Spring Water Velocity: Protecting Water Quality with Water Quantity Regulation

Photo by John Moran.

A Report for the Florida Springs Institute

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Algae Accumulation and Water Velocity

Florida springs are highly valued environmental resources renowned for their aesthetic and recreational value, as well as for their biodiversity. The Florida Legislature, via the Florida Spring and Aquifer Protection Act, has declared that springs are a unique part of Florida's scenic beauty, embody immeasurable natural, recreational, economic, and inherent value, and provide recreational opportunities for swimming, canoeing, wildlife watching, fishing, cave diving, and many other activities.[1] Unfortunately, Florida springs are currently facing a number of anthropogenic stressors that impair the quality and quantity of their water and ecosystems.

One major sign of ecological harm observed in Florida springs is the accumulation of filamentous algae, which can smother habitat occupied by other organisms and native aquatic vegetation. These algae reduce recreational, aesthetic, and overall water quality of these resources.[2] "Instead of the lush carpet of the natural aquatic community, recent visitors to the Rainbow River were greeted with extensive, thick mats of *Spirogyra* -- filamentous green algae that smothers the eelgrass and Strap-leaf *Sagittaria*. Rather than experiencing the spectacular beauty of one of Florida's natural treasures, visitors are witnessing first-hand the results of excessive nutrients and reduced flows. "[Our springs] are being diminished, and people are noticing and sounding the alarm."[3] "It was disgusting, the green algae are covering everything, I've never seen it like this" reported one swimmer.

In several Florida spring systems, filamentous algal abundance increased with lower flow velocities and lower spring discharge.[4] One study found that velocity was inversely related to algal

[1] Fla. Stat. §373.801(1)
[2] Stevenson, R. J., Pinowska, A., Albertin, A., & Sickman, J. O. (2007). Ecological condition of algae and nutrients in Florida springs: the synthesis report. Tallahassee, FL: Florida Department of Environmental Protection.
[3] Quote from Bill Vibbert ,Director, Rainbow River Conservation, LLC
[4] King, S.A. 2014. Hydrodynamic control of filamentous macroalgae in a sub-tropical spring-fed river in Florida, USA. Hydrobiologia 734:27–37; Hoyer, M.V., T.K. Frazer, S.K. Notestein, and D.E. Canfield, Jr. 2004. Vegetative characteristics of three low-lying Florida coastal rivers in relation to flow, light, salinity and nutrients. Hydrobiologia 528:31–43.

cover.[5] These scientific findings suggest that water quantity indicators, in this case velocity, can be as relevant to macroalgal proliferation in Florida spring-fed rivers as water quality indicators such as nitrogen concentration.[6] Considering these findings, the establishment of velocity criteria above specific thresholds could be necessary to minimize macroalgal proliferation and the associated impacts in spring-fed rivers and streams.[7]

Minimum Flows and Levels (MFLs)

Since velocity is directly linked to the stage (level) and discharge (flow) of a river, existing Florida law regulating the minimum and flows and levels (MFLs) of waterbodies is well suited to achieve a minimum velocity standard. The Florida Water Resources Act of 1972 authorizes the establishment of MFLs by rule, stating in relevant part:

> 373.042(1) Within each section, or the water management district as a whole, the *department or the governing board shall establish* the following:
> (a) Minimum flow for all surface watercourses in the area. *The minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area.*
> (b) Minimum water level. *The minimum water level shall be the level of groundwater in an aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area.*
> The minimum flow and minimum water level *shall be calculated by the department and the governing board using the best information available*. When appropriate, minimum flows and levels may be calculated to reflect seasonal variations. *The department and the governing board shall also consider, and at their discretion may provide for, the protection of non-consumptive uses in the establishment of minimum flows and levels.*
> (2)…, the development of a priority list and compliance with the schedule for the establishment of minimum flows and levels pursuant to this subsection shall satisfy the requirements of subsection (1). (emphasis added)

