Notes for Water Availability Conference Presentation with Alison Teetor

Slide 1

Today we will discuss a brief history of Instream-flow research, current approaches to these studies, and discuss the work that the USGS has been doing in cooperation with the Northern Shenandoah Valley Regional Commission in Virginia. Instream flow techniques have been used in investigations since the late 1960's and have lead to a growth in understanding of the relation between streamflow and aquatic habitats. Most studies have focused on fish and macroinvertebrate habitats. Instream flow studies have helped move water management away from fixed minimum flows determined solely by gage data such as 7Q10's or Mean Annual Flows. In the past, the best information managers had to use. The basic idea was to keep the river at or above some minimum flow. Now the objectives of the studies we are conducting work toward describing seasonal and annual flow regimes, to provide a broader context about flows required to sustain habitat.

Slide 2

Instream flow studies that have used fish as indicators of the health of the aquatic community attempt to understand how flow supports habitat needs of fry, juvenile, and adult species. Even while considering fish habitat, many studies have resulted in minimum instream flows, but the trend is to examine many variables to best describe the variation of habitat with flow. Examples of variables considered are velocity, depth, and substrate—these are the main three components that are included. In addition water temperature, and other chemical properties may be examined. For example, for temperature sensitive species, there may be a threshold flow volume that can not be lowered in order to maintain cool temperatures.

Slide 3

In the late 70's following large-scale reservoir development, resource managers were left seeking information about the impact on habitat and waterquality below dams. Studies emerged that included imperical observations of fish habitat quality with hydrologic analysis of flows below dams. These usually resulted in a mimum release flow needed by 1 species or group of species, below which water may not be withdrawn for consumptive use. These minimal release did not account for seasonal flow patterns, or natural wet and dry years.

Currently we are in an era of adaptive management to address the daily, seasonal, and yearly needs of aquatic organisms to attempt to manage dam releases in a natural way. The figure on this slide illustrates the Alabama River system, and shows just how altered river systems can become. Some 90 % of rivers throughout the US have some sort of regulation in place today. On the Tallapoosa river in GA and AL scientists at the Patuxent Research Center in Georgia are working toward understanding habitat and flow requirements in regulated systems.

Slide 4

As the science of instream flows shifts from a low-flow statistic, to a minimum flow based on habitat variables of one species, to the development of habitat vs. discharge relations for aquatic communities, tools have been developed to assist managers in evaluating alternative flow scenarios. In PA and MD cold water trout streams less than 100 mi2 have been the focus of an instream-flow study. The objective was to determine the amount habitat available for all life stages present in a season of the year for a range of streamflows. A variety of state and federal agencies have partnered to accomplish the modeling project to provide information about how withdrawals may affect trout populations before water withdrawal permits are issued. They are also considering the affects of ground water withdrawals on streamflow in this area. The figure shows percent habitat loss with varying percentages of withdrawals for Brook Trout in the Ridge and Valley Province.

Slide 5

A summary of the ideas behind instream-flow studies is represented in the Natural Flow Regime concept. Managers are under pressure to consider daily water use during each season and to decide which portion of the river basin or fishery will be favored during droughts. These recommendations require the consideration of all sources of water, and the four components of the natural flow regime.

As presented in some recent papers, the Magnitude and Frequency of flows, timing, duration, and rate of change are topics of interest and study in the scientific community today. The USGS has more than a century of data for many of the rivers of the United States, and that data can provide excellent historical flow regime context regarding these four components. As we move forward, studies will focus more and more on defining the natural flow regime, assessing current conditions, and then helping mangers to maintain flow conditions similar to the historic or natural condition.

Slide 6

An example of the importance of the magnitude of flows and the affect of human-ateration of channel form can be seen on the Yellowstone River. The work done by Ken Bovee and others examines the spatial distribution of juvenile fish habitat over a range of flows. The habitat of interest is shallow-depth, slow-current areas, usually in the flood plain or marginal vegetated areas. The natural variation of flows shows the increase in this shallow habitat during high flows—typical of spring.We;ll see identical flow simulations for 2 sections of the Yellowstone river, one in an un-altered channel with access to the floodplain, the second with some channelization to protect a city from flooding.

You can imagine that in either section of river if flows were set to one minimum flow constantly, the shallow depth habitat would be restricted. This is an example of 2-dimentional modeling that is quite powerful because it easily illustrates the habitat loss with alternate flow scenarios.

Slide 7

Our work on the North Fork Shenandoah River is 1-dimentional modeling, including time series analysis of habitat loss or protection with alternate flow scenarios. The objectives were to present a whole picture of a watershed, by examining physical features, fish habitat, hydrology, water quality, and predictive modeling. With low-flow periods in 1999 and 2001, it has become apparent that water supplies are limited, and may become more taxed in future years with increased growth in this basin. The focus of this study is to define low-flow habitat conditions, to help managers work to sustain habitat during future low-flow periods. The study was conducted on the North Fork Shenandoah river, a major tributary to the Shenandoah River. This is a large basin approximately 1000 mi2 and 100 river miles in length. The basin is unregulated, rural basin which is experience population growth at a rare of 30% between1980-2000. Increasing development and increasing water withdrawals for public, industrial, and agricultural water supply have threaten to reduce streamflows, especially during drough periods

Slide 8

The North Fork Shenandoah River is located within the Ridge and Valley Province and fows from south to North, into the Shenandoah River and Potomac. In the upper reaches, the North Fork flows east through the valleys and ridges, within mostly sandstone formations. This upper section contains, karst topography within limestone and dolomite formations that contribute to the presence of sinkholes, springs, and ground-water discharge to the river. Then it turns north and flows along the eastern side of the valley floor in wide, gradual meanders until it reaches the town of Edinburg, Va. Downstream of Edinburg, Va., the river enters the Seven Bends area where it is characterized by extremely narrow meanders, following fracture zones in the Martinsburg Shale bedrock, which helped to form the river morphology unique to the Seven Bends area.

