Instream Water Use in the United States—Water Laws and Methods for Determining Flow Requirements

By Berton L. Lamb[1] and Harvey R. Doerksen[2]

INTRODUCTION

Water use generally is divided into two primary classes—offstream use and instream use. In offstream use, sometimes called out-of-stream or diversionary use, water is withdrawn (diverted) from a stream or aquifer and transported to the place of use. Examples are irrigated agriculture, municipal water supply, and industrial use. Each of these offstream uses, which decreases the volume of water available downstream from the point of diversion, is discussed in previous articles in this volume. Instream use, which generally does not diminish the flow downstream from its point of use, and its importance are described in this article.

One of the earliest instream uses of water in the United States was to turn the water wheels that powered much of the Nation's industry in the 18th and 19th centuries. Although a small volume of water might have been diverted to a mill near streamside, that water usually was returned to the stream near the point of diversion and, thus, the flow was not diminished downstream from the mill. Over time, the generation of hydroelectric power replaced mill wheels as a means of converting water flow into energy. Since the 1920's, the generation of hydroelectric power increasingly has become a major instream use of water. By 1985, more than 3 billion acre-feet of water (3,050,000 million gallons per day) was used annually for hydropower generation (Solley and others, 1988, p. 45)—enough water to cover the State of Colorado to a depth of 51 feet.

Navigation is another instream use with a long history. The Lewis and Clark expedition journals and many of Mark Twain's novels illustrate the extent to which the Nation originally depended on adequate streamflows for basic transportation. Navigation in the 1980's is still considered to be an instream use; however, it often is based upon a stream system that has been modified greatly through channelization, diking, and construction of dams and locks. The present (1987) inland water navigation system in the conterminous United States consists of about 12,000 miles of maintained waterways, over which about 500 million tons of cargo is carried each year (U.S. Army Corps of Engineers, 1988, p. 16).

Although not so widely practiced in recent years, streams have been used to dispose of raw waste products from homes, communities, and factories. This use has been discouraged by law and public policy because of public health concerns and the damage it causes to the environment.

Beginning in the mid-1960's, other instream uses gained new prominence in the water-resources arena—the assertion of a legal right to a free-flowing stream for biological, recreational, and esthetic purposes. These uses themselves, however, are not new. Riverine habitat always has produced fish, and the beauty of flowing water always has evoked a strong sense of esthetic appreciation. What is new is the emerging legitimacy and awareness of these non-economic uses under State and Federal laws and regulations. In the past, environmental uses of flowing water were ignored, for the most part, under a long-standing legal tradition that favored offstream uses and certain instream uses that had a strong economic basis.

The history of the instream-flow policy debate really concerns these recently recognized types of instream uses. Although the more traditional water uses have been protected by law, the recognition of other instream uses has resulted in substantial changes in State water laws. Although methods for determining the volume of water needed for most traditional water uses are relatively straight-forward and well-established, methods for determining water requirements for the instream uses have been developed only recently and are continuing to evolve.

Water laws that have favored the more traditional water uses, the inherent nature of conflict between instream and offstream water uses, and the special kinds of technological and philosophical problems posed by the "newer" types of instream uses are described below. Water laws that have been passed to accommodate the more recently recognized instream uses are summarized.

WATER-LAW CHANGES—THE WEST

Water is a finite but renewable resource. In times and places of plentiful supply or small demand, major conflict over the available supply is not common. In the Western States, however, because of the chronic scarcity of water, it is not surprising that "water wars" are common. It also is not surprising that the water laws in this arid region evolved to protect those who "got there first."