Section 373.042(1)'s requirement to consider non-consumptive uses is a source of authority to protect instream uses. Pursuant to Section 373.042(2), water management districts comply with the statute by establishing a priority list and schedule of MFLs and complying with them. Once adopted, MFLs must be

[5] Cohen, M., R. Hensley, N. Anderson, and L. Korhnak. 2015. Sediment and Algal Dynamics in the Rainbow River, 2015 Annual Report. Prepared for the Southwest Florida Water Management District, Brooksville, Florida.
[6] Hydrodynamic control of filamentous macroalgae in a sub-tropical spring-fed river in Florida, USA.
[7] Id.

protected in water management district decisions on water-use permits and related resource protection matters. MFLs are reevaluated periodically and may be modified through rulemaking. When MFLs are exceeded or are expected to be exceeded, a water management district must issue recovery or prevention strategies and may issue Consumptive Use Permits "only if they meet applicable District rules, including those implementing the recovery or prevention strategy."[8]

MFLs have primarily focused on ecological resources such as fish passage, aquatic habitat and floodplain inundation. However, given the impact of velocity on algae prevalence, MFLs for Florida springs should be adopted that prevent groundwater withdrawals from reducing velocity below the critical threshold where algae thrive.[9] Velocity, a function of the discharge and level in spring sheds, appears to be an effective metric for establishing regulatory criteria to inhibit macroalgal proliferation.[10]

Most recently, modeling and analysis of algal cover, submerged aquatic vegetation (SAV) cover, and velocity datasets from several Florida springs have identified critical velocities and shear stresses that predict algal and SAV prevalence.[11] Several springs ecosystems were found to have an overall mean algae-inhibiting velocity threshold of approximately 0.215 m s-1, a value also indicated by earlier studies.[12] This modeling also found a credible link between increased SAV and a shift in the stage/discharge relationship that ultimately reduced velocity below the threshold and facilitated greater algal colonization.[13] These data suggest that decreased velocity due to reduced discharge increases the amount of SAV and algae, and that the subsequent drag can sustain lower velocity even as discharge recovers. This study further supports the need for MFLs that yield at least the minimum velocity, since increased and algal cover produces conditions where such velocity becomes even more difficult to

[8] FAC Rule 62-40.473(8), F.A.C.
[9] Hydrodynamic control of filamentous macroalgae in a sub-tropical spring-fed river in Florida, USA.
[10] Id.
[11] Collaborative Research Initiative on Sustainability and Protection of Springs CRISPS FINAL REPORT 2014 – 2017, St. Johns River Water Management District Springs Protection Initiative [SPI], UF Contract # 27789, https://www.sjrwater management districts.com/static/waterways/springs-science/CRISPS_Final_Report-All_Sections.pdf
[12] Id.
[13] Id.

achieve. Although some scientific debate remains over the exact cause of algal proliferation in springs, which undoubtedly is a response to several environmental conditions[14], the consensus among springs scientists is that when flow velocities are high, algal cover is low.

Water Resources Implementation Rule

According to the Water Resource Implementation Rule[15], in establishing Minimum Flows and Levels (MFLs), consideration shall be given to the protection of water resources, natural seasonal fluctuations in water flows or levels, and environmental values associated with coastal, estuarine, aquatic, and wetlands ecology, including:

> (a) *Recreation* in and on the water; (b) Fish and wildlife habitats and the passage of fish; (c) Estuarine resources; (d) Transfer of detrital material; (e) Maintenance of freshwater storage and supply; (f) Aesthetic and scenic attributes; (g) Filtration and absorption of nutrients and other pollutants; (h) Sediment loads; (i) *Water quality;* and (j) *Navigation*."(emphasis added)

The Water Resource Implementation Rule states that "MFLs should be expressed as multiple flows or levels defining a minimum hydrologic regime, to the extent practical and necessary, to establish the limit beyond which further withdrawals would be significantly harmful to the water resources or the ecology of the area."[16]

To comply with the Water Resources Implementation Rule, water management districts are required to address the ten water resource values in the development of Springs MFLs reports like those for the Silver and Rainbow Rivers. At least three of these water resource values – (a), (f), and (i) – are severely compromised by algal proliferation. However, within these reports, algae growth is only cursorily addressed under the relevant "water quality" resource value (i) and is entirely absent in the discussion under "recreation" (a) and "aesthetic and scenic attributes" resource values (f).