The three stream gages in red are rough boundaries to our study, providing reference historical data, and serve as boundaries for model output. The study sites are pictured in yellow.

Slide 9

During the North Fork Study the physical habitat was classified to document the macro-scale habitat properties. This helps us compare habitat conditions from the headwaters areas to the mouth. Habitat mapping was completed by canoeing and stream walking approximately 100 river miles. This allows us an understanding of the size and extent of individual habitats, as well as how habitats vary throughout the river. The North Fork is dominated by runs (67%), pools (19%), riffles (14%).

Slide 10

Substrate changes from the upper section to the lower and ranges from gravel-coble sandstone to shale bedrock in the lower section. The cumulative habitat graph shows the abundance of each habitat class from the upper reaches to the lower reaches. Our work has shown that it is dominated by run habitat throughout, but there is a shift from small repeating habitat units in the upper section to longer, drawn out runs and pools that flow into each other in the lower section.

Slide 11

We had an opportunity to partner with professor Dr. Orth of Virginia Tech and students to conduct the micro-scale habitat analysis for the fish community. They used snorkeling and electro-shocking techniques to collect species and habitat preference data for 37 fish species throughout the North Fork. The fish species and life-stages were grouped into fish guilds or groups of species and life stages with similar habitat requirements for depth, velocity, substrate, and cover. Riffle Guild example Fluvial Specialists: High velocity, Shallow water
Examples: Central Stoneroller, Mottled Sculpin, Longnose Dace

Slide 12

The micro-scale habitat data were used to create fish habitat-suitability curves for the modeling process. These guilds help to represent the entire fish community, in a manageable way. It has also given us river-specific habitat suitability criteria on which to base our modeling work. For the riffle guild, depths of 1 foot are 100 % suitable, but 1.5 feet depths are only 50 % suitable. These suitability ratings were used in the modeling phase of this research.

Slide 14

Hydraulic information was collected by the USGS with assistance of Virginia tech students and staff. This included 6 study sites, 36 crossections, and the collection of depths, vels, substrate channel index values over a range of low to high wadeable flows.

Slide 13

A stage (water surface elevation) to discharge rating was established within the habitat simulation model, and the fish habitat suitability criteria were combined with the hydraulic data to simulate habitat and flow for a range of 30 flows. The modeling process results in the creation of useable habitat area curves for each guild.

Slide 15

We will only examine one set of curves and flow scenarios for the Norht Fork today. I want to highlight the upper watershec section near Cootes Stores. This graph shows discharge, or flow on the bottom, and useable habitat area on the side (y-axis). Habitat for the riffle guild is shown in red, the fast generalist in green, Canoeing is in *black*.

At first glance, we might ask what flow would support the maximum habitat? Look for the hightest area, and the flow associated with it. The next question is are these flows common or easily sustained throughout the year or season? We have been talking about the Natural Flow Regime, and it is good to put the habitat-flow relations into this context as well. First we need to recognize common flows. These are shown in the gray rectangle. Since this study in aimed at providing information about summer low-flow months, and to assist in drought management planning, the statistics we've been using are those specifically for low-flow months of July, August, and September.
The gray rectangle represents flows that occur 50 % of the time during these months. This range of flows is 4.4- 40 CFS, and does not include the maximum habitat area. Flows which support the maximum habitat area occur less than 25 % of the time during low-flow months. This provides a healthy expectation of habitat area in the stream.

What we also want to know is which flows could limit useable habitat area, and be detrimental for fish survival. Flows of 1.6 cfs (1.0 MGD) are shown by the orange dashed line. This is the tail end of the habitat-flow relation, but these habitat conditions should typically occur 10 percent of the time during summer months. Knowing what amount of habitat area is expected with each season should help in water management planning. Lets keep flows less than 4.4 cfs—the lower end of the normal range of flows for July, August and September, in mind for the next two slides.

Slide 16

How can we apply the habitat-flow relation to a management-type scenario? A time-series analysis overlays the habitat-flow relation, or the useable habitat area curves, on the historic streamflow record to assign a habitat value to each daily-flow value. This allows us to look back in time and simulate how habitat may have varied during previous low-flow periods.

This graph shows flow (black) and simulated fast-generalist habitat (Green) for every day of the year 1999, (Jan-Dec) which was a year with extreme low-flow conditions in the mid-to late summer. During wet months (December-June), habitat availability is relatively constant and sustained. Habitat area declined with flow in July and August. You can see that as flow gets to be 25 cfs, it continues to drop, as does habitat area. With continued decline in flows habitat eventually bottoms out to almost zero. What can be done to limit habitat loss?

Slide 17

The average surface water-withdrawals for agriculture for June, July, August, and September from (1998-2002), are 3.0 cfs for the upper river section. To simulate habitat area under a conservation-scheme, water withdrawals were added back to the historic flow data. This simulates the potential success of water conservation during low-flow periods. The orange line shows habitat area if water withdrawals are completely stopped. It shows the maximum protection possible with water conservation methods.

We have put together other alternative flow scenarios for each section of the North Fork Shenandoah River, and incorporated historic flow statistics and water quality information to provide a comprehensive dataset for the planning district to work from in the development of a low-flow agreement.