In the arid West, two early and major water uses were hydraulic mining and irrigated agriculture. These uses, which often required water to be transported for long distances from the stream to the point of use, also often consumed a large part of the diverted water (Gould, 1977, p. 4-5). To recognize this offstream nature of water use and to protect the earliest users, a body of water law, known as the appropriation doctrine, evolved. This law has two primary principles—first in time is first in right, and beneficial use of water is the basis of the right. First in time means that the earliest water-right holder has a right to all the water needed to fulfill the right, and then the second, the third, and so forth, can claim their rights. Each water right depends upon supplies available after all prior rights have been satisfied (Gould, 1977, p. 5). Thus, as the supply decreases, lower priority water right holders must stop using water until the more senior users can be satisfied.

[1]U.S. Fish and Wildlife Service. [2]U.S. Department of the Interior, Office of Program Analysis.

As applied in most Western States, the beneficial-use principle requires the user who diverts water to comply with State procedural requirements and to apply water to beneficial uses. State constitutions generally identify those uses considered beneficial, such as municipal, irrigation, industrial, mining, and livestock watering, and frequently list them in descending order of priority. The beneficial-use requirement, as defined by State laws, provides the basis for the legitimacy of a water right. However, for most water uses, the key determinant of the value and the reliability of a water right has been the priority date.

Conflict over such an essential resource as water has been almost a natural part of water-resources management over the years. The system of water law serves two important functions—it provides a means for resolving the myriad of conflicts among water users and it serves to protect the integrity and reliability of established water uses. However, the water-law system has proved to be an adversary to the so-called new instream water uses that emphasize a nondevelopmental, qualitative emphasis upon moving water within natural watercourses for esthetic enjoyment, instream recreation, fish and wildlife habitat, and enhancement of the quality of life. This point was emphasized by Dewsnup and Jensen (1977, p. 1), who wrote,

> To fully understand and appreciate the programs that are emerging in the various Western States to protect instream values, it is important to remember the circumstances surrounding the development of the appropriation doctrine of the West. The important point to keep in mind here is that the basic water law of the States was developed at a time when the prevailing theme was to divert and utilize as much water as was necessary to sustain agriculture, promote and maintain industrial growth, and satisfy community needs. The public interest was primarily an economic one.

As a consequence of existing water laws in many States, instream flows for these new uses were not considered beneficial, were unable to meet the diversion requirement, and (or) were given a priority date so junior that the authorized right could be rarely exercised. However, during the past 20 years State water laws and the interpretation of Federal laws have undergone significant changes to accommodate the newer, nondevelopmental instream uses of water.

The earliest formal legislative recognition of the need to protect instream uses of water occurred in 1915 when the State of Oregon prohibited the diversion of water from certain streams because they fed the spectacular falls in the Columbia River Gorge. Because this provision for instream flows protected esthetics as a legitimate water use, it was, in one sense, a clear departure from the past. The waterfalls in the gorge, however, provided a strong economic base for Oregon's important tourism industry. Consequently, the legal provision could be seen as the protection of an economic resource rather than as the explicit recognition of esthetic purposes as a beneficial use of instream flows. Furthermore, the legislature simply sheltered the stream from diversion; it did not provide a water right for the instream use.

In a similar situation only 2 years earlier (1913), the courts in the State of Colorado relaxed somewhat the requirement that a legal water right must be based on a diversion from a stream. Cascade Town was a resort area for tourists who were attracted to the local waterfall and the luxuriant vegetation nurtured by the spray from the fall. A power company planned to divert the stream above the falls through a turbine, thus depriving the falls of water. In an attempt to protect the falls, a lawsuit was filed (*Empire Water and Power Co. v. Cascade Town Co.*). The court maintained that the use of the falls for purely esthetic purposes was not a beneficial use. However, the court decided that the spray from the falls, which watered the vegetation, was a diversion, and that human diversion was not necessarily required. This decision became an important precedent for instream flows, even though its application was quite limited and indirect (Gould, 1977, p. 7).

Oregon took the lead among Western States in establishing more generalized protection of instream flows. In 1955, the State legislature established a policy recognizing the importance of instream uses. The law permits the water administrative body of the State to establish flow quantities that will minimize the effect of altered flows on the salmon fishery. This important law, however, still fell short of actually granting a water right for fishery use of water.

