instream flow law, but about all we can do with that law is protect whatever flow is still unappropriated. It's virtually impossible to use our law to restore flow in streams even when there are willing parties who would like to do so.

Another of the several take home messages here is the importance of using the right tools to obtain needed answers or recommendations. There is no one way to do an instream flow quantification study. Every stream is unique and every situation is different. You may not need to look at all five of the riverine elements I talked about earlier, but you still want to acknowledge that you considered them all so you are able to say whether each one is a legitimate issue or not when designing and conducting flow studies. Be specific and use the right tool; don't think you can just slap the same method on every stream and get the answers that you want or need.

One last critically important thing to understand is that instream flows really are an important state tool. It is very unfortunate that there is this "us" versus "them" notion on instream flows. Every state in the country that has had this instream flow discussion has experienced this great debate of whether instream flows are good or bad or are needed or not. But at the end of the day, an instream flow water right is just another water right. But they are really important when you think about the fact that supportive instream flow laws are a needed way to affirm states rights over the administration of water, especially in the face of many federal water-related mandates. When states are faced with federal laws such as the Endangered Species Act (ESA) and Wild and Scenic Water Management River initiatives, it is often better to manage water administration with a state mechanism rather than a federal mechanism. If you don't have a state mechanism for formally administering instream flows, the feds will have one for you.

Instream flow capacity provides ecosystem services and benefits for the public because water is owned by the public – not by any one person or one agency. So in some settings these are private property rights issues as well in the sense that if legislation is provided effectively, instream flow opportunities can add flexibility, value, and opportunity to an existing irrigation right without taking away any of the other important values associated with existing uses of water or water rights.

Thank you.