Surface Water Withdrawal
Intake Design and Operation Standards

VA Dept. of Wildlife Resources
Surface Water Intake Working Group

The Virginia Department of Wildlife Resources (DWR) is responsible for reviewing and providing input on many surface water intake applications and reissuances. To minimize impacts upon resident aquatic fauna we typically recommend that the intake meet the following Intake Design and Operation Standards (standards) which serve to minimize impingement and entrainment and are considered reasonably protective of aquatic resources given the currently available knowledge base:

- **That the intake is fitted with a screen that has openings no larger than 1 millimeter (mm).**
- **That the approach velocity, as measured across the entire screen at 6" or closer to the screen, not exceed 0.25 fps.** If measuring the approach velocity at 6" or less from the screen cannot be accomplished, it should be measured as close to the screen as possible and as approved by DWR.
- **That sweeping velocity, which protects the earliest life stages (eggs, larvae) from impingement and entrainment, be considered as part of project design and implemented where and as often as practicable. To best protect these life stages, sweeping velocity, as measured across the entire screen at 6" or closer to the screen, should exceed 0.25 fps as often as possible.** If measuring the approach velocity at 6" or less from the screen cannot be accomplished, it should be measured as close to the screen as possible and as approved by DWR.

In addition, to ensure continued access to necessary instream habitats by resident aquatic species, we recommend the following:

- **That the intake not withdraw more than 10% of instantaneous flow* (90% flowby)**

*in most situations what is referred to as "instantaneous flow" is actually mean daily flow, often based on the previous days flows. Also this is meant to represent a 10% cumulative flow reduction, taking into consideration all withdrawals from, and inputs to, the system.

While our preference is that surface water intakes meet the above standards, we recognize that there may be situations for which adherence to the standards is not necessary or practicable. In such situations we are supportive of the applicant performing site- or system-specific analyses, in coordination with the appropriate resource agencies, which may find alternate intake design and use parameters as protective of the aquatic fauna as the standards above. Additional analyses could include literature reviews, empirical data collection, further analysis of project impacts, and/or mitigation methods that may further minimize and/or offset any unavoidable adverse impacts to aquatic fauna and their habitats resulting from intake installation and operation.

We note that the standards listed above are not meant to apply to most hydropower projects and that each water use/supply project is considered on its own merits. We may recommend that projects with storage or that manage large reservoir systems adhere to certain standards and not others, depending on the nature of the project, the aquatic system on which the project relies, and any applicable laws or regulations. However, if a project is designed and operated using the standards above, DWR would not request further analysis to ensure minimization of impingement and entrainment and loss of habitat

access or availability resulting from flow alterations due to operation of the intake.

History of our Intake Design and Operation Standards development:
In the early days of surface water intake standards development, our priorities for wildlife protection were focused on ensuring that minimum instream flows were available during operation of the intake. In the 1970's, it was typical practice to determine instream flow requirements for intakes using the water quality 7Q10. As we moved into the 1980's we began using the Tennant Method, which determined flows based as a percentage of Mean Annual Flow (MAF) and derivatives. During this same time period we began to consider intake design as a way to minimize impingement and entrainment. The intake design standards were first only related to screen opening size, with the typical recommendations at the time being that the intake screen have openings from 3/8 – 1/2 –inch.

During the 1990's our learning progressed rather quickly, resulting in recommendations for instream flows being based on seasonal or monthly exceedance flows and intake screen openings of 2mm becoming more routine. Also during this timeframe, we saw intake velocities being considered, and recommendations that it not exceed 0.5 fps. The late 1990's brought use of Instream Flow Incremental Methodology (IFIM) / Physical Habitat Simulation (PHABSIM) / Habitat Suitability Index (HSI) and other studies to inform instream flow requirements. Also during the late 1990's, Dr. Gowan (Randolph Macon College) Dr. Garman (Virginia Commonwealth University; VCU), and Will Shuart (VCU grad student) studied the issue and found that even stricter standards are more appropriate and better protected our aquatic fauna. The standards recommended by Gowan et al are those we use today: intake screens with openings no larger than 1mm and intake velocities no greater than 0.25 fps. However, in their paper, they mention that at some point in the future, when intake design has improved, a standard of intake screens with openings no larger than 0.5 mm and maximum intake velocities of 0.1 fps should be considered for adoption.

As our learning about intake design improved, our recommendations regarding instream flows evolved. By the early 2000's we, and our conservation partners, had adopted the use of seasonal or daily flows (instantaneous flow) to inform instream flow requirements, using a 90% flow by as the accepted standard. Analyses of PHABSIM data collected in multiple Virginia streams demonstrates that a 10% alteration in stream discharge begins to impact habitat quality/availability for the most flow-sensitive species/life stages present. Thus, alterations in stream discharge of <10% are considered to have no significant impact on even the most sensitive fauna. This standard also maintains the natural hydrograph (magnitude, duration, timing, etc.) of flow events, which have been shown to be critically important for maintaining the integrity of stream biota.

Ongoing consultation with our federal conservation partners, other US state fish and wildlife agencies, non-governmental organizations, and academia indicates that the standards above fall in line with how water intake design and operation is being approached across the US and Canada. As consultation continues and our library of literature grows, this document will be updated to reflect that learning.

The following papers and assessments have informed the development of our Intake Design and Operation Standards:

- Benner et al. 2013. Recommendations for Estimating Flows to Maintain Ecological Integrity in Streams and Rivers in North Carolina. North Carolina Ecological Flows Science Advisory Board.
- Canadian Science Advisory Secretariat. 2013. Framework for Assessing the Ecological Flow Requirements to Support Fisheries in Canada. National Capital Region, Science Advisory Report. Ottowa, Ontario.
- Electric Power Research Institute. 2006. Field Evaluation of Wedgewire Screens for Protecting Early Life Stages of Fish at Cooling Water Intake Structures. Chesapeake Bay Studies, Technical

Report. Palo Alto, CA.
- Freeman, Mary C. and Marcinek, Paula A. 2005. Effects of Water Supply Development on Stream Fishes in the Piedmont Region of Georgia. Athens, GA.
- Gowan et al. 1999. Design Criteria for Fish Screens in Virginia: Recommendations Based on a Review of the Literature. Richmond, VA.
- Hamilton, D. A., and P. W. Seelbach. 2011. Michigan's Water Withdrawal Assessment Process and Internet Screening Tool. Michigan Department of Natural Resources, Fisheries Special Report 55. Lansing, MI.
- Holt et al. 2017. Division of Water Technical and Operational Guidance Series. New York State Department of Environmental Conservation.
- Leonard, Paul M. 2011. *Proceedings of the 2011 Georgia Water Resources Conference*. Emerging Trends in Environmental Flow Science. Athens, GA.
- Maloney et al. 2021. *Environmental Management*. Linking Altered Flow Regimes to Biological Condition: an Example Using Benthic Macroinvertebrates in Small Streams of the Chesapeake Bay Watershed.
- McManamay, Ryan A. and Bevelhimer, Mark S. 2013. A Holistic Framework for Environmental Flows Determination in Hydropower Contexts. Oak Ridge, TN.
- National Oceanic and Atmospheric Association. 1997. Fish Screening Criteria for Anadromous Salmonids. National Marine Fisheries Service, Southwest Region.
- Richter et al. 2011. A Presumptive Standard for Environmental Flow Protection. Charlottesville, VA.