Instream Flow Issues and Their Consequences for the Hydrology and Aquatic Community of the North Fork Shenandoah River, Virginia.

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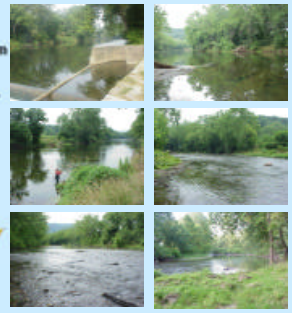
Abstract

Citizens of Virginia's North Fork Shenandoah River Basin are facing issues regarding future water allocation. This basin provides only 20% of the mainstem Shenandoah River's discharge yet received 60% of the population growth during the 1980's. Water use projections predict that demand will exceed supply during low flow conditions by 2025. During periods of low flow in the summer of 1999, dissolved oxygen levels in the river were lower than Virginia water quality standards. A multi-part study was initiated to gain an understanding of how the river's ecosystem is affected by low flow conditions. This study includes an examination of the longitudinal distribution of mesohabitats, the development of a hydrologic model for evaluating fish habitat at different flows, the establishment of habitat suitability criteria for the fish community, and a temperature model of the river. Four mesohabitat types (runs, pocket runs, pools, and riffles) were identified and mapped. Based on the distribution of mesohabitats, representative reaches were selected to develop a hydrologic model of the river using PHABSIM. A habitat guild approach, focusing on four flow dependent guilds, will be used to develop habitat suitability criteria for the fish community. This approach will develop criteria for both representative species and entire habitat guilds. The temperature model will be used to examine empirical relationships between air and water temperature in order to assess water quality during low flow conditions. These combined components will produce management alternatives that biologists and water managers can use when making water allocation decisions.

Introduction

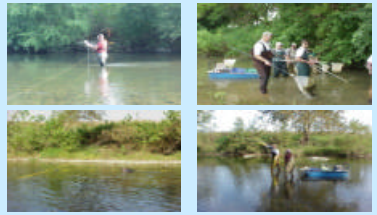
- The North Fork Shenandoah River is located in the Valley and Ridge Physiographic region of northern Virginia.
- The North Fork is a primary source of water in the Shenandoah Valley and an important recreational destination.
- There is a growing concern in the valley over water allocation and the health of the river.
- A multi-agency IFIM study was initiated to examine how the river is affected by low flows.
- The study involves Virginia Tech, United States Geological Survey, Virginia Department of Environmental Quality, Virginia Department of Game and Inland Fisheries, and Lord Fairfax Planning District Commission.
- The study examines four main issues facing the drainage: what is the water supply, what are the water withdrawals, what habitats are important to the fish community, and how is the river's habitat affected by changes in flow.
- Hydraulic and habitat data collected at the representative reaches will be evaluated using PHABSIM.
- Fish species using habitats most affected by low flows will be the focus of habitat suitability criteria development.
- The output from this model will used to develop water management strategies for the North Fork Shenandoah River.



Distribution of sampling reaches on the North Fork Shenandoah River (Above). Pictures (from top left to bottom right) of Winchester Dam, Rt. 648, Posey Hollow, Spring Hollow, Laurel Hill Farm, and Plains Mill.

Methods

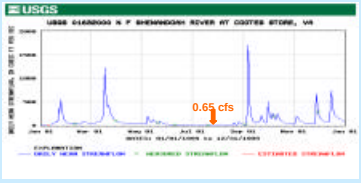
- In the fall of 1998 and spring of 1999, Hayes and Ruhl (USGS) conducted a mesohabitat inventory to classify and quantify the habitat of the river.
- Based on the habitat classification, a total of 36 transects, across six stream reaches, were selected to characterize the river.
- During 2000 and 2001, the hydraulic and habitat characteristics (discharge, water surface elevation, depth, velocity, cover and substrate) for each reach were measured at the high, medium, and low flows.
- Water temperature loggers were placed at the three stream gauge locations.
- An air temperature logger was placed at the Laurel Hill Farm Site.
- During summer of 2001, a survey of the fish community was conducted using a barge electrofishing unit.
- Fish species were placed into habitat guilds for the development of habitat suitability criteria.
- During the summer of 2001, fish habitat data was gathered for the selected species using two separate sampling methods: snorkeling and throwable-anode electrofishing.



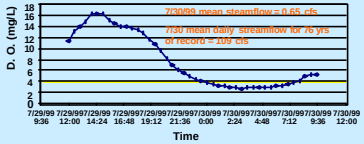
Pictures of field techniques (top left to right) Don Hayes (USGS) taking hydraulic measurements, barge electrofishing during the community sampling, (bottom left to right) Adrienne Wiemer snorkeling for fish, and Jason Persinger and Adrienne using the throwable-anode.

Issues and Results

Issue 1: What is the water supply on the North Fork Shenandoah River during periods of low flow and how is water quality affected by low flows?

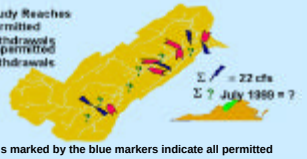


The 1999 hydrograph of the North Fork Shenandoah River at Cootes Store Gauge. The mean daily streamflow on 7/30/99 was 0.65 cubic feet per second.