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[14] Generally, Water Management Districts find that the increase in nitrogen is hypothesized to be the primary source of the imbalance of algae and is implicated as a cause of impairment. Also, water quality issues are purported to be chiefly an increase in nitrates, a documented decrease in water transparency over the past 50 years, and a concomitant increase in attached algae. See Rainbow River and Silver River MFL Reports

[15] FAC Chapter 62-40.473

[16] Id.

Even when addressed by these reports, algae growth is not casually-connected to fluctuations in water flow or velocity. For example, in the Rainbow River MFL report, an increase in nitrogen is hypothesized to be the primary source of the imbalance of algae and implicated as the cause of impairment.[17] The Silver River MFL report further discounts the potential relevance of velocity by concluding that nitrogen concentration, independent of flow and stage, is the primary cause of algal proliferation.[18] In spite of a growing – perhaps even firm – consensus among scientists who study springs hydrology, these MFL reports do not address, and in some cases contest, the relationship between velocity and algae. While there may be insufficient data to absolutely prove the link between velocity and algal proliferation or a critical velocity that inhibits algae growth in every spring system, water management districts at a minimum should address this possible mechanism in their reports so that MFLs can be promptly revised as further research develops.

In fact, in response to the emergent studies demonstrating that velocity plays a significant role in algal cover, the Peer Review of the Recommended Flow for the Rainbow River System concluded that it was, "surprising to see consideration of this algal proliferation issue [velocity-algae relationship] not mentioned. Given that the link with discharge is direct, it warrants explicit mention in the report."[19] The Southwest Florida Water Management District's (SWFWMD) response to the Peer Review Panel's comment was "The report will be revised to expand discussion regarding flow effects on filamentous algal mats and recreational-use impacts to submerged aquatic vegetation (SAV) and how these factors

[17] Recommended Minimum Flow for the Rainbow River System REVISED FINAL DRAFT, June 2017, Southwest Florida Water Management District (citing Holland, K. and R. Hicks. 2013. Nutrient TMDL for Rainbow Springs Group and Rainbow Springs Group Run (WBIDs 1320A and 1320B). Prepared by Ground Water Management Section, Florida Department of Environmental Protection, Tallahassee, Florida.), https://www.swfwmd.state.fl.us/projects/mfl/reports/Rainbow/Rainbow_MFL-Revised_Final_Draft.pdf

[18] Minimum Flows Determination for Silver Springs, Marion County, Florida, St. John Water Management District, Technical Publication SJ2017-2, ftp://secure.sjrwater management districts.com/technicalreports/TP/SJ2017-2.pdf

[19] Peer Review of the Recommended Minimum Flow for the Rainbow River System, Final Panel Review Document November 21, 2016, http://www.swfwater management districts.state.fl.us/projects/mfl/reports/Rainbow_Peer_Rev_Rpt_2016.pdf

will continue to be assessed during the re-evaluation period."[20] Despite the Panel's recommendation and SWFWMD's acknowledgement thereof, the Rainbow River MFL report has yet to formally address the issue.