The establishment of a water right for instream use is vitally important because of the nature of western water law. First, the acquisition of a water right means that a use has passed all the tests of legal legitimacy and that the terms of the right are spelled out. Second, the acquisition of a water right provides each use with a priority date, so that it is superior to all subsequent rights. Third, even if the right is junior in time to many other rights, a junior water user can legally prohibit a change in stream conditions from those existing at the time that the junior right was established if the change would damage the junior right (Gould, 1977, p. 9).

In 1969, Montana became the first State to provide for the legal acquisition of a water right for instream uses, and the State Department of Fish, Game, and Parks was allowed to acquire such rights (Revised Code of Montana, Sec.89-801). Since then, other States have followed suit. At the present time (1987), water rights can be obtained by a State agency or other entity in Arizona, California, Idaho, Kansas, Montana, Nebraska, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming (Lamb and Meshorer, 1983; McKinney and Taylor, 1988). The diversity of forms that the instream-flow programs in selected Western States have taken is shown in table 16.

WATER-LAW CHANGES—THE EAST

In the East, water quality is the problem, whereas in the West, prevailing wisdom long maintained that the volume of water is the problem. This follows from the fact that the West is sparsely settled, arid,

Table 16. Programs providing an appropriative water right in selected Western States as of 1987

[This is a partial listing; all States west of the Mississippi River, except New Mexico, have some sort of instream-flow program. Sources: As indicated by footnotes]

State	Program purpose(s)	Scope	Approach	Instream-right holders
Alaska[1]	Fish and wildlife; recreation; water quality; navigation.	Statewide	Stream-by-stream	Any public or private entity.
Arizona[2]	Fish and wildlife; recreation.	do	By stream segment	Do.
California[2]	Fish and wildlife; wild and scenic river; public trust.	do	Stream-by-stream; review of each diversionary water right.	Conditions on new water rights.
Idaho[1]	Fish and wildlife; recreation; visual quality; water quality; navigation.	do	Stream-by-stream	Idaho Water Resources Board.
Montana[1]	Fish and wildlife; recreation; water quality; future consumptive uses.	do	Basin-wide planning	Any political subdivision of the State.
Nevada[2]	Fish and wildlife; recreation; water quality.	do	By stream segment	Any public or private entity.
Oregon[2]	do	do	Basin-wide planning	Departments of Fish and Wildlife and Environmental Quality.
Utah[1]	Fish and wildlife	Limited	Stream-by-stream	State Division of Wildlife Resources.
Washington[1]	Fish and wildlife; recreation; visual quality; water quality; navigation.	Statewide	Basin-wide planning	State Department of Ecology.
Wyoming[1]	Fish and wildlife	Limited	Stream-by-stream	State of Wyoming.

[1]McKinney and Taylor (1988). [2]Shupe, 1988.

Table 17. Programs providing for instream flows in selected Eastern States as of 1987

[This is a partial listing; most Eastern States have some sort of statutory provision that could be used to protect streamflows. Source: Lamb, 1986]

State	Program purpose(s)	Scope	Approach	Type of protection
Iowa	Natural environment	Statewide	Stream-by-stream	Administrative rule.
Maine	River resources	16 streams	Important streams	Governor's executive order.
Michigan	Natural rivers; natural environment.	Statewide	Stream-by-stream	State and local administrative rules.
Minnesota	Natural environment	do	do	Administrative rule.
Pennsylvania	Fish habitat	Hydroelectric projects.	do	Do.
Wisconsin	Natural environment; navigation.	Statewide	do	Do.

and relatively free of pollution, whereas the East is more densely populated, water rich, industrial, and subject to pollution.