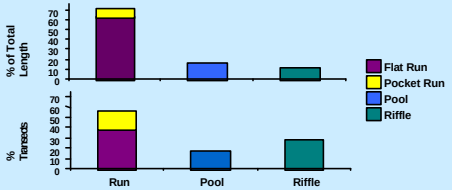
Dissolved Oxygen measurements taken downstream of Cootes Store, VA over a 24 hour period on 7/29/1999 and 7/30/1999. The yellow line represents Virginia minimum water quality standards.

Issue 2: How much water withdrawal is going on in the basin and where is it occurring?

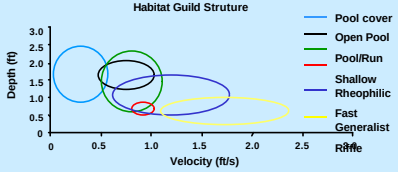


Locations marked by the blue markers indicate all permitted industrial, agricultural, and municipal water withdrawal sites. Green question marks represent unpermitted agricultural withdrawals. Total withdrawal from these sites is unknown.

Issue 3: What habitat types are found in the system and which ones are the most important to the fish community?



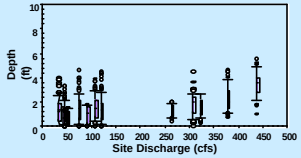
Relative percentages of mesohabitat types. The top graph illustrates the relative percentages actually found in the North Fork. The bottom graph illustrates the relative percentages found in the sampled reaches.



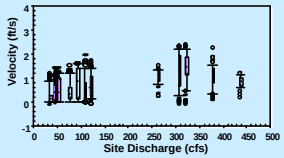
Guild structure used for selection of representative species in the North Fork Shenandoah River. Modified version of guild structure from Vadas and Orth 2000. Priority given to species in guilds most affected by low flows.

Example species from the pool/run, fast generalist, and riffle habitat guilds. 20 of the 33 species found in the system were in these three guilds. (Left to Right) River chub (*Nocomis micropogon*) is in the pool/run guild, least flow sensitive guild examined, margined madtom (*Noturus insignis*) is in the fast generalist guild, and longnose dace (*Rhinichthys cataractae*) is in the riffle guild, most flow sensitive guild.

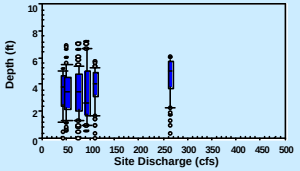
Issue 4: How is the physical habitat found in the North Fork affected by changes in flow and which habitat types are most affected by flow alterations?



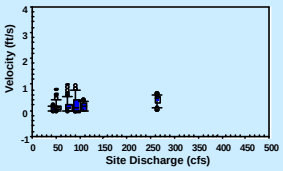
The changes in run depth associated with changes in flow at the Plains Mill site.



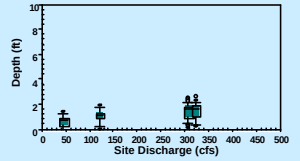
The changes in run velocities associated with changes in flow at the Plains Mill site.



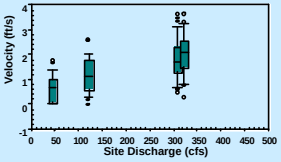
The changes in pool depth associated with changes in flow at the Plains Mill site.



The changes in pool velocities associated with changes in flow at the Plains Mill site.



The changes in riffle depth associated with changes in flow at the Plains Mill site.



The changes in riffle velocities associated with changes in flow at the Plains Mill site.

Relative sensitivity of measures of depth and velocity in runs, pools, and riffles to changes in flow. In run habitat (top graphs) depth and velocity vary only slightly with changes in flow. In pool habitat (middle graphs) depth and velocity show almost no variation with changes in flow. In riffle habitat (bottom graphs) depth and especially velocity show large variation with changes in flow.

Current Status and Future Plans

- Hydraulic and habitat data has been collected at high, medium, and low calibration flows.
- A years worth of water and air temperature data has been collected.
- Habitat data has been collected for the fish species in the selected habitat guilds.
- Final species selection for the development of habitat suitability criteria to be inserted into the habitat models will occur in fall 2001.
- Habitat suitability criteria will be developed and tested for the fish community of the North Fork Shenandoah River.
- Data will be inserted into PHABSIM models to determine how habitat availability changes with changes in flow.
- Data from ongoing water temperature monitoring will be modeled against different flow regimes.
- Fish growth for three species, Redbreast Sunfish (*Lepomis auritus*), Northern Hogsucker (*Hypentelium nigricans*), and Fallfish (*Semotilus corporalis*) will be examined to look for effects of the drought of 1999.
- Conduct an evaluation of the effects of low flows on the state endangered Brook Floater (*Alasmidonta varicosa*) as well as other mussel species found in the system.
- Development of a Shenandoah Valley Water Authority to monitor water use and develop strategies for establishing aquatic conservation flows.

Acknowledgements

- Lord Fairfax Planning District Commission.
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