The Panel also considered linkages other than velocity for algae growth and concluded that,

> "nutrient loading is relevant when assigning the MFL in that it can lead to vegetation changes (increased SAV) which in turn lead to hydrologic changes (reduced flow relative to aquifer head). It appears that the District has not yet resolved all the causal relations of interest to explain the change in flows … The Panel is sympathetic to the relative absence of data for these sorts of determinations, but it's only by documenting these knowledge gaps formally in reviews like this that future knowledge acquisition efforts are motivated. In the absence of key supporting data, the District should consider capping withdrawals at current levels (or with a minimal allowable increase) until the nutrient issues are effectively addressed. … consideration should be given to allow no reduction in flow unless there is a corresponding decrease in loading so that there is no net increase in projected nitrate concentrations. … Underlying this recommendation is our perception that the system … is substantially overused to the point that any reduction in flow could impact water quality and should be of concern."[21]

Although indicating a non-velocity mechanism for the increase in SAV and algal cover, the Panel's recommendation coincides with the scientific research that suggests increased SAV and algal cover creates drag and reduces velocity at uniform discharge rates. Regardless of whether greater SAV and algal cover can be attributed more to nutrient loading or decreased vegetative scouring due to persistent reduced velocity, the Panel ultimately concludes that a minimum velocity functions as a critical stop-gap measure to prevent further degradation by increased algae growth. Therefore, setting spring MFLs that produce a sufficient minimum velocity to prevent further algal growth appears to constitute effective protection even in the face of existing nutrient problems.

Generally, however, studies have demonstrated the significance of velocity on the amount of algae and SAV observed in spring watersheds. Such research not only confirms that lower velocity encourages algal accumulation presently, it also hypothesizes that lower velocity creates a stable-state

[20] District Response to the Peer Review of the Recommended Minimum Flow for the Rainbow River System, January 2017, Southwest Florida Water Management District, http://www.swfwater management districts.state.fl.us/projects/mfl/reports/District_Response-Peer_Review-RainbowMFL-010617.pdf
[21] Peer Review of the Recommended Minimum Flow for the Rainbow River System

condition of increased SAV and algal cover that sustains reduced velocity. As such, discharges higher than some adopted MFLs may be necessary to reach the critical velocity that inhibits algae proliferation. Therefore, MFLs that allow significant periods below the critical velocity appear to exacerbate deteriorating water quality by creating a hydrological environment conducive to further degradation caused by numerous factors, including nutrient loading and low velocity.

Legal Challenges and Potential Remedies

The purpose of spring MFLs is to establish regulatory protection against significant harm to spring ecosystems caused by the cumulative effects of consumptive use permits. These MFLs are focused on water quantity effects on water resources and the ecology of the area, but should also address changes in water quality, including algal accumulation, under the ten criteria outlined in the Water Resource Implementation Rule. Thus far, there has been no serious acknowledgement in the State's spring MFLs of a relationship between velocity and algae. However, in the face of mounting scientific evidence establishing the relevance of velocity to algae proliferation, MFL rulemaking that continues to ignore this relationship becomes more susceptible to legal challenge.

A challenge to agency rules is authorized by Section 120.56(2), Florida Statutes. The grounds for invalidation are that a rule represents an "invalid exercise of delegated legislative authority." This term is defined in Section 120.52(8), in relevant part as, "… (e)The rule is arbitrary or capricious. A rule is arbitrary if it is not supported by logic or the necessary facts; a rule is capricious if it is adopted without thought or reason or is irrational; …"

An affected person may request a hearing before the secretary of the Department of Environmental Protection (DEP) to present evidence and argument relating to a proposed rule's consistency with the Water Resource Implementation Rule. "If the department determines that the rule

is inconsistent with the Water Resource Implementation Rule, it may order the water management district to initiate rulemaking proceedings to amend or repeal the rule."[22]

Florida law authorizes a petition to DEP within 30 days of rule adoption and an evidentiary hearing relating to the consistency of a proposed rule with the water resource implementation rule.[23] The Petition would ask DEP to reasonably interpret and apply the Water Resource Implementation Rule and to find that the proposed MFL is not consistent with the Water Resource Implementation Rule. Presumably water management districts would refer the matter to State of Florida, Division of Administrative Hearings (DOAH) to resolve any disputed issues of material fact.

An administrative challenge invoking the velocity-algae link might be based on one or more of three possible arguments. First, all spring MFL rulemaking is subject to an independent scientific peer review, which must consist of a panel of independent, recognized experts in the fields of hydrology, hydrogeology, limnology, biology, and other scientific disciplines relevant to the establishment of the minimum flow or minimum water level.[24] The report of the independent scientific peer review is admissible as evidence in the final hearing challenging the agency's rulemaking.[25] "The department or the governing board shall give significant weight to the final report of the peer review panel when establishing the minimum flow or minimum water level."[26] Therefore, to the extent an MFL does not adequately consider the findings of the peer review, it is likely in violation of the arbitrary and capricious standard of its legislative authority. Within the context of the Rainbow River MFL report, the peer review explicitly referred to insufficient evaluation of the velocity-algal accumulation relationship. Such evidence could prove substantively that the MFL rule is invalid in a DOAH hearing.

[22] Fla. Stat. §373.114(2)(a)
[23] Id.
[24] Fla. Stat. §373.042(6)(a),(d)
[25] Fla. Stat. §373.042(5)
[26] Fla. Stat. §373.042(6)(b)e

The second argument relates to best information. For adopted MFLs, "[m]inimum flows and minimum water levels shall be reevaluated periodically and revised as needed."[27] MFLs shall be calculated by the Water Management Districts and its governing board using the best information available, and failure to do so violates the law.[28] If existing MFLs reports have not considered the developing research on the relationship between velocity and algal accumulation, reevaluation and revision of the reports' conclusions are required. Release of new scientific reports, particularly the CRISPS report initiated by the St. Johns Water Management District itself[29], requires inclusion in updated spring MFL reports. For the emergency Rainbow River MFL and the final Silver River MFL, failure to re-evaluate these MFLs based on the findings of the comprehensive study that examined, in part, the relationship between velocity and algal growth appears to be an arbitrary and capricious exercise of the requirement to use the best information available.

The third and final legal argument is that spring MFLs that fail to adequately consider the impact of algal proliferation on water resource values appear to be inconsistent with the Florida Water Resource Implementation Rule. Although the Rainbow and Silver River MFLs reference the ten water resource values, their analyses fail to adequately address the impact of algae on the recreational, scenic and water quality values of the spring ecosystem, and more specifically the apparent effect that velocity has on algae proliferation. Updates or final adoption of MFLs should include this information. Otherwise, they would appear vulnerable to a challenge under the arbitrary and capricious standard of agency review.

Conclusion

[27] Fla. Stat. §373.0421(5)
[28] Fla. Stat. §373.042(1)(b)
[29] Collaborative Research Initiative on Sustainability and Protection of Springs CRISPS FINAL REPORT 2014 – 2017

Ongoing research is clarifying the inextricable relationship between water quantity and quality issues affecting Florida springs. Although separate chapters of Florida Statues exist to address these issues, the rulemaking authority conferred to water management districts to regulate water quantity in order to prevent significant ecological harm to springs requires consideration of values such as water quality, recreation, and aesthetics.

Probably the most palpable manifestations of ecological harm to springs is filamentous algae, which mars the otherwise pristine, crystal-clear water that make them so renowned. While there are multiple factors including nitrate pollution that contribute to algal proliferation in spring environments, water velocity flowing from the spring is now widely recognized as a significant factor in determining algae establishment, survival, and growth. Despite this understanding, velocity has yet to be significantly addressed in the MFLs or in regulation of water withdrawals in general. However, because velocity is directly determined by flow and level, a regime of flows and levels could be adopted to guarantee that sufficient velocity is present to prevent further degradation by algae. As scientific understanding of spring ecology increases, so does the obligation of the regulatory authorities to incorporate these advances to best protect these ecosystems.