In the East, water law is based on the riparian doctrine, in which (in its purest form) owners of land along a watercourse are entitled to have the stream flow through their land not perceptibly retarded, diminished, or polluted by others (Ausness, 1983, p. 548). Unlike the appropriation doctrine, the early riparian system was consistent with the concept of instream flows; thus, instream flow as an issue in the East did not exist until recently, as explained below.

Population pressures, industrial growth, and an increase in irrigated agriculture in the Eastern United States and their attendant requirements for water have challenged the assumption that this region is "water rich." The concept of "natural flow" gave way to "reasonable use" as the guiding principle governing the exercise of a water right. Under the reasonable-use principle, any particular riparian land owner was entitled to use water for any beneficial purpose if that use did not unreasonably interfere with the water rights of others on the watercourse (Ausness, 1983, p. 549). In addition, many of the Eastern States have been moving toward a form of permit, or water-allocation system, as a means of providing water to persons who do not own riparian lands.

As a result of these increasing pressures on available supplies for offstream uses of water, several States in the East, as well as the Midwest, have established, or are considering, instream-flow protection programs. In 1949, Iowa became one of the first States to implement such a program by passing legislation to set flow standards on its streams. These standards limit the ability of riparian users to take water in times of shortage. This is accomplished, in part, by administratively designating streams as "protected." Iowa's instream-flow program is the most comprehensive of any Eastern State and has had long-standing success. Other Eastern States and their form of instream-flow protection are listed in table 17.

FEDERAL RESERVED WATER RIGHTS

As a matter of public policy, the States traditionally have been given precedence in the development of water laws. During the 1970's, a new legal concept in water rights, which is called the Federal Reserved Water Rights, emerged that was long thought to apply only to Indian reservations. This doctrine allows the Federal government to claim early priority dates for water rights on certain Federal lands. As described by the U.S. Supreme Court (*Cappaert v. United States, 1976*):

> This Court has long held that when the Federal Government withdraws its lands from the public domain and reserves it for a Federal purpose, the Government, by implication, reserves appurtenant water then unappropriated to the extent needed to accomplish the purpose of the reservation. In doing so the United States acquires a reserved water right in unappropriated water which vests on the date of the reservation and is superior to the rights of future appropriators.

Under this doctrine, the lands that are set aside (reserved) from the public domain for a particular purpose, such as national forests, national parks, national wildlife refuges, and wild and scenic rivers, are inferred to have a water rights to carry out the purposes of the reservation.

The quantity of the water right is limited to the quantity needed to accomplish the purpose(s) of the reservation. The priority date, as it relates to water rights created under State laws, is the date on which action was initiated to create or change a Federal reservation (President's Task Force on Non-Indian Federal Water Rights, 1980).

The Federal Reserved Water Rights doctrine for instream-flow purposes is important for two reasons—it establishes as legitimate certain instream uses of water (for example, watershed management, fishery maintenance, recreation, and esthetics) that otherwise might not have been recognized as "beneficial" under State water laws, and it gives these instream uses a priority date much earlier than would have been possible by using State water-rights procedures. Because Federal Reserved Water Rights apply to future as well as present water needs and might supersede senior rights in some cases, the doctrine introduces considerable uncertainty for State water managers and existing water users. To date (1987), claims under the doctrine have been for very small amounts of water.

METHODS FOR DETERMINING INSTREAM-FLOW REQUIREMENTS

As both State and Federal water laws have recognized various types of instream uses, technical methods have been developed and refined to determine quantities of water to meet the needs of each use. One of the "new" instream uses—fish-habitat maintenance—actually has been part of the water-management scene for a number of years. Before the concept of instream flow became widely known in the 1970's, State and Federal fishery agencies had negotiated for "fish flows" for the operation of a number of dams, under provisions of the Fish and Wildlife Coordination Act of 1943 (first passed in 1934 and subsequently strengthened through amendment). These fish flows typically were expressed as "minimum flows."

These efforts to obain fish flows challenged the dominance of economically oriented, diversionary uses of water. Nevertheless, from the perspective of today's understanding, there were six serious flaws in the concept of minimum flows for fish-habitat maintenance.

- These early "minimum flows" were considered to be just that—a minimum-flow level below which fish populations (or other values, such as recreation) would be seriously harmed. In fact, if true minimum flows were maintained for extended periods of time, fisheries and other instream uses would be seriously curtailed and might cease to exist. The ability of a fish population to survive a single 1-in-10-year low-flow event might give the false impression that the fish population could remain viable even if this minimum flow (drought) condition was imposed continuously.

The long-term effects of continuously maintaining these artificial minimum flows seldom are the same as the infrequent, naturally occurring, short-term effects that appear in the historic record. As water projects were built and operated, it became apparent that, in many instances, the fishery resources were decimated as a result of imposing minimum-flow standards (Trihey and Stalnaker, 1985, p. 177).

- Long-term imposition of low flow ignores the importance of periodic flushing events to the maintenance of fish habitat. The channel shape and bedforms to which fish have adapted has formed in response to cycles of flooding and low flows. Continuous low flow could drastically alter the nature of a channel so that it no longer is a viable habitat (Tennant, 1976, p. 7).
- Minimum flows for fisheries were perceived as limits imposed on legitimate water uses rather than as legitimate uses in their own right. Within the water development community, instream flow tended to be viewed as water wasted.
- Minimum flows were unenforceable because they were not based on water rights. They were only as good as the word of the operator of a dam or diversion. Even if minimum flows were provided, they were available for appropriation for other uses just below the dam or diversion.
- The concept of minimum flows was too rigid to be a useful negotiating tool. It had an "all or nothing at all" ring to it. Water developers asked such questions as, "How much would a fishery be improved by a little additional water?" or "What would happen to the fishery with a little less water?". Biologists could not answer these questions.
- The minimum-flow concept, as practiced in earlier years, failed to recognize the different water-flow requirements of the various instream uses. A commonly held belief was that fish required a greater minimum flow than all other uses. Therefore, according to the prevailing wisdom, if there is enough water for fish, there is enough water for other instream uses.

During the early 1970's, as streamflows for fishery maintenance and management, recreation, water-quality maintenance, esthetics, and maintenance of estuarine ecosystems were recognized as legitimate uses of water, the terms "instream flow" and "instream-flow needs" began to replace the concept of minimum flow. Instream uses now were thought to have their own set of flow requirements that could not be satisfied by water "left over" after other uses were satisfied; for example, flow requirements for a particular instream use might not be just a single minimum, but could vary seasonally or even daily. Further, instream needs were found to be different for each use and often were in conflict with one another (fig. 58). Until 1976, the hydrographs shown in figure 58 for fish and wildlife, estuary inflow, waste assimilation, and recreation would have appeared as straight lines (constant minimum flow), if included at all, in an analysis of streamflow allocation.

Two conferences—one on a description of existing instream-flow methodologies and the other on the major legal, institutional, and technical problems associated with instream flows—that were held in the 1970's focused national attention on this issue (Orsborn and Allman, 1976; Stalnaker and Arnette, 1976). Of the problems identified in both conferences, one was emphasized over and over—the need for an incremental methodology. A means was needed to determine the value of an increment of flow to assess adequately needs and to negotiate flow releases sufficient to satisfy those needs.

Since the mid-1970's, instream-flow methodology has advanced significantly; it now includes the development of incremental approaches for assessing

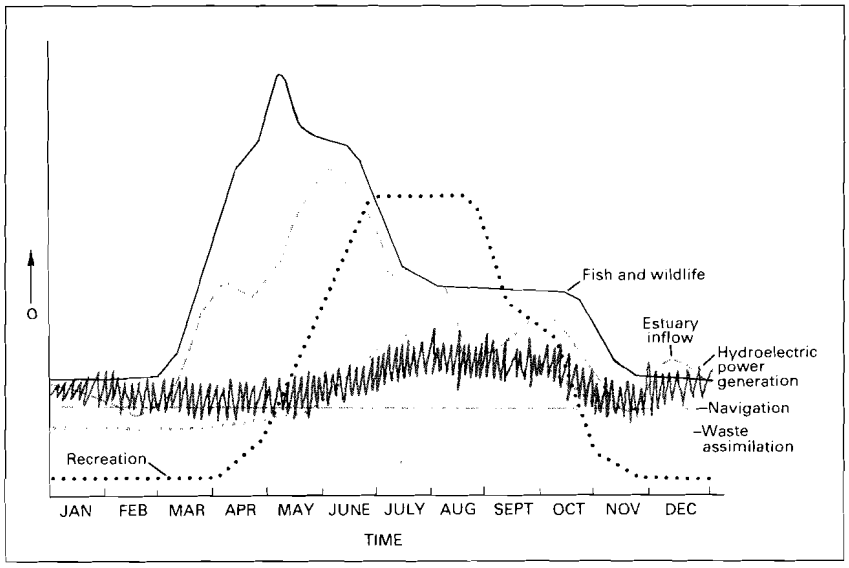

Figure 58. Schematic of the nature of streamflow requirements for instream uses throughout a calendar year. (Source: Modified from U.S. Water Resources Council, 1978, v. 1, p. 42.)

the effects of varying flow regimes on fish habitat, recreation, and other instream values. Several important research reports reflect past research and also serve as references for future methodological advances. Bovee (1982) addressed instream-flow assessments for fish habitat; his report has become the baseline for discussion of emerging technologies. Tennant (1976, p. 10) described the need for periodic flushing events to maintain certain hydrologic characteristics of the channel necessary to protect the environment for fish. Hyra (1978) analyzed the streamflow requirements of recreational activities.

The technologies developed since 1978 fall into two categories—those appropriate to preliminary planning and those designed for project impact assessment. The preliminary planning methods are related most closely to the traditional concept of minimum flow. These methods typically use a streamflow characteristic that represents the minimum flow for a particular instream use. Examples include 40 percent of mean annual flow, the point at which the size of wetted perimeter begins to fall sharply with small reductions in flow, flows equaled or exceeded 90 percent of the time, 10 percent of the mean annual flow, or the lowest flow on record (Trihey and Stalnaker, 1985).

Project impact assessment requires a different approach. During the 1970's, instream-flow assessment methods that attempted to evaluate fish habitat in terms of changes in the environment were developed. These "incremental" methods estimate the quality of fish habitats at different increments of streamflow. Early investigators of these approaches used depth, velocity, and substrate criteria to evaluate the influence of incremental changes in streamflow on the quality of spawning habitat for salmon in Washington streams (Collings and others, 1972). Waters (1976) applied weighted criteria for depth, velocity, and substrate/cover and introduced computer simulation to evaluate the response of rainbow trout habitat to streamflow in California.

The application of hydraulic modeling methods in conjunction with streamflow-dependent criteria for fish habitat began with single transect methods in which the stream model was based on the measurements taken at a single cross-section of the stream. The U.S. Forest Service introduced one such method called R-2 CROSS (Isaacson, 1976).

Single transect methods were followed by more sophisticated multiple transect methods in which the stream models were based on several representative cross sections of the stream channel. Fishery impact assessment methods were adapted from water-surface profile (WSP) simulation models that were used by the U.S. Bureau of Reclamation, the U.S. Soil Conservation Service, and the U.S. Army Corps of Engineers. The multiple transect techniques support predictions of depth and velocity at points across a transect and changes in the wetted perimeter of the channel as a function of flow (Dooley, 1976). The development and refinement of hydraulic simulation models to facilitate evaluation of habitat conditions under a wider range of streamflow conditions has continued to the present (Milhous, 1984). The Physical Habitat Simulation Model (PHABSIM) is an important analytical component of the Instream Flow Incremental Methodology (IFIM) described by Bovee (1982).

In general, project impact assessment approaches are more labor and data intensive, and more costly, than preliminary planning methods. Thus, the first question facing the manager is which of the two approaches to use. The decision is based on the magnitude and nature of the problems being addressed. Generally, preliminary planning methods would be appropriate whenever a specific project has relatively benign effects; fisheries, recreational, and other instream values are limited; or development is not anticipated for several years in the future (Trihey and Stalnaker, 1985).

The more complex and data-intensive project impact assessment methods are used when alteration of the streamflow, stream temperature, channel structure, or water chemistry is anticipated and there are concerns about the effects of these alterations on instream values. These methods can help answer the question, "What will happen if the minimum flow standards are violated?". These methods also might provide useful guidance to resource agencies seeking opportunities to improve existing fish populations or to alter the species composition of a stream.

Once the decision is made as to the type of method to use, the manager has an array of specific methods available. The choice of method depends on the resource agency's management policy, the region of the country, the type of instream uses to be provided, and, for fishery uses, the species of concern.

The more frequently used methods of determining instream flows are listed in table 18. Two conclusions can be drawn from those data. First, they show the diversity of available methods. This diversity is the result of many people independently attempting to solve the technological problems associated with assessing appropriate streamflow levels for instream uses and also of the variation of instream uses. Second,

Table 18. Methods for determining instream-flow requirements and number of States using method

[Source: American Fisheries Society survey conducted by Dudley Reiser in 1987 (unpublished). More complete information on each method can be obtained from Lamb, 1989]

Method	Number of States using method
Instream flow incremental methodology (IFIM)	38
Tennant method	16
Wetted perimeter	6
Aquatic Base Flow (ABF)	5
7-Day, 10-Year Low Flow (7Q10)	5
Professional judgment	4
Single Cross Section (R-2 CROSS)	3
USGS Toe-Width	2
Flow records/duration	2
Water quality	2
Average Depth Predictor (AVDEPTH)	1
Arkansas	1
Habitat quality index	1
Oregon	1
Vermont fish-flow	1
U.S. Army Corps of Engineers Hydraulic Modeling (HEC-2)	1

the data demonstrate that some methods are beginning to be accepted as "standard"; for example, the IFIM (a project impact assessment method) and the Tennant Method (a preliminary planning method) are used by 38 and 16 States, respectively.

CONCLUSIONS

Since the mid-1960's, instream uses of water for fisheries and environmental purposes have gained legal legitimacy along with the traditional offstream water uses, such as irrigation and domestic uses, and the commercially oriented instream uses, such as navigation and hydroelectric power generation. There is a continuing trend toward adoption of instream protection laws and policies by the States, although the legal approach to instream flows differs from State to State. Each State appears to adjust its water program to fit the circumstances of abundance, allocation law, and development. As a result, traditional water-management organizations are accommodating instream uses in their day-to-day operations. The Federal Reserved Water Rights doctrine has opened the door for water rights to be claimed to carry out the purpose of certain Federal lands. However, the actual quantities of these rights typically are determined in State water-adjudication procedures.

Instream uses for environmental purposes also have gained scientific legitimacy, as certain methods of determining instream flow are becoming broadly recognized as "standard," in contrast to the earlier regionally oriented approaches. Questions currently under discussion center around the issue of how much reliance should be placed on the results of simulated models as compared with field observations. Although every method is based on some stream measurements, there is a question of the extent to which extrapolations from existing data can take the place of long-term field observations.

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FOR ADDITIONAL INFORMATION

Berton L. Lamb, U.S. Fish and Wildlife Service, National Ecology Center, Aquatics System Branch, 2627 Redwing Road, Fort Collins, CO 80526-2899 and Harvey R. Doerksen, U.S. Department of the Interior, Office of Program Analysis, 18th and C Streets, N.W., Washington, DC